SELECTION GUIDES

How To Use The Data Book
Numerical Index
Alphabetical Index
Device Outlines
GENERAL INFORMATION

SILICON ZENER DIODES
Regulator Diodes, Reference Diodes, Precision Reference Diodes and Reference Amplifiers

SILICON RECTIFIERS

SILICON RECTIFIER ASSEMBLIES
Bridge, Full-Wave, Voltage-Doubler and High-Voltage Assemblies

THYRISTORS and TRIGGERS
SCRs, 3-Layer and 4-Layer Diodes

POWER TRANSISTORS
Silicon and Germanium General-Purpose, High-Power Transistors For Use Up to 60 MHz

GERMANIUM MILLIWATT TRANSISTORS
Alloy Transistors for Low-Frequency Switching and Amplifier Applications

SWITCHING AND GENERAL PURPOSE TRANSISTORS
Silicon and Germanium Devices for High-Speed Switching and High-Frequency Amplifier Applications

RF TRANSISTORS
Silicon and Germanium Transistors Designed for Use at VHF and UHF Frequencies in Receivers and Transmitters

FIELD EFFECT TRANSISTORS

MULTIPLE and SPECIAL DEVICES
Dual Transistors, Dual Diodes, and Field Effect Current Limiters

VARACTORS
Voltage-Variable Capacitance Diodes for High-Power Frequency Multiplication and Tuning

Digital
Linear
INTEGRATED CIRCUITS

HARDWARE
Heat Sinks, Mounting Hardware and Integrated Circuit Inter-Connecting Patch Boards

LATE ADDITIONS

APPLICATION NOTES

the semiconductor data book

One of the major problems facing workers in the electronics field is the identification and selection of semiconductor devices. Type numbers themselves are of little value since they indicate neither device parameters nor applications. Because it is difficult even to identify the many thousands of device type numbers, let alone evaluate their merits for a particular application, engineers often limit their designs to a few well-known device types — despite the fact that newer or more suitable devices may be available.

This book identifies and characterizes all semiconductor devices with 1N---, 2N---, and 3N--- numbers registered with the Electronics Industries Association at the close of the production date for the book, as well as a broad line of devices with special in-house type numbers. It provides complete data-sheet specifications for a wide range of semiconductors, encompassing devices ranging from diodes to integrated circuits. And in addition, to simplify the selection of the most useful semiconductor type numbers, it contains carefully prepared selector guides with recommended devices for specific applications. Properly used, it can be a valuable aid for the design engineer, the component engineer and the purchasing agent in narrowing the broad categories of potentially useable components to those best suited for a specific project.

The information in this book has been carefully checked and is believed to be reliable; however, no responsibility is assumed for inaccuracies. Furthermore, this information does not convey to the purchaser of semiconductor devices any license under the patent rights of any manufacturer.

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HOW TO USE THE SEMICONDUCTOR DATA BOOK

This book is designed to serve three specific functions:

1. To permit quick identification of any semiconductor device bearing an EIA registered 1N, 2N, and 3N number, as well as special in-house numbers.
2. To permit quick selection of preferred devices for specific circuit applications.
3. To permit quick selection of preferred devices that best meet a desired set of electrical specifications.

The following examples illustrate how the book can be used to quickly solve these device identification and preselection problems.

EXAMPLE 1

Known: EIA-registered type number or special house number.
Needed Information: Identification, short-form specifications.
Procedure: If the device type number begins with 1N, turn to the table on page 1-2 entitled

1N Type Numbers – Complete Index, and Short-Form Device Specifications

This table lists all 1N type numbers in numerical sequence and provides short-form specifications for these devices.

If the device type number begins with 2N or 3N, turn to the table on page 1-104 entitled

2N and 3N Type Numbers – Complete Index and Bi-Polar Transistor Short-Form Specifications

This table serves two functions. It lists all 2N and 3N type numbers in numerical sequence, and it provides short-form specifications for all bi-polar transistor types. Those 2N type numbers representing semiconductor devices other than bi-polar transistors (i.e. SCRs, FETs, etc.) are identified in blocks (i.e. 2N– through 2N–) and are referenced to a subsequent table where they are individually tabulated and characterized.

If the device type number is non-registered, turn to the index on page 1-180 which refers you to a page number in the book where complete data sheet specifications for the device are given.

EXAMPLE 2

Known: Desired application or desired device parameters.
Needed Information: Specific type numbers of devices to fit known applications or device parameters.
Procedure: This book is divided into 12 main data sheet sections, each containing data sheet specifications for major device categories (i.e. Power Transistors). Preceding the actual data sheet specification in each main section are a number of Quick Selection Charts and Tables in which the devices described in the section are broken down by major parameters and recommended applications.

To find the recommended devices, refer to the appropriate main section of the book and consult Quick Selection Charts and Tables at the beginning of the section. Then turn to the specific data sheets within the section (these are given in alpha-numerical sequence) for more detailed specifications.

NUMERICAL INDEX

1N--- TYPE NUMBERS — COMPLETE INDEX and SHORT-FORM DEVICE SPECIFICATIONS

The following table lists, in numerical sequence, all EIA-registered devices with 1N--- type numbers, and provides major electrical specifications for these devices. Semiconductors included in this tabular listing are Rectifier Diodes, Zener Diodes, Reference Diodes, Signal Diodes and Varactor Diodes.

Since the major electrical characteristics for devices in each of the above groups differ from one another, the table heading consists of four different sets of specifications, each applying to a specific group of devices. Specifications for the fifth group of devices — Varactor Diodes — are given in a separate table on page 1-99.

KEY

RECTIFIER DIODES

V_R = DC Blocking Voltage
V_F = Average Forward Voltage Drop
I_O = Average Rectifier Forward Current
I_R = Average Reverse Current
I_{surge} = Peak Surge Current

ZENER DIODES

V_Z (min) = Minimum Zener Breakdown Voltage (Volts)
V_Z (max) = Maximum Zener Breakdown Voltage (used only when a corresponding V_Z (min) is specified. Otherwise, this column refers to V_Z (nom) Nominal Zener Breakdown Voltage.)
Tol = Tolerance, for specified Nominal breakdown Voltage
P_D = Maximum Power Dissipation. M = milliwatts, W = watts

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS: V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	ZENER DIODES: V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES: PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	REFERENCE DIODES: TC %/°C	V_Z	T(min) °C	T(max) °C
Numerical Listing of Registered Type Numbers					SHADING INDICATES SIGNAL DIODES					SHADING INDICATES REFERENCE DIODES			
	S = Silicon G = Germanium				PRV = Peak Reverse Voltage					TC = Temperature Coefficient			
		Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book			V_F @ I_F = Maximum Forward Voltage at Indicated Forward Current — M = milliamps, A = amps					V_Z = Zener Breakdown Voltage			
			Page in this book on which the device or its replacement device is fully characterized		I_R = Reverse Current — M = milliamps, * = microamps N = nanoamps					T(min) } Temperature Range T(max) } over which indicated temperature coefficient is applicable.			
					t_{rr} = Reverse Recovery Time								

The three codes listed below define the listed device and indicate the appropriate specification column heading:

R — Rectifier
RD — Reference Diode
ZD — Zener Diode

The seven following codes define signal diodes:

GP — General Purpose
HC — High Conductance (≥ 20 mA @ ≤ 1 V)
HS — High Speed Switch (Max t_{rr} < 0.3 μs)
CS — High Conductance, High Speed Switch
MS — Medium Speed Switch
PA — Parametric Amplifier
SP — Special Purpose

1N--- TYPE NUMBERS — INDEX & SHORT-FORM SPECIFICATIONS

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 34	G			GP	60	1	8.5M	15*						
1N 34A	G			GP	60	1	5M	30*						
1N 35	G			SP	50			2M						
1N 38	G			GP	100	1	7.5M	25*						
1N 38A	G			GP	100	1	4M	6*						
1N 38B	G			GP	100	1	4M	6*						
1N 39	G			GP	200	1	5M	40*						
1N 39A	G			GP	200	1	5M	40*						
1N 39B	G			GP	200	1	4M	650*						
1N 40	G			SR	25									
1N 41	G			SP	25									
1N 42	G			SP	50									
1N 43	G			GP	60	1	5M	20*						
1N 44	G			GP	115	1	3M	410*						
1N 45	G			GP	75	1	3M	410*						
1N 46	G			GP	50	1	3M	1.5M						
1N 47	G			GP		1	5M	400*						
1N 48	G			GP	85	1	4M	833*						
1N 49	G			GP	50	1	4M							
1N 50	G			GP	50	1	4M							
1N 51	G			GP	50	1	2.5M							
1N 52	G			GP	85	1	4M	150*						
1N 52A	G			GP	50	1	5M	100*						
1N 54	G			GP	35	1	5M	10*						
1N 54A	G			GP	50	1	5M	7*						
1N 55	G			GP	150	1	3M	.3M						
1N 55A	G			GP	150	1	4M	500*						
1N 55B	G			GP	190	1	5M	500*						
1N 56	G			GP	30	1	15M	300*						
1N 56A	G			GP	40	1	15M	300*						
1N 57	G			GP	80	1	3.6M	300*						
1N 58	G			GP	100	1	5M	800*						
1N 58A	G			GP	100	1	4M	600*						
1N 59	G			GP	250	1	3M	800*						
1N 60	G			GP	50	1	5M	40*						
1N 60A	G			GP	40									
1N 61	G			GP	130	1	5M	300*						
1N 62	G			GP	110	1	5M	700*						
1N 63	G			GP	125	1	4M	50*						
1N 63A	G			GP	100	1	4M	50*						
1N 64	G			GP	20									
1N 65	G			GP	85	1	2.5M	200*						
1N 66	G			GP	60	1	5M	50*						
1N 66A	G			GP	60	1	5M	50*						
1N 67	G			GP	80	1	4M	5*						
1N 67A	G			GP	100	1	4M	5*						
1N 68	G			GP	100	1	3M	625*						
1N 68A	G			GP	130	1	3M	625*						
1N 69	G			GP	75	1	5M	50*						
1N 69A	G			GP	60	1	5M	30*						
1N 70	G			GP	125	1	3M	25*						
1N 70A	G			GP	100	1	3M	25*						
1N 71	G			SP	40	1	15M	.3M						
1N 73	G			SP		1.7	15M	.05M						
1N 74	G			SP		1.8	15M	.05M						
1N 75	G			GP	125	1	2.5M	50*						
1N 81	G			GP	50	1	3M	10*						
1N 81A	G			GP	40	1	3M	10*						
1N 83	G			GP	225	1	5M	30*						
1N 84	G			GP	12	1	60M	.1M						
1N 86	G			GP	70	1	4M	50*						
1N 88	G			GP	85	1	2.5M	.1M						
1N 89	G			GP	100	1	3.5M	8*						
1N 90	G			GP	75	1	5M	800*						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N91 — 1N200

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 91				R	100	.5	.15	4	25				
1N 92				R	200	.5	.1	2	25				
1N 93				R	300	.5	.075	1.3	25				
1N 94	G			R	380	.7	.5	.8	25				
1N 95	G			GP	75	1	10M	800*					
1N 96	G			HC	75	1	20M	800*					
1N 96A	G			HC	60	1	40M	500*					
1N 97	G			GP	100	1	10M	100*					
1N 98	G			HC	100	1	20M	100*					
1N 98A	G			HC	250	1	40M	100*					
1N 99	G			GP	100	1	10M	50*					
1N 100	G			HC	100	1	20M	50*					
1N 100A	G			HC	80	1	40M	.05M					
1N 101	G			GP	150	1	10M	10*					
1N 102	G			GP	75	1	15M	3*					
1N 103	G			GP	12	1	30M	.1M					
1N 104	G			GP	12	1	30M	.1M					
1N 106	G			HC	300	1	20M	70*					
1N 107	G			HC	10	1	150M	200*					
1N 108	G			HC	50	1	50M	200*					
1N 109	G			SP	15	1	1M	.1M					
1N 111	G			GP	70	1	5M	25*					
1N 112	G			GP	70	1	5M	50*					
1N 113	G			GP	70	1	2.5M	25*					
1N 114	G			GP	70	1	2.5M	50*					
1N 115	G			GP	70	1	2.5M	100*					
1N 116	G			GP	75	1	5M	100*					
1N 117	G			GP	75	1	10M	100*					
1N 118	G			HC	75	1	20M	100*					
1N 118A	G			HC	60	1	40M	.1M					
1N 119	G			MS	60	1	5M		.5				
1N 120	G			MS	60	1	5M		.5				
1N 126				GP	75	1	5M	50*					
1N 126A				GP	75	1	25M	50*					
1N 127				GP	125	1	3M	25*					
1N 127A				GP	125	1	25M	25*					
1N 128				GP	50	1	3M	10*					
1N 128A	G			GP	40	1	3M	10*					
1N 132	G			SP	25								
1N 137B	S			HC	36	1	20M	.03*					
1N 138B	S			HC	18	1	40M	.01*					
1N 139	G			HC	40	1	20M	1.5M					
1N 140	G			HC	70	1	40M	300*					
1N 141	G			HC	70	1	20M	50*					
1N 142	G			GP	100	1	5M	100*					
1N 143	G			HC	100	1	40M	100*					
1N 144	G			HC	30	1	100M	200*					
1N 145	G			HC	30	1	40M	100*					
1N 151	G			R	100	.7	.5	2.4	25				
1N 152	G			R	200	.7	.5	1.9	25				
1N 153	G			R	300	.7	.5	1.2	25				
1N 158	G			R	380	1.4	.5	.8	25				
1N 190	G			SP	3	.75	10M	.8M					
1N 191	G			MS	90	1	5M		.5				
1N 192	G			GP	70	1	5M		.5				
1N 193	S			GP	40	2	1M	40*	.5				
1N 194	S			GP	40	2	1.5M	10*	.2				
1N 194A	S			GP	40	1	1M	10*	.2				
1N 195	S			GP	40	2	2M	10*	.3				
1N 196	S			GP	40	2	1M	10*	.1				
1N 198	G			GP	80	1	4M	10*					
1N 198A	G			GP	80	1	4M	10*					
1N 198B	G			MS	80	1	4M	10*	.3				
1N 200	S			ZD						7.5			150M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max $t_{rr} < 0.3\,\mu s$)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 201	S			ZD						9			150M	
1N 202	S			ZD						11			150M	
1N 203	S			ZD						13.5			150M	
1N 204	S			ZD						17			150M	
1N 205	S			ZD						20			150M	
1N 206	S			ZD						25			150M	
1N 207	S			ZD						30			150M	
1N 208	S			ZD						37			150M	
1N 209	S			ZD						43			150M	
1N 210	S			ZD						52			150M	
1N 211	S			ZD						62			150M	
1N 212	S			ZD						75			150M	
1N 213	S			ZD						90			150M	
1N 214	S			ZD						110			150M	
1N 215	S			ZD						135			150M	
1N 216	S			ZD						170			150M	
1N 217	S			ZD						200			150M	
1N 218	S			ZD						250			150M	
1N 219	S			ZD						300			150M	
1N 220	S			ZD						370			150M	
1N 221	S			ZD						430			150M	
1N 222	S			ZD						520			150M	
1N 225	S			ZD						7.5	10		150M	
1N 225A	S			ZD							9.1	5	150M	
1N 226	S			ZD						9	12		150M	
1N 226A	S			ZD							10	5	150M	
1N 227	S			ZD						11	14.5		150M	
1N 227A	S			ZD							12	5	150M	
1N 228	S			ZD						13.5	18		150M	
1N 228A	S			ZD							15	5	150M	
1N 229	S			ZD						17	21		150M	
1N 229A	S			ZD							18	5	150M	
1N 230	S			ZD						20	27		150M	
1N 231	S			ZD						25	32		150M	
1N 232	S			ZD						30	39		150M	
1N 233	S			ZD						37	45		150M	
1N 234	S			ZD						43	54		150M	
1N 235	S			ZD						52	64		150M	
1N 236	S			ZD						62	80		150M	
1N 237	S			ZD						75	100		150M	
1N 238	S			ZD						90	120		150M	
1N 239	S			ZD						110	145		150M	
1N 248		1N248B	3-8	R	50	1.5	10	5	200					
1N 248A		1N248B	3-8	R	50	1.5	20	5	250					
1N 248B	S	1N248B	3-8	R	50	1.5	20	5	250					
1N 248C	S	1N248C	3-8	R	39	1.2	20	3.8	350					
1N 249		1N249A	3-8	R	100	1.5	10	5	200					
1N 249A		1N249B	3-8	R	100	1.5	20	5	250					
1N 249B	S	1N249B	3-8	R	100	1.5	20	5	250					
1N 249C	S	1N249C	3-8	R	77	1.2	20	3.6	350					
1N 250		1N250A	3-8	R	200	1.5	10	5	200					
1N 250A		1N250B	3-8	R	200	1.5	20	5	250					
1N 250B	S	1N250B	3-8	R	200	1.5	20	5	250					
1N 250C	S	1N250C	3-8	R	154	1.2	20	3.4	350					
1N 251	S			HS	30	1	5M	.1*	.15					
1N 252	S			HS	20	1	10M	.1*	.15					
1N 253	S	1N4002	3-23	R	95	1.5	1	.1	4					
1N 254	S	1N4003	3-23	R	190	1.5	.4		1.5					
1N 255	S	1N4004	3-23	R	380	1.5	.4		1.5					
1N 256	S	1N4005	3-23	R	570	1.5	.2		1					
1N 265	G			GP	90	1	3.2M	100*						
1N 266	G			GP	60	1	4M	75*						
1N 267	G			GP	25	1	3.5M	12*						
1N 268	G			GP	30	1	2.5M	20*						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N270 — 1N331

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 270	G			HC	80	1	200M	100*						
1N 273	G			HC	30	1	100M	20*						
1N 276	G			HC	50	1	40M	100*	.3					
1N 277	G			HC	100	1	100M	75*						
1N 278	G			HC	50	1	20M	125*						
1N 279	G			HC	30	1	100M	200*						
1N 281	G			HC	60	1	100M	30*						
1N 282	G			GP		1	40M	20M						
1N 283	G			HC	20	1	200M	20*						
1N 287	G			HC	60	1	20M	1.5M						
1N 288	G			HC	85	1	40M	350*						
1N 289	G			HC	85	1	20M	50*						
1N 290	G			GP	120	1	5M	100*						
1N 291	G			HC	120	1	40M	100*						
1N 292	G			HC	75	1	100M	200*						
1N 294	G			GP	60	1	5M	10*						
1N 294A	G			GP	60	1	5M	10*						
1N 295	G			GP	40			200*						
1N 295A	G			GP	40			200*						
1N 296	G			SP	40			200M						
1N 297	G			GP	80	1	3.5M	10*						
1N 297A	G			GP	80	1	3.5M	10*						
1N 298	G			GP	70	2	30M							
1N 298A	G			GP	30	2	30M	250*						
1N 299	G			SP		.5	3M	200M						
1N 300	S			GP	15	1	15M	001*						
1N 300A	S			GP	15	1	30M	001*						
1N 300B	S			HC	15	1	50M	001*						
1N 301	S			GP	70	1	5M	.05*						
1N 301A	S			GP	70	1	18M	.05*						
1N 301B	S			HC	70	1	50M	.01*						
1N 302	S			GP	225	1	1M	.2*						
1N 302A	S			GP	225	1	5M	.2*						
1N 303	S			GP	125	1	3M	.1*						
1N 303A	S			GP	125	1	12M	.1*						
1N 303B	S			HC	125	1	50M	.01*						
1N 304	S			GP	55	1.5	2M	2*						
1N 305	G			HC	60	.8	100M	20*						
1N 306	G			HC	15	.8	100M	2*						
1N 307	G			HC	125	1	100M	5*						
1N 308	G			HC	8	1	300M	500*						
1N 309	G			HC	40	1	100M	100*						
1N 310	G			HC	125	1	40M	20*						
1N 312	G			HC	60	1	70M	50*						
1N 313	G			HC	125	1	40M	10*						
1N 314	G			SP				.05M						
1N 315	G			R	300	.48	.075	.3	25					
1N 315A	G			R	200	.48	.1	.16	25					
1N 316	S	1N4001	3-23	R	50	2.0	.2		2					
1N 317	S	1N4002	3-23	R	100	2.0	.2		2					
1N 318	S	1N4003	3-23	R	200	2.0	.2		2					
1N 319	S	1N4004	3-23	R	350	2.0	.2		2					
1N 320	S	1N4005	3-23	R	500	2.0	.2		2					
1N 321	S	1N4007	3-23	R	850	1.2	.25	1.0	10					
1N 322	S			R	850	1.2	.25	1.0	10					
1N 323	S			R	50	2.0	.4		2					
1N 324	S			R	100	2.0	.4		2					
1N 325	S			R	200	2.0	.4		2					
1N 326	S			R	350	2.0	.4		2					
1N 327	S			R	500	2.0	.4		2					
1N 328	S			R	850	1.2	.4	.06	10					
1N 329	S			R	1000	1.2	.4	.06	10					
1N 330	S			GP	32	1	3M	.03*						
1N 331	S			GP	16	1	5M	.01*						

R — Rectifier, RD — Reference Diode, ZD — Zener Diode, GP — General Purpose, HC — High Conductance (≥ 20 mA @ ≤ 1 V), HS — High Speed Switch (Max t_{rr} < 0.3 μs) CS — High Conductance, High Speed Switch, MS — Medium Speed Switch, PA — Parametric Amplifier, SP — Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 332	S	1N4004	3-23	R	400	2	.4	.2	10				
1N 333	S	1N4004	3-23	R	400	2	.2	.2	5				
1N 334	S	1N4004	3-23	R	300	2	.4	.2	10				
1N 335	S	1N4004	3-23	R	300	2	.2	.2	5				
1N 336	S	1N4003	3-23	R	200	2	.4	.1	10				
1N 337	S	1N4003	3-23	R	200	2	.2	.1	5				
1N 338	S	1N4002	3-23	R	100	2	1	.2	20				
1N 339	S	1N4002	3-23	R	100	2	.4	.1	10				
1N 340	S	1N4002	3-23	R	100	2	.2	.1	5				
1N 341	S	1N4004	3-23	R	400	2	.4	.5	10				
1N 342	S	1N4004	3-23	R	400	2	.2	.5	5				
1N 343	S	1N4004	3-23	R	300	2	.4	.5	10				
1N 344	S	1N4004	3-23	R	300	2	.2	.5	5				
1N 345	S	1N4003	3-23	R	200	2	.4	.5	10				
1N 346	S	1N4003	3-23	R	200	2	.2	.5	5				
1N 347	S	1N4002	3-23	R	100	2	1	.5	20				
1N 348	S	1N4002	3-23	R	100	2	.4	.5	10				
1N 349	S	1N4002	3-23	R	100	2	.2	.5	5				
1N 350	S			HC	70	1	20M	.03*					
1N 351	S			HC	120	1	20M	.03*					
1N 352	S			HC	170	1	20M	.05*					
1N 353	S			HC	225	1	20M	.1*					
1N 354	S			HC	325	1	20M	.1*					
1N 355	G			GP	100	1	4M	50*					
1N 359	S			R	50	2.0	.1		2				
1N 360	S			R	100	2.0	.1		2				
1N 361	S			R	200	2.0	.1		2				
1N 362	S			R	350	2.0	.1		2				
1N 363	S			R	500	2.0	.1		2				
1N 364	S			R	850	1.2	.1	.06	10				
1N 365	S			R	1000	1.2	.1	.06	10				
1N 367	G			SP	15								
1N 368	G			R	200	.5	.1	.3	25				
1N 368A	G			R	200	.5	.1	.16	25				
1N 370	S			ZD						1.5	2.2		200M
1N 371	S			ZD						2.0	2.7		200M
1N 372	S			ZD						2.5	3.3		200M
1N 373	S			ZD						3.1	3.9		200M
1N 374	S			ZD						3.7	4.5		200M
1N 375	S			ZD						4.3	5.4		200M
1N 376	S			ZD						5.2	6.4		200M
1N 377	S			ZD						6.2	8.0		200M
1N 378	S			ZD						7.5	10		200M
1N 379	S			ZD						9	12		200M
1N 380	S			ZD						11	14.5		200M
1N 381	S			ZD						13.5	18		200M
1N 382	S			ZD						17	21		200M
1N 383	S			ZD						20	27		200M
1N 384	S			ZD						25	32		200M
1N 385	S			ZD						30	39		200M
1N 386	S			ZD						37	45		200M
1N 387	S			ZD						43	54		200M
1N 388	S			ZD						52	64		200M
1N 389	S			ZD						62	80		200M
1N 390	S			ZD						75	100		200M
1N 391	S			ZD						90	120		200M
1N 392	S			ZD						110	145		200M
1N 393	S			ZD						135	180		200M
1N 394	S			ZD						170	210		200M
1N 395	S			ZD						200	270		200M
1N 396	S			ZD						250	320		200M
1N 397	S			ZD						300	390		200M
1N 398	S			ZD						370	450		200M
1N 399	S			ZD						430	540		200M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N400 — 1N466B

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 400	S			ZD						520	640		200M
1N 411B	S	MR1210SB	3-35	R	50	1.5	50	25	525				
1N 412B	S	MR1211SB	3-35	R	100	1.5	50	25	525				
1N 413B	S	MR1213SB	3-35	R	200	1.5	50	25	525				
1N 417	G			MS	60				.3				
1N 418	G			MS	60	1	7M		.3				
1N 419	G			MS	80	1	125M		.3				
1N 429	S	1N429	2-32	RD							6.2		
1N 430	S	1N3156	2-32	RD						.002	8.4	-55	100
1N 430A	S	1N3157	2-32	RD						.001	8.4	-55	100
1N 430B	S			RD						.001	8.4	-55	150
1N 431	S			GP	68	.55	15M						
1N 432	S			GP	40	1	10M	5N					
1N 432A	S			GP	40	1	20M	5N					
1N 433	S			GP	145	1	3M	.1*					
1N 433A	S			GP	145	1	10M	.1*					
1N 434	S			GP	180	1	2M	.1*					
1N 434A	S			GP	180	1	7M	.1*					
1N 435	G			SP	40			.3M					
1N 440	S	1N4002	3-23	R	100	1.5	.3	.3					
1N 440B	S	1N4002	3-23	R	100	1.5		.3	15				
1N 441	S	1N4003	3-23	R	200	1.5	.3	.75					
1N 441B	S	1N4003	3-23	R	200	1.5			15				
1N 442	S	1N4004	3-23	R	300	1.5	.3	1					
1N 442B	S	1N4004	3-23	R	300	1.5		.001	15				
1N 443	S	1N4004	3-23	R	400	1.5	.3	1.5					
1N 443B	S	1N4004	3-23	R	400	1.5			15				
1N 444	S	1N4005	3-23	R	500	1.5	.3	1.75					
1N 444B	S	1N4005	3-23	R	500	1.5			15				
1N 445	S	1N4005	3-23	R	600	1.5	.3	2					
1N 445B	S	1N4005	3-23	R	600	1.5		.002	15				
1N 447	G			GP	30	1	25M	20*					
1N 448	G			GP	100	1	25M	30*					
1N 449	G			GP	30	1	50M	10*					
1N 450	G			GP	100	1	50M	30*					
1N 451	G			GP	150	1	50M	150*					
1N 452	G			GP	30	1	100M	30*					
1N 453	G			GP	100	1	100M	30*					
1N 454	G			GP	50	1	200M	50*					
1N 455	G			GP	30	1	300M	30*					
1N 456	S			HC	25	1	40M	25N					
1N 456A	S			HC	25	1	100M	25N					
1N 457	S			HC	60	1	20M	25N					
1N 457A	S			HC	60	1	100M	25N					
1N 458	S			GR	125	1	2M	25N					
1N 458A	S			HC	125	1	100M	25N					
1N 459	S			GR	175	1	3M	25N					
1N 459A	S			HC	175	1	100M	25N					
1N 460	S			GP	90	1	5M	.1*					
1N 460A	S			GP	90	1	15M	.1*					
1N 461	S			GP	25	1	15M	.5*					
1N 461A	S			HC	25	1	100M	.5*					
1N 462	S			GP	60	1	5M	.5*					
1N 462A	S			HC	60	1	100M	.5*					
1N 463	S			GP	175	1	1M	.5*					
1N 463A	S			HC	175	1	100M	.5*					
1N 464	S			GP	125	1	3M	.5*					
1N 464A	S			HC	125	1	100M	.5*					
1N 465	S	1N4371	2-10	ZD						2.0	3.2		200M
1N 465A	S	1N4371A	2-10	ZD							2.7	5	200M
1N 465B	S			ZD							2.7	1	200M
1N 466	S	1N746	2-10	ZD						3.0	3.9		200M
1N 466A	S	1N746A	2-10	ZD							3.3	5	200M
1N 466B	S			ZD							3.3	1	200M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 467	S	1N749	2-10	ZD						3.7	4.5		200M
1N 467A	S	1N749A	2-10	ZD							3.9	5	200M
1N 467B	S			ZD							3.9	1	200M
1N 468	S	1N750	2-10	ZD						4.3	5.4		200M
1N 468A	S	1N750A	2-10	ZD							4.7	5	200M
1N 468B	S			ZD							4.7	1	200M
1N 469	S	1N752	2-10	ZD						5.2	6.4		200M
1N 469A	S	1N752A	2-10	ZD							5.6	5	200M
1N 469B	S			ZD							5.6	1	200M
1N 470	S	1N754	2-10	ZD						6.2	8.0		200M
1N 470A	S	1N754A	2-10	ZD							6.8	5	200M
1N 470B	S			ZD							6.8	1	200M
1N 471	S			ZD						3.0	3.9		200M
1N 471A	S			ZD							3.3	5	200M
1N 472	S			ZD						3.7	4.5		200M
1N 472A	S			ZD							3.9	5	200M
1N 473	S			ZD						4.3	5.4		200M
1N 473A	S			ZD							4.7	5	200M
1N 474	S			ZD						5.2	6.4		200M
1N 474A	S			ZD							5.6	5	200M
1N 475	S			ZD						6.2	8.0		150M
1N 475A	S			ZD							6.8	5	200M
1N 476	G			GP	90	1	2.5M	11*					
1N 477	G			GP	90	1	2.5M	11*					
1N 478	G			GP	90	1	5M	7*					
1N 479	G			GP	90	1	5M	7*					
1N 480	G			MS	60	1	5M		.5				
1N 481	G			R	200	.5	.1	1.9	25				
1N 482	S			HC	36	1.1	100M	.25*					
1N 482A	S			HC	36	1	100M	25N					
1N 482B	S			HC	36	1	100M	25N					
1N 483	S			HC	70	1	100M	25N					
1N 483A	S			HC	70	1	100M	25N					
1N 483B	S			HC	70	1	100M	25N					
1N 484	S			HC	130	1.1	100M	.25*					
1N 484A	S			HC	130	1	100M	25N					
1N 484B	S			HC	130	1	100M	25N					
1N 485	S			HC	180	1.1	100M	.25*					
1N 485A	S			HC	180	1	100M	25N					
1N 485B	S			HC	180	1	100M	25N					
1N 486	S			HC	225	1.1	100M	.25*					
1N 486A	S			HC	225	1	100M	.05*					
1N 486B	S			HC	225	1	100M	.05*					
1N 487	S			HC	300	1.1	100M	.25*					
1N 487A	S			HC	300	1	100M	.1*					
1N 487B	S			HC	300	1	100M	.1*					
1N 488	S			HC	380	1.1	100M	.25*					
1N 488A	S			HC	380	1	100M	.1*					
1N 488B	S			HC	380	1	100M	.1*					
1N 490	G			MS	90	1	5M		.5				
1N 497	G			GP	30	1	100M	20*					
1N 498	G			GP	60	1	100M	25*					
1N 499	G			GP	75	1	100M	30*					
1N 500	G			GP	80	1	100M	40*					
1N 501	G			GP	100	1	100M	40*					
1N 502	G			GP	120	1	100M	50*					
1N 503	S			R	50	1.2	.33	.5					
1N 504	S			R	100	1.2	.33	.5					
1N 505	S			R	200	1.2	.33	.5					
1N 506	S			R	300	1.2	.33	.5					
1N 507	S			R	400	1.2	.33	.25					
1N 508	S			R	600	1.2	.33	.25					
1N 509	S			R	800	1.2	.33	.25					
1N 510	S			R	1000	1.2	.33	.25					

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N511 — 1N589

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 511	S			R	50	1.2	1	.5					
1N 512	S			R	100	1.2	1	.5					
1N 513	S			R	200	1.2	1	.5					
1N 514	S			R	300	1.2	1	.5					
1N 515	S			R	400	1.2	1	.25					
1N 516	S			R	600	1.2	1	.25					
1N 517	S			R	800	1.2	1	.25					
1N 518	S			R	1000	1.2	1	.25					
1N 519	S			R	50	1.2	1.25	.5					
1N 520	S			R	100	1.2	1.25	.5					
1N 521	S			R	200	1.2	1.25	.5					
1N 522	S			R	300	1.2	1.25	.5					
1N 523	S			R	400	1.2	1.25	.25					
1N 524	S			R	600	1.2	1.25	.25					
1N 525	S			R	800	1.2	1.25	.25					
1N 526	S			R	1000	1.2	1.25	.25					
1N 527	G			GP	10	.3	1M	50*					
1N 530	S	1N4002	3-23	R	100	2	.3	.003	3				
1N 531	S	1N4003	3-23	R	200	2	.3		3				
1N 532	S	1N4004	3-23	R	300	2	.3	.01	3				
1N 533	S	1N4004	3-23	R	400	2	.3	.015	3				
1N 534	S	1N4005	3-23	R	500	2	.3		3				
1N 535	S	1N4005	3-23	R	600	2	.3	.02	3				
1N 536	S	1N4001	3-23	R	50	.5	.25	.4	15				
1N 537	S	1N4002	3-23	R	100	.4	.25	.5	15				
1N 538	S	1N4003	3-23	R	200	.3	.25	.5	15				
1N 539	S	1N4004	3-23	R	300	.5	.25	.3	15				
1N 540	S	1N4004	3-23	R	400	.5	.25	.3	15				
1N 541	G			GP	45	2.2	10M	18*					
1N 542	G			SP									
1N 543	S			R	1000	10	.005	.1					
1N 543A	S			R	1000	8	.025	.1					
1N 544	S			R	1000	10	.015	.1					
1N 544A	S			R	1000	10	.075	.1					
1N 547	S	1N4005	3-23	R	600	1.1	.25	.35	15				
1N 548	S			R	900	1.1	.3	.35	15				
1N 549	S			R	1200	1.1	.3	.35	15				
1N 550	S	1N4002	3-23	R	100	1.5	.5		4				
1N 551	S	1N4003	3-23	R	200	1.5	.5	.001	4				
1N 552	S	1N4004	3-23	R	300	1.5	.5		4				
1N 553	S	1N4004	3-23	R	400	1.5	.5		4				
1N 554	S	1N4005	3-23	R	500	1.5	.5		4				
1N 555	S	1N4005	3-23	R	600	1.5	.5	.005	4				
1N 560	S	1N4006	3-23	R	800	1.75	.25	.015	2				
1N 561	S	1N4007	3-23	R	1000	1.75	.25	.02	2				
1N 562	S	1N4006	3-23	R	800	1.75	.4	.015	3				
1N 563	S	1N4007	3-23	R	1000	1.75	.4	.02	3				
1N 566	G			GP	220	1	20M	.2M					
1N 567	G			MS	100	1	150M	.15M	.3				
1N 568	G			MS	7	.32	5M	.1M	.08				
1N 569	G			HC	12	.5	250M	.05M					
1N 570	S			R	1250	10	37.5	.1					
1N 571	G			HC		1	200M	100*	4				
1N 573	G			R	380	.15	.25						
1N 574	G			R	380	.15	.3						
1N 575	G			R	380	.3	.35						
1N 575A	G			R	380	.15	.35						
1N 576A	G			R	380	.15	.4						
1N 581	G			R	380	.15	.25						
1N 582	G			R	380	.15	.3						
1N 583	G			R	380	.15	.35						
1N 584	G			R	380	.15	.4						
1N 588	S			R	1500	1.75	.1	.1	5				
1N 589	S			R	1500	1.75	.25	.1	10				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs) CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 590	S			R	1500	8	.075	.1						
1N 591	S			R	1500	8	.075	.1						
1N 596	S	1N4005	3-23	R	600	3	.125	.025	1					
1N 597	S	1N4006	3-23	R	800	3	.125	.025	1					
1N 598	S	1N4007	3-23	R	1000	3	.125	.025	1					
1N 599	S	1N4001	3-23	R	50	1.5	.3	.025	2					
1N 599A	S	1N4001	3-23	R	50	1.5	.3	.001	2					
1N 600	S	1N4002	3-23	R	100	1.5	.3	.025	2					
1N 600A	S	1N4002	3-23	R	100	1.5	.3	.001	2					
1N 601	S	1N4003	3-23	R	150	1.5	.3	.025	2					
1N 601A	S	1N4003	3-23	R	150	1.5	.3	.001	2					
1N 602	S	1N4003	3-23	R	200	1.5	.3	.025	2					
1N 602A	S	1N4003	3-23	R	200	1.5	.3	.001	2					
1N 603	S	1N4004	3-23	R	300	1.5	.3	.025	2					
1N 603A	S	1N4004	3-23	R	300	1.5	.3	.001	2					
1N 604	S	1N4004	3-23	R	400	1.5	.3	.025	2					
1N 604A	S	1N4004	3-23	R	400	1.5	.3		2					
1N 605	S	1N4005	3-23	R	500	1.5	.3	.025	2					
1N 605A	S	1N4005	3-23	R	500	1.5	.3	.002	2					
1N 606	S	1N4005	3-23	R	600	1.5	.3	.025	2					
1N 606A	S	1N4005	3-23	R	600	1.5	.3		2					
1N 607	S	1N4001	3-23	R	50	1.5	.8	.025	3					
1N 607A	S	1N4001	3-23	R	50	1.5	.8	.001	3					
1N 608	S	1N4002	3-23	R	100	1.5	.8	.025	3					
1N 608A	S	1N4002	3-23	R	100	1.5	.8	.001	3					
1N 609	S	1N4003	3-23	R	150	1.5	.8	.025	3					
1N 609A	S	1N4003	3-23	R	150	1.5	.8	.001	3					
1N 610	S	1N4003	3-23	R	200	1.5	.8	.025	3					
1N 610A	S	1N4003	3-23	R	200	1.5	.8	.001	3					
1N 611	S	1N4004	3-23	R	300	1.5	.8	.025	3					
1N 611A	S	1N4004	3-23	R	300	1.5	.8	.001	3					
1N 612	S	1N4004	3-23	R	400	1.5	.8	.025	3					
1N 612A	S	1N4004	3-23	R	400	1.5	.8	1.5	3					
1N 613	S	1N4005	3-23	R	500	1.5	.8	025	3					
1N 613A	S	1N4005	3-23	R	500	1.5	.8	.002	3					
1N 614	S	1N4005	3-23	R	600	1.5	.8	.025	3					
1N 614A	S	1N4005	3-23	R	600	1.5	.8	2.5	3					
1N 615	G			R	300		.075	1.2	25					
1N 616	G			SP	20	1	8M	.4M						
1N 617	G			GP	115	1	3M	11*						
1N 618	G			GP	115	1	5M	7*						
1N 619	S			GP	30	1	3M	.08*						
1N 622	S			GP	150	1	7M	.16*						
1N 625	S			MS		1.5	4M	1*	1					
1N 626	S			MS		1.5	4M	1*	1					
1N 627	S			MS		1.5	4M	1*	1					
1N 628	S			MS		1.5	4M	1*	1					
1N 629	S			MS		1.5	4M	1*	1					
1N 631	G			MS	60				.3					
1N 632	G			MS	60	1	7M		.3					
1N 633	G			MS	80	1	125M		.3					
1N 634	G			GP	100	1	50M	45*						
1N 635	G			GP	150	1	50M	175*						
1N 636	G			GP	60	1	2.5M	10*						
1N 643	S			MS	175	1	10M	1*	.3					
1N 643A	S			HC	175	1	100M	1*	.3					
1N 645	S	1N4004	3-23	HC	225	1	400M	.2*						
1N 645A	S	1N4004	3-23	HC	225	1	400M	.05*						
1N 646	S	1N4004	3-23	HC	300	1	400M	.2*						
1N 647	S	1N4004	3-23	HC	400	1	400M	.2*						
1N 648	S	1N4005	3-23	HC	500	1	400M	.2*						
1N 649	S	1N4005	3-23	HC	600	1	400M	.2*						
1N 658	S			HC	100	1	100M	.05*	.3					
1N 658A	S			HC	120	1	100M	25N	.3					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N659—1N711

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 659	S			MS	50	1	6M	5*	.3					
1N 659A	S			MS	60	1	10M	25N	.3					
1N 660	S			MS	100	1	6M	5*	.3					
1N 660A	S			MS	120	1	10M	25N	.3					
1N 661	S			MS	200	1	6M	10*	.3					
1N 661A	S			MS	240	1	10M	25N	.3					
1N 662	S			MS	80	1	10M	1*	.5					
1N 662A	S			HC	80	1	100M	1*	.3					
1N 663	S			MS	80	1	100M	5*	.5					
1N 663A	S			HC	80	1	100M	.1*	.3					
1N 664	S			ZD							8.2	10	250M	
1N 665	S			ZD						10.8	13.2		.25W	
1N 666	S			ZD						14.2	15.8		.25W	
1N 667	S			ZD						16.2	19.8		.25W	
1N 668	S			ZD						19.8	24.2		.25W	
1N 669	S			ZD						24.3	29.7		.25W	
1N 670	S			ZD							68	5	250M	
1N 671	S			ZD						90	110		.25W	
1N 672	S			ZD						135	165		.25W	
1N 673	S			HC	350	1	250M	1*						
1N 674	S			ZD							4.7	10	250M	
1N 675	S			ZD							6.2	5	250M	
1N 676	S	1N4002	3-23	R	100	1	.075	.2	3					
1N 677	S	1N4002	3-23	R	100	1	.15	.2	5					
1N 678	S	1N4003	3-23	R	200	1	.075	.2	3					
1N 679	S	1N4003	3-23	R	200	1	.15	.2	5					
1N 681	S	1N4004	3-23	R	300	1	.075	.2	3					
1N 682	S	1N4004	3-23	R	300	1	.15	.2	5					
1N 683	S	1N4004	3-23	R	400	1	.075	.2	3					
1N 684	S	1N4004	3-23	R	400	1	.15	.2	5					
1N 685	S	1N4005	3-23	R	500	1	.075	.2	3					
1N 686	S	1N4005	3-23	R	500	1	.15	.2	5					
1N 687	S	1N4005	3-23	R	600	1	.075	.2	3					
1N 689	S	1N4005	3-23	R	600	1	.15	.2	5					
1N 690	S			HC	36	1	400M	.25*	.8					
1N 691	S			HC	70	1	400M	.25*	.8					
1N 692	S			HC	100	1	400M	.25*	.8					
1N 693	S			HC	130	1	400M	.25*	.8					
1N 695	G			HC	20	1	100M	2*	.3					
1N 695A	G			MS	25	.5	10M	2*	.3					
1N 696	S			HS	30	1	10M	15N	5					
1N 697	S			CS		1	.25A	1*						
1N 698	G			HC	25	.65	30M	160*	.5					
1N 699	G			HC	80	1	100M		.3					
1N 701	S			ZD						9.5	10.5		.25W	
1N 702	S	1N4371	2-10	ZD						2.0	3.2		250M	
1N 702A	S	1N4371A	2-10	ZD						2.3	2.9		250M	
1N 703	S	1N746	2-10	ZD						3.0	3.9		250M	
1N 703A	S	1N746A	2-10	ZD						3.23	3.67		250M	
1N 704	S	1N749	2-10	ZD						3.7	4.5		250M	
1N 704A	S	1N749A	2-10	ZD						3.9	4.3		250M	
1N 705	S	1N750	2-10	ZD						4.3	5.4		250M	
1N 705A	S	1N750A	2-10	ZD						4.58	5.12		250M	
1N 706	S	1N752	2-10	ZD						5.2	6.4		250M	
1N 706A	S	1N752A	2-10	ZD						5.5	6.1		250M	
1N 707	S	1N754	2-10	ZD						6.2	8.0		250M	
1N 707A	S	1N754A	2-10	ZD						6.65	7.55		250M	
1N 708	S	1N752	2-10	ZD							5.6	10	250M	
1N 708A	S	1N752A	2-10	ZD							5.6	5	250M	
1N 709	S	1N753	2-10	ZD							6.2	10	250M	
1N 709A	S	1N753A	2-10	ZD							6.2	5	250M	
1N 710	S	1N957	2-11	ZD							6.8	10	250M	
1N 710A	S	1N957A	2-11	ZD							6.8	5	250M	
1N 711	S	1N958A	2-11	ZD							7.5	10	250M	

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TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 711A	S	1N958B	2-11	ZD							7.5	5	250M	
1N 712	S	1N959A	2-11	ZD							8.2	10	250M	
1N 712A	S	1N959B	2-11	ZD							8.2	5	250M	
1N 713	S	1N960A	2-11	ZD							9.1	10	250M	
1N 713A	S	1N960B	2-11	ZD							9.1	5	250M	
1N 714	S	1N961A	2-11	ZD							10	10	250M	
1N 714A	S	1N961B	2-11	ZD							10	5	250M	
1N 715	S	1N962A	2-11	ZD							11	10	250M	
1N 715A	S	1N962B	2-11	ZD							11	5	250M	
1N 716	S	1N963A	2-11	ZD							12	10	250M	
1N 716A	S	1N963B	2-11	ZD							12	5	250M	
1N 717	S	1N964A	2-11	ZD							13	10	250M	
1N 717A	S	1N964B	2-11	ZD							13	5	250M	
1N 718	S	1N965A	2-11	ZD							15	10	250M	
1N 718A	S	1N965B	2-11	ZD							15	5	250M	
1N 719	S	1N966A	2-11	ZD							16	10	250M	
1N 719A	S	1N966B	2-11	ZD							16	5	250M	
1N 720	S	1N967A	2-11	ZD							18	10	250M	
1N 720A	S	1N967B	2-11	ZD							18	5	250M	
1N 721	S	1N968A	2-11	ZD							20	10	250M	
1N 721A	S	1N968B	2-11	ZD							20	5	250M	
1N 722	S	1N969A	2-11	ZD							22	10	250M	
1N 722A	S	1N969B	2-11	ZD							22	5	250M	
1N 723	S	1N970A	2-11	ZD							24	10	250M	
1N 723A	S	1N970B	2-11	ZD							24	5	250M	
1N 724	S	1N971A	2-11	ZD							27	10	250M	
1N 724A	S	1N971B	2-11	ZD							27	5	250M	
1N 725	S	1N972A	2-11	ZD							30	10	250M	
1N 725A	S	1N972B	2-11	ZD							30	5	250M	
1N 726	S	1N973A	2-11	ZD							33	10	250M	
1N 726A	S	1N973B	2-11	ZD							33	5	250M	
1N 727	S	1N974A	2-11	ZD							36	10	250M	
1N 727A	S	1N974B	2-11	ZD							36	5	250M	
1N 728	S	1N975A	2-11	ZD							39	10	250M	
1N 728A	S	1N975B	2-11	ZD							39	5	250M	
1N 729	S	1N976A	2-11	ZD							43	10	250M	
1N 729A	S	1N976B	2-11	ZD							43	5	250M	
1N 730	S	1N977A	2-11	ZD							47	10	250M	
1N 730A	S	1N977B	2-11	ZD							47	5	250M	
1N 731	S	1N978A	2-11	ZD							51	10	250M	
1N 731A	S	1N978B	2-11	ZD							51	5	250M	
1N 732	S	1N979A	2-11	ZD							56	10	250M	
1N 732A	S	1N979B	2-11	ZD							56	5	250M	
1N 733	S	1N980A	2-11	ZD							62	10	250M	
1N 733A	S	1N980B	2-11	ZD							62	5	250M	
1N 734	S	1N981A	2-11	ZD							68	10	250M	
1N 734A	S	1N981B	2-11	ZD							68	5	250M	
1N 735	S	1N982A	2-11	ZD							75	10	250M	
1N 735A	S	1N982B	2-11	ZD							75	5	250M	
1N 736	S	1N983A	2-11	ZD							82	10	250M	
1N 736A	S	1N983B	2-11	ZD							82	5	250M	
1N 737	S	1N984A	2-11	ZD							91	10	250M	
1N 737A	S	1N984B	2-11	ZD							91	5	250M	
1N 738	S	1N985A	2-11	ZD							100	10	250M	
1N 738A	S	1N985B	2-11	ZD							100	5	250M	
1N 739	S	1N986A	2-11	ZD							110	10	250M	
1N 739A	S	1N986B	2-11	ZD							110	5	250M	
1N 740	S	1N987A	2-11	ZD							120	10	250M	
1N 740A	S	1N987B	2-11	ZD							120	5	250M	
1N 741	S	1N988A	2-11	ZD							130	10	250M	
1N 741A	S	1N988B	2-11	ZD							130	5	250M	
1N 742	S	1N989A	2-11	ZD							150	10	250M	
1N 742A	S	1N989B	2-11	ZD							150	5	250M	
1N 743	S	1N990A	2-11	ZD							160	10	250M	

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1N743A — 1N793

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N 743A	S	1N990B	2-11	ZD							160	5	250M	
1N 744	S	1N991A	2-11	ZD							180	10	250M	
1N 744A	S	1N991B	2-11	ZD							180	5	250M	
1N 745	S	1N992A	2-11	ZD							200	10	250M	
1N 745A	S	1N992B	2-11	ZD							200	5	250M	
1N 746	S		2-10	ZD							3.3	10	400M	
1N 746A	S		2-10	ZD							3.3	5	400M	
1N 747	S		2-10	ZD							3.6	10	400M	
1N 747A	S		2-10	ZD							3.6	5	400M	
1N 748	S		2-10	ZD							3.9	10	400M	
1N 748A	S		2-10	ZD							3.9	5	400M	
1N 749	S		2-10	ZD							4.3	10	400M	
1N 749A	S		2-10	ZD							4.3	5	400M	
1N 750	S		2-10	ZD							4.7	10	400M	
1N 750A	S		2-10	ZD							4.7	5	400M	
1N 751	S		2-10	ZD							5.1	10	400M	
1N 751A	S		2-10	ZD							5.1	5	400M	
1N 752	S		2-10	ZD							5.6	10	400M	
1N 752A	S		2-10	ZD							5.6	5	400M	
1N 753	S		2-10	ZD							6.2	10	400M	
1N 753A	S		2-10	ZD							6.2	5	400M	
1N 754	S		2-10	ZD							6.8	10	400M	
1N 754A	S		2-10	ZD							6.8	5	400M	
1N 755	S		2-10	ZD							7.5	10	400M	
1N 755A	S		2-10	ZD							7.5	5	400M	
1N 756	S		2-10	ZD							8.2	10	400M	
1N 756A	S		2-10	ZD							8.2	5	400M	
1N 757	S		2-10	ZD							9.1	10	400M	
1N 757A	S		2-10	ZD							9.1	5	400M	
1N 758	S		2-10	ZD							10.0	10	400M	
1N 758A	S		2-10	ZD							10.0	5	400M	
1N 759	S		2-10	ZD							12.0	10	400M	
1N 759A	S		2-10	ZD							12.0	5	400M	
1N 761	S	1N751A	2-10	ZD						4.3	5.4		250M	
1N 762	S	1N753A	2-10	ZD						5.2	6.4		250M	
1N 763	S	1N757	2-10	ZD						6.2	8.0		250M	
1N 764	S	1N959A	2-11	ZD						7.5	10.0		250M	
1N 765	S	1N961A	2-11	ZD						9.0	12.0		250M	
1N 766	S	1N964A	2-11	ZD						11.0	14.5		250M	
1N 767	S	1N966A	2-11	ZD						13.5	18.0		250M	
1N 768	S	1N967A	2-11	ZD						17.0	21.0		250M	
1N 769	S	1N970	2-11	ZD						20.0	27.0		250M	
1N 770	G			MS	20	.42	5M	4D*	.35					
1N 771	G			HC	80	1	100M	25*						
1N 771A	G			HC	80	1	200M	25*						
1N 771B	G			HC	80	1	400M	25*						
1N 772	G			HC	70	1	100M	50*						
1N 772A	G			HC	70	1	200M	50*						
1N 773	G			HC	65	1	100M	10*						
1N 773A	G			HC	65	1	200M	10*						
1N 774	G			HC	60	1	100M	15*						
1N 774A	G			HC	60	1	200M	15*						
1N 775	G			HC	60	1	100M	20*						
1N 776	G			HC	20	1	50M	200*						
1N 777	G			HC	60	1	100M	25*	.5					
1N 778	S			MS	100	1	10M	.5*	.3					
1N 779	S			MS	175	1	10M	.5*	.3					
1N 781	G			MS	40	.45	10M	5*	.5					
1N 781A	G			MS	40	.45	10M	5*	.5					
1N 789	S			HS		1	10M	1*	.5					
1N 790	S			MS		1	10M	5*	.25					
1N 791	S			HC		1	50M	5*	.5					
1N 792	S			HC		1	100M	5*	.5					
1N 793	S			MS		1	10M	1*	.5					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 794	S			HS		1	10M	5*	.25				
1N 795	S			HC		1	50M	5*	.5				
1N 796	S			HC		1	100M	5*	.5				
1N 797	S			MS		1	10M	1*	.5				
1N 798	S			HS		1	10M	5*	.25				
1N 799	S			HC		1	50M	5*	.5				
1N 800	S			HC		1	100M	5*	.5				
1N 801	S			MS		1	10M	1*	.5				
1N 802	S			MS		1	50M	5*	.5				
1N 803	S			MS		1	10M	5*	.5				
1N 804	S			HC		1	50M	10*	.5				
1N 805	G			GP	40	1	3M	100*					
1N 806	S			MS	100	1	4M	.5*	.3				
1N 807	S			MS	180	1	4M	.5*	.3				
1N 808	S			HC	100	1	100M	1*	.3				
1N 809	S			HC	200	1	100M	1*	.3				
1N 810	S			HS	50	1	10M	1*	50				
1N 811	S			HS	20	1	1M	1*	.25				
1N 812	S			HS	30	1	1M	.1*	.25				
1N 813	S			HS	15	1	5M	.5*	.25				
1N 814	S			HS	40	1	2M	.1*	.25				
1N 815	S			CS	15	1.5	100M	.5*	.25				
1N 816	S			HC	6	1	100M	.1*					
1N 817	S			GP	200	1.5	6M	20*	1				
1N 818	S			MS	80	1.5	30M	.25*	.5				
1N 819	S			HC	80	1	200M	25N					
1N 821	S		2-32	RD						.01	6.500	-55	100
1N 821A	S		2-32	RD						.01	6.500	-55	100
1N 822	S			RD						.01	6.500	-55	100
1N 823	S		2-32	RD						.005	6.500	-55	100
1N 823A	S		2-32	RD						.005	6.500	-55	100
1N 824	S			RD						.005	6.500	-55	100
1N 825	S		2-32	RD						.002	6.500	-55	100
1N 825A	S		2-32	RD						.002	6.500	-55	100
1N 826	S			RD						.002	6.9	50	100
1N 827	S		2-32	RD						.001	6.500	-55	100
1N 827A	S		2-32	RD						.001	6.500	-55	100
1N 828	S			RD						.001	6.9	50	100
1N 829	S		2-32	RD						.0005	6.5	50	100
1N 835	G			GP	30	.5	5M	20*	.5				
1N 836	G			PA	5								
1N 837	S			HC		1	150M	.1*	.5				
1N 837A	S			HC		1	150M	.1*	.3				
1N 838	S			HC		1	150M	.1*	.5				
1N 839	S			HC		1	150M	.1*	.5				
1N 840	S			HC		1	150M	.1*	.3				
1N 841	S			HC		1	150M	.1*	.3				
1N 842	S			HC		1	150M	.1*	.3				
1N 843	S			HC		1	150M	.1*	.3				
1N 844	S			HC		1	200M	.1*	.5				
1N 845	S			HC		1	200M	.1*	.5				
1N 846	S	1N4001	3-23	GP	50	.6	200M	20*					
1N 847	S	1N4002	3-23	GP	100	.6	200M	20*					
1N 848	S	1N4003	3-23	GP	200	.6	200M	20*					
1N 849	S	1N4004	3-23	GP	300	.6	200M	20*					
1N 850	S	1N4004	3-23	GP	400	.6	200M	20*					
1N 851	S	1N4005	3-23	GP	500	.6	200M	20*					
1N 852	S	1N4005	3-23	GP	600	.6	200M	20*					
1N 853	S	1N4006	3-23	GP	700	.6	200M	20*					
1N 854	S	1N4006	3-23	GP	800	.6	200M	20*					
1N 855	S	1N4007	3-23	GP	900	.6	200M	20*					
1N 856	S	1N4007	3-23	GP	1K	.6	200M	20*					
1N 857	S	1N4001	3-23	GP	50	.6	150M	20*					
1N 858	S	1N4002	3-23	GP	100	.6	150M	20*					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N859—1N914

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z(min)	V_Z(nom) V_Z(max)	Tol V_Z%	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 859	S	1N4003	3-23	GP	200	.6	150M	20*					
1N 860	S	1N4004	3-23	GP	300	.6	150M	20*					
1N 861	S	1N4004	3-23	GP	400	.6	150M	20*					
1N 862	S	1N4005	3-23	GP	500	.6	150M	20*					
1N 863	S	1N4005	3-23	GP	600	.6	150M	20*					
1N 864	S	1N4006	3-23	GP	700	.6	150M	20*					
1N 865	S	1N4006	3-23	GP	800	.6	150M	20*					
1N 866	S	1N4007	3-23	GP	900	.6	150M	20*					
1N 867	S	1N4007	3-23	GP	1K	.6	150M	20*					
1N 868	S	1N4001	3-23	GP	50	.6	100M	20*					
1N 869	S	1N4002	3-23	GP	100	.6	100M	20*					
1N 870	S	1N4003	3-23	GP	200	.6	100M	20*					
1N 871	S	1N4004	3-23	GP	300	.6	100M	20*					
1N 872	S	1N4004	3-23	GP	400	.6	100M	20*					
1N 873	S	1N4005	3-23	GP	500	.6	100M	20*					
1N 874	S	1N4005	3-23	GP	600	.6	100M	20*					
1N 875	S	1N4006	3-23	GP	700	.6	100M	20*					
1N 876	S	1N4006	3-23	GP	800	.6	100M	20*					
1N 877	S	1N4007	3-23	GP	900	.6	100M	20*					
1N 878	S	1N4007	3-23	GP	1K	.6	100M	20*					
1N 879	S	1N4001	3-23	GP	50	.6	50M	20*					
1N 880	S	1N4002	3-23	GP	100	.6	50M	20*					
1N 881	S	1N4003	3-23	GP	200	.6	50M	20*					
1N 882	S	1N4004	3-23	GP	300	.6	50M	20*					
1N 883	S	1N4004	3-23	GP	400	.6	50M	20*					
1N 884	S	1N4005	3-23	GP	500	.6	50M	20*					
1N 885	S	1N4005	3-23	GP	600	.6	50M	20*					
1N 886	S	1N4006	3-23	GP	700	.6	50M	20*					
1N 887	S	1N4006	3-23	GP	800	.6	50M	20*					
1N 888	S	1N4007	3-23	GP	900	.6	50M	20*					
1N 889	S	1N4007	3-23	GP	1K	.6	50M	20*					
1N 890	S			HC	60	1	20M	25N					
1N 891	S			HC		1	50M	.1*	.3				
1N 892	S			HC		1	50M	.1*	.3				
1N 893	S			HC		1	50M	.1*	.3				
1N 894	G			PA	5								
1N 895	G			PA	5								
1N 896	G			PA	5								
1N 897	S			MS	2.5	1	5M	.1*	1				
1N 898	S			HC	2.5	1	100M	5*	.3				
1N 899	S			MS	85	1	5M	.1*	.3				
1N 900	S			HC	85	1	50M	.1*	.3				
1N 901	S			HC	85	1	100M	.5*	.3				
1N 902	S			MS	170	1	10M	1*	.3				
1N 903	S			HS	40	1	10M	.1*	4				
1N 903A	S			CS	40	1	20M	.1*	4				
1N 904	S			HS	30	1	10M	.1*	4				
1N 904A	S			CS	30	1	20M	.1*	4				
1N 905	S			HS	20	1	10M	.1*	4				
1N 905A	S			CS	20	1	20M	.1*	4				
1N 906	S			MS	20	1	10M	.1*	4				
1N 906A	S			CS	20	1	20M	.1*	4				
1N 907	S			MS	30	1	10M	.1*	4				
1N 907A	S			CS	30	1	20M	.1*	4				
1N 908	S			MS	40	1	10M	.1*	4				
1N 908A	S			HC	40	1	20M	.1*	4				
1N 909	G			HC	50	1	100M	10*					
1N 910	G			HC	30	1	100M	10*					
1N 911	G			HC	20	1	100M	10*					
1N 912	S			GP	10	.62	1M	1*					
1N 912A	S			GP	10	.62	1M	1*					
1N 913	S			GP	10	.62	1M	5*					
1N 913A	S			GP	10	.62	1M	1*					
1N 914	S			MS	75	1	10M	5*	4				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max $t_{rr} < 0.3\,\mu s$), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 914A	S			HC	75	1	20M	5*	4				
1N 914B	S			CS	75	1	100M	5*	4				
1N 915	S			CS	50	1	50M	5*	10				
1N 916	S			MS	75	1	10M	5*	4				
1N 916A	S			HC	75	1	20M	5*	4				
1N 916B	S			CS	75	1	30M	5*	4				
1N 917	S			HS	30	1	10M	.05*	3				
1N 919	S			MS	150	1	100M	.5*	.3				
1N 920	S			HC	36	1	500M	.25*	.3				
1N 921	S			HC	70	1	500M	.25*	.3				
1N 922	S			HC	100	1	500M	.25*	.3				
1N 923	S			HC	130	1	500M	.25*	.3				
1N 925	S			HS	32	1	5M	1*	.15				
1N 926	S			HS	32	1	5M	.1*	.15				
1N 927	S			HS	52	1	10M	.1*	.15				
1N 928	S			HS	96	1	10M	.1*	.15				
1N 929	S			HC	20	1	20M	.1*					
1N 930	S			HC	50	1	20M	.1*					
1N 931	S			HC	100	1	20M	.1*					
1N 932	S			HC	200	1	20M	.1*					
1N 933	G			MS	100	1	14M	10*	.4				
1N 934	S			HC	60	1	30M	25N	1				
1N 935	S		2-32	RD						.01	9.45	0	75
1N 935A	S		2-32	RD						.01	9.45	-55	100
1N 935B	S		2-32	RD						.01	9.45	-55	150
1N 936	S		2-32	RD						.005	9.45	0	75
1N 936A	S		2-32	RD						.005	9.45	-55	100
1N 936B	S		2-32	RD						.005	9.45	-55	150
1N 937	S		2-32	RD						.002	9.45	0	75
1N 937A	S		2-32	RD						.002	9.45	-55	100
1N 937B	S		2-32	RD						.002	9.45	-55	150
1N 938	S		2-32	RD						.001	9.45	0	75
1N 938A	S		2-32	RD						.001	9.45	-55	100
1N 938B	S		2-32	RD						.001	9.45	-55	150
1N 939	S		2-32	RD						.0005	9.45	0	75
1N 939A	S		2-32	RD						.0005	9.45	-55	100
1N 939B	S		2-32	RD						.0005	9.45	-55	150
1N 940	S			RD						.0002	9	0	75
1N 940A	S			RD						.0002	9	-55	100
1N 940B	S			RD						.0002	9	-55	150
1N 941	S		2-32	RD						.01	12.28	0	75
1N 941A	S		2-32	RD						.01	12.28	-55	100
1N 941B	S		2-32	RD						.01	12.28	-55	150
1N 942	S		2-32	RD						.005	12.28	0	75
1N 942A	S		2-32	RD						.005	12.28	-55	100
1N 942B	S		2-32	RD						.005	12.28	-55	150
1N 943	S		2-32	RD						.002	12.28	0	75
1N 943A	S		2-32	RD						.002	12.28	-55	100
1N 943B	S		2-32	RD						.002	12.28	-55	150
1N 944	S		2-32	RD						.001	12.28	0	75
1N 944A	S		2-32	RD						.001	12.28	-55	100
1N 944B	S		2-32	RD						.001	12.28	-55	150
1N 945	S		2-32	RD						.0005	12.28	0	75
1N 945A	S		2-32	RD						.0005	12.28	-55	100
1N 945B	S		2-32	RD						.0005	12.28	-55	150
1N 946	S			RD						.0002	11.7	0	75
1N 946A	S			RD						.0002	11.7	-55	100
1N 946B	S			RD						.0002	11.7	-55	150
1N 947	S			GP		1	400M	2*					
1N 948	S			MS	36	1.5	100M	.25*	1				
1N 949	G			GP	50	.39	10M	10*					
1N 950 thru 1N 956	Varactor Diodes, see table on page 1-99												

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N957 — 1N977A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 957	S		2-11	ZD							6.8	20	400M
1N 957A	S		2-11	ZD							6.8	10	400M
1N 957B	S		2-11	ZD							6.8	5	400M
1N 958	S		2-11	ZD							7.5	20	400M
1N 958A	S		2-11	ZD							7.5	10	400M
1N 958B	S		2-11	ZD							7.5	5	400M
1N 959	S		2-11	ZD							8.2	20	400M
1N 959A	S		2-11	ZD							8.2	10	400M
1N 959B	S		2-11	ZD							8.2	5	400M
1N 960	S		2-11	ZD							9.1	20	400M
1N 960A	S		2-11	ZD							9.1	10	400M
1N 960B	S		2-11	ZD							9.1	5	400M
1N 961	S		2-11	ZD							10	20	400M
1N 961A	S		2-11	ZD							10	10	400M
1N 961B	S		2-11	ZD							10	5	400M
1N 962	S		2-11	ZD							11	20	400M
1N 962A	S		2-11	ZD							11	10	400M
1N 962B	S		2-11	ZD							11	5	400M
1N 963	S		2-11	ZD							12	20	400M
1N 963A	S		2-11	ZD							12	10	400M
1N 963B	S		2-11	ZD							12	5	400M
1N 964	S		2-11	ZD							13	20	400M
1N 964A	S		2-11	ZD							13	10	400M
1N 964B	S		2-11	ZD							13	5	400M
1N 965	S		2-11	ZD							15	20	400M
1N 965A	S		2-11	ZD							15	10	400M
1N 965B	S		2-11	ZD							15	5	400M
1N 966	S		2-11	ZD							16	20	400M
1N 966A	S		2-11	ZD							16	10	400M
1N 966B	S		2-11	ZD							16	5	400M
1N 967	S		2-11	ZD							18	20	400M
1N 967A	S		2-11	ZD							18	10	400M
1N 967B	S		2-11	ZD							18	5	400M
1N 968	S		2-11	ZD							20	20	400M
1N 968A	S		2-11	ZD							20	10	400M
1N 968B	S		2-11	ZD							20	5	400M
1N 969	S		2-11	ZD							22	20	400M
1N 969A	S		2-11	ZD							22	10	400M
1N 969B	S		2-11	ZD							22	5	400M
1N 970	S		2-11	ZD							24	20	400M
1N 970A	S		2-11	ZD							24	10	400M
1N 970B	S		2-11	ZD							24	5	400M
1N 971	S		2-11	ZD							27	20	400M
1N 971A	S		2-11	ZD							27	10	400M
1N 971B	S		2-11	ZD							27	5	400M
1N 972	S		2-11	ZD							30	20	400M
1N 972A	S		2-11	ZD							30	10	400M
1N 972B	S		2-11	ZD							30	5	400M
1N 973	S		2-11	ZD							33	20	400M
1N 973A	S		2-11	ZD							33	10	400M
1N 973B	S		2-11	ZD							33	5	400M
1N 974	S		2-11	ZD							36	20	400M
1N 974A	S		2-11	ZD							36	10	400M
1N 974B	S		2-11	ZD							36	5	400M
1N 975	S		2-11	ZD							39	20	400M
1N 975A	S		2-11	ZD							39	10	400M
1N 975B	S		2-11	ZD							39	5	400M
1N 976	S		2-11	ZD							43	20	400M
1N 976A	S		2-11	ZD							43	10	400M
1N 976B	S		2-11	ZD							43	5	400M
1N 977	S		2-11	ZD							47	20	400M
1N 977A	S		2-11	ZD							47	10	400M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N 977B	S		2-11	ZD							47	5	400M
1N 978	S		2-11	ZD							51	20	400M
1N 978A	S		2-11	ZD							51	10	400M
1N 978B	S		2-11	ZD							51	5	400M
1N 979	S		2-11	ZD							56	20	400M
1N 979A	S		2-11	ZD							56	10	400M
1N 979B	S		2-11	ZD							56	5	400M
1N 980	S		2-11	ZD							62	20	400M
1N 980A	S		2-11	ZD							62	10	400M
1N 980B	S		2-11	ZD							62	5	400M
1N 981	S		2-11	ZD							68	20	400M
1N 981A	S		2-11	ZD							68	10	400M
1N 981B	S		2-11	ZD							68	5	400M
1N 982	S		2-11	ZD							75	20	400M
1N 982A	S		2-11	ZD							75	10	400M
1N 982B	S		2-11	ZD							75	5	400M
1N 983	S		2-11	ZD							82	20	400M
1N 983A	S		2-11	ZD							82	10	400M
1N 983B	S		2-11	ZD							82	5	400M
1N 984	S		2-11	ZD							91	20	400M
1N 984A	S		2-11	ZD							91	10	400M
1N 984B	S		2-11	ZD							91	5	400M
1N 985	S		2-11	ZD							100	20	400M
1N 985A	S		2-11	ZD							100	10	400M
1N 985B	S		2-11	ZD							100	5	400M
1N 986	S		2-11	ZD							110	20	400M
1N 986A	S		2-11	ZD							110	10	400M
1N 986B	S		2-11	ZD							110	5	400M
1N 987	S		2-11	ZD							120	20	400M
1N 987A	S		2-11	ZD							120	10	400M
1N 987B	S		2-11	ZD							120	5	400M
1N 988	S		2-11	ZD							130	20	400M
1N 988A	S		2-11	ZD							130	10	400M
1N 988B	S		2-11	ZD							130	5	400M
1N 989	S		2-11	ZD							150	20	400M
1N 989A	S		2-11	ZD							150	10	400M
1N 989B	S		2-11	ZD							150	5	400M
1N 990	S		2-11	ZD							160	20	400M
1N 990A	S		2-11	ZD							160	10	400M
1N 990B	S		2-11	ZD							160	5	400M
1N 991	S		2-11	ZD							180	20	400M
1N 991A	S		2-11	ZD							180	10	400M
1N 991B	S		2-11	ZD							180	5	400M
1N 992	S		2-11	ZD							200	20	400M
1N 992A	S		2-11	ZD							200	10	400M
1N 992B	S		2-11	ZD							200	5	400M
1N 993	S			MS	20	1.2	10M	1*	4				
1N 994	G			HS	6.5	1	10M	30*	2				
1N 995	G			HS	15	.5	10M	10*	6				
1N 996	G			HC	20	.8	40M	15*	.3				
1N 997	S			HS	35	1	10M	25N	.15				
1N 998	S			HC	150	1	200M	1N					
1N 999	S			CS	100	1	50M	1N	4				
1N1005	G			R	380	.15	.25						
1N1007	G			R	380	.3	.35						
1N1008	S			R	380	.3	.4						
1N1013	G			R	380	.15	.25						
1N1016	G			R	380	.15	.4						
1N1021	G			R	380	.15	.25						
1N1022	G			R	380	.15	.3						
1N1023	G			R	380	.15	.35						
1N1024	G			R	380	.15	.4						
1N1028	S			R	50	1.5	.25		15				
1N1029	S			R	100	1.5	.25		15				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N1030—1N1093

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_O
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1030	S			R	150	1.5	.25		15				
1N1031	S			R	200	1.5	.25		15				
1N1032	S			R	300	1.5	.25		15				
1N1033	S			R	400	1.5	.25		15				
1N1034	S			R	50	1.5	.5		15				
1N1035	S			R	100	1.5	.5		15				
1N1036	S			R	150	1.5	.5		15				
1N1037	S			R	200	1.5	.5		15				
1N1038	S			R	300	1.5	.5		15				
1N1039	S			R	400	1.5	.5		15				
1N1040	S			R	50	1.5	.5		15				
1N1041	S			R	100	1.5	.5		15				
1N1042	S			R	150	1.5	.5		15				
1N1043	S			R	200	1.5	.5		15				
1N1044	S			R	300	1.5	.5		15				
1N1045	S			R	400	1.5	.5		15				
1N1046	S			R	50	1.5	.5		15				
1N1047	S			R	100	1.5	.5		15				
1N1048	S			R	150	1.5	.5		15				
1N1049	S			R	200	1.5	.5		15				
1N1050	S			R	300	1.5	.5		15				
1N1051	S			R	400	1.5	.5		15				
1N1052	S			R	50	1.5	.5		20				
1N1053	S			R	100	1.5	.5		20				
1N1054	S			R	150	1.5	.5		20				
1N1055	S			R	200	1.5	.5		20				
1N1056	S			R	300	1.5	.5		20				
1N1057	S			R	400	1.5	.5		20				
1N1058	S			R	50	1.5	1.5		20				
1N1059	S			R	100	1.5	1.5		20				
1N1060	S			R	150	1.5	1.5		20				
1N1061	S			R	200	1.5	1.5		20				
1N1062	S			R	300	1.5	1.5		20				
1N1063	S			R	400	1.5	1.5		20				
1N1064	S			R	50	1.5	1.5		20				
1N1065	S			R	100	1.5	1.5		20				
1N1066	S			R	150	1.5	1.5		20				
1N1067	S			R	200	1.5	1.5		20				
1N1068	S			R	300	1.5	1.5		20				
1N1069	S			R	400	1.5	1.5		20				
1N1070	S			R	50	1.5	1.5		20				
1N1071	S			R	100	1.5	1.5		20				
1N1072	S			R	150	1.5	1.5		20				
1N1073	S			R	200	1.5	1.5		20				
1N1074	S			R	300	1.5	1.5		20				
1N1075	S			R	400	1.5	1.5		20				
1N1076	S			R	50	1.5	5		50				
1N1077	S			R	100	1.5	5		50				
1N1078	S			R	150	1.5	5		50				
1N1079	S			R	200	1.5	5		50				
1N1080	S			R	300	1.5	5		50				
1N1081	S	1N4002	3-23	R	100	1.5	.25		15				
1N1082	S	1N4003	3-23	R	200	1.5	.25		15				
1N1083	S	1N4004	3-23	R	300	1.5	.25		15				
1N1084	S	1N4004	3-23	R	400	1.5	.25		15				
1N1085	S			R	100	1.5	.6		24				
1N1086	S			R	200	1.5	.6		24				
1N1087	S			R	300	1.5	.6		24				
1N1088	S			R	400	1.5	.6		24				
1N1089	S			R	100	1.5	2		24				
1N1090	S			R	200	1.5	2		24				
1N1091	S			R	300	1.5	2		24				
1N1092	S			R	400	1.5	2		24				
1N1093	G			MS	15	.4	5M	25*	.5				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1095	S	1N4005	3-23	R	500	.5	.425	.3	15				
1N1096	S	1N4005	3-23	R	600	.5	.4	.3	15				
1N1100	S	1N4002	3-23	R	100	1.2	.25	.2	15				
1N1101	S	1N4003	3-23	R	200	1.2	.25	.2	15				
1N1102	S	1N4004	3-23	R	300	1.2	.25	.2	15				
1N1103	S	1N4004	3-23	R	400	1.2	.25	.2	15				
1N1104	S	1N4005	3-23	R	500	1.2	.25	.2	15				
1N1105	S	1N4005	3-23	R	600	1.2	.25	.2	15				
1N1108	S			R	800	3	.225		13.5				
1N1109	S			R	1200	4.5	.212		12.7				
1N1110	S			R	1600	6	.2		12				
1N1111	S			R	2000	7.5	.187		11.2				
1N1112	S			R	2400	9	.175		10.5				
1N1113	S			R	2800	10.5	.162		9.7				
1N1115	S	1N4720	3-24	R	100	.65	.6	.4	15				
1N1116	S	1N4721	3-24	R	200	.65	.6	.3	15				
1N1117	S	MR1033A	3-24	R	300	.65	.6	.3	15				
1N1118	S	1N4722	3-24	R	400	.65	.6	.3	15				
1N1119	S	MR1035A	3-24	R	500	.65	.6	.3	15				
1N1120	S	1N4723	3-24	R	600	.65	.6	.3	15				
1N1124	S	1N4721	3-24	R	200	1.1		.3	25				
1N1124A		1N4721	3-24	R	200		3.3	.3	25				
1N1125	S	MR1033A	3-24	R	300	1.1		.3	25				
1N1125A	S	MR1033A	3-24	R	300		3.3	.3	25				
1N1126	S	1N4722	3-24	R	400	1.1	1	.3	25				
1N1126A		1N4722	3-24	R	400		3.3	.3	25				
1N1127	S	MR1035A	3-24	R	500	1.1	1	.3	25				
1N1127A	S	MR1035A	3-24	R	500		3.3	.3	25				
1N1128	S	1N4723	3-24	R	600	1.1	1	.3	25				
1N1128A		1N4723	3-24	R	600		3.3	.3	25				
1N1130	S			R	1500	15	.3	.05					
1N1131	S			R	1500	15	.3	.05					
1N1133				R	1500	15	.085	.025	3.5				
1N1134				R	1500	7.5	.115	.025	3.5				
1N1135				R	1800	18	.075	.025	3.5				
1N1136				R	1800	9	.095	.025	3.5				
1N1137				R	2400	24	.057	.025	3.5				
1N1138				R	2400	12	.070	.025	3.5				
1N1139				R	3600	27	.075	.025	3.5				
1N1140				R	3600	18	.075	.025	3.5				
1N1141				R	4800	36	.070	.025	3.5				
1N1142				R	4800	24	.057	.025	3.5				
1N1143				R	6000	45	.057	.025	3.5				
1N1143A				R	6000	30	.075	.025	3.5				
1N1144				R	7200	54	.057	.025	3.5				
1N1145				R	7200	36	.070	.025	3.5				
1N1146				R	8000	60	.050	.025	3.5				
1N1147				R	12K	60	.050	.025	3.5				
1N1148				R	14K	52	.057	.025	3.5				
1N1149				R	16K	60	.050	.025	3.5				
1N1150	S			R	1600		.75		8				
1N1150A	S			R	1600	6.5	.375	1.0	10				
1N1157	S			R	50		20		200				
1N1158	S			R	100		20						
1N1159	S			R	200		20						
1N1160	S			R	300		20						
1N1161	S			R	50		35		350				
1N1162	S			R	100		35		350				
1N1163	S			R	200		35		350				
1N1164	S			R	300		35		350				
1N1165	S			R	50		100		1000				
1N1166	S			R	100		100		1000				
1N1167	S			R	200		100		1000				
1N1168	S			R	300		100		1000				

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N1169—1N1204A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1169	S	1N4004	3-23	R			.5						
1N1169A	S			R	400		.5	3.5					
1N1170	G			SP	50	1	4M	5*					
1N1171	S			R	50		20						
1N1172	S			R	100		20						
1N1173	S			R	200		20						
1N1174	S			R	300		20						
1N1175	S			P	50		35		350				
1N1176	S			R	100		35		350				
1N1177	S			R	200		35		350				
1N1178	S			R	300		35		350				
1N1179	S			R	50		100		1000				
1N1180	S			R	100		100		1000				
1N1181	S			R	200		100		1000				
1N1182	S			R	300		100		1000				
1N1183	S	1N1183	3-10	R	50	1.7	35	10	500				
1N1183A	S	MR1200FL	3-32	R	50	1.3	40	2.5	800				
1N1184	S	1N1184	3-10	R	100	1.7	35	10	500				
1N1184A	S	MR1201FL	3-10	R	100	1.3	40	2.5	800				
1N1185	S	1N1185	3-10	R	150	1.7	35	10	500				
1N1185A	S	MR1202FL	3-32	R	150	1.3	40	2.5	800				
1N1186	S	1N1186	3-19	R	200	1.7	35	10	500				
1N1186A	S	MR1203FL	3-32	R	200	1.3	40	2.5	800				
1N1187	S	1N1187	3-10	R	300	1.7	35	10	500				
1N1187A	S	MR1205FL	3-32	R	300	1.2	40	2.5	800				
1N1188	S	1N1188	3-10	R	400	1.7	35	10	500				
1N1188A	S	MR1207FL	3-32	R	400	1.2	40	2.2	800				
1N1189	S	1N1189	3-10	R	500	1.7	35	10	500				
1N1189A	S			R	500	1.2	40	2	800				
1N1190	S	1N1190	3-10	R	600	1.7	35	10	500				
1N1190A	S			R	600	1.2	40	1.8	800				
1N1191	S	1N1191	3-8	R	50	2.35	18	5	220				
1N1191A	S			R	50	2	22	2.5	500				
1N1192	S	1N1192	3-8	R	100	2.35	18	5	220				
1N1192A	S			R	100	2	22	2.5	500				
1N1193	S	1N1193	3-8	R	150	2.35	18	5	220				
1N1193A	S			R	150	2	22	2.5	500				
1N1194	S	1N1194	3-8	R	200	2.35	18	5	220				
1N1194A	S			R	200	2	22	2.5	500				
1N1195	S	1N1195	3-8	R	300	2.35	18	5	220				
1N1195A	S	1N1195A	3-8	R	300	.6	20	3.2	350				
1N1196	S	1N1196	3-8	R	400	2.35	18	5	220				
1N1196A	S	1N1196A	3-8	R	400	.6	20	2.5	350				
1N1197	S	1N1197	3-8	R	500	2.35	18	5	220				
1N1197A	S	1N1197A	3-8	R	500	.6	20	2.2	350				
1N1198	S	1N1198	3-8	R	600	2.35	18	5	220				
1N1198A	S	1N1198A	3-8	R	600	.6	20	1.5	350				
1N1199	S	MR1120	3-28	R	50		12	10					
1N1199A	S	MR1120	3-28	R	50	1.35	12	3	240				
1N1199B	S			R	50	1.2	12	.9	250				
1N1200	S	MR1121	3-28	R	100		12	10					
1N1200A	S	MR1121	3-28	R	100	1.35	50	2.5	12				
1N1200B	S			R	100	1.2	12	.9	250				
1N1201	S	MR1122	3-28	R	150		12	10					
1N1201A	S	MR1122	3-28	R	150	1.35	50	2.25	12				
1N1201B	S			R	150	1.2	12	.9	250				
1N1202	S	MR1122	3-28	R	200		12	10					
1N1202A	S	MR1122	3-28	R	200	1.35	50	2.0	12				
1N1202B	S			R	200	1.2	12	.9	250				
1N1203	S	MR1123	3-28	R	300		12	10					
1N1203A	S	MR1123	3-28	R	300	1.35	50	1.75	12				
1N1203B	S			R	300	1.2	12	.9	250				
1N1204	S	MR1124	3-28	R	400		12	10					
1N1204A	S	MR1124	3-28	R	400	1.35	50	1.5	12				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1204B	S			R	400	1.2	12	.9	250				
1N1205	S	MR1125	3-28	R	500		12	10					
1N1205A	S	MR1125	3-28	R	500	1.35	50	1.25	12				
1N1205B	S			R	500	1.2	12	.9	250				
1N1206	S	MR1126	3-28	R	600		12	10					
1N1206A	S	MR1126	3-28	R	600	1.35	50	1.0	12				
1N1206B	S			R	600	1.2	12	.9	250				
1N1217	S	1N4001	3-23	R	50	1.0	1.6	1.5	20				
1N1217A	S	1N4001	3-23	R	50	1.5	1.6	.05					
1N1217B	S			R	50	1.7	1.35	.3	25				
1N1218	S	1N4002	3-23	R	100	1.0	1.6	1.5	20				
1N1218A	S	1N4002	3-23	R	100	1.5	1.6	.05					
1N1218B	S			R	100	1.7	1.35	.3	25				
1N1219	S	1N4003	3-23	R	150	1.0	1.6	1.5	20				
1N1219A	S	1N4003	3-23	R	150	1.5	1.6	.05					
1N1219B	S			R	150	1.7	1.35	.3	25				
1N1220	S	1N4003	3-23	R	200	1.0	1.6	1.5	20				
1N1220A	S	1N4003	3-23	R	200	1.5	1.6	.05					
1N1220B	S			R	200	1.7	1.35	.3	25				
1N1221	S	1N4004	3-23	R	300	1.0	1.6	1.5	20				
1N1221A	S	1N4004	3-23	R	300	1.5	1.6	.05					
1N1221B	S			R	300	1.7	1.35	.3	25				
1N1222	S	1N4004	3-23	R	400	1.0	1.6	1.5	20				
1N1222A	S			R	400	1.5	1.6	.05					
1N1222B	S			R	400	1.7	1.35	.3	25				
1N1223	S	1N4005	3-23	R	500	1.0	1.6	1.5	20				
1N1223A	S			R	500	1.5	1.6	.05					
1N1223B	S			R	500	1.7	1.35	.3	25				
1N1224	S	1N4005	3-23	R	600	1.0	1.6	1.5	20				
1N1224A	S	1N4005	3-23	R	600	1.5	1.6	.05					
1N1224B	S			R	600	1.62	1.25	.3	25				
1N1225	S	1N4006	3-23	R	700	1.0	1.6	1.5	20				
1N1225A	S	1N4006	3-23	R	700	1.55	1.1	.5	25				
1N1225B	S			R	700	1.62	1.25	.3	25				
1N1226	S	1N4006	3-23	R	800	1.0	1.6	1.5	20				
1N1226A	S	1N4006	3-23	R	800	1.50	1.1	.5	25				
1N1226B	S			R	800	1.58	1.15	.3	25				
1N1227	S	1N4719	3-24	R	50	1.0	1.6	1.5	20				
1N1227A	S			R	50	1.5	1.6	.05					
1N1228	S	1N4720	3-24	R	100	1.0	1.6	1.5	20				
1N1228A	S			R	100	1.5	1.6	.05					
1N1229	S	1N4721	3-24	R	150	1.0	1.6	1.5	20				
1N1229A	S			R	150	1.5	1.6	.05					
1N1230	S	1N4721	3-24	R	200	1.0	1.6	1.5	20				
1N1230A	S			R	200	1.5	1.6	.05					
1N1231	S	MR1033A	3-24	R	300	1.0	1.6	1.5	20				
1N1231A	S			R	300	1.5	1.6	.05					
1N1232	S	1N4722	3-24	R	400	1.0	1.6	1.5	20				
1N1232A	S			R	400	1.5	1.6	.05					
1N1233	S	MR1035A	3-24	R	500	1.0	1.6	1.5	20				
1N1233A	S			R	500	1.5	1.6	.05					
1N1234	S	1N4723	3-24	R	600	1.0	1.6	1.5	20				
1N1234A	S			R	600	1.5	1.6	.05					
1N1235	S	1N4724	3-24	R	700	1.0	1.6	1.5	20				
1N1236	S	1N4724	3-24	R	800	1.0	1.6	1.5	20				
1N1237	S			R	1600		.75		8				
1N1238	S			R	1600		.75		8				
1N1239	S			R	2800		.5		5				
1N1240	S			R	50	1	.25	.5	5				
1N1241	S			R	100	1	.25	.5	5				
1N1242	S			R	200	1	.25	.5	5				
1N1243	S			R	300	1	.2	.5	5				
1N1244	S			R	400	1	.15	.5					
1N1244A	S			R	400	1	.2	.5	5				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max $t_{rr} < 0.3\,\mu s$) CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N1245—1N1314A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1245	S			R	500	1	.13	.4					
1N1246	S			R	600	1	.115	.3					
1N1247	S			R	700	1	.1	.2					
1N1248	S			R	800	1	.08	.1					
1N1249	S			R	900	1	.065	.1					
1N1250	S			R	1000	1	.05	.1					
1N1251	S	1N4002	3-23	R	50	1	.25	.5	5				
1N1252	S	1N4002	3-23	R	100	1	.25	.5	5				
1N1253	S	1N4003	3-23	R	200	1	.25	.5	5				
1N1254	S	1N4004	3-23	R	300	1	.2	.5	5				
1N1255	S	1N4004	3-23	R	400	1	.15	.5					
1N1255A	S			R	400	1	.2	.5	5				
1N1256	S			R	500	1	.13	.4					
1N1257	S			R	600	1	.115	.3					
1N1258	S			R	700	1	.1	.2					
1N1259	S			R	800	1	.08	.1					
1N1260	S			R	900	1	.065	.1					
1N1261	S			R	1000	1	.05	.1					
1N1262	S			R	4500		.25		2.5				
1N1263	S			R	50		150		1500				
1N1263A	S			R	50		200		2000				
1N1264	S			R	100		150		1500				
1N1264A	S			R	100		200		2000				
1N1265	S			R	200		150		1500				
1N1265A	S			R	200		200		2000				
1N1266	S			R	300		150		1500				
1N1266A	S			R	300		200		2000				
1N1267	S			R	50		150		1500				
1N1267A	S			R	50		200		2000				
1N1268	S			R	100		150		1500				
1N1268A	S			R	100		200		2000				
1N1269	S			R	200		150		1500				
1N1269A	S			R	200		200		2000				
1N1270	S			R	300		150		1500				
1N1270A	S			R	300		200		2000				
1N1271	S			R	50		160	40					
1N1272	S			R	100		160	40					
1N1273	S			R	150		160	40					
1N1274	S			R	200		160	40					
1N1275	S			R	300		160	40					
1N1276	S			R	400		160	40					
1N1277	S			R	500		160	40					
1N1281	S			R	50		160	40					
1N1282	S			R	100		160	40					
1N1283	S			R	150		160	40					
1N1284	S			R	200		160	40					
1N1285	S			R	300		160	40					
1N1286	S			R	400		160	40					
1N1287	S			R	500		160	40					
1N1291	S			R	50		160	40					
1N1292	S			R	100		160	40					
1N1293	S			R	150		160	40					
1N1294	S			R	200		160	40					
1N1295	S			R	300		160	40					
1N1296	S			R	400		160	40					
1N1297	S			R	500		160	40					
1N1301	S			R	50	.63	17.5	15	300				
1N1302	S			R	100	.63	17.5	5	300				
1N1304	S			R	200	.63	17.5	5	300				
1N1306	S			R	300	.63	17.5	5	300				
1N1313	S		2-12	ZD							8	5	150M
1N1313A	S		2-12	ZD							9.1	5	150M
1N1314	S		2-12	ZD							10	5	150M
1N1314A	S		2-12	ZD							10	5	150M

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≧ 20 mA @ ≦ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1315	S		2-12	ZD							12	5	150M	
1N1315A	S		2-12	ZD							12	5	150M	
1N1316	S		2-12	ZD							15	5	150M	
1N1316A	S		2-12	ZD							15	5	150M	
1N1317	S		2-12	ZD							20	5	150M	
1N1317A	S		2-12	ZD							18	5	150M	
1N1318	S		2-12	ZD							25	5	150M	
1N1318A	S		2-12	ZD							22	5	150M	
1N1319	S		2-12	ZD							30	5	150M	
1N1319A	S		2-12	ZD							27	5	150M	
1N1320	S		2-12	ZD							35	5	150M	
1N1320A	S		2-12	ZD							33	5	150M	
1N1321	S		2-12	ZD							40	5	150M	
1N1321A	S		2-12	ZD							39	5	150M	
1N1322	S		2-12	ZD							50	5	150M	
1N1322A	S		2-12	ZD							47	5	150M	
1N1323	S		2-12	ZD							60	5	150M	
1N1323A	S		2-12	ZD							56	5	150M	
1N1324	S		2-12	ZD							70	5	150M	
1N1325	S		2-12	ZD							90	5	150M	
1N1326	S		2-12	ZD							105	5	150M	
1N1327	S		2-12	ZD							125	5	150M	
1N1329	S			R	1500	1.3	.1	.02	2					
1N1330	S			R	50		240	50						
1N1331	S			R	100		240	50						
1N1332	S			R	150		240	50						
1N1333	S			R	200		240	50						
1N1334	S			R	300		240	50						
1N1335	S			R	400		240	50						
1N1336	S			R	500		240	50						
1N1341	S	MR1120	3-28	R	50	1.6	6	4	150					
1N1341A	S	MR1120	3-28	R	50	1.4	6	3.0	150					
1N1341B	S			R	50	1.2	6	.45	160					
1N1342	S	MR1121	3-28	R	100	1.6	6	4	150					
1N1342A	S	MR1121	3-28	R	100	1.4	6	2.5	150					
1N1342B	S			R	100	1.2	6	.45	160					
1N1343	S	MR1122	3-28	R	150	1.6	6	4	150					
1N1343A	S	MR1122	3-28	R	150	1.4	6	2.25	150					
1N1343B	S			R	150	1.2	6	.45	160					
1N1344	S	MR1122	3-28	R	200	1.6	6	4	150					
1N1344A	S	MR1122	3-28	R	200	1.4	6	2.0	150					
1N1344B	S			R	200	1.2	6	.45	160					
1N1345	S	MR1123	3-28	R	300	1.6	6	4	150					
1N1345A	S	MR1123	3-28	R	300	1.4	6	1.75	150					
1N1345B	S			R	300	1.2	6	.45	160					
1N1346	S	MR1124	3-28	R	400	1.6	6	4	150					
1N1346A	S	MR1124	3-28	R	400	1.4	6	1.5	150					
1N1346B	S			R	400	1.2	6	.45	160					
1N1347	S	MR1125	3-28	R	500	1.6	6	4	150					
1N1347A	S	MR1125	3-28	R	500	1.4	6	1.25	150					
1N1347B	S			R	500	1.2	6	.45	160					
1N1348	S	MR1126	3-28	R	600	1.6	6	4	150					
1N1348A	S	MR1126	3-28	R	600	1.4	6	1.0	150					
1N1348B	S			R	600	1.2	6	.45	160					
1N1351	S	1N2974A	2-18	ZD							10	10	10W	
1N1351A	S	1N2974B	2-18	ZD							10	5	10W	
1N1352	S	1N2975A	2-18	ZD							11	10	10W	
1N1352A	S	1N2975B	2-18	ZD							11	5	10W	
1N1353	S	1N2976A	2-18	ZD							12	10	10W	
1N1353A	S	1N2976B	2-18	ZD							12	5	10W	
1N1354	S	1N2977A	2-18	ZD							13	10	10W	
1N1354A	S	1N2977B	2-18	ZD							13	5	10W	
1N1355	S	1N2979A	2-18	ZD							15	10	10W	
1N1355A	S	1N2979B	2-18	ZD							15	5	10W	

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N1356 — 1N1414

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1356	S	1N2980A	2-18	ZD							16	10	10W
1N1356A	S	1N2980B	2-18	ZD							16	5	10W
1N1357	S	1N2982A	2-18	ZD							18	10	10W
1N1357A	S	1N2982B	2-18	ZD							18	5	10W
1N1358	S	1N2984A	2-18	ZD							20	10	10W
1N1358A	S	1N2984B	2-18	ZD							20	5	10W
1N1359	S	1N2985A	2-18	ZD							22	10	10W
1N1359A	S	1N2985B	2-18	ZD							22	5	10W
1N1360	S	1N2986A	2-18	ZD							24	10	10W
1N1360A	S	1N2986B	2-18	ZD							24	5	10W
1N1361	S	1N2988A	2-18	ZD							27	10	10W
1N1361A	S	1N2988B	2-18	ZD							27	5	10W
1N1362	S	1N2989A	2-18	ZD							30	10	10W
1N1362A	S	1N2989B	2-18	ZD							30	5	10W
1N1363	S	1N2990A	2-18	ZD							33	10	10W
1N1363A	S	1N2990B	2-18	ZD							33	5	10W
1N1364	S	1N2991A	2-18	ZD							36	10	10W
1N1364A	S	1N2991B	2-18	ZD							36	5	10W
1N1365	S	1N2992A	2-18	ZD							39	10	10W
1N1365A	S	1N2992B	2-18	ZD							39	5	10W
1N1366	S	1N2993A	2-18	ZD							43	10	10W
1N1366A	S	1N2993B	2-18	ZD							43	5	10W
1N1367	S	1N2995A	2-18	ZD							47	10	10W
1N1367A	S	1N2995B	2-18	ZD							47	5	10W
1N1368	S	1N2997A	2-18	ZD							51	10	10W
1N1368A	S	1N2997B	2-18	ZD							51	5	10W
1N1369	S	1N2999A	2-18	ZD							56	10	10W
1N1369A	S	1N2999B	2-18	ZD							56	5	10W
1N1370	S	1N3000A	2-18	ZD							62	10	10W
1N1370A	S	1N3000B	2-18	ZD							62	5	10W
1N1371	S	1N3001A	2-18	ZD							68	10	10W
1N1371A	S	1N3001B	2-18	ZD							68	5	10W
1N1372	S	1N3002A	2-18	ZD							75	10	10W
1N1372A	S	1N3002B	2-18	ZD							75	5	10W
1N1373	S	1N3003A	2-18	ZD							82	10	10W
1N1373A	S	1N3003B	2-18	ZD							82	5	10W
1N1374	S	1N3004A	2-18	ZD							91	10	10W
1N1374A	S	1N3004B	2-18	ZD							91	5	10W
1N1375	S	1N3005A	2-18	ZD							100	10	10W
1N1375A	S	1N3005B	2-18	ZD							100	5	10W
1N1376	S			R	50		240	50					
1N1377	S			R	100		240	50					
1N1378	S			R	150		240	50					
1N1379	S			R	200		240	50					
1N1380	S			R	300		240	50					
1N1381	S			R	400		240	50					
1N1382	S			R	500		240	50					
1N1396	S	MR1210SB	3-35	R	50	1.55	70	15	1200				
1N1397	S	MR1211SB	3-35	R	100	1.55	70	15	1200				
1N1398	S	MR1212SB	3-35	R	150	1.55	70	15	1200				
1N1399	S	MR1213SB	3-35	R	200	1.55	70	15	1200				
1N1400	S	MR1215SB	3-35	R	300	1.55	70	15	1200				
1N1401	S	MR1217SB	3-35	R	400	1.55	70	15	1200				
1N1402	S			R	500	1.55	70	15	1200				
1N1403	S			R	600	1.55	70	15	1200				
1N1406	S			R	600	5.0	.1	.1	3.5				
1N1407	S			R	800	5.0	1	.1	3.5				
1N1408	S			R	1000	5.0	1	.1	3.5				
1N1409	S			R	1200	5.0	.1	.1	3.5				
1N1410	S			R	1500	6.25	.1	.1	3.5				
1N1411	S			R	1800	7.5	.1	.1	3.5				
1N1412	S			R	2000	6.25	.1	.1	3.5				
1N1413	S			R	2400	7.5	.1	.1	3.5				
1N1414	S			R	400	1.25	10	1	100				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1415	S			GP		1.1	1A	1*						
1N1416	S	1N2972B	2-18	ZD							8.2	5	10W	
1N1417	S	1N2976B	2-18	ZD							12	5	10W	
1N1418	S	1N2979B	2-18	ZD							15	5	10W	
1N1419	S	1N2982B	2-18	ZD							18	5	10W	
1N1420	S	1N2985B	2-18	ZD							22	5	10W	
1N1421	S	1N2988B	2-18	ZD							27	5	10W	
1N1422	S	1N3001B	2-18	ZD							68	5	10W	
1N1423	S	1N3005B	2-18	ZD							100	5	10W	
1N1424	S	1N3011B	2-18	ZD							150	5	10W	
1N1425	S	1N3018B	2-19	ZD							8.2	10	1W	
1N1426	S	1N3022B	2-19	ZD							12	10	1W	
1N1427	S	1N3024B	2-19	ZD							15	10	1W	
1N1428	S	1N3026B	2-19	ZD							18	10	1W	
1N1429	S	1N3028B	2-19	ZD							22	10	1W	
1N1430	S	1N3030B	2-19	ZD							27	10	1W	
1N1431	S	1N3040B	2-19	ZD							68	5	1W	
1N1432	S	1N3044B	2-19	ZD							100	5	1W	
1N1433	S	1N3048B	2-19	ZD							150	5	1W	
1N1434	S			R	50	1.2	30	5						
1N1435	S			R	100	1.2	30	5						
1N1436	S			R	200	1.2	30	5						
1N1437	S			R	400	1.2	30	5						
1N1438	S			R	600	1.2	30	5						
1N1440	S			R	200	1.2	.75	.5	30					
1N1441	S			R	300	1.2	.75	.5	30					
1N1442	S			R	400	1.2	.75	.5	30					
1N1443	S	1N4007	3-23	R	1000	1.0	1.6	1.5	20					
1N1443A	S			R	1000	1.45	1.1	.5	25					
1N1443B	S			R	1000	1.55	1.1	.3	25					
1N1444	S	1N4725	3-24	R	1000	1.0	1.6	1.5	20					
1N1445	S			R	360	2	.2	4						
1N1446	S			R	100	2		2						
1N1447	S			R	200	2		2						
1N1448	S			R	300	1.4		2						
1N1449	S			R	400	2		2						
1N1450	S			R	100	1.4		5						
1N1451	S			R	200	1.4		5						
1N1452	S			R	300	1.4		5						
1N1453	S			R	400	1.4		5						
1N1454	S			R	100	1.5	25	25						
1N1455	S			R	200	1.5	25	25						
1N1456	S			R	300	1.5	25	25						
1N1457	S			R	400	1.5	25	25						
1N1458	S			R	100	1.5	35	25						
1N1459	S			R	200	1.5	35	25						
1N1460	S			R	300	1.5	35	25						
1N1461	S			R	400	1.5	35	25						
1N1462	S			R	100	1.5	50	50						
1N1463	S			R	200	1.5	50	50						
1N1464	S			R	300	1.5	50	50						
1N1465	S			R	400	1.5	50	50						
1N1466	S	MR1221FB	3-38	R	100	1.5	75	50						
1N1467	S	MR1223FB	3-38	R	200	1.5	75	50						
1N1468	S	MR1225FB	3-38	R	300	1.5	75	50						
1N1469	S	MR1227FB	3-38	R	400	1.5	75	50						
1N1470	S			R	100	1.5	100	100						
1N1471	S			R	200	1.5	100	100						
1N1472	S			R	300	1.5	100	100						
1N1473	S			R	400	1.5	100	100						
1N1474	S			R	100	1.5	150	100						
1N1475	S			R	200	1.5	150	100						
1N1476	S			R	300	1.5	150	100						
1N1477	S			R	400	1.5	150	100						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N1478 — 1N1539

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1478	S	MR1241SB	3-44	R	100	1.5	200	100					
1N1479	S	MR1243SB	3-44	R	200	1.5	200	100					
1N1480	S	MR1245SB	3-44	R	300	1.5	200	100					
1N1481	S	MR1247SB	3-44	R	400	1.5	200	100					
1N1482	S	1N3995A	2-24	ZD						4.47	4.93		10W
1N1483	S	1N3998A	2-24	ZD						5.90	6.50		10W
1N1484	S	1N3825A	2-23	ZD						4.47	4.93		1W
1N1485	S	1N3828A	2-23	ZD							6.2	5	1W
1N1486	S	1N4005	3-23	R	500		.5	3.5					
1N1487	S	1N4002	3-23	R	100	.55	.25	.4	15				
1N1488	S	1N4003	3-23	R	200	.55	.25	.3	15				
1N1489	S	1N4004	3-23	R	300	.55	.25	.3	15				
1N1490	S	1N4004	3-23	R	400	.55	.25	.3	15				
1N1491	S	1N4005	3-23	R	500	.55		.3	15				
1N1492	S	1N4005	3-23	R	600	.55		.3	15				
1N1507	S	1N3823	2-23	RD							3.9		
1N1507A	S	1N3823A	2-23	RD							3.9		
1N1508	S	1N3825	2-23	RD							4.7		
1N1508A	S	1N3825A	2-23	RD							4.7		
1N1509	S	1N3827	2-23	RD							5.6		
1N1509A	S	1N3827A	2-23	RD							5.6		
1N1510	S	1N3016A	2-19	RD							6.8		
1N1510A	S	1N3016B	2-19	RD							6.8		
1N1511	S	1N3018A	2-19	RD							8.2		
1N1511A	S	1N3018B	2-19	RD							8.2		
1N1512	S	1N3020A	2-19	RD							10		
1N1512A	S	1N3020B	2-19	RD							10		
1N1513	S	1N3022A	2-19	RD							12		
1N1513A	S	1N3022B	2-19	RD							12		
1N1514	S	1N3024A	2-19	RD							15		
1N1514A	S	1N3024B	2-19	RD							15		
1N1515	S	1N3026A	2-19	RD							18		
1N1515A	S	1N3026B	2-19	RD							18		
1N1516	S	1N3028A	2-19	RD							22		
1N1516A	S	1N3028B	2-19	RD							22		
1N1517	S	1N3030A	2-19	RD							27		
1N1517A	S	1N3030B	2-19	RD							27		
1N1518	S	1N3823	2-23	RD							3.9		
1N1518A	S	1N3823A	2-23	RD							3.9		
1N1519	S	1N3825	2-23	RD							4.7		
1N1519A	S	1N3825A	2-23	RD							4.7		
1N1520	S	1N3827	2-23	RD							5.6		
1N1520A	S	1N3827A	2-23	RD							5.6		
1N1521	S	1N3016A	2-19	RD							6.8		
1N1521A	S	1N3016B	2-19	RD							6.8		
1N1522	S	1N3018A	2-19	RD							8.2		
1N1522A	S	1N3018B	2-19	RD							8.2		
1N1523	S	1N3020A	2-19	RD							10		
1N1523A	S	1N3020B	2-19	RD							10		
1N1524	S	1N3022A	2-19	RD							12		
1N1524A	S	1N3022B	2-19	RD							12		
1N1525	S	1N3024A	2-19	RD							15		
1N1525A	S	1N3024B	2-19	RD							15		
1N1526	S	1N3026A	2-19	RD							18		
1N1526A	S	1N3026B	2-19	RD							18		
1N1527	S	1N3028A	2-19	RD							22		
1N1527A	S	1N3028B	2-19	RD							22		
1N1528	S	1N3030A	2-19	RD							27		
1N1528A	S	1N3030B	2-19	RD							27		
1N1530	S	1N3156	2-19	RD							8.4	-55	100
1N1530A	S	1N3157	2-19	RD							8.4	-55	100
1N1537	S			R	50	1.5	1.6	.05					
1N1538	S	1N4002	3-23	R	100	1.5	1.6	.05					
1N1539	S	1N4003	3-23	R	150	1.5	1.6	.05					

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1540	S	1N4003	3-23	R	200	1.5	1.6	.05					
1N1541	S	1N4004	3-23	R	300	1.5	1.6	.05					
1N1542	S	1N4004	3-23	R	400	1.5	1.6	.05					
1N1543	S	1N4005	3-23	R	500	1.5	1.6	.05					
1N1544	S	1N4005	3-23	R	600	1.5	1.6	.05					
1N1551	S			R	100	1.4		1					
1N1552	S			R	200	1.4		1					
1N1553	S			R	300	1.4		1					
1N1554	S			R	400	1.4		1					
1N1555	S			R	500	1.4		1					
1N1556	S			R	100	1.4		1					
1N1557	S			R	200	1.4		1					
1N1558	S			R	300	1.4		1					
1N1559	S			R	400	1.4		1					
1N1560	S			R	500	1.4		1					
1N1561	G			HC	25	.4	12M	25*					
1N1562	G			HC	25	.4	8M	25*					
1N1563	S			R	100	1.5	1	.003	70				
1N1563A	S			R	100	1.5	1.5	.003	70				
1N1564	S			R	200	1.5	1	.003	70				
1N1564A	S			R	200	1.5	1.5	.003	70				
1N1565	S			R	300	1.5	1	.003	70				
1N1565A	S			R	300	1.5	1.5	.003	70				
1N1566	S			R	400	1.5	1	.003	70				
1N1566A	S			R	400	1.5	1.5	.003	70				
1N1567	S			R	500	1.2	1	.005	70				
1N1567A	S			R	500	1.5	1.5	.003	70				
1N1568	S			R	600	1.2	1	.005	70				
1N1568A	S			R	600	1.5	1.5	.003	70				
1N1569	S			R	100	1.5	1	.005	70				
1N1570	S			R	200	1.5	1	.005	70				
1N1571	S			R	300	1.5	1	.005	70				
1N1572	S			R	400	1.5	1	.005	70				
1N1573	S			R	500	1.5	1	.005	70				
1N1574	S			R	600	1.5	1	.005	70				
1N1575	S			R	100	1.5	3.5	.005	70				
1N1576	S			R	200	1.5	3.5	.005	70				
1N1577	S			R	300	1.5	3.5	.005	70				
1N1578	S			R	400	1.5	3.5	.005	70				
1N1579	S			R	500	1.5	3.5	.005	70				
1N1580	S			R	600	1.5	3.5	.005	70				
1N1581	S	MR1120	3-28	R	50	1.5	3	5	40				
1N1582	S	MR1121	3-28	R	100	1.5	3	5	40				
1N1583	S	MR1122	3-28	R	200	1.5	3	5	40				
1N1584	S	MR1123	3-28	R	300	1.5	3	5	40				
1N1585	S	MR1124	3-28	R	400	1.5	3	5	40				
1N1586	S	MR1125	3-28	R	500	1.5	3	5	40				
1N1587	S	MR1126	3-28	R	600	1.5	3	5	40				
1N1588	S	1N3993	2-24	RD							3.9		
1N1588A	S	1N3993A	2-24	RD							3.9		
1N1589	S	1N3995	2-24	RD							4.7		
1N1589A	S	1N3995A	2-24	RD							4.7		
1N1590	S	1N3997	2-24	RD							5.6		
1N1590A	S	1N3997A	2-24	RD							5.6		
1N1591	S	1N2970R	2-18	RD							6.8		
1N1591A	S	1N2970RB	2-18	RD							6.8		
1N1592	S	1N2972RA	2-18	RD							8.2		
1N1592A	S	1N2972RB	2-18	RD							8.2		
1N1593	S	1N2974RA	2-18	RD							10		
1N1593A	S	1N2974RB	2-18	RD							10		
1N1594	S	1N2976RA	2-18	RD							12		
1N1594A	S	1N2976RB	2-18	RD							12		
1N1595	S	1N2979RA	2-18	RD							15		
1N1595A	S	1N2979RB	2-18	RD							15		

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N1596 — 1N1646

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	Isurge (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1596	S	1N2982RA	2-18	RD							18			
1N1596A	S	1N2982RB	2-18	RD							18			
1N1597	S	1N2985RA	2-18	RD							22			
1N1597A	S	1N2985RB	2-18	RD							22			
1N1598	S	1N2988RA	2-18	RD							27			
1N1598A	S	1N2988RB	2-18	RD							27			
1N1599	S	1N3993	2-24	RD							3.9			
1N1599A	S	1N3993A	2-24	RD							3.9			
1N1600	S	1N3995	2-24	RD							4.7			
1N1600A	S	1N3995A	2-24	RD							4.7			
1N1601	S	1N3997	2-24	RD							5.6			
1N1601A	S	1N3997A	2-24	RD							5.6			
1N1602	S	1N2970A	2-18	RD							6.8			
1N1602A	S	1N2970B	2-18	RD							6.8			
1N1603	S	1N2972A	2-18	RD							8.2			
1N1603A	S	1N2972B	2-18	RD							8.2			
1N1604	S	1N2974A	2-18	RD							10			
1N1604A	S	1N2974B	2-18	RD							10			
1N1605	S	1N2976A	2-18	RD							12			
1N1605A	S	1N2976B	2-18	RD							12			
1N1606	S	1N2979A	2-18	RD							15			
1N1606A	S	1N2979B	2-18	RD							15			
1N1607	S	1N2982A	2-18	RD							18			
1N1607A	S	1N2982B	2-18	RD							18			
1N1608	S	1N2985A	2-18	RD							22			
1N1608A	S	1N2985B	2-18	RD							22			
1N1609	S	1N2988A	2-18	RD							27			
1N1609A	S	1N2988B	2-18	RD							27			
1N1612	S	MR1120	3-28	R	50	1.5	5	1						
1N1613	S	MR1121	3-28	R	100	1.5	5	1						
1N1614	S	MR1122	3-28	R	200	1.5	5	1						
1N1615	S	MR1124	3-28	R	400	1.5	5	1						
1N1616	S	MR1126	3-28	R	600	1.5	5	1						
1N1617	S	1N4002	3-23	R	100	1.2	1.5		60					
1N1618	S	1N4003	3-23	R	200	1.2	1.5		60					
1N1619	S	1N4004	3-23	R	300	1.2	1.5		60					
1N1620	S	1N4004	3-23	R	400	1.2	1.5		60					
1N1621	S			R	100	1.2	10		80					
1N1622	S			R	200	1.2	10		80					
1N1623	S			R	300	1.2	10		80					
1N1624	S			R	400	1.2	10		80					
1N1625				R	48	1		.015	.005					
1N1625A				R	48	1		.015	.01					
1N1626				R	96	2		.015	.005					
1N1626A				R	96	2		.015	.01					
1N1627				R	48	1		.027	.08					
1N1628				R	96	2		.027	.08					
1N1629				R	144	3		.027	.08					
1N1630				R	192	4		.027	.08					
1N1631				R	240	5		.027	.08					
1N1632				R	288	6		.027	.08					
1N1633				R	336	7		.027	.08					
1N1634				R	384	8		.027	.08					
1N1635				R	48	1		.108	.25					
1N1636				R	96	2		.108	.25					
1N1637				R	144	3		.108	.25					
1N1638				R	192	4		.108	.25					
1N1639				R	240	5		.108	.25					
1N1640				R	48	1	.028	.240	.55					
1N1641				R	96	2	.028	.240	.55					
1N1642				R	144	3	.028	.240	.55					
1N1644	S			R	50	.5	.25	.4	15					
1N1645	S			R	100	.5	.25	.4	15					
1N1646	S			R	150	.5	.25	.3	15					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs) CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1647	S			R	200	.5	.25	.3	15				
1N1648	S			R	250	.5	.25	.3	15				
1N1649	S			R	300	.5	.25	.3	15				
1N1650	S			R	350	.5	.25	.3	15				
1N1651	S			R	400	.5	.25	.3	15				
1N1652	S			R	500	.5	.25	.3	15				
1N1653	S			R	600	.5	.25	.3	15				
1N1660	S	MR1210SB	3-35	R	50		160	40					
1N1661	S	MR1211SB	3-35	R	100		160	40					
1N1662	S	MR1212SB	3-35	R	150		160	40					
1N1663	S	MR1213SB	3-35	R	200		160	40					
1N1664	S	MR1215SB	3-35	R	300		160	40					
1N1665	S	MR1217SB	3-35	R	400		160	40					
1N1666	S			R	500		160	40					
1N1670	S			R	50		240	50					
1N1671	S			R	100		240	50					
1N1672	S			R	150		240	50					
1N1673	S			R	200		240	50					
1N1674	S			R	300		240	50					
1N1675	S			R	400		240	50					
1N1676	S			R	500		240	50					
1N1680	S			R	150	1.1	50	25	700				
1N1681	S			R	250	1.1	50	25	700				
1N1682	S			R	300	1.1	50	25	700				
1N1683	S			R	350	1.1	50	25	700				
1N1684	S			R	400	1.1	50	25	700				
1N1685	S			R	450	1.1	50	25	700				
1N1686	S			R	500	1.1	50	25	700				
1N1687	S			R	600	1.1	50	25	700				
1N1688	S			R	700	1.1	50	25	700				
1N1689	S			R	800	1.1	50	25	700				
1N1690	S			R	900	1.1	50	25	700				
1N1691	S			R	1000	1.1	50	25	700				
1N1692	S	1N4002	3-23	R	100	.6	.25	.5	20				
1N1693	S	1N4003	3-23	R	200	.6	.25	.5	20				
1N1694	S	1N4004	3-23	R	300	.6	.25	.5	20				
1N1695	S	1N4004	3-23	R	400	.6	.25	.5	20				
1N1696	S	1N4005	3-23	R	500	.6		.5	20				
1N1697	S	1N4005	3-23	R	600	.6		.5	20				
1N1698	S			R	6600	33	.062						
1N1699	S			R	10K	37	.058						
1N1700	S			R	12K	45	.05						
1N1701	S	1N4001	3-23	R	50	1.3	.3	.2	8				
1N1702	S	1N4002	3-23	R	100	1.3	.3	.2	8				
1N1703	S	1N4003	3-23	R	200	1.3	.3	.2	8				
1N1704	S	1N4004	3-23	R	300	1.3	.3	.2	8				
1N1705	S	1N4004	3-23	R	400	1.3	.3	.2	8				
1N1706	S	1N4005	3-23	R	500	1.3	.3	.2	8				
1N1707	S	1N4001	3-23	R	50	1.15	.5	.2	10				
1N1708	S	1N4002	3-23	R	100	1.15	.5	.2	10				
1N1709	S	1N4003	3-23	R	200	1.15	.5	.2	10				
1N1710	S	1N4004	3-23	R	300	1.15	.5	.2	10				
1N1711	S	1N4004	3-23	R	400	1.15	.5	.2	10				
1N1712	S	1N4005	3-23	R	500	1.15	.5	.2	10				
1N1730	S	1N4007	3-23	R	1000		5	.1	2.5				
1N1730A	S			R	1000		.35		6				
1N1731	S		3-6	R	1500		5	.1	2.5				
1N1731A	S			R	1500		.35		6				
1N1732	S		3-6	R	2000		9	.1	2.5				
1N1732A	S			R	2000		.35		6				
1N1733	S		3-6	R	3000		12	.1	2.5				
1N1733A	S			R	3000		.35		6				
1N1734	S		3-6	R	5000		18	.1	2.5				
1N1734A	S			R	5000		.35		6				

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N1735—1N1777

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1735	S	1N821	2-32	ZD							6.2	5	200M
1N1736	S	1N941A	2-32	ZD							12.4	5	400M
1N1736A	S	1N942A	2-32	ZD							12.4	5	400M
1N1737	S	1N1737	2-32	ZD							18.6	5	600M
1N1737A	S	1N1737A	2-32	ZD							18.6	5	600M
1N1738	S	1N1738	2-32	ZD							24.8	5	800M
1N1738A	S	1N1738A	2-32	ZD							24.8	5	800M
1N1739	S	1N1739	2-32	ZD							31.0	5	1W
1N1739A	S	1N1739A	2-32	ZD							31.0	5	1W
1N1740	S	1N1740	2-32	ZD							37.2	5	1.2W
1N1740A	S	1N1740A	2-32	ZD							37.2	5	1.2W
1N1741	S	1N1741	2-32	ZD							43.4	5	1.4W
1N1741A	S	1N1741A	2-32	ZD							43.4	5	1.4W
1N1742	S	1N1742	2-32	ZD							49.6	5	1.6W
1N1742A	S	1N1742A	2-32	ZD							49.6	5	1.6W
1N1743	S			ZD							10	5	10W
1N1744	S			ZD							10	10	1W
1N1745	S			R	1500	15	.32	.2	3.5				
1N1746	S			R	1500	7.5	.5	.2	3.5				
1N1747	S			R	1800	18	.31	.2	3.5				
1N1748	S			R	1800	9	.38	.2	3.5				
1N1749	S			R	2400	24	.37	.2	3.5				
1N1750	S			R	2400	12	.32	.2	3.5				
1N1751	S			R	3600	27	.42	.2	3.5				
1N1752	S			R	3600	18	.41	.2	3.5				
1N1753	S			R	4800	36	.38	.2	3.5				
1N1754	S			R	4800	24	.37	.2	3.5				
1N1755	S			R	6000	45	.33	.2	3.5				
1N1756	S			R	6000	30	.41	.2	3.5				
1N1757	S			R	7200	54	.33	.2	3.5				
1N1758	S			R	7200	36	.38	.2	3.5				
1N1759	S			R	8000	60	.29	.2	3.5				
1N1760	S			R	12K	60	.29	.2	3.5				
1N1761	S			R	14K	52	.34	.2	3.5				
1N1762	S			R	16K	60	.29	.2	3.5				
1N1763	S	1N4004	3-23	R	400	3	.5	.1	35				
1N1763A	S			R	400	1.2	1	.5	25				
1N1764	S	1N4005	3-23	R	500	3	.5	.1	35				
1N1764A	S			R	500	1.2	1	.5	25				
1N1765	S			ZD							5.6	10	1W
1N1765A	S			ZD							5.6	5	1W
1N1766	S			ZD							6.2	10	1W
1N1766A	S			ZD							6.2	5	1W
1N1767	S	1N3016A	2-19	ZD							6.8	10	1W
1N1767A	S	1N3016B	2-19	ZD							6.8	5	1W
1N1768	S	1N3017A	2-19	ZD							7.5	10	1W
1N1768A	S	1N3017B	2-19	ZD							7.5	5	1W
1N1769	S	1N3018A	2-19	ZD							8.2	10	1W
1N1769A	S	1N3018B	2-19	ZD							8.2	5	1W
1N1770	S	1N3019A	2-19	ZD							9.1	10	1W
1N1770A	S	1N3019B	2-19	ZD							9.1	5	1W
1N1771	S	1N3020A	2-19	ZD							10	10	1W
1N1771A	S	1N3020B	2-19	ZD							10	5	1W
1N1772	S	1N3021A	2-19	ZD							11	10	1W
1N1772A	S	1N3021B	2-19	ZD							11	5	1W
1N1773	S	1N3022A	2-19	ZD							12	10	1W
1N1773A	S	1N3022B	2-19	ZD							12	5	1W
1N1774	S	1N3023A	2-19	ZD							13	10	1W
1N1774A	S	1N3023B	2-19	ZD							13	5	1W
1N1775	S	1N3024A	2-19	ZD							15	10	1W
1N1775A	S	1N3024B	2-19	ZD							15	5	1W
1N1776	S	1N3025A	2-19	ZD							16	10	1W
1N1776A	S	1N3025B	2-19	ZD							16	5	1W
1N1777	S	1N3026A	2-19	ZD							18	10	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1777A	S	1N3026B	2-19	ZD							18	5	1W	
1N1778	S	1N3027A	2-19	ZD							20	10	1W	
1N1778A	S	1N3027B	2-19	ZD							20	5	1W	
1N1779	S	1N3028A	2-19	ZD							22	10	1W	
1N1779A	S	1N3028B	2-19	ZD							22	5	1W	
1N1780	S	1N3029A	2-19	ZD							24	10	1W	
1N1780A	S	1N3029B	2-19	ZD							24	5	1W	
1N1781	S	1N3030A	2-19	ZD							27	10	1W	
1N1781A	S	1N3030B	2-19	ZD							27	5	1W	
1N1782	S	1N3031A	2-19	ZD							30	10	1W	
1N1782A	S	1N3031B	2-19	ZD							30	5	1W	
1N1783	S	1N3032A	2-19	ZD							33	10	1W	
1N1783A	S	1N3032B	2-19	ZD							33	5	1W	
1N1784	S	1N3033A	2-19	ZD							36	10	1W	
1N1784A	S	1N3033B	2-19	ZD							36	5	1W	
1N1785	S	1N3034A	2-19	ZD							39	10	1W	
1N1785A	S	1N3034B	2-19	ZD							39	5	1W	
1N1786	S	1N3035A	2-19	ZD							43	10	1W	
1N1786A	S	1N3035B	2-19	ZD							43	5	1W	
1N1787	S	1N3036A	2-19	ZD							47	10	1W	
1N1787A	S	1N3036B	2-19	ZD							47	5	1W	
1N1788	S	1N3037A	2-19	ZD							51	10	1W	
1N1788A	S	1N3037B	2-19	ZD							51	5	1W	
1N1789	S	1N3038A	2-19	ZD							56	10	1W	
1N1789A	S	1N3038B	2-19	ZD							56	5	1W	
1N1790	S	1N3039A	2-19	ZD							62	10	1W	
1N1790A	S	1N3039B	2-19	ZD							62	5	1W	
1N1791	S	1N3040A	2-19	ZD							68	10	1W	
1N1791A	S	1N3040B	2-19	ZD							68	5	1W	
1N1792	S	1N3041A	2-19	ZD							75	10	1W	
1N1792A	S	1N3041B	2-19	ZD							75	5	1W	
1N1793	S	1N3042A	2-19	ZD							82	10	1W	
1N1793A	S	1N3042B	2-19	ZD							82	5	1W	
1N1794	S	1N3043A	2-19	ZD							91	10	1W	
1N1794A	S	1N3043B	2-19	ZD							91	5	1W	
1N1795	S	1N3044A	2-19	ZD							100	10	1W	
1N1795A	S	1N3044B	2-19	ZD							100	5	1W	
1N1796	S	1N3045A	2-19	ZD							110	10	1W	
1N1796A	S	1N3045B	2-19	ZD							110	5	1W	
1N1797	S	1N3046A	2-19	ZD							120	10	1W	
1N1797A	S	1N3046B	2-19	ZD							120	5	1W	
1N1798	S	1N3047A	2-19	ZD							130	10	1W	
1N1798A	S	1N3047B	2-19	ZD							130	5	1W	
1N1799	S	1N3048A	2-19	ZD							150	10	1W	
1N1799A	S	1N3048B	2-19	ZD							150	5	1W	
1N1800	S	1N3049A	2-19	ZD							160	10	1W	
1N1800A	S	1N3049B	2-19	ZD							160	5	1W	
1N1801	S	1N3050A	2-19	ZD							180	10	1W	
1N1801A	S	1N3050B	2-19	ZD							180	5	1W	
1N1802	S	1N3051A	2-19	ZD							200	10	1W	
1N1802A	S	1N3051B	2-19	ZD							200	5	1W	
1N1803	S	1N3997	2-24	ZD							5.6	10	10W	
1N1803A	S	1N3997A	2-24	ZD							5.6	5	10W	
1N1804	S	1N3998	2-24	ZD							6.2	10	10W	
1N1804A	S	1N3998A	2-24	ZD							6.2	5	10W	
1N1805	S	1N2970A	2-18	ZD							6.8	10	10W	
1N1805A	S	1N2970B	2-18	ZD							6.8	5	10W	
1N1806	S	1N2971A	2-18	ZD							7.5	10	10W	
1N1806A	S	1N2971B	2-18	ZD							7.5	5	10W	
1N1807	S	1N2972A	2-18	ZD							8.2	10	10W	
1N1807A	S	1N2972B	2-18	ZD							8.2	5	10W	
1N1808	S	1N2973A	2-18	ZD							9.1	10	10W	
1N1808A	S	1N2973B	2-18	ZD							9.1	5	10W	
1N1809	S	1N3007A	2-18	ZD							110	10	10W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N1809A—1N1847

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1809A	S	1N3007B	2-18	ZD							110	5	10W
1N1810	S	1N3008A	2-18	ZD							120	10	10W
1N1810A	S	1N3008B	2-18	ZD							120	5	10W
1N1811	S	1N3009A	2-18	ZD							130	10	10W
1N1811A	S	1N3009B	2-18	ZD							130	5	10W
1N1812	S	1N3011A	2-18	ZD							150	10	10W
1N1812A	S	1N3011B	2-18	ZD							150	5	10W
1N1813	S	1N3012A	2-18	ZD							160	10	10W
1N1813A	S	1N3012B	2-18	ZD							160	5	10W
1N1814	S	1N3014A	2-18	ZD							180	10	10W
1N1814A	S	1N3014B	2-18	ZD							180	5	10W
1N1815	S	1N3015A	2-18	ZD							200	10	10W
1N1815A	S	1N3015B	2-18	ZD							200	5	10W
1N1816	S	1N2977A	2-18	ZD							13	10	10W
1N1816A	S	1N2977B	2-18	ZD							13	5	10W
1N1817	S	1N2979A	2-18	ZD							15	10	10W
1N1817A	S	1N2979B	2-18	ZD							15	5	10W
1N1818	S	1N2980A	2-18	ZD							16	10	10W
1N1818A	S	1N2980B	2-18	ZD							16	5	10W
1N1819	S	1N2982A	2-18	ZD							18	10	10W
1N1819A	S	1N2982B	2-18	ZD							18	5	10W
1N1820	S	1N2984A	2-18	ZD							20	10	10W
1N1820A	S	1N2984B	2-18	ZD							20	5	10W
1N1821	S	1N2985A	2-18	ZD							22	10	10W
1N1821A	S	1N2985B	2-18	ZD							22	5	10W
1N1822	S	1N2986A	2-18	ZD							24	10	10W
1N1822A	S	1N2986B	2-18	ZD							24	5	10W
1N1823	S	1N2988A	2-18	ZD							27	10	10W
1N1823A	S	1N2988B	2-18	ZD							27	5	10W
1N1824	S	1N2989A	2-18	ZD							30	10	10W
1N1824A	S	1N2989B	2-18	ZD							30	5	10W
1N1825	S	1N2990A	2-18	ZD							33	10	10W
1N1825A	S	1N2990B	2-18	ZD							33	5	10W
1N1826	S	1N2991A	2-18	ZD							36	10	10W
1N1826A	S	1N2991B	2-18	ZD							36	5	10W
1N1827	S	1N2992A	2-18	ZD							39	10	10W
1N1827A	S	1N2992B	2-18	ZD							39	5	10W
1N1828	S	1N2993A	2-18	ZD							43	10	10W
1N1828A	S	1N2993B	2-18	ZD							43	5	10W
1N1829	S	1N2995A	2-18	ZD							47	10	10W
1N1829A	S	1N2995B	2-18	ZD							47	5	10W
1N1830	S	1N2997A	2-18	ZD							51	10	10W
1N1830A	S	1N2997B	2-18	ZD							51	5	10W
1N1831	S	1N2999A	2-18	ZD							56	10	10W
1N1831A	S	1N2999B	2-18	ZD							56	5	10W
1N1832	S	1N3000A	2-18	ZD							62	10	10W
1N1832A	S	1N3000B	2-18	ZD							62	5	10W
1N1833	S	1N3001A	2-18	ZD							68	10	10W
1N1833A	S	1N3001B	2-18	ZD							68	5	10W
1N1834	S	1N3002A	2-18	ZD							75	10	10W
1N1834A	S	1N3002B	2-18	ZD							75	5	10W
1N1835	S	1N3003A	2-18	ZD							82	10	10W
1N1835A	S	1N3003B	2-18	ZD							82	5	10W
1N1836	S	1N3004A	2-18	ZD							91	10	10W
1N1836A	S	1N3004B	2-18	ZD							91	5	10W
1N1839	S			R	6.8		.085		.26				
1N1840	S			R	10		.077		.23				
1N1841	S			R	15		.063		.19				
1N1842	S			R	22		.05		.15				
1N1843	S			R	33		.04		.12				
1N1844	S			R	47		.03		.095				
1N1845	S			R	68		.023	.001	.072				
1N1846	S			R	100		.016	.001	.050				
1N1847	S			R	150		.011	.003	.035				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs) CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1848	S			R	220		.009	.005	.028					
1N1849	S			R	330			.005	.024					
1N1850	S			R	470		.006	.005	.020					
1N1851	S			R	6.8		.085		.26					
1N1852	S			R	10		.077		.23					
1N1853	S			R	15		.063		.190					
1N1854	S			R	22		.05		.150					
1N1855	S			R	33		.04		.120					
1N1856	S			R	47		.03		.095					
1N1857	S			R	68		.023	.001	.072					
1N1858	S			R	100		.016	.001	.050					
1N1859	S			R	150		.011	.003	.035					
1N1860	S			R	220		.009	.005	.028					
1N1861	S			R	330			.005	.024					
1N1862	S			R	470		.006	.005	.020					
1N1863	S			R	6.8		.085		.260					
1N1864	S			R	10		.077		.230					
1N1865	S			R	15		.063		.190					
1N1866	S			R	22		.05		.150					
1N1867	S			R	33		.04		.120					
1N1868	S			R	47		.03		.095					
1N1869	S			R	68		.023	.001	.072					
1N1870	S			R	100		.016	.001	.050					
1N1871	S			R	150		.011	.003	.035					
1N1872	S			R	220		.009	.005	.028					
1N1873	S			R	330			.005	.024					
1N1874	S			R	470		.006	.005	.020					
1N1875	S	1N3018A	2-19	ZD							8.2	10		1W
1N1876	S	1N3020A	2-19	ZD							10	10		1W
1N1877	S	1N3022A	2-19	ZD							12	10		1W
1N1878	S	1N3024A	2-19	ZD							15	10		1W
1N1879	S	1N3026A	2-19	ZD							18	10		1W
1N1880	S	1N3028A	2-19	ZD							22	10		1W
1N1881	S	1N3030A	2-19	ZD							27	10		1W
1N1882	S	1N3032A	2-19	ZD							33	10		1W
1N1883	S	1N3034A	2-19	ZD							39	10		1W
1N1884	S	1N3036A	2-19	ZD							47	10		1W
1N1885	S	1N3038A	2-19	ZD							56	10		1W
1N1886	S	1N3040A	2-19	ZD							68	10		1W
1N1887	S	1N3042A	2-19	ZD							82	10		1W
1N1888	S	1N3044A	2-19	ZD							100	10		1W
1N1889	S			ZD							120	10		1W
1N1890	S			ZD							150	10		1W
1N1891	S	1N2972A	2-18	ZD							8.2	10		10W
1N1892	S	1N2974A	2-18	ZD							10	10		10W
1N1893	S	1N2976A	2-18	ZD							10	10		10W
1N1894	S	1N2979A	2-18	ZD							15	10		10W
1N1895	S	1N2982A	2-18	ZD							18	10		10W
1N1896	S	1N2985A	2-18	ZD							22	10		10W
1N1897	S	1N2988A	2-18	ZD							27	10		10W
1N1898	S	1N2990A	2-18	ZD							33	10		10W
1N1899	S	1N2992A	2-18	ZD							39	10		10W
1N1900	S	1N2995A	2-18	ZD							47	10		10W
1N1901	S	1N2999A	2-18	ZD							56	10		10W
1N1902	S	1N3001A	2-18	ZD							68	10		10W
1N1903	S	1N3003A	2-18	ZD							82	10		10W
1N1904	S	1N3005A	2-18	ZD							100	10		10W
1N1905	S			ZD							120	10		10W
1N1906	S			ZD							150	10		10W
1N1907	S	1N4001	3-23	R	50	1.0	1.5	.01	30					
1N1908	S	1N4002	3-23	R	100	1.0	1.5	.01	30					
1N1909	S	1N4003	3-23	R	200	1.0	1.5	.01	30					
1N1910	S			R	300	1.0	1.5	.01	30					
1N1911	S	1N4004	3-23	R	400	1.0	1.5	.01	30					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N1912—1N1975

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N1912	S	1N4005	3-23	R	500	1.0	1.5	.01	30					
1N1913	S	1N4005	3-23	R	600	1.0	1.5	.01	30					
1N1914	S	1N4006	3-23	R	700	1.0	1.5	.01	30					
1N1915	S	1N4006	3-23	R	800	1.0	1.5	.01	30					
1N1916	S	1N4007	3-23	R	900	1.0	1.5	.01	30					
1N1917	S			R	50	1.0	4	.01	30					
1N1918	S			R	100	1.0	4	.01	30					
1N1919	S			R	200	1.0	4	.01	30					
1N1920	S			R	300	1.0	4	.01	30					
1N1921	S			R	400	1.0	4	.01	30					
1N1922	S			R	500	1.0	4	.01	30					
1N1923	S			R	600	1.0	4	.01	30					
1N1924	S			R	700	1.0	4	.01	30					
1N1925	S			R	800	1.0	4	.01	30					
1N1926	S			R	900	1.0	4	.01	30					
1N1927	S	1N748	2-10	ZD							3.9	10	200M	
1N1928	S	1N750	2-10	ZD							4.7	10	200M	
1N1929	S	1N752	2-10	ZD							5.6	10	200M	
1N1930	S	1N754	2-10	ZD							6.8	10	200M	
1N1931	S	1N959A	2-11	ZD							8.2	10	200M	
1N1932	S	1N961A	2-11	ZD							10	10	200M	
1N1933	S	1N963A	2-11	ZD							12	10	200M	
1N1934	S	1N965A	2-11	ZD							15	10	200M	
1N1935	S	1N967A	2-11	ZD							18	10	200M	
1N1936	S	1N969A	2-11	ZD							22	10	200M	
1N1937	S	1N971A	2-11	ZD							27	10	200M	
1N1938	S	1N973A	2-11	ZD							33	10	200M	
1N1939	S	1N975A	2-11	ZD							39	10	200M	
1N1940	S	1N977A	2-11	ZD							47	10	200M	
1N1941	S	1N979A	2-11	ZD							56	10	200M	
1N1942	S	1N981A	2-11	ZD							68	10	200M	
1N1943	S	1N983A	2-11	ZD							82	10	200M	
1N1944	S	1N985A	2-11	ZD							100	10	200M	
1N1945	S	1N987A	2-11	ZD							120	10	200M	
1N1946	S	1N988A	2-11	ZD							150	10	200M	
1N1947	S	1N991A	2-11	ZD							180	10	200M	
1N1948	S			ZD							220	10	200M	
1N1949	S			ZD							270	10	200M	
1N1950	S			ZD							330	10	200M	
1N1951	S			ZD							390	10	200M	
1N1952	S			ZD							470	10	200M	
1N1953	S			ZD							560	10	200M	
1N1954	S	1N748	2-10	ZD							3.9	10	400M	
1N1955	S	1N750	2-10	ZD							4.7	10	400M	
1N1956	S	1N752	2-10	ZD							5.6	10	400M	
1N1957	S	1N754	2-10	ZD							6.8	10	400M	
1N1958	S	1N959A	2-11	ZD							8.2	10	400M	
1N1959	S	1N961A	2-11	ZD							10	10	400M	
1N1960	S	1N963A	2-11	ZD							12	10	400M	
1N1961	S	1N965A	2-11	ZD							15	10	400M	
1N1962	S	1N967A	2-11	ZD							18	10	400M	
1N1963	S	1N969A	2-11	ZD							22	10	400M	
1N1964	S	1N971A	2-11	ZD							27	10	400M	
1N1965	S	1N973A	2-11	ZD							33	10	400M	
1N1966	S	1N975A	2-11	ZD							39	10	400M	
1N1967	S	1N977A	2-11	ZD							47	10	400M	
1N1968	S	1N979A	2-11	ZD							56	10	400M	
1N1969	S	1N981A	2-11	ZD							68	10	400M	
1N1970	S	1N983A	2-11	ZD							82	10	400M	
1N1971	S	1N985A	2-11	ZD							100	10	400M	
1N1972	S	1N987A	2-11	ZD							120	10	400M	
1N1973	S	1N989A	2-11	ZD							150	10	400M	
1N1974	S	1N991A	2-11	ZD							180	10	400M	
1N1975	S			ZD							220	10	400M	

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs) **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N1976	S			ZD							270	10	400M
1N1977	S			ZD							330	10	400M
1N1978	S			ZD							390	10	400M
1N1979	S			ZD							470	10	400M
1N1980	S			ZD							560	10	400M
1N1981	S	1N748	2-10	ZD							3.9	10	150M
1N1982	S	1N750	2-10	ZD							4.7	10	150M
1N1983	S	1N752	2-10	ZD							5.6	10	150M
1N1984	S	1N754	2-10	ZD							6.8	10	150M
1N1985	S	1N959A	2-11	ZD							8.2	10	150M
1N1986	S	1N961A	2-11	ZD							10	10	150M
1N1987	S	1N963A	2-11	ZD							12	10	150M
1N1988	S	1N965A	2-11	ZD							15	10	150M
1N1989	S	1N967A	2-11	ZD							18	10	150M
1N1990	S	1N969A	2-11	ZD							22	10	150M
1N1991	S	1N971A	2-11	ZD							27	10	150M
1N1992	S	1N973A	2-11	ZD							33	10	150M
1N1993	S	1N975A	2-11	ZD							39	10	150M
1N1994	S	1N977A	2-11	ZD							47	10	150M
1N1995	S	1N979A	2-11	ZD							56	10	150M
1N1996	S	1N981A	2-11	ZD							68	10	150M
1N1997	S	1N983A	2-11	ZD							82	10	150M
1N1998	S	1N985A	2-11	ZD							100	10	150M
1N1999	S	1N987A	2-11	ZD							120	10	150M
1N2000	S	1N989A	2-11	ZD							150	10	150M
1N2001	S	1N991A	2-11	ZD							180	10	150M
1N2002	S			ZD							220	10	150M
1N2003	S			ZD							270	10	150M
1N2004	S			ZD							330	10	150M
1N2005	S			ZD							390	10	150M
1N2006	S			ZD							470	10	150M
1N2007	S			ZD							560	10	150M
1N2008	S	1N3005A	2-18	ZD							100	10	10W
1N2009	S	1N3007A	2-18	ZD							110	10	10W
1N2010	S	1N3008A	2-18	ZD							120	10	10W
1N2011	S	1N3009A	2-18	ZD							130	10	10W
1N2012	S	1N3011A	2-18	ZD							150	10	10W
1N2013	S			R	50	1.2	.25	.25	10				
1N2014	S			R	100	1.2	.25	.25	10				
1N2015	S			R	150	1.2	.25	.25	10				
1N2016	S			R	200	1.2	.25	.25	10				
1N2017	S			R	250	1.2	.25	.25	10				
1N2018	S			R	300	1.2	.25	.25	10				
1N2019	S			R	350	1.2	.25	.25	10				
1N2020	S			R	400	1.2	.25	.25	10				
1N2021	S			R	150	1.5	10	5	110				
1N2022	S			R	250	1.5	10	5	110				
1N2023	S			R	300	1.5	10	5	110				
1N2024	S			R	350	1.5	10	5	110				
1N2025	S			R	400	1.5	10	5	110				
1N2026	S			R	50	2	1	.5	25				
1N2027	S			R	200	2	1	.5	25				
1N2028	S			R	300	2	1	.5	25				
1N2029	S			R	400	2	1	.5	25				
1N2030	S			R	500	2	1	.5	25				
1N2031	S			R	600	2	1	.5	25				
1N2032	S	1N3825	2-23	ZD						4.3	5.4		250M
1N2033	S	1N3826	2-23	ZD						5.2	6.4		750M
1N2034	S	1N3829	2-23	ZD						6.2	8.0		750M
1N2035	S	1N3018A	2-19	ZD						7.5	10.0		750M
1N2036	S	1N3020A	2-19	ZD						9.0	12.0		750M
1N2037	S	1N3023	2-19	ZD						11.0	14.5		750M
1N2038	S	1N3025A	2-19	ZD						13.5	18.0		750M
1N2039	S	1N3027A	2-19	ZD						17.0	21.0		750M

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N2040 — 1N2111

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2040	S	1N3029A	2-19	ZD						20.0	27.0		750M
1N2041	S	1N3995	2-24	ZD						4.3	5.4		10W
1N2042	S	1N3997	2-24	ZD						5.2	6.4		10W
1N2043	S	1N3997A	2-24	ZD						6.2	8.0		10W
1N2044	S	1N2973A	2-18	ZD						7.5	10.0		10W
1N2045	S	1N2974A	2-18	ZD						9.0	12.0		10W
1N2046	S	1N2977A	2-18	ZD						11.0	14.5		10W
1N2047	S	1N2980A	2-18	ZD						13.5	18.0		10W
1N2048	S	1N2983A	2-18	ZD						17.0	21.0		10W
1N2049	S	1N2986A	2-18	ZD						20.0	27.0		10W
1N2054	S	MR1230SB	3-41	R	50	1.6	250	55	4500				
1N2055	S	MR1231SB	3-41	R	100	1.6	250	55	4500				
1N2056	S	MR1232SB	3-41	R	150	1.6	250	55	4500				
1N2057	S	MR1233SB	3-41	R	200	1.6	250	55	4500				
1N2058	S	MR1234SB	3-41	R	250	1.6	250	55	4500				
1N2059	S	MR1235SB	3-41	R	300	1.6	250	55	4500				
1N2060	S	MR1236SB	3-41	R	350	1.6	250	55	4500				
1N2061	S	MR1237SB	3-41	R	400	1.6	250	55	4500				
1N2062	S			R	450	1.6	250	55	4500				
1N2063	S			R	500	1.6	250	55	4500				
1N2064	S			R	600	1.6	250	55	4500				
1N2065	S			R	700	1.6	250	55	4500				
1N2066	S			R	800	1.6	250	55	4500				
1N2067	S			R	900	1.6	250	55	4500				
1N2068	S			R	1000	1.6	250	55	4500				
1N2069		1N4003	3-23	R	200	.6	.75	.2	22				
1N2069A		1N4003	3-23	R	200	.5	.75	.05	22				
1N2070		1N4004	3-23	R	400	.6	.75	.2	22				
1N2070A		1N4004	3-23	R	400	.5	.75	.05	22				
1N2071		1N4005	3-23	R	600	.6	.75	.2	22				
1N2071A		1N4005	3-23	R	600	.5	.75	.05	22				
1N2072	S	1N4001	3-23	R	50	1.1	.625	.25	30				
1N2073	S	1N4002	3-23	R	100	1.1	.625	.25	30				
1N2074	S	1N4003	3-23	R	150	1.1	.625	.25	30				
1N2075	S	1N4003	3-23	R	200	1.1	.625	.25	30				
1N2076	S	1N4004	3-23	R	250	1.1	.625	.25	30				
1N2077	S	1N4004	3-23	R	300	1.1	.625	.25	30				
1N2078	S	1N4004	3-23	R	400	1.1	.625	.25	30				
1N2079	S	1N4005	3-23	R	500	1.1	.625	.25	30				
1N2080	S			R	50	.75	.5	.35	15				
1N2081	S			R	100	.75	.5	.35	15				
1N2082	S			R	200	.75	.5	.35	15				
1N2083	S			R	300	.75	.5	.35	15				
1N2084	S			R	400	.75	.5	.35	15				
1N2085	S			R	500	.75	.5	.35	15				
1N2086	S			R	600	.75	.5	.35	15				
1N2088	S			R	500	1.2	.75	.5	30				
1N2089	S			R	600	1.2	.75	.5	30				
1N2090	S			R	50	.5	.5	.25	15				
1N2091	S			R	100	.5	.5	.25	15				
1N2092	S			R	200	.5	.5	.25	15				
1N2093	S			R	300	.5	.5	.25	15				
1N2094	S			R	400	.5	.5	.25	15				
1N2095	S			R	500	.5	.5	.25	15				
1N2096	S			R	600	.5	.5	.25	15				
1N2103	S	1N4001	3-23	R	50	1.2	.75	.3	10				
1N2104	S	1N4002	3-23	R	100	1.2	.75	.3	10				
1N2105	S	1N4003	3-23	R	200	1.2	.75	.3	10				
1N2106	S	1N4004	3-23	R	300	1.2	.75	.3	10				
1N2107	S	1N4004	3-23	R	400	1.2	.75	.3	10				
1N2108	S	1N4005	3-23	R	500	1.2	.75	.3	10				
1N2109	S			R	50	1.2	2	.3	10				
1N2110	S			R	100	1.2	2	.3	10				
1N2111	S			R	200	1.2	2	.3	10				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2112	S			R	300	1.2	2	.3	10				
1N2113	S			R	400	1.2	2	.3	10				
1N2114	S			R	500	1.2	2	.3	10				
1N2115	S			R	365	.8	.2	.25	10				
1N2116	S			R	400	1.4	.5	.4	15				
1N2117	S			R	720	1.3	.75	.010	15				
1N2128	S	MR1200FL	3-32	R	50	2.0	60	10	700				
1N2128A	S	MR1200FL	3-32	R	50	2.0	60	10	900				
1N2129	S	MR1201FL	3-32	R	100	2.0	60	10	700				
1N2129A	S	MR1201FL	3-32	R	100	2.0	60	10	900				
1N2130	S	MR1202FL	3-32	R	150	2.0	60	10	700				
1N2130A	S	MR1202FL	3-32	R	150	2.0	60	10	900				
1N2131	S	MR1203FL	3-32	R	200	2.0	60	10	700				
1N2131A	S	MR1203FL	3-32	R	200	2.0	60	10	900				
1N2132	S	MR1204FL	3-32	R	250	2.0	60	10	700				
1N2132A	S	MR1204FL	3-32	R	250	2.0	60	10	900				
1N2133	S	MR1205FL	3-32	R	300	2.0	60	10	700				
1N2133A	S	MR1205FL	3-32	R	300	2.0	60	10	900				
1N2134	S	MR1206FL	3-32	R	350	2.0	60	10	700				
1N2134A	S	MR1206FL	3-32	R	350	2.0	60	10	900				
1N2135	S	MR1207FL	3-32	R	400	2.0	60	10	700				
1N2135A	S	MR1207FL	3-32	R	400	2.0	60	10	900				
1N2136	S			R	450	2.0	60	10	700				
1N2136A	S			R	450	2.0	60	10	900				
1N2137	S			R	500	2.0	60	10	700				
1N2137A	S			R	500	2.0	60	10	900				
1N2138	S			R	600	2.0	60	10	700				
1N2138A	S			R	600	2.0	60	10	900				
1N2139	S			R	20K	60	.052	.2	3.5				
1N2146	S			CS	120	1.1	500M	1*	.1				
1N2147	S			R	50	1.2	6	.5	150				
1N2147A	S			R	50	1	6	.1	150				
1N2148	S			R	100	1.2	6	.5	150				
1N2148A	S			R	100	1	6	.1	150				
1N2149	S			R	200	1.2	6	.5	150				
1N2149A	S			R	200	1	6	.1	150				
1N2150	S			R	300	1.2	6	.5	150				
1N2150A	S			R	300	1	6	.1	150				
1N2151	S			R	400	1.2	6	.5	150				
1N2151A	S			R	400	1	6	.1	150				
1N2152	S			R	500	1.2	6	.5	150				
1N2152A	S			R	500	1	6	.1	150				
1N2153	S			R	600	1.2	6	.5	150				
1N2153A	S			R	600	1	6	.1	150				
1N2154	S	1N1183	3-10	R	50	.6	25	5.0	300				
1N2155	S	1N1184	3-10	R	100	.6	25	4.5	300				
1N2156	S	1N1186	3-10	R	200	.6	25	4.0	300				
1N2157	S	1N1187	3-10	R	300	.6	25	3.5	300				
1N2158	S	1N1188	3-10	R	400	.6	25	3.0	300				
1N2159	S	1N1189	3-10	R	500	.6	25	2.5	300				
1N2160	S	1N1190	3-10	R	600	.6	25	2.0	300				
1N2163	S	1N2621	2-32	RD						.005	9.8	0	70
1N2163A	S			RD						.005	9.6	0	70
1N2164	S	1N2621A	2-32	RD						.005	9.8	-55	125
1N2164A	S			RD						.005	9.6	-55	125
1N2165	S	1N2621B	2-32	RD						.005	9.8	-55	185
1N2165A	S			RD						.005	9.6	-55	185
1N2166	S	1N2623	2-32	RD						.001	9.8	0	70
1N2166A	S			RD						.001	9.6	0	70
1N2167	S	1N2623A	2-32	RD						.001	9.8	-55	125
1N2167A	S			RD						.001	9.6	-55	125
1N2168	S	1N2623B	2-32	RD						.001	9.8	-55	185
1N2168A	S			RD						.001	9.6	-55	185
1N2169	S	1N2624	2-32	RD						.0005	9.8	0	70

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N2169A — 1N2227A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2169A	S			RD						.0005	9.6	0	70
1N2170	S	1N2624A	2-32	RD						.0005	9.8	-55	125
1N2170A	S			RD						.0005	9.6	-55	125
1N2171	S	1N2624B	2-32	RD						.0005	9.8	-55	185
1N2171A	S			RD						.0005	9.6	-55	185
1N2172	S			R	50	1.5	50	.25	525				
1N2173	S			R	100	1.5	50	.25	525				
1N2174	S			R	200	1.5	50	.25	525				
1N2176	S			R	50	1.1	3	.3	15				
1N2177	S			R	100	1.1	3	.3	15				
1N2178	S			R	150	1.1	3	.3	15				
1N2179	S			R	200	1.1	3	.3	15				
1N2180	S			R	300	1.1	3	.3	15				
1N2181	S			R	400	1.1	3	.3	15				
1N2182	S			R	500	1.1	3	.3	15				
1N2183	S			R	600	1.1	3	.3	15				
1N2184	S			R	50	1.5	3	5	40				
1N2185	S			R	100	1.5	3	5	40				
1N2186	S			R	150	1.5	3	5	40				
1N2187	S			R	200	1.5	3	5	40				
1N2188	S			R	300	1.5	3	5	40				
1N2189	S			R	400	1.5	3	5	40				
1N2190	S			R	500	1.5	3	5	40				
1N2191	S			R	600	1.5	3	5	40				
1N2192	S			R	800	1.5	3	5	40				
1N2193	S			R	1000	1.5	3	5	40				
1N2194	S			R	50	1.25	6	10	100				
1N2195	S			R	100	1.25	6	10	100				
1N2196	S			R	150	1.25	6	10	100				
1N2197	S			R	200	1.25	6	10	100				
1N2198	S			R	300	1.25	6	10	100				
1N2199	S			R	400	1.25	6	10	100				
1N2200	S			R	500	1.25	6	10	100				
1N2201	S			R	600	1.25	6	10	100				
1N2202	S			R	800	1.25	6	10	100				
1N2203	S			R	1000	1.25	6	10	100				
1N2204	S			R	50	1.25	12	10	200				
1N2205	S			R	100	1.25	12	10	200				
1N2206	S			R	150	1.25	12	10	200				
1N2207	S			R	200	1.25	12	10	200				
1N2208	S			R	300	1.25	12	10	200				
1N2209	S			R	400	1.25	12	10	200				
1N2210	S			R	500	1.25	12	10	200				
1N2211	S			R	600	1.25	12	10	200				
1N2212	S			R	800	1.25	12	10	200				
1N2213	S			R	1000	1.25	12	10	200				
1N2214	S	1N3827A	2-23	RD						.03	5.6	25	25
1N2217	S			R	50		1.5	.003	20				
1N2218	S			R	500	1.2	.4	.003	20				
1N2219	S			R	500		1.5	.003	20				
1N2220	S			R	600	1.2	.4	.003	20				
1N2221	S			R	600		1.5	.003	20				
1N2222	S			R	800	1.2	.3	.003	20				
1N2222A	S			R	800	1.2	.3	.003	20				
1N2223	S			R	800		1	.003	20				
1N2223A	S			R	800		1	.003	20				
1N2224	S			R	1000	1.2	.3	.003	20				
1N2224A	S			R	1000	1.2	.3	.003	20				
1N2225	S			R	1000		1	.003	20				
1N2225A	S			R	1000		1	.003	20				
1N2226	S			R	1200	1.2	.3	.003	20				
1N2226A	S			R	1200	1.2	.3	.003	20				
1N2227	S			R	1200		1	.003	20				
1N2227A	S			R	1200		1	.003	20				

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Sneed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2228	S			R	50	1.2	1	.003	100				
1N2228A	S			R	50	1.2	1.6	.003	100				
1N2229	S			R	50		5	.003	100				
1N2229A	S			R	50		5	.003	100				
1N2230	S			R	200	1.2	1	.003	100				
1N2230A	S			R	200	1.2	1.6	.003	100				
1N2231	S			R	200		5	.003	100				
1N2231A	S			R	200		5	.003	100				
1N2232	S			R	300	1.2	1	.003	100				
1N2232A	S			R	300	1.2	1.6	.003	100				
1N2233	S			R	300		5	.003	100				
1N2233A	S			R	300		5	.003	100				
1N2234	S			R	400	1.2	1	.003	100				
1N2234A	S			R	400	1.2	1.6	.003	100				
1N2235	S			R	400		5	.003	100				
1N2235A	S			R	400		5	.003	100				
1N2236	S			R	500	1.2	1	.003	100				
1N2236A	S			R	500	1.2	1.6	.003	100				
1N2237	S			R	500		5	.003	100				
1N2237A	S			R	500		5	.003	100				
1N2238	S			R	600	1.2	1	.003	100				
1N2238A	S			R	600	1.2	1.6	.003	100				
1N2239	S			R	600		5	.003	100				
1N2239A	S			R	600		5	.003	100				
1N2240	S			R	800	1.2	1.5	.003	100				
1N2240A	S			R	800	1.2	1.5	.003	100				
1N2241	S			R	800		5	.003	100				
1N2241A	S			R	800		5	.003	100				
1N2242	S			R	1000	1.2	1.5	.003	100				
1N2242A	S			R	1000	1.2	1.6	.003	100				
1N2243	S			R	1000		5	.003	100				
1N2243A	S			R	1000		5	.003	100				
1N2244	S			R	1200	1.2	1.5	.003	100				
1N2244A	S			R	1200	1.2	1.6	.003	100				
1N2245	S			R	1200		5	.003	100				
1N2245A	S			R	1200		5	.003	100				
1N2246	S			R	50	1.2	3	.005	200				
1N2246A	S			R	50	1.2	3	.003	200				
1N2247	S			R	50		10	.005	200				
1N2247A	S			R	50		10	.003	200				
1N2248	S			R	100	1.2	3	.005	200				
1N2248A	S			R	100	1.2	3	.003	200				
1N2249	S			R	100		10	.005	200				
1N2249A	S			R	100		10	.003	200				
1N2250	S			R	200	1.2	3	.005	200				
1N2250A	S			R	200	1.2	3	.003	200				
1N2251	S			R	200		5	.005	200				
1N2251A	S			R	200		10	.003	200				
1N2252	S			R	300	1.2	3	.005	200				
1N2252A	S			R	300	1.2	3	.003	200				
1N2253	S			R	300		10	.005	200				
1N2253A	S			R	300		10	.003	200				
1N2254	S			R	400	1.2	3	.005	200				
1N2254A	S			R	400	1.2	3	.003	200				
1N2255	S			R	400		10	.005	200				
1N2255A	S			R	400		10	.003	200				
1N2256	S			R	500	1.2	3	.005	200				
1N2256A	S			R	500	1.2	3	.003	200				
1N2257	S			R	500		10	.005	200				
1N2257A	S			R	500		10	.005	200				
1N2258	S			R	600	1.2	3	.005	200				
1N2258A	S			R	600	1.2	3	.003	200				
1N2259	S			R	600		10	.005	200				
1N2259A	S			R	600		10	.003	200				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N2260 — 1N2312

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2260	S			R	800	1.2	3	.003	200				
1N2260A	S			R	800	1.2	3	.005	200				
1N2261	S			R	800		10	.01	200				
1N2261A	S			R	800		10	.005	200				
1N2262	S			R	1000	1.2	3	.010	200				
1N2262A	S			R	1000	1.2	3	.005	200				
1N2263	S			R	1000		10	.01	200				
1N2263A	S			R	1000		10	.005	200				
1N2264	S			R	1200	1.2	3	.010	200				
1N2264A	S			R	1200	1.2	3	.005	200				
1N2265	S			R	1200		10	.01	200				
1N2265A	S			R	1200		10	.005	200				
1N2266	S			R	50	1.2	.3	.003	20				
1N2267	S			R	50		1	.003	20				
1N2268	S			R	500	1.2	.3	.003	20				
1N2269	S			R	500		1	.003	20				
1N2270	S			R	600	1.2	.3	.003	20				
1N2271	S			R	600		1	.003	20				
1N2272	S			R	50	1.2	6	1.0	400				
1N2273	S			R	100	1.2	6	1.0	400				
1N2274	S			R	200	1.2	6	1.0	400				
1N2275	S			R	300	1.2	6	1.0	400				
1N2276	S			R	400	1.2	6	1.0	400				
1N2277	S			R	500	1.2	6	1.0	400				
1N2278	S			R	600	1.2	6	1.0	400				
1N2279	S			R	800	1.2	6	1.0	400				
1N2280	S			R	1000	1.2	6	1.0	400				
1N2281	S			R	1200	1.2	6	1.0	400				
1N2282	S			R	300	1.5	20	5.0	400				
1N2283	S			R	400	1.5	20	5.0	400				
1N2284	S			R	500	1.5	20	5.0	400				
1N2285	S			R	600	1.5	20	5.0	400				
1N2286	S			R	800	1.5	20	5.0	400				
1N2287	S			R	1000	1.5	20	5.0	400				
1N2288	S			R	1200	1.5	20	5.0	400				
1N2289	S			R	100		1.5	.003	20				
1N2289A	S			R	100		1.5	.003	20				
1N2290	S			R	100		5	.003	100				
1N2290A	S			R	100		5	.003	100				
1N2291	S			R	200		1.5	.003	20				
1N2291A	S			R	200		1.5	.003	20				
1N2292	S			R	300		1.5	.003	20				
1N2292A	S			R	300		1.5	.003	20				
1N2293	S			R	400		1.5	.003	20				
1N2293A	S			R	400		1.5	.003	20				
1N2294	S			R	50	1.1	22	10	160				
1N2295	S			R	100	1.1	22	10	160				
1N2296	S			R	150	1.1	22	10	160				
1N2297	S			R	200	1.1	22	10	160				
1N2298	S			R	250	1.1	22	10	160				
1N2299	S			R	300	1.1	22	10	160				
1N2300	S			R	350	1.1	22	10	160				
1N2301	S			R	400	1.1	22	10	160				
1N2302	S			R	50	1.1	22	10	160				
1N2303	S			R	100	1.1	22	10	160				
1N2304	S			R	150	1.1	22	10	160				
1N2305	S			R	200	1.1	22	10	160				
1N2306	S			R	250	1.1	22	10	160				
1N2307	S			R	300	1.1	22	10	160				
1N2308	S			R	350	1.1	22	10	160				
1N2309	S			R	400	1.1	22	10	160				
1N2310	S			R	50	1.1	35	20	300				
1N2311	S			R	100	1.1	35	20	300				
1N2312	S			R	150	1.1	35	20	300				

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≧ 20 mA @ ≦ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2313	S			R	200	1.1	35	20	300				
1N2314	S			R	250	1.1	35	20	300				
1N2315	S			R	300	1.1	35	20	300				
1N2316	S			R	350	1.1	35	20	300				
1N2317	S			R	400	1.1	35	20	300				
1N2318	S			R	50	1.1	35	20	300				
1N2319	S			R	100	1.1	35	20	300				
1N2320	S			R	150	1.1	35	20	300				
1N2321	S			R	200	1.1	35	20	300				
1N2322	S			R	250	1.1	35	20	300				
1N2323	S			R	300	1.1	35	20	300				
1N2324	S			R	350	1.1	35	20	300				
1N2325	S			R	400	1.1	35	20	300				
1N2326	G			GP	1	.150	2M						
1N2327	S			HC	300	3.3	400M	1.5*					
1N2328	S			HC	300	3.3	400M	1.5*					
1N2348	S			R	50	1.1	3	.3	15				
1N2349	S			R	100	1.1	3	.3	15				
1N2350	S			R	150	1.1	3	.3	15				
1N2357	S			R	1400		.4	.001	15				
1N2358	S			R	1500		.4	.001	15				
1N2359	S			R	1600		.4	.001	15				
1N2360	S			R	1800		.4	.001	15				
1N2361	S			R	2000		.4	.001	15				
1N2362	S			R	1400		1	.001	15				
1N2362A	S			R	1400		5	.001	20				
1N2362B	S			R	1400		10	.001	25				
1N2363	S			R	1400		1	.001	15				
1N2363A	S			R	1400		5	.001	20				
1N2363B	S			R	1400		10	.001	25				
1N2364	S			R	1500		1	.001	15				
1N2364A	S			R	1500		5	.001	20				
1N2364B	S			R	1500		10	.001	25				
1N2365	S			R	1500		1	.001	15				
1N2365A	S			R	1500		5	.001	20				
1N2365B	S			R	1500		10	.001	25				
1N2366	S			R	1600		1	.001	15				
1N2366A	S			R	1600		5	.001	20				
1N2366B	S			R	1600		10	.001	25				
1N2367	S			R	1600		1	.001	15				
1N2367A	S			R	1600		5	.001	20				
1N2367B	S			R	1600		10	.001	25				
1N2368	S			R	1800		1	.001	15				
1N2368A	S			R	1800		5	.001	20				
1N2368B	S			R	1800		10	.001	25				
1N2369	S			R	1800		1	.001	15				
1N2369A	S			R	1800		5	.001	20				
1N2369B	S			R	1800		10	.001	25				
1N2370	S			R	2000		1	.001	15				
1N2370A	S			R	2000		5	.001	20				
1N2370B	S			R	2000		10	.001	25				
1N2371	S			R	2000		1	.001	15				
1N2371A	S			R	2000		5	.001	20				
1N2371B	S			R	2000		10	.001	25				
1N2372	S			R	1000	2	.2	.5	12				
1N2373	S	1N4005	3-23	R	600	3.0	.1	.250	12				
1N2374	S	1N4007	3-23	R	1000	3.0	.1	.250	12				
1N2375	S	MR991	3-26	R	1500	4.5	.1	.250	12				
1N2376	S	MR992	3-26	R	2000	7.5	.1	.250	12				
1N2377	S	MR993	3-26	R	2400	9.0	.075	.250	12				
1N2378	S	MR994	3-26	R	3000	9.0	.075	.250	12				
1N2379	S	1N2382	3-6	R	4000	15.0	.05	.250	12				
1N2380	S	1N2383	3-6	R	6000	22.5	.05	.250	12				
1N2381	S	1N2385	3-6	R	10K	37.5	.025	.250	12				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N2382 — 1N2498

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2382	S		3-6	R	4000	18	.15	.2	6				
1N2382A	S			R	4000	6	.35	.2	6				
1N2383	S		3-6	R	6000	27	.1	.2	6				
1N2383A	S			R	6000	9	.35	.2	6				
1N2384	S		3-6	R	8000	27	.07	.2	6				
1N2384A	S			R	8000	12	.275	.2	6				
1N2385	S			R	10K	39	.07	.2	6				
1N2385A	S			R	10K	15	.2	.2	6				
1N2386	G			PA	5								
1N2387	S	1N3031B	2-19	RD						.001	30	25	125
1N2389	S			R	1600	4.8	.6	.5	15				
1N2390	S			R	50	1.2	1.5	.3	35				
1N2391	S			R	100	1.2	1.5	.3	35				
1N2392	S			R	200	1.2	1.5	.3	35				
1N2393	S			R	300	1.2	1.5	.3	35				
1N2394	S			R	400	1.2	1.5	.3	35				
1N2395	S			R	500	1.2	1.5	.3	35				
1N2396	S			R	600	1.2	1.5	.3	35				
1N2397	S			R	700	1.2	1.5	.3	35				
1N2398	S			R	800	1.2	1.5	.3	35				
1N2399	S			R	50	1.2	1.5	.3	35				
1N2400	S			R	100	1.2	1.5	.3	35				
1N2401	S			R	200	1.2	1.5	.3	35				
1N2402	S			R	300	1.2	1.5	.3	35				
1N2403	S			R	400	1.2	1.5	.3	35				
1N2404	S			R	500	1.2	1.5	.3	35				
1N2405	S			R	600	1.2	1.5	.3	35				
1N2406	S			R	700	1.2	1.5	.3	35				
1N2407	S			R	800	1.2	1.5	.3	35				
1N2408	S			R	50	1.2	1.5	.3	35				
1N2409	S			R	100	1.2	1.5	.3	35				
1N2410	S			R	200	1.2	1.5	.3	35				
1N2411	S			R	300	1.2	1.5	.3	35				
1N2412	S			R	400	1.2	1.5	.3	35				
1N2413	S			R	500	1.2	1.5	.3	35				
1N2414	S			R	600	1.2	1.5	.3	35				
1N2415	S			R	700	1.2	1.5	.3	35				
1N2416	S			R	800	1.2	1.5	.3	35				
1N2417	S			R	50	1.2	1.5	.3	35				
1N2418	S			R	100	1.2	1.5	.3	35				
1N2419	S			R	200	1.2	1.5	.3	35				
1N2420	S			R	300	1.2	1.5	.3	35				
1N2421	S			R	400	1.2	1.5	.3	35				
1N2422	S			R	500	1.2	1.5	.3	35				
1N2423	S			R	600	1.2	1.5	.3	35				
1N2424	S			R	700	1.2	1.5	.3	35				
1N2425	S			R	800	1.2	1.5	.3	35				
1N2482	S	1N4003	3-23	R	200	1.2	.75	.5	30				
1N2483	S	1N4004	3-23	R	400	1.2	.75	.5	30				
1N2484	S	1N4005	3-23	R	500	1.2	.75	.5	30				
1N2485	S	1N4003	3-23	R	200	1.2	.75	.5	30				
1N2486	S	1N4004	3-23	R	300	1.2	.75	.5	30				
1N2487	S	1N4004	3-23	R	400	1.2	.75	.5	30				
1N2488	S	1N4005	3-23	R	500	1.2	.75	.5	30				
1N2489	S	1N4005	3-23	R	600	1.2	.75	.5	30				
1N2490	S			R	1600	4.8	.5	.5	15				
1N2491	S			R	50	1.5	6	2	150				
1N2492	S			R	100	1.5	6	2	150				
1N2493	S			R	200	1.5	6	2	150				
1N2494	S			R	300	1.5	6	2	150				
1N2495	S			R	400	1.5	6	2	150				
1N2496	S			R	500	1.5	6	2	150				
1N2497	S			R	600	1.5	6	2	150				
1N2498	S		2-14	ZD							10	10	10W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2498A	S		2-14	ZD							10	5	10W	
1N2499	S		2-14	ZD							11	10	10W	
1N2499A	S		2-14	ZD							11	5	10W	
1N2500	S		2-14	ZD							12	10	10W	
1N2500A	S		2-14	ZD							12	5	10W	
1N2501	S			R	800	1.7	.15	.2	2.5					
1N2502	S			R	1000	1.7	.15	.2	2.5					
1N2503	S			R	1200	1.7	.15	.2	2.5					
1N2504	S			R	1500	1.7	.15	.2	2.5					
1N2505	S			R	800	1.7	.3	.2	2.5					
1N2506	S			R	1000	1.7	.3	.2	2.5					
1N2507	S			R	1200	1.7	.3	.2	2.5					
1N2508	S			R	1500	1.7	.3	.2	2.5					
1N2512	S			R	100	1.1		.002	30					
1N2513	S			R	200	1.1		.002	30					
1N2514	S			R	300	1.1		.002	30					
1N2515	S			R	400	1.1		.002	30					
1N2516	S			R	500	1.1		.002	30					
1N2517	S			R	600	1.1		.002	30					
1N2518	S			R	100	1.1		.002	30					
1N2519	S			R	200	1.1		.002	30					
1N2520	S			R	300	1.1		.002	30					
1N2521	S			R	400	1.1		.002	30					
1N2522	S			R	500	1.1		.002	30					
1N2523	S			R	600	1.1		.002	30					
1N2524	S			R	50	1.2	2.5	.5	50					
1N2525	S			R	100	1.2	2.5	.5	50					
1N2526	S			R	200	1.2	2.5	.5	50					
1N2527	S			R	300	1.2	2.5	.5	50					
1N2528	S			R	400	1.2	2.5	.5	50					
1N2529	S			R	500	1.2	2.5	.5	50					
1N2530	S			R	600	1.2	2.5	.5	50					
1N2531	S			R	700	1.2	2.5	.5	50					
1N2532	S			R	800	1.2	2.5	.5	50					
1N2533	S			R	900	1.2	2.5	.5	50					
1N2534	S			R	1000	1.2	2.5	.5	50					
1N2535	S			R	50	1.0	2.5	.1	50					
1N2536	S			R	100	1.0	2.5	.1	50					
1N2537	S			R	200	1.0	2.5	.1	50					
1N2538	S			R	300	1.0	2.5	.1	50					
1N2539	S			R	400	1.0	2.5	.1	50					
1N2540	S			R	500	1.0	2.5	.1	50					
1N2541	S			R	600	1.0	2.5	.1	50					
1N2542	S			R	700	1.0	2.5	.1	50					
1N2543	S			R	800	1.0	2.5	.1	50					
1N2544	S			R	900	1.0	2.5	.1	50					
1N2545	S			R	1000	1.0	2.5	.1	50					
1N2546	S			R	50	1.5	2.5	1.0	50					
1N2547	S			R	100	1.5	2.5	1.0	50					
1N2548	S			R	200	1.5	2.5	1.0	50					
1N2549	S			R	300	1.5	2.5	1.0	50					
1N2550	S			R	400	1.5	2.5	1.0	50					
1N2551	S			R	500	1.5	2.5	1.0	50					
1N2552	S			R	600	1.5	2.5	1.0	50					
1N2553	S			R	700	1.5	2.5	1.0	50					
1N2554	S			R	800	1.5	2.5	1.0	50					
1N2555	S			R	900	1.5	2.5	1.0	50					
1N2556	S			R	1000	1.5	2.5	1.0	50					
1N2557	S			R	700	1.2	6	.5	150					
1N2558	S			R	800	1.2	6	.5	150					
1N2559	S			R	900	1.2	6	.5	150					
1N2560	S			R	1000	1.2	6	.5	150					
1N2561	S			R	700	1.0	6	.1	150					
1N2562	S			R	800	1.0	6	.1	150					

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N2563—1N2622

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z%	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2563	S			R	900	1.0	6	.1	150					
1N2564	S			R	1000	1.0	6	.1	150					
1N2565	S			R	50	1.5	6	1.0	150					
1N2566	S			R	100	1.5	6	1.0	150					
1N2567	S			R	200	1.5	6	1.0	150					
1N2568	S			R	300	1.5	6	1.0	150					
1N2569	S			R	400	1.5	6	1.0	150					
1N2570	S			R	500	1.5	6	1.0	150					
1N2571	S			R	600	1.5	6	1.0	150					
1N2572	S			R	700	1.5	6	1.0	150					
1N2573	S			R	800	1.5	6	1.0	150					
1N2574	S			R	900	1.5	6	1.0	150					
1N2575	S			R	1000	1.5	6	1.0	150					
1N2576	S			R	50	1.2	12	1.0	250					
1N2577	S			R	100	1.2	12	1.0	250					
1N2578	S			R	200	1.2	12	1.0	250					
1N2579	S			R	300	1.2	12	1.0	250					
1N2580	S			R	400	1.2	12	1.0	250					
1N2581	S			R	500	1.2	12	1.0	250					
1N2582	S			R	600	1.2	12	1.0	250					
1N2583	S			R	700	1.2	12	1.0	250					
1N2584	S			R	800	1.2	12	1.0	250					
1N2585	S			R	900	1.2	12	1.0	250					
1N2586	S			R	1000	1.2	12	1.0	250					
1N2587	S			R	50	1.0	12	.2	250					
1N2588	S			R	100	1.0	12	.2	250					
1N2589	S			R	200	1.0	12	.2	250					
1N2590	S			R	300	1.0	12	.2	250					
1N2591	S			R	400	1.0	12	.2	250					
1N2592	S			R	500	1.0	12	.2	250					
1N2593	S			R	600	1.0	12	.2	250					
1N2594	S			R	700	1.0	12	.2	250					
1N2595	S			R	800	1.0	12	.2	250					
1N2596	S			R	900	1.0	12	.2	250					
1N2597	S			R	1000	1.0	12	.2	250					
1N2598	S			R	50	1.5	12	2.0	250					
1N2599	S			R	100	1.5	12	2.0	250					
1N2600	S			R	200	1.5	12	2.0	250					
1N2601	S			R	300	1.5	12	2.0	250					
1N2602	S			R	400	1.5	12	2.0	250					
1N2603	S			R	500	1.5	12	2.0	250					
1N2604	S			R	600	1.5	12	2.0	250					
1N2605	S			R	700	1.5	12	2.0	250					
1N2606	S			R	800	1.5	12	2.0	250					
1N2607	S			R	900	1.5	12	2.0	250					
1N2608	S			R	1000	1.5	12	2.0	250					
1N2609	S	1N4001	3-23	R	50	1.1	.75	.3	30					
1N2610	S	1N4002	3-23	R	100	1.1	.75	.3	30					
1N2611	S	1N4003	3-23	R	200	1.1	.75	.3	30					
1N2612	S	1N4004	3-23	R	300	1.1	.75	.3	30					
1N2613	S	1N4004	3-23	R	400	1.1	.75	.3	30					
1N2614	S	1N4005	3-23	R	500	1.1	.75	.3	30					
1N2615	S	1N4005	3-23	R	600	1.1	.75	.3	30					
1N2616	S	1N4006	3-23	R	800	1.1	.75	.3	30					
1N2617	S	1N4007	3-23	R	1000	1.1	.75	.3	30					
1N2618	S			R	1200	1.1	.75	.3	30					
1N2619	S			R	1500	1.1	.75	.3	30					
1N2620	S		2-32	RD						.01	9.7	0	75	
1N2620A	S		2-32	RD						.01	9.7	-55	100	
1N2620B	S		2-32	RD						.01	9.7	-55	150	
1N2621	S		2-32	RD						.005	9.7	0	75	
1N2621A	S		2-32	RD						.005	9.7	-55	100	
1N2621B	S		2-32	RD						.005	9.7	-55	150	
1N2622	S		2-32	RD						.002	9.7	0	75	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2622A	S		2-32	RD						.002	9.7	-55	100	
1N2622B	S		2-32	RD						.002	9.7	-55	150	
1N2623	S		2-32	RD						.001	9.7	0	75	
1N2623A	S		2-32	RD						.001	9.7	-55	100	
1N2623B	S		2-32	RD						.001	9.7	-55	150	
1N2624	S		2-32	RD						.0005	9.7	0	75	
1N2624A	S		2-32	RD						.0005	9.7	-55	100	
1N2624B	S		2-32	RD						.0005	9.7	-55	150	
1N2625	S			RD						.0002	9.4	0	75	
1N2625A	S			RD						.0002	9.4	-55	100	
1N2625B	S			RD						.0002	9.4	-55	150	
1N2626	S			RD						.0001	9.4	0	75	
1N2626A	S			RD						.0001	9.4	-55	100	
1N2626B	S			RD						.0001	9.4	-55	150	
1N2627 1N2628	Varactor Diodes, see table on page 1-99													
1N2629	G			PA	5									
1N2630	S			R	1500	2.25	.085	.5	5					
1N2631	S			R	1600	3.0	.6	.5	5					
1N2632	S			R	2800	6.0	.2	.5	5					
1N2633	S			R	1600	3.0	.6	.5	5					
1N2634	S			R	1600	3.0	.6	.5	5					
1N2635	S			R	1500	2.25	.085	.5	5					
1N2636	S			R	1500	2.25	.085	.5	5					
1N2637	S			R		28.0	.25	.5	5					
1N2638	S			R	100	1.3	1.5	.3	15					
1N2641	S			R	200	1.3	1.5	.3	15					
1N2644	S			R	300	1.3	1.5	.3	15					
1N2647	S			R	400	1.3	1.5	.3	15					
1N2650	S			R	600	2.6	1.5	.3	15					
1N2653	S			R	800	2.6	1.5	.3	15					
1N2656	S			R	1200	3.9	1.5	.8	15					
1N2659	S			R	1600	5.2	1.5	.8	15					
1N2662	S			R	2000	6.5	1.5	.8	15					
1N2664	S			R	2400	7.8	1.5	.8	15					
1N2666	S			R	3200	10.4	1.5	.8	15					
1N2667	S			R	4000	13	1.5	.8	15					
1N2668	S			R	4800	15.6	1.5	.8	15					
1N2669	S			R	100	1.3	3.6	.3	15					
1N2673	S			R	200	1.3	3.6	.3	15					
1N2677	S			R	300	1.3	3.6	.3	15					
1N2681	S			R	400	1.3	3.6	.3	15					
1N2685	S			R	600	2.6	3.6	.3	15					
1N2687	S			R	800	2.6	3.6	.3	15					
1N2689	S			R	900	3.9	3.6	.8	15					
1N2690	S			R	1200	3.9	3.6	.8	15					
1N2691	S			R	1600	5.2	3.6	.8	15					
1N2692	S			R	100	1.3	7.2	.3	15					
1N2694	S			R	200	1.3	7.2	.3	15					
1N2696	S			R	300	1.3	7.2	.3	15					
1N2698	S			R	400	1.3	7.2	.3	15					
1N2700	S			R	600	2.6	7.2	.3	15					
1N2701	S			R	800	2.6	7.2	.3	15					
1N2702	S			R	100	1.3	3	.2	15					
1N2705	S			R	200	1.3	3	.2	15					
1N2708	S			R	300	1.3	3	.2	15					
1N2711	S			R	400	1.3	3	.2	15					
1N2714	S			R	600	2.6	3	.2	15					
1N2717	S			R	800	2.6	3	.2	15					
1N2720	S			R	1200	3.9	3	.8	15					
1N2722	S			R	1600	5.2	3	.8	15					
1N2723	S			R	2000	6.5	3	.8	15					
1N2724	S			R	2400	7.8	3	.8	15					
1N2725	S	1N4720	3-24	R	100	1.3	3	.3	15					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N2728 — 1N2806A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2728	S	1N4721	3-24	R	200	1.3	3	.3	15					
1N2731	S	MR1033A	3-24	R	300	1.3	3	.3	15					
1N2734	S	1N4722	3-24	R	400	1.3	3	.3	15					
1N2737	S	1N4723	3-24	R	600	2.6	3	.3	15					
1N2738	S	1N4724	3-24	R	800	2.6	3	.3	15					
1N2739	S			R	1200	3.9	3	.8	15					
1N2740	S			R	100	1.3	3.6	.3	15					
1N2742	S			R	200	1.3	3.6	.3	15					
1N2744	S			R	300	1.3	3.6	.3	15					
1N2746	S			R	400	1.3	3.6	.3	15					
1N2748	S			R	600	2.6	3.6	.3	15					
1N2749	S			R	800	2.6	3.6	.3	15					
1N2750	S			R	100	1.3	3	.3	15					
1N2753	S			R	200	1.3	3	.3	15					
1N2756	S			R	300	1.3	3	.3	15					
1N2759	S			R	400	1.3	3	.3	15					
1N2762	S			R	600	2.6	3	.3	15					
1N2763	S			R	800	2.6	3	.3	15					
1N2764	S			R	1200	3.9	3	.8	15					
1N2765	S			ZD							6.8	5		
1N2765A	S			ZD							6.8	5		
1N2766	S			ZD							13.6	5		
1N2767	S		2-32	ZD							20.4	5		
1N2768	S		2-32	ZD							27.2	5		
1N2769	S		2-32	ZD							34	5		
1N2770	S		2-32	ZD							40.8	5		
1N2772	S			R	700	1.8	.5		15					
1N2773	S			R	800	1.8	.5		15					
1N2774	S			R	900	1.8	.5		15					
1N2775	S			R	1000	1.8	.5		15					
1N2776	S			R	1100	1.8	.5		15					
1N2777	S			R	1200	1.8	.5		15					
1N2778	S			R	1300	1.8	.5		15					
1N2779	S			R	1400	1.8	.5		15					
1N2780	S			R	1500	1.8	.5		15					
1N2781	S			R	1600	1.8	.5		15					
1N2782	S			SP	5			2*						
1N2783	S			RD						.0016	62	25	125	
1N2784	S			R	200	1.5	8	5.0	200					
1N2785	S			R	400	1.5	8	5.0	200					
1N2786	S			R	200	1.2	10	10.0	180					
1N2787	S			R	400	1.2	10	10.0	180					
1N2788	S			R	200	1.3	12.5	5.0	340					
1N2789	S			R	400	1.3	12.5	5.0	340					
1N2790	S			ZD							8.5	5	1W	
1N2791	S			HC		1.3	50M	.05*	4					
1N2793	S	1N1183	3-10	R	50	1.25	5	5	75					
1N2794	S	1N1184	3-10	R	100	1.25	5	5	75					
1N2795	S	1N1185	3-10	R	150	1.25	5	5	75					
1N2796	S	1N1186	3-10	R	200	1.25	5	5	75					
1N2797	S	1N1187	3-10	R	250	1.25	5	5	75					
1N2798	S	1N1188	3-10	R	300	1.25	5	5	75					
1N2799	S	1N1188	3-10	R	350	1.25	5	5	75					
1N2800	S	1N1188		R	400	1.25	5	5	75					
1N2801	G			HS	20	.36	5M	2*	500					
1N2803	S			R	400	1.2	250	36	3500					
1N2804	S		2-15	ZD							6.8	20	50W	
1N2804A	S		2-15	ZD							6.8	10	50W	
1N2804B	S		2-15	ZD							6.8	5	50W	
1N2805	S		2-15	ZD							7.5	20	50W	
1N2805A	S		2-15	ZD							7.5	10	50W	
1N2805B	S		2-15	ZD							7.5	5	50W	
1N2806	S		2-15	ZD							8.2	20	50W	
1N2806A	S		2-15	ZD							8.2	10	50W	

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≧ 2D mA @ ≦ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2806B	S		2-15	ZD							8.2	5	50W
1N2807	S		2-15	ZD							9.1	20	50W
1N2807A	S		2-15	ZD							9.1	10	50W
1N2807B	S		2-15	ZD							9.1	5	50W
1N2808	S		2-15	ZD							10	20	50W
1N2808A	S		2-15	ZD							10	10	50W
1N2808B	S		2-15	ZD							10	5	50W
1N2809	S		2-15	ZD							11	20	50W
1N2809A	S		2-15	ZD							11	10	50W
1N2809B	S		2-15	ZD							11	5	50W
1N2810	S		2-15	ZD							12	20	50W
1N2810A	S		2-15	ZD							12	10	50W
1N2810B	S		2-15	ZD							12	5	50W
1N2811	S		2-15	ZD							13	20	50W
1N2811A	S		2-15	ZD							13	10	50W
1N2811B	S		2-15	ZD							13	5	50W
1N2812	S		2-15	ZD							14	20	50W
1N2812A	S		2-15	ZD							14	10	50W
1N2812B	S		2-15	ZD							14	5	50W
1N2813	S		2-15	ZD							15	20	50W
1N2813A	S		2-15	ZD							15	10	50W
1N2813B	S		2-15	ZD							15	5	50W
1N2814	S		2-15	ZD							16	20	50W
1N2814A	S		2-15	ZD							16	10	50W
1N2814B	S		2-15	ZD							16	5	50W
1N2815	S		2-15	ZD							17	20	50W
1N2815A	S		2-15	ZD							17	10	50W
1N2815B	S		2-15	ZD							17	5	50W
1N2816	S		2-15	ZD							18	20	50W
1N2816A	S		2-15	ZD							18	10	50W
1N2816B	S		2-15	ZD							18	5	50W
1N2817	S		2-15	ZD							19	20	50W
1N2817A	S		2-15	ZD							19	10	50W
1N2817B	S		2-15	ZD							19	5	50W
1N2818	S		2-15	ZD							20	20	50W
1N2818A	S		2-15	ZD							20	10	50W
1N2818B	S		2-15	ZD							20	5	50W
1N2819	S		2-15	ZD							22	20	50W
1N2819A	S		2-15	ZD							22	10	50W
1N2819B	S		2-15	ZD							22	5	50W
1N2820	S		2-15	ZD							24	20	50W
1N2820A	S		2-15	ZD							24	10	50W
1N2820B	S		2-15	ZD							24	5	50W
1N2821	S		2-15	ZD							25	20	50W
1N2821A	S		2-15	ZD							25	10	50W
1N2821B	S		2-15	ZD							25	5	50W
1N2822	S		2-15	ZD							27	20	50W
1N2822A	S		2-15	ZD							27	10	50W
1N2822B	S		2-15	ZD							27	5	50W
1N2823	S		2-15	ZD							30	20	50W
1N2823A	S		2-15	ZD							30	10	50W
1N2823B	S		2-15	ZD							30	5	50W
1N2824	S		2-15	ZD							33	20	50W
1N2824A	S		2-15	ZD							33	10	50W
1N2824B	S		2-15	ZD							33	5	50W
1N2825	S		2-15	ZD							36	20	50W
1N2825A	S		2-15	ZD							36	10	50W
1N2825B	S		2-15	ZD							36	5	50W
1N2826	S		2-15	ZD							39	20	50W
1N2826A	S		2-15	ZD							39	10	50W
1N2826B	S		2-15	ZD							39	5	50W
1N2827	S		2-15	ZD							43	20	50W
1N2827A	S		2-15	ZD							43	10	50W
1N2827B	S		2-15	ZD							43	5	50W

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N2828 — 1N2855

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z		T(min) °C	T(max) °C	
1N2828	S		2-15	ZD							45		20	50W
1N2828A	S		2-15	ZD							45		10	50W
1N2828B	S		2-15	ZD							45		5	50W
1N2829	S		2-15	ZD							47		20	50W
1N2829A	S		2-15	ZD							47		10	50W
1N2829B	S		2-15	ZD							47		5	50W
1N2830	S		2-15	ZD							50		20	50W
1N2830A	S		2-15	ZD							50		10	50W
1N2830B	S		2-15	ZD							50		5	50W
1N2831	S		2-15	ZD							51		20	50W
1N2831A	S		2-15	ZD							51		10	50W
1N2831B	S		2-15	ZD							51		5	50W
1N2832	S		2-15	ZD							56		20	50W
1N2832A	S		2-15	ZD							56		10	50W
1N2832B	S		2-15	ZD							56		5	50W
1N2833	S		2-15	ZD							62		20	50W
1N2833A	S		2-15	ZD							62		10	50W
1N2833B	S		2-15	ZD							62		5	50W
1N2834	S		2-15	ZD							68		20	50W
1N2834A	S		2-15	ZD							68		10	50W
1N2834B	S		2-15	ZD							68		5	50W
1N2835	S		2-15	ZD							75		20	50W
1N2835A	S		2-15	ZD							75		10	50W
1N2835B	S		2-15	ZD							75		5	50W
1N2836	S		2-15	ZD							82		20	50W
1N2836A	S		2-15	ZD							82		10	50W
1N2836B	S		2-15	ZD							82		5	50W
1N2837	S		2-15	ZD							91		20	50W
1N2837A	S		2-15	ZD							91		10	50W
1N2837B	S		2-15	ZD							91		5	50W
1N2838	S		2-15	ZD							100		20	50W
1N2838A	S		2-15	ZD							100		10	50W
1N2838B	S		2-15	ZD							100		5	50W
1N2839	S		2-15	ZD							105		20	50W
1N2839A	S		2-15	ZD							105		10	50W
1N2839B	S		2-15	ZD							105		5	50W
1N2840	S		2-15	ZD							110		20	50W
1N2840A	S		2-15	ZD							110		10	50W
1N2840B	S		2-15	ZD							110		5	50W
1N2841	S		2-15	ZD							120		20	50W
1N2841A	S		2-15	ZD							120		10	50W
1N2841B	S		2-15	ZD							120		5	50W
1N2842	S		2-15	ZD							130		20	50W
1N2842A	S		2-15	ZD							130		10	50W
1N2842B	S		2-15	ZD							130		5	50W
1N2843	S		2-15	ZD							140		20	50W
1N2843A	S		2-15	ZD							140		10	50W
1N2843B	S		2-15	ZD							140		5	50W
1N2844	S		2-15	ZD							160		20	50W
1N2844A	S		2-15	ZD							160		10	50W
1N2844B	S		2-15	ZD							160		5	50W
1N2845	S		2-15	ZD							180		20	50W
1N2845A	S		2-15	ZD							180		10	50W
1N2845B	S		2-15	ZD							180		5	50W
1N2846	S		2-15	ZD							200		20	50W
1N2846A	S		2-15	ZD							200		10	50W
1N2846B	S		2-15	ZD							200		5	50W
1N2847	S			R	100	2.0	1.5	.3	15					
1N284B	S			R	200	2.0	11.5	.2	15					
1N2849	S			R	300	2.0	11.5	.2	15					
1N2850	S			R	400	2.0	11.5	.2	15					
1N2851	S			R	500	2.0	11.5	.2	15					
1N2852	S			R	600	2.0	11.5	.2	15					
1N2855	S			R	600	1.2	250	25	3500					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2856	S			R	800	1.2	250	20	4500					
1N2857	S			R	1000	1.2	250	15	4500					
1N2858	S	1N4001	3-23	R	50	1.2	.75	.3	40					
1N2858A	S			R	50	1.2	1	.3	25					
1N2859	S	1N4002	3-23	R	100	1.2	.75	.3	40					
1N2859A	S			R	100	1.2	1	.3	25					
1N2860	S	1N4003	3-23	R	200	1.2	.75	.3	40					
1N2860A	S			R	200	1.2	1	.3	25					
1N2861	S	1N4004	3-23	R	300	1.2	.75	.2	40					
1N2861A	S			R	300	1.2	1	.3	25					
1N2862	S	1N4004	3-23	R	400	1.2	.75	.2	40					
1N2862A	S			R	400	1.2	1	.3	25					
1N2863	S	1N4005	3-23	R	500	1.2	.75	.2	40					
1N2863A	S			R	500	1.2	1	.3	25					
1N2864	S	1N4005	3-23	R	600	1.2	.75	.2	40					
1N2864A	S			R	600	1.2	1	.3	25					
1N2865	S			R	1000	2.5	.7	.1	7					
1N2866	S			R	1500	2.5	.7	.1	7					
1N2867	S			R	1000	2.5	.7	.1	7					
1N2868	S			R	1500	2.5	.7	.1	7					
1N2878	S	1N4006	3-23	HC	700	2	250M	.5*						
1N2879	S	1N4006	3-23	HC	700	2	250M	.5*						
1N2880	S	1N4007	3-23	HC	1K	2	250M	.5*						
1N2881	S	1N4007	3-23	HC	1K	2	250M	.5*						
1N2882	S	1N4007	3-23	HC	050	3	250M	.5*						
1N2883	S	1N4007	3-23	HC	050	3	250M	.5*						
1N2884	S	MR991	3-26	HC	400	4	250M	.5*						
1N2885	S	MR991	3-26	HC	400	4	250M	.5*						
1N2886	S	MR991	3-26	HC	500	3	250M	.5*						
1N2887	S	MR991	3-26	HC	500	3	250M	.5*						
1N2888	S			HC	750	5	250M	.5*						
1N2889	S	MR992	3-26	HC	750	5	250M	.5*						
1N2890	S	MR992	3-26	HC	2K	4	250M	.5*						
1N2891	S	MR992	3-26	HC	2K	4	250M	.5*						
1N2892	S	MR993	3-26	HC	100	6	250M	.5*						
1N2893	S	MR993	3-26	HC	100	6	250M	.5*						
1N2894	S	MR994	3-26	HC	450	7	250M	.5*						
1N2895	S	MR994	3-26	HC	450	7	250M	.5*						
1N2896	S	MR994	3-26	HC	500	5	250M	.5*						
1N2897	S	MR994	3-26	HC	500	5	250M	.5*						
1N2898	S			HC	800	8	250M	.5*						
1N2899	S			HC	800	8	250M	.5*						
1N2900	S			HC	3K	6	250M	.5*						
1N2901	S			HC	3K	6	250M	.5*						
1N2902	S			HC	150	9	250M	.5*						
1N2903	S			HC	150	9	250M	.5*						
1N2904	S			HC	500	7	250M	.5*						
1N2905	S			HC	500	7	250M	.5*						
1N2906	S			HC	500	10	250M	.5*						
1N2907	S			HC	500	10	250M	.5*						
1N2908	S			HC	850	11	250M	.5*						
1N2909	S			HC	850	11	250M	.5*						
1N2910	S			HC	4K	8	250M	.5*						
1N2911	S			HC	4K	8	250M	.5*						
1N2912	S			HC	200	12	250M	.5*						
1N2913	S			HC	200	12	250M	.5*						
1N2914	S			HC	500	9	250M	.5*						
1N2915	S			HC	500	9	250M	.5*						
1N2916	S			HC	550	13	250M	.5*						
1N2917	S			HC	550	13	250M	.5*						
1N2918	S			HC	5K	10	250M	.5*						
1N2919	S			HC	5K	10	250M	.5*						
1N2920	S			HC	500	11	250M	.5*						
1N2921	S			HC	500	11	250M	.5*						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N2922 — 1N2989

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N2922	S			HC	6K	12	250M	.5*					
1N2923	S			HC	6K	12	250M	.5*					
1N2924	S			HC	500	13	250M	.5*					
1N2925	S			HC	500	13	250M	.5*					
1N2937	S			ZD						42.5	57.5		10W
1N2938	S			ZD						.75	1.05		2W
1N2970	S		2-18	ZD							6.8	20	10W
1N2970A	S		2-18	ZD							6.8	10	10W
1N2970B	S		2-18	ZD							6.8	5	10W
1N2971	S		2-18	ZD							7.5	20	10W
1N2971A	S		2-18	ZD							7.5	10	10W
1N2971B	S		2-18	ZD							7.5	5	10W
1N2972	S		2-18	ZD							8.2	20	10W
1N2972A	S		2-18	ZD							8.2	10	10W
1N2972B	S		2-18	ZD							8.2	5	10W
1N2973	S		2-18	ZD							9.1	20	10W
1N2973A	S		2-18	ZD							9.1	10	10W
1N2973B	S		2-18	ZD							9.1	5	10W
1N2974	S		2-18	ZD							10	20	10W
1N2974A	S		2-18	ZD							10	10	10W
1N2974B	S		2-18	ZD							10	5	10W
1N2975	S		2-18	ZD							11	20	10W
1N2975A	S		2-18	ZD							11	10	10W
1N2975B	S		2-18	ZD							11	5	10W
1N2976	S		2-18	ZD							12	20	10W
1N2976A	S		2-18	ZD							12	10	10W
1N2976B	S		2-18	ZD							12	5	10W
1N2977	S		2-18	ZD							13	20	10W
1N2977A	S		2-18	ZD							13	10	10W
1N2977B	S		2-18	ZD							13	5	10W
1N2978	S		2-18	ZD							14	20	10W
1N2978A	S		2-18	ZD							14	10	10W
1N2978B	S		2-18	ZD							14	5	10W
1N2979	S		2-18	ZD							15	20	10W
1N2979A	S		2-18	ZD							15	10	10W
1N2979B	S		2-18	ZD							15	5	10W
1N2980	S		2-18	ZD							16	20	10W
1N2980A	S		2-18	ZD							16	10	10W
1N2980B	S		2-18	ZD							16	5	10W
1N2981	S		2-18	ZD							17	20	10W
1N2981A	S		2-18	ZD							17	10	10W
1N2981B	S		2-18	ZD							17	5	10W
1N2982	S		2-18	ZD							18	20	10W
1N2982A	S		2-18	ZD							18	10	10W
1N2982B	S		2-18	ZD							18	5	10W
1N2983	S		2-18	ZD							19	20	10W
1N2983A	S		2-18	ZD							19	10	10W
1N2983B	S		2-18	ZD							19	5	10W
1N2984	S		2-18	ZD							20	20	10W
1N2984A	S		2-18	ZD							20	10	10W
1N2984B	S		2-18	ZD							20	5	10W
1N2985	S		2-18	ZD							22	20	10W
1N2985A	S		2-18	ZD							22	10	10W
1N2985B	S		2-18	ZD							22	5	10W
1N2986	S		2-18	ZD							24	20	10W
1N2986A	S		2-18	ZD							24	10	10W
1N2986B	S		2-18	ZD							24	5	10W
1N2987	S		2-18	ZD							25	20	10W
1N2987A	S		2-18	ZD							25	10	10W
1N2987B	S		2-18	ZD							25	5	10W
1N2988	S		2-18	ZD							27	20	10W
1N2988A	S		2-18	ZD							27	10	10W
1N2988B	S		2-18	ZD							27	5	10W
1N2989	S		2-18	ZD							30	20	10W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N2989A	S		2-18	ZD							30	10	10W	
1N2989B	S		2-18	ZD							30	5	10W	
1N2990	S		2-18	ZD							33	20	10W	
1N2990A	S		2-18	ZD							33	10	10W	
1N2990B	S		2-18	ZD							33	5	10W	
1N2991	S		2-18	ZD							36	20	10W	
1N2991A	S		2-18	ZD							36	10	10W	
1N2991B	S		2-18	ZD							36	5	10W	
1N2992	S		2-18	ZD							39	20	10W	
1N2992A	S		2-18	ZD							39	10	10W	
1N2992B	S		2-18	ZD							39	5	10W	
1N2993	S		2-18	ZD							43	20	10W	
1N2993A	S		2-18	ZD							43	10	10W	
1N2993B	S		2-18	ZD							43	5	10W	
1N2994	S		2-18	ZD							45	20	10W	
1N2994A	S		2-18	ZD							45	10	10W	
1N2994B	S		2-18	ZD							45	5	10W	
1N2995	S		2-18	ZD							47	20	10W	
1N2995A	S		2-18	ZD							47	10	10W	
1N2995B	S		2-18	ZD							47	5	10W	
1N2996	S		2-18	ZD							50	20	10W	
1N2996A	S		2-18	ZD							50	10	10W	
1N2996B	S		2-18	ZD							50	5	10W	
1N2997	S		2-18	ZD							51	20	10W	
1N2997A	S		2-18	ZD							51	10	10W	
1N2997B	S		2-18	ZD							51	5	10W	
1N2998	S		2-18	ZD							52	20	10W	
1N2998A	S		2-18	ZD							52	10	10W	
1N2998B	S		2-18	ZD							52	5	10W	
1N2999	S		2-18	ZD							56	20	10W	
1N2999A	S		2-18	ZD							56	10	10W	
1N2999B	S		2-18	ZD							56	5	10W	
1N3000	S		2-18	ZD							62	20	10W	
1N3000A	S		2-18	ZD							62	10	10W	
1N3000B	S		2-18	ZD							62	5	10W	
1N3001	S		2-18	ZD							68	20	10W	
1N3001A	S		2-18	ZD							68	10	10W	
1N3001B	S		2-18	ZD							68	5	10W	
1N3002	S		2-18	ZD							75	20	10W	
1N3002A	S		2-18	ZD							75	10	10W	
1N3002B	S		2-18	ZD							75	5	10W	
1N3003	S		2-18	ZD							82	20	10W	
1N3003A	S		2-18	ZD							82	10	10W	
1N3003B	S		2-18	ZD							82	5	10W	
1N3004	S		2-18	ZD							91	10	10W	
1N3004A	S		2-18	ZD							91	10	10W	
1N3004B	S		2-18	ZD							91	5	10W	
1N3005	S		2-18	ZD							100	20	10W	
1N3005A	S		2-18	ZD							100	10	10W	
1N3005B	S		2-18	ZD							100	5	10W	
1N3006	S		2-18	ZD							105	20	10W	
1N3006A	S		2-18	ZD							105	10	10W	
1N3006B	S		2-18	ZD							105	5	10W	
1N3007	S		2-18	ZD							110	20	10W	
1N3007A	S		2-18	ZD							110	10	10W	
1N3007B	S		2-18	ZD							110	5	10W	
1N3008	S		2-18	ZD							120	20	10W	
1N3008A	S		2-18	ZD							120	10	10W	
1N3008B	S		2-18	ZD							120	5	10W	
1N3009	S		2-18	ZD							130	20	10W	
1N3009A	S		2-18	ZD							130	10	10W	
1N3009B	S		2-18	ZD							130	5	10W	
1N3010	S		2-18	ZD							140	20	10W	
1N3010A	S		2-18	ZD							140	10	10W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3010B — 1N3031B

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3010B	S		2-18	ZD							140	5	10W
1N3011	S		2-18	ZD							150	20	10W
1N3011A	S		2-18	ZD							150	10	10W
1N3011B	S		2-18	ZD							150	10	10W
1N3012	S		2-18	ZD							160	20	10W
1N3012A	S		2-18	ZD							160	10	10W
1N3012B	S		2-18	ZD							160	5	10W
1N3013	S		2-18	ZD							175	20	10W
1N3013A	S		2-18	ZD							175	10	10W
1N3013B	S		2-18	ZD							175	5	10W
1N3014	S		2-18	ZD							180	20	10W
1N3014A	S		2-18	ZD							180	10	10W
1N3014B	S		2-18	ZD							180	5	10W
1N3015	S		2-18	ZD							200	20	10W
1N3015A	S		2-18	ZD							200	10	10W
1N3015B	S		2-18	ZD							200	5	10W
1N3016	S		2-19	ZD							6.8	20	1W
1N3016A	S		2-19	ZD							6.8	10	1W
1N3016B	S		2-19	ZD							6.8	5	1W
1N3017	S		2-19	ZD							7.5	20	1W
1N3017A	S		2-19	ZD							7.5	10	1W
1N3017B	S		2-19	ZD							7.5	5	1W
1N3018	S		2-19	ZD							8.2	20	1W
1N3018A	S		2-19	ZD							8.2	10	1W
1N3018B	S		2-19	ZD							8.2	5	1W
1N3019	S		2-19	ZD							9.1	20	1W
1N3019A	S		2-19	ZD							9.1	20	1W
1N3019B	S		2-19	ZD							9.1	5	1W
1N3020	S		2-19	ZD							10	20	1W
1N3020A	S		2-19	ZD							10	10	1W
1N3020B	S		2-19	ZD							10	5	1W
1N3021	S		2-19	ZD							11	20	1W
1N3021A	S		2-19	ZD							11	10	1W
1N3021B	S		2-19	ZD							11	5	1W
1N3022	S		2-19	ZD							12	20	1W
1N3022A	S		2-19	ZD							12	10	1W
1N3022B	S		2-19	ZD							12	5	1W
1N3023	S		2-19	ZD							13	20	1W
1N3023A	S		2-19	ZD							13	10	1W
1N3023B	S		2-19	ZD							13	5	1W
1N3024	S		2-19	ZD							15	20	1W
1N3024A	S		2-19	ZD							15	10	1W
1N3024B	S		2-19	ZD							15	5	1W
1N3025	S		2-19	ZD							16	20	1W
1N3025A	S		2-19	ZD							16	10	1W
1N3025B	S		2-19	ZD							16	5	1W
1N3026	S		2-19	ZD							18	20	1W
1N3026A	S		2-19	ZD							18	10	1W
1N3026B	S		2-19	ZD							18	5	1W
1N3027	S		2-19	ZD							20	20	1W
1N3027A	S		2-19	ZD							20	10	1W
1N3027B	S		2-19	ZD							20	5	1W
1N3028	S		2-19	ZD							22	20	1W
1N3028A	S		2-19	ZD							22	10	1W
1N3028B	S		2-19	ZD							22	5	1W
1N3029	S		2-19	ZD							24	20	1W
1N3029A	S		2-19	ZD							24	10	1W
1N3029B	S		2-19	ZD							24	5	1W
1N3030	S		2-19	ZD							27	20	1W
1N3030A	S		2-19	ZD							27	10	1W
1N3030B	S		2-19	ZD							27	5	1W
1N3031	S		2-19	ZD							30	20	1W
1N3031A	S		2-19	ZD							30	10	1W
1N3031B	S		2-19	ZD							30	5	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3032	S		2-19	ZD							33	20	1W	
1N3032A	S		2-19	ZD							33	10	1W	
1N3032B	S		2-19	ZD							33	5	1W	
1N3033	S		2-19	ZD							36	20	1W	
1N3033A	S		2-19	ZD							36	10	1W	
1N3033B	S		2-19	ZD							36	5	1W	
1N3034	S		2-19	ZD							39	20	1W	
1N3034A	S		2-19	ZD							39	10	1W	
1N3034B	S		2-19	ZD							39	5	1W	
1N3035	S		2-19	ZD							43	20	1W	
1N3035A	S		2-19	ZD							43	10	1W	
1N3035B	S		2-19	ZD							43	5	1W	
1N3036	S		2-19	ZD							47	20	1W	
1N3036A	S		2-19	ZD							47	10	1W	
1N3036B	S		2-19	ZD							47	5	1W	
1N3037	S		2-19	ZD							51	20	1W	
1N3037A	S		2-19	ZD							51	10	1W	
1N3037B	S		2-19	ZD							51	5	1W	
1N3038	S		2-19	ZD							56	20	1W	
1N3038A	S		2-19	ZD							56	10	1W	
1N3038B	S		2-19	ZD							56	5	1W	
1N3039	S		2-19	ZD							62	20	1W	
1N3039A	S		2-19	ZD							62	10	1W	
1N3039B	S		2-19	ZD							62	5	1W	
1N3040	S		2-19	ZD							68	20	1W	
1N3040A	S		2-19	ZD							68	10	1W	
1N3040B	S		2-19	ZD							68	5	1W	
1N3041	S		2-19	ZD							75	20	1W	
1N3041A	S		2-19	ZD							75	10	1W	
1N3041B	S		2-19	ZD							75	5	1W	
1N3042	S		2-19	ZD							82	20	1W	
1N3042A	S		2-19	ZD							82	10	1W	
1N3042B	S		2-19	ZD							82	5	1W	
1N3043	S		2-19	ZD							91	20	1W	
1N3043A	S		2-19	ZD							91	10	1W	
1N3043B	S		2-19	ZD							91	5	1W	
1N3044	S		2-19	ZD							100	20	1W	
1N3044A	S		2-19	ZD							100	10	1W	
1N3044B	S		2-19	ZD							100	5	1W	
1N3045	S		2-19	ZD							110	20	1W	
1N3045A	S		2-19	ZD							110	10	1W	
1N3045B	S		2-19	ZD							110	5	1W	
1N3046	S		2-19	ZD							120	20	1W	
1N3046A	S		2-19	ZD							120	10	1W	
1N3046B	S		2-19	ZD							120	5	1W	
1N3047	S		2-19	ZD							130	20	1W	
1N3047A	S		2-19	ZD							130	10	1W	
1N3047B	S		2-19	ZD							130	5	1W	
1N3048	S		2-19	ZD							150	20	1W	
1N3048A	S		2-19	ZD							150	10	1W	
1N3048B	S		2-19	ZD							150	5	1W	
1N3049	S		2-19	ZD							160	20	1W	
1N3049A	S		2-19	ZD							160	10	1W	
1N3049B	S		2-19	ZD							160	5	1W	
1N3050	S		2-19	ZD							180	20	1W	
1N3050A	S		2-19	ZD							180	10	1W	
1N3050B	S		2-19	ZD							180	5	1W	
1N3051	S		2-19	ZD							200	20	1W	
1N3051A	S		2-19	ZD							200	10	1W	
1N3051B	S		2-19	ZD							200	5	1W	
1N3052	S			R	12K	70	.1	.2	6					
1N3053	S			R	14K	75	.1	.2	6					
1N3054	S			R	16K	80	.1	.2	6					
1N3055	S			R	18K	85	.1	.2	6					

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N3056 — 1N3144

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3056	S			R	20K	90	.1	.2	6				
1N3057	S			R	22K	95	.1	.2	6				
1N3058	S			R	24K	100	.1	.2	6				
1N3059	S			R	26K	105	.1	.2	6				
1N3060	S			R	28K	120	.1	.2	6				
1N3061	S			R	30K	125	.1	.2	6				
1N3062	S			CS	75	1	20M	.1*	2				
1N3063	S			HS	75	.85	10M	.1*	2				
1N3064	S			HS	75	1	10M	.1*	4				
1N3065	S			CS	75	1	20M	.1*	2				
1N3066	S			HS	75	1	10M	.1*	2				
1N3067	S			HS	30	1	5M	.1*	2				
1N3068	S			HS	30	1	5M	.1*	50				
1N3069	S			CS	65	1	50M	.1*	50				
1N3070	S			CS	200	1	100M	.1*	50				
1N3071	S			CS	200	1	100M	.1*	50				
1N3072	S			R	50	1.5	.2	.5	10				
1N3073	S			R	100	1.5	.2	.5	10				
1N3074	S			R	150	1.5	.2	.5	10				
1N3075	S			R	200	1.5	.2	.5	10				
1N3076	S			R	250	1.5	.2	.5	10				
1N3077	S			R	300	1.5	.2	.5	10				
1N3078	S			R	350	1.5	.2	.5	10				
1N3079	S			R	400	1.5	.2	.5	10				
1N3080	S			R	500	1.5	.2	.5	10				
1N3081	S			R	600	1.5	.2	.5	10				
1N3082	S			R	200	1.25	.5	.2	15				
1N3083	S			R	400	1.25	.5	.2	15				
1N3084	S			R	600	1.25	.5	.2	15				
1N3085	S	MR1221SB	3-38	R	100	1.1	150	40	1500				
1N3086	S	MR1223SB	3-38	R	200	1.1	150	40	1500				
1N3087	S	MR1225SB	3-38	R	300	1.1	150	40	1500				
1N3088	S	MR1227SB	3-38	R	400	1.1	150	40	1500				
1N3089	S			R	500	1.1	150	40	1500				
1N3090	S			R	600	1.1	150	40	1500				
1N3091	S			R	800	1.1	150	40	1500				
1N3092	S			R	1000	1.1	150	40	1500				
1N3097	G			MS	30	.5	10M	4*	.5				
1N3098	S	1N3046A	2-19	ZD						110	130		1W
1N3099	S	1N3048A	2-19	ZD						130	160		1W
1N3100	S	1N3050A	2-19	ZD						160	200		1W
1N3101	S	1N3051	2-19	ZD						200	240		1W
1N3102	S	1N3008A	2-18	ZD						110	130		10W
1N3103	S	1N3011	2-18	ZD						130	160		10W
1N3104	S	1N3014A	2-18	ZD						160	200		10W
1N3105	S	1N3015	2-18	ZD						200	240		10W
1N3106	S			R	800	1.6	.75	.3	30				
1N3107	S			R	1200	3.2	.5	.3	15				
1N3108	S			R	800	1.6	1.5	.3	30				
1N3109	S			R	1200	3.2	.7	.3	15				
1N3110	G			GP	8	.45	5M	20*					
1N3111	S	MR1220SB	3-38	R	50	1.1	150	40	1500				
1N3112	S	1N3017B	2-19	ZD						7.13	7.88		1W
1N3121	G			MS	50	.25	.1M	3.5*	.5				
1N3122	G			GP	20	.3	1M	4.5*					
1N3123	S			HS	40	1.5	10M	.1*	4				
1N3124	S			HS	40	1	20M	.1*	4				
1N3125	G			MS	40	.4	5M	100*	.3				
1N3128		Varactor Diodes, see table on page 1-99											
1N3139	S			R	50	1.55	70	15	1200				
1N3140	S			R	100	1.55	70	15	1200				
1N3141	S			R	150	1.55	70	15	1200				
1N3142	S			R	200	1.55	70	15	1200				
1N3144	G			MS	20	.3	1M	20*	.5				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3145	G			GP	65	.45	10M	25*					
1N3146	G			CS	20	1	50M	100*	2				
1N3147	S			HC	45	1	100M		1				
1N3148	S			ZD						8.10	8.90		400M
1N3151	S			R	7200	27	.1	250	12				
1N3154	S		2-32	RD						.01	8.8	-55	100
1N3154A	S		2-32	RD						.01	8.8	-55	150
1N3155	S		2-32	RD						.005	8.8	-55	100
1N3155A	S		2-32	RD						.005	8.8	-55	150
1N3156	S		2-32	RD						.002	8.8	-55	100
1N3156A	S		2-32	RD						.002	8.8	-55	150
1N3157	S		2-32	RD						.001	8.8	-55	100
1N3157A	S		2-32	RD						.001	8.8	-55	150
1N3159	G			MS	15	.45	10M		.3				
1N3160	G			GP	60	1	5M	12*					
1N3161	S	MR1230SB	3-41	R	50	1.30	240	16	3000				
1N3162	S	MR1231SB	3-41	R	100	1.30	240	16	3000				
1N3163	S	MR1232SB	3-41	R	150	1.30	240	16	3000				
1N3164	S	MR1233SB	3-41	R	200	1.30	240	16	3000				
1N3165	S	MR1234SB	3-41	R	250	1.30	240	16	3000				
1N3166	S	MR1235SB	3-41	R	300	1.30	240	16	3000				
1N3167	S	MR1236SB	3-41	R	350	1.30	240	16	3000				
1N3168	S	MR1237SB	3-41	R	400	1.30	240	16	3000				
1N3169	S			R	500	1.30	240	16	3000				
1N3170	S			R	600	1.30	240	16	3000				
1N3171	S			R	700	1.92	240	16	3000				
1N3171A	S			R	700	1.9	240	16	3000				
1N3172	S			R	800	1.92	240	16	3000				
1N3172A	S			R	800	1.9	240	16	3000				
1N3173	S			R	900	1.92	240	16	3000				
1N3173A	S			R	900	1.9	240	16	3000				
1N3174	S			R	1000	1.92	240	16	3000				
1N3174A	S			R	1000	1.9	240	16	3000				
1N3175	S			R	1200	1.4	240	15	3000				
1N3176	S			R	1400	1.4	240	15	3000				
1N3177	S			R	1600	1.4	240	15	3000				
1N3179	S			HC	200	1	100M	10*					
1N3180	S			HC	110	1.5	500M	5*					
1N3181	S			ZD							8.2	10	600M
1N3183	S			R	350	1	.5		4				
1N3184	S			R	500	1	.5		4				
1N3185	S			R	700	2	.5		4				
1N3186	S			R	1000	2	.5		4				
1N3187	S			R	1500	3	.5		4				
1N3188	S			R	2000	4	.5		4				
1N3189	S	1N4003	3-23	R	200	1.1	1	.2	30				
1N3190	S	1N4004	3-23	R	400	1.1	1	.2	30				
1N3191	S	1N4005	3-23	R	600	1.1	1	.2	30				
1N3192	S			SP	200	1	100M	10*					
1N3193	S	1N4003	3-23	R	200	1.2	.75	.2	40				
1N3194	S	1N4004	3-23	R	400	1.2	.75	.2	40				
1N3195	S	1N4005	3-23	R	600	1.2	.75	.2	40				
1N3196	S	1N4006	3-23	R	800	1.2	.75	.2	40				
1N3197	G			MS	30	1	150M	50*	.3				
1N3198	S			RD							2.25		
1N3199	S			RD						.005	8.8	50	100
1N3200	S			RD						.003	8.8	50	100
1N3201	S			RD						.002	8.8	50	100
1N3202	S			RD						.001	8.8	50	100
1N3203	G			MS	25	.5	35M	50*	.3				
1N3206	S			HS	80	1	10M	5*	4				
1N3207	S			CS	50	1	150M	.05*	6				
1N3208	S		3-13	R	50	1.5	15	10	250				
1N3209	S		3-13	R	100	1.5	15	10	250				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3210—1N3285

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3210	S		3-13	R	200	1.5	15	10	250					
1N3211	S		3-13	R	300	1.5	15	10	250					
1N3212	S		3-13	R	400	1.5	15	10	250					
1N3213	S		3-8	R	500	1.5	15	10	250					
1N3214	S		3-8	R	600	1.5	15	10	250					
1N3215	S			HS	80	.7	1M	10*	.25					
1N3223	S			MS	150	1.5	4M	20*	800					
1N3225	G			MS	40	1	5M	33*	.5					
1N3227	S			R	100	3.3	.5	.250	12.5					
1N3228	S			R	200	3.3	.5	.250	12.5					
1N3229	S			R	400	3.3	.5	.250	12.5					
1N3230	S			R	600	3.3	.5	.250	12.5					
1N3231	S			R	800	3.3	.5	.250	12.5					
1N3232	S			R	1000	3.3	.5	.250	12.5					
1N3233	S			R	1200	3.3	.5	.250	12.5					
1N3234	S			R	1500	3.3	.5	.250	12.5					
1N3235	S			R	1800	3.3	.5	.250	12.5					
1N3236	S			R	2000	3.3	.5	.250	12.5					
1N3237	S			R	50	2.2	.75	.250	15.0					
1N3238	S			R	100	2.2	.75	.250	15.0					
1N3239	S			R	200	2.2	.75	.250	15.0					
1N3240	S			R	400	2.2	.75	.250	15.0					
1N3241	S			R	600	2.2	.75	.250	15.0					
1N3242	S			R	800	2.2	.75	.250	15.0					
1N3243	S			R	1000	2.2	.75	.250	15.0					
1N3244	S			R	1200	2.2	.75	.250	15.0					
1N3245	S			R	1500	2.2	.75	.250	15.0					
1N3246	S			R	50	1.1	1	.250	20.0					
1N3247	S			R	100	1.1	1	.250	20.0					
1N3248	S			R	200	1.1	1	.250	20.0					
1N3249	S			R	400	1.1	1	.250	20.0					
1N3250	S			R	600	1.1	1	.250	20.0					
1N3251	S			R	800	1.1	1	.250	20.0					
1N3252	S			R	1000	1.1	1	.250	20.0					
1N3253	S	1N4003	3-23	R	200	1.2	.75	.2	40					
1N3254	S	1N4004	3-23	R	400	1.2	.75	.2	40					
1N3255	S	1N4005	3-23	R	600	1.2	.75	.2	40					
1N3256	S	1N4006	3-23	R	800	1.2	.5	.2	40					
1N3260	S	MR1220SB	3-38	R	50	1.6	160	12	2000					
1N3261	S	MR1221SB	3-38	R	100	1.6	160	12	2000					
1N3262	S	MR1222SB	3-38	R	150	1.6	160	12	2000					
1N3263	S	MR1223SB	3-38	R	200	1.6	160	12	2000					
1N3264	S	MR1224SB	3-38	R	250	1.6	160	12	2000					
1N3265	S	MR1225SB	3-38	R	300	1.6	160	12	2000					
1N3266	S	MR1226SB	3-38	R	350	1.6	160	12	2000					
1N3267	S	MR1227SB	3-38	R	400	1.6	160	12	2000					
1N3268	S			R	500	1.6	160	12	2000					
1N3269	S			R	600	1.6	160	12	2000					
1N3270	S			R	700	1.6	160	12	2000					
1N3271	S			R	800	1.6	160	12	2000					
1N3272	S			R	900	1.6	160	12	2000					
1N3273	S			R	1000	1.6	160	12	2000					
1N3274	S			R	1200	1.4	160	12	2000					
1N3275	S			R	1400	1.4	160	12	2000					
1N3276	S			R	1600	1.4	160	12	2000					
1N3277	S			R	200	1.3	.75		25					
1N3278	S			R	400	1.3	.75		25					
1N3279	S			R	600	1.3	.75		25					
1N3280	S			R	800	1.3	.75		25					
1N3281	S			R	1000	1.3	.75		25					
1N3282	S			R	1000	3.7	.1		2.5					
1N3283	S			R	1500	3.7	.1		2.5					
1N3284	S			R	2000	3.7	.1		2.5					
1N3285	S			R	2500	3.7	.1		2.5					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 20 mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3286	S			R	3000	3.7	.1		2.5				
1N3287	G			SP	6	.312	1M	15*					
1N3288	S	MR1211SB	3-35	R	100	1.5	100	200	1600				
1N3288A	S			R	100	1.5	100	24	2300				
1N3289	S	MR1213SB	3-35	R	200	1.5	100	300	1600				
1N3289A	S			R	200	1.5	100	24	2300				
1N3290	S	MR1215SB	3-35	R	300	1.5	100	400	1600				
1N3290A	S			R	300	1.5	100	24	2300				
1N3291	S	MR1217SB	3-35	R	400	1.5	100	525	1600				
1N3291A	S			R	400	1.5	100	24	2300				
1N3292	S			R	500	1.5	100	650	1600				
1N3292A	S			R	500	1.5	100	21	1600				
1N3292B	S			R	500	1.5	100	21	2300				
1N3293	S			R	600	1.5	100	800	1600				
1N3293A	S			R	600	1.5	100	17	2300				
1N3294	S			R	800	1.5	100	1050	1600				
1N3294A	S			R	800	1.5	100	13	2300				
1N3295	S			R	1000	1.5	100	1300	1600				
1N3295A	S			R	1000	1.5	100	11	2300				
1N3296	S			R	1200	1.5	100	1600	1600				
1N3296A	S			R	1200	1.5	100	9	2300				
1N3297	S			R	1400	1.5	100	1800	1600				
1N3297A	S			R	1400	1.5	100	7	2300				
1N3298	S			CS	70	.9	500M	.2*	20				
1N3298A	S			CS	70	.9	.5A	.2*					
1N3305	S		2-15	ZD							6.8	20	50W
1N3305A	S		2-15	ZD							6.8	10	50W
1N3305B	S		2-15	ZD							6.8	5	50W
1N3306	S		2-15	ZD							7.5	20	50W
1N3306A	S		2-15	ZD							7.5	10	50W
1N3306B	S		2-15	ZD							7.5	5	50W
1N3307	S		2-15	ZD							8.2	20	50W
1N3307A	S		2-15	ZD							8.2	10	50W
1N3307B	S		2-15	ZD							8.2	5	50W
1N3308	S		2-15	ZD							9.1	20	50W
1N3308A	S		2-15	ZD							9.1	10	50W
1N3308B	S		2-15	ZD							9.1	5	50W
1N3309	S		2-15	ZD							10	20	50W
1N3309A	S		2-15	ZD							10	10	50W
1N3309B	S		2-15	ZD							10	5	50W
1N3310	S		2-15	ZD							11	20	50W
1N3310A	S		2-15	ZD							11	10	50W
1N3310B	S		2-15	ZD							11	5	50W
1N3311	S		2-15	ZD							12	20	50W
1N3311A	S		2-15	ZD							12	10	50W
1N3311B	S		2-15	ZD							12	5	50W
1N3312	S		2-15	ZD							13	20	50W
1N3312A	S		2-15	ZD							13	10	50W
1N3312B	S		2-15	ZD							13	5	50W
1N3313	S		2-15	ZD							14	20	50W
1N3313A	S		2-15	ZD							14	10	50W
1N3313B	S		2-15	ZD							14	5	50W
1N3314	S		2-15	ZD							15	20	50W
1N3314A	S		2-15	ZD							15	10	50W
1N3314B	S		2-15	ZD							15	5	50W
1N3315	S		2-15	ZD							16	20	50W
1N3315A	S		2-15	ZD							16	10	50W
1N3315B	S		2-15	ZD							16	5	50W
1N3316	S		2-15	ZD							17	20	50W
1N3316A	S		2-15	ZD							17	10	50W
1N3316B	S		2-15	ZD							17	5	50W
1N3317	S		2-15	ZD							18	20	50W
1N3317A	S		2-15	ZD							18	10	50W
1N3317B	S		2-15	ZD							18	5	50W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3318 — 1N3339

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3318	S		2-15	ZD							19	20	50W
1N3318A	S		2-15	ZD							19	10	50W
1N3318B	S		2-15	ZD							19	5	50W
1N3319	S		2-15	ZD							20	20	50W
1N3319A	S		2-15	ZD							20	10	50W
1N3319B	S		2-15	ZD							20	5	50W
1N3320	S		2-15	ZD							22	20	50W
1N3320A	S		2-15	ZD							22	10	50W
1N3320B	S		2-15	ZD							22	5	50W
1N3321	S		2-15	ZD							24	20	50W
1N3321A	S		2-15	ZD							24	10	50W
1N3321B	S		2-15	ZD							24	5	50W
1N3322	S		2-15	ZD							25	20	50W
1N3322A	S		2-15	ZD							25	10	50W
1N3322B	S		2-15	ZD							25	5	50W
1N3323	S		2-15	ZD							27	20	50W
1N3323A	S		2-15	ZD							27	10	50W
1N3323B	S		2-15	ZD							27	5	50W
1N3324	S		2-15	ZD							30	20	50W
1N3324A	S		2-15	ZD							30	10	50W
1N3324B	S		2-15	ZD							30	5	50W
1N3325	S		2-15	ZD							33	20	50W
1N3325A	S		2-15	ZD							33	10	50W
1N3325B	S		2-15	ZD							33	5	50W
1N3326	S		2-15	ZD							36	20	50W
1N3326A	S		2-15	ZD							36	10	50W
1N3326B	S		2-15	ZD							36	5	50W
1N3327	S		2-15	ZD							39	20	50W
1N3327A	S		2-15	ZD							39	10	50W
1N3327B	S		2-15	ZD							39	5	50W
1N3328	S		2-15	ZD							43	20	50W
1N3328A	S		2-15	ZD							43	10	50W
1N3328B	S		2-15	ZD							43	5	50W
1N3329	S		2-15	ZD							45	20	50W
1N3329A	S		2-15	ZD							45	10	50W
1N3329B	S		2-15	ZD							45	5	50W
1N3330	S		2-15	ZD							47	20	50W
1N3330A	S		2-15	ZD							47	10	50W
1N3330B	S		2-15	ZD							47	5	50W
1N3331	S		2-15	ZD							50	20	50W
1N3331A	S		2-15	ZD							50	10	50W
1N3331B	S		2-15	ZD							50	5	50W
1N3332	S		2-15	ZD							51	20	50W
1N3332A	S		2-15	ZD							51	10	50W
1N3332B	S		2-15	ZD							51	5	50W
1N3333	S		2-15	ZD							52	20	50W
1N3333A	S		2-15	ZD							52	10	50W
1N3333B	S		2-15	ZD							52	5	50W
1N3334	S		2-15	ZD							56	20	50W
1N3334A	S		2-15	ZD							56	10	50W
1N3334B	S		2-15	ZD							56	5	50W
1N3335	S		2-15	ZD							62	20	50W
1N3335A	S		2-15	ZD							62	10	50W
1N3335B	S		2-15	ZD							62	5	50W
1N3336	S		2-15	ZD							68	20	50W
1N3336A	S		2-15	ZD							68	10	50W
1N3336B	S		2-15	ZD							68	5	50W
1N3337	S		2-15	ZD							75	20	50W
1N3337A	S		2-15	ZD							75	10	50W
1N3337B	S		2-15	ZD							75	5	50W
1N3338	S		2-15	ZD							82	20	50W
1N3338A	S		2-15	ZD							82	10	50W
1N3338B	S		2-15	ZD							82	5	50W
1N3339	S		2-15	ZD							91	20	50W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3339A	S		2-15	ZD							91	10	50W	
1N3339B	S		2-15	ZD							91	5	50W	
1N3340	S		2-15	ZD							100	20	50W	
1N3340A	S		2-15	ZD							100	10	50W	
1N3340B	S		2-15	ZD							100	5	50W	
1N3341	S		2-15	ZD							105	20	50W	
1N3341A	S		2-15	ZD							105	10	50W	
1N3341B	S		2-15	ZD							105	5	50W	
1N3342	S		2-15	ZD							110	20	50W	
1N3342A	S		2-15	ZD							110	10	50W	
1N3342B	S		2-15	ZD							110	5	50W	
1N3343	S		2-15	ZD							120	20	50W	
1N3343A	S		2-15	ZD							120	10	50W	
1N3343B	S		2-15	ZD							120	5	50W	
1N3344	S		2-15	ZD							130	20	50W	
1N3344A	S		2-15	ZD							130	10	50W	
1N3344B	S		2-15	ZD							130	5	50W	
1N3345	S		2-15	ZD							140	20	50W	
1N3345A	S		2-15	ZD							140	10	50W	
1N3345B	S		2-15	ZD							140	5	50W	
1N3346	S		2-15	ZD							150	20	50W	
1N3346A	S		2-15	ZD							150	10	50W	
1N3346B	S		2-15	ZD							150	5	50W	
1N3347	S		2-15	ZD							160	20	50W	
1N3347A	S		2-15	ZD							160	10	50W	
1N3347B	S		2-15	ZD							160	5	50W	
1N3348	S		2-15	ZD							175	20	50W	
1N3348A	S		2-15	ZD							175	10	50W	
1N3348B	S		2-15	ZD							175	5	50W	
1N3349	S		2-15	ZD							180	20	50W	
1N3349A	S		2-15	ZD							180	10	50W	
1N3349B	S		2-15	ZD							180	5	50W	
1N3350	S		2-15	ZD							200	20	50W	
1N3350A	S			ZD							200	10	50W	
1N3350B	S			ZD							200	5	50W	
1N3354	S			R	10	1.2	3	.020	30					
1N3355	S			R	15	1.2	3	.020	30					
1N3356	S			R	25	1.2	3	.010	30					
1N3357	S			R	50	1.2	3	.010	30					
1N3358	S			R	75	1.2	3	.010	30					
1N3359	S			R	100	1.2	3	.010	30					
1N3360	S			R	150	1.2	3	.010	30					
1N3361	S			R	200	1.2	3	.010	30					
1N3362	S			R	300	1.2	3	.010	30					
1N3363	S			R	400	1.2	3	.010	30					
1N3364	S			R	500	1.2	3	.010	30					
1N3365	S			R	600	1.2	3	.010	30					
1N3366	S			R	700	1.2	3	.010	30					
1N3367	S			R	800	2.0	3	.010	30					
1N3368	S			R	900	2.0	3	.010	30					
1N3369	S			R	1000	2.5	3	.025	30					
1N3370	S			R	1200	2.5	3	.025	30					
1N3371	S			R	1500	2.5	3	.025	30					
1N3372	S			R	10	1.0	20	.315	200					
1N3373	S			R	25	1.0	20	.315	200					
1N3374	S			R	50	1.0	20	.315	200					
1N3375	S			R	100	1.0	20	.315	200					
1N3376	S			R	150	1.0	20	.315	200					
1N3377	S			R	200	1.0	20	.315	200					
1N3378	S			R	300	1.0	20	.315	200					
1N3379	S			R	400	1.0	20	.315	200					
1N3380	S			R	500	1.0	20	.315	200					
1N3381	S			HC	15	1	500M	10*						
1N3382	S			HC	15	1	500M	10*						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3383—1N3446

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3383	S			HC	50	1	500M	10*					
1N3384	S			HC	75	1	500M	15*					
1N3385	S			HC	100	1	500M	20*					
1N3386	S			HC	150	1	500M	20*					
1N3387	S			HC	200	1	500M	20*					
1N3388	S			HC	250	1	500M	25*					
1N3389	S			HC	300	1	500M	25*					
1N3390	S			HC	400	1	500M	25*					
1N3391	S			HC	500	1	500M	25*					
1N3392	S			ZD							1.5	10	500M
1N3393	S			ZD							1.8	10	500M
1N3394	S			ZD							2.2	10	500M
1N3395	S			ZD							2.7	10	500M
1N3396	S			ZD							3.3	10	500M
1N3397	S			ZD							3.9	10	500M
1N3398	S			ZD							4.7	10	500M
1N3399	S			ZD							5.6	10	500M
1N3400	S			ZD							6.8	10	500M
1N3401	S			ZD							8.2	10	500M
1N3402	S			ZD							10	10	500M
1N3403	S			ZD							12	10	500M
1N3404	S			ZD							15	10	500M
1N3405	S			ZD							18	10	500M
1N3406	S			ZD							22	10	500M
1N3407	S			ZD							27	10	500M
1N3408	S			ZD							33	10	500M
1N3409	S			ZD							39	10	500M
1N3410	S			ZD							47	10	500M
1N3411	S			ZD							6.2	10	500M
1N3412	S			ZD							6.8	10	500M
1N3413	S			ZD							7.5	10	500M
1N3414	S			ZD							8.2	10	500M
1N3415	S			ZD							10	10	500M
1N3416	S			ZD							12	10	500M
1N3417	S			ZD							15	10	500M
1N3418	S			ZD							18	10	500M
1N3419	S			ZD							22	10	500M
1N3420	S			ZD							27	10	500M
1N3421	S			ZD							30	10	500M
1N3422	S			ZD							33	10	500M
1N3423	S			ZD							39	10	500M
1N3424	S			ZD							47	10	500M
1N3425	S			ZD							56	10	500M
1N3426	S			ZD							68	10	500M
1N3427	S			ZD							82	10	500M
1N3428	S			ZD							100	10	500M
1N3429	S			ZD							120	10	500M
1N3430	S			ZD							150	10	500M
1N3431	S			ZD							180	10	500M
1N3432	S			ZD							220	10	500M
1N3433	S			ZD							8.2		2W
1N3434	S			ZD							10.0		2W
1N3435	S			ZD							12.0		2W
1N3436	S			ZD							15.0		2W
1N3437	S			ZD							18.0		2W
1N3438	S			ZD							22.0		2W
1N3439	S			ZD							27.0		2W
1N3440	S			ZD							33.0		2W
1N3441	S			ZD							39.0		2W
1N3442	S			ZD							47.0		2W
1N3443	S			ZD							6.2	10	2W
1N3444	S			ZD							6.8	10	2W
1N3445	S			ZD							8.2	10	2W
1N3446	S			ZD							10	10	2W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs) CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3447	S			ZD							12	10	2W
1N3448	S			ZD							15	10	2W
1N3449	S			ZD							18	10	2W
1N3450	S			ZD							22	10	2W
1N3451	S			ZD							27	10	2W
1N3452	S			ZD							30	10	2W
1N3453	S			ZD							33	10	2W
1N3454	S			ZD							39	10	2W
1N3455	S			ZD							47	10	2W
1N3456	S			ZD							56	10	2W
1N3457	S			ZD							68	10	2W
1N3458	S			ZD							82	10	2W
1N3459	S			ZD							100	10	2W
1N3460	S			ZD							120	10	2W
1N3461	S			ZD							150	10	2W
1N3462	S			ZD							180	10	2W
1N3463	S			ZD							220	10	2W
1N3464	S			R	8500	30.0	.1	.001	2				
1N3465	G			HC	60	1	200M	20*					
1N3466	G			HC	40	1	200M	15*					
1N3467	G			HS	15	.5	20M	15*	2				
1N3468	G			GP	15	.5	20M	60*	2				
1N3469	G			HC	35	.5	600M	15*					
1N3470	G			HC	35	.5	600M	30*					
1N3471	S			HS	40	1	10M	20N	2				
1N3473	S			R	200	1.4	.75	.5	20				
1N3474	S			R	400	1.4	.75	.5	20				
1N3475	S			R	600	1.4	.75	.5	20				
1N3476	S			R	800	1.4	.5	.5	20				
1N3477	S			ZD							2.2	10	250M
1N3477A	S			ZD							2.2	5	250M
1N3478	S			HC	200	1	500M	10*					
1N3479	S			HC	400	1	500M	10*					
1N3480	S			HC	600	1	500M	10*					
1N3483	G			GP	8	.6	10M	30*					
1N3484	G			GP	75	.45	10M	4*					
1N3485	S			HS	175	1	10M	25N	.05				
1N3486	S			R	1000	2.0	.4	.05	10				
1N3487	S			R	1200	2.0	.4	.05	10				
1N3488	Varactor Diodes, see table on page 1-99												
1N3491	S			R	50	1.7	18	1.0	300				
1N3492	S			R	100	1.7	18	1.0	300				
1N3493	S			R	200	1.7	18	1.0	300				
1N3494	S			R	300	1.7	18	1.0	300				
1N3495	S			R	400	1.7	18	1.0	300				
1N3496	S			RD						.005	6.5	0	75
1N3497	S	1N827	2-32	RD						.002	6.5	0	75
1N3498	S	1N825	2-32	RD						.001	6.5	0	75
1N3499	S	1N823	2-32	RD						.0005	6.5	0	75
1N3500	S	1N821	2-32	RD						.01	6.5	0	75
1N3501	S			RD							6.500	25	100
1N3502	S			RD							6.500	25	100
1N3503	S			RD							6.500	25	100
1N3504	S			RD							6.500	25	100
1N3506	S			ZD							3.3	5	400M
1N3507	S			ZD							3.6	5	400M
1N3508	S			ZD							3.9	5	400M
1N3509	S			ZD							4.3	5	400M
1N3510	S			ZD							4.7	5	400M
1N3511	S			ZD							5.1	5	400M
1N3512	S			ZD							5.6	5	400M
1N3513	S			ZD							6.2	5	400M
1N3514	S			ZD							6.8	5	400M
1N3515	S			ZD							7.5	5	400M

R— Rectifier, RD— Reference Diode, ZD— Zener Diode, GP— General Purpose, HC— High Conductance (≧ 20 mA @ ≦ 1 V), HS— High Speed Switch (Max t_{rr} < 0.3 μs), CS— High Conductance, High Speed Switch, MS— Medium Speed Switch, PA— Parametric Amplifier, SP— Special Purpose.

1N3516 — 1N3583A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3516	S			ZD							8.2	5	400M	
1N3517	S			ZD							9.1	5	400M	
1N3518	S			ZD							10	5	400M	
1N3519	S			ZD							11	5	400M	
1N3520	S			ZD							12	5	400M	
1N3521	S			ZD							13	5	400M	
1N3522	S			ZD							15	5	400M	
1N3523	S			ZD							16	5	400M	
1N3524	S			ZD							18	5	400M	
1N3525	S			ZD							20	5	400M	
1N3526	S			ZD							22	5	400M	
1N3527	S			ZD							24	5	400M	
1N3528	S			ZD							27	5	400M	
1N3529	S			ZD							30	5	400M	
1N3530	S			ZD							33	5	400M	
1N3531	S			ZD							36	5	400M	
1N3532	S			ZD							39	5	400M	
1N3533	S			ZD							43	5	400M	
1N3534	S			ZD							47	5	400M	
1N3535	S			GP	200	.549	100							
1N3536	S			GP	70	.65	1M	25N						
1N3537	S			ZD							12		1W	
1N3538	S			GP	150		2.5M	2*						
1N3544	S	1N4002	3-23	R	100	1.5	.6	.2	15					
1N3545	S	1N4003	3-23	R	200	1.5	.6	.2	15					
1N3546	S	1N4004	3-23	R	300	1.5	.6	.2	15					
1N3547	S	1N4004	3-23	R	400	1.5	.6	.2	15					
1N3548	S	1N4005	3-23	R	500	1.5	.6	.2	15					
1N3549	S	1N4005	3-23	R	600	1.5	.6	.2	15					
1N3550	S			MS	180	1	50M		1.5					
1N3551 1N3552		Varactor Diodes, see table on page 1-99												
1N3553	S	1N821	2-32	RD						.0001	6.3	-55	100	
1N3554 thru 1N3557		Varactor Diodes, see table on page 1-99												
1N3563	S			R	1000	1.2	.4	.2	40					
1N3564														
1N3565	S			HC	6	2	2A	25M						
1N3566	S			R	800	2.25	1	.5	20					
1N3567	S			CS	50	1	100M	.05*	2					
1N3568	S			CS	80	1	20M	1*	2					
1N3569	S	1N4720	3-24	R	100	1.3	3.5	.4	35					
1N3570	S	1N4721	3-24	R	200	1.3	3.5	.4	35					
1N3571	S	MR1033A	3-24	R	300	1.3	3.5	.4	35					
1N3572	S	1N4722	3-24	R	400	1.3	3.5	.4	35					
1N3573	S	MR1035A	3-24	R	500	1.3	3.5	.4	35					
1N3574	S	1N4723	3-24	R	600	1.3	3.5	.4	35					
1N3575	S			GP	60	.74	1M	.75N						
1N3576	S			GP	125	.74	1M	.75N						
1N3577	S			GP	175	.74	1M	.75N						
1N3578	S			GP	225	.74	1M	.75N						
1N3579	S			GP	275	.74	1M	.75N						
1N3580	S		2-32	RD						.01	12.28	0	75	
1N3580A	S		2-32	RD						.01	12.28	-55	100	
1N3580B	S		2-32	RD						.01	12.28	-55	150	
1N3581	S		2-32	RD						.005	12.28	0	75	
1N3581A	S		2-32	RD						.005	12.28	-55	100	
1N3581B	S		2-32	RD						.005	12.28	-55	150	
1N3582	S		2-32	RD						.002	12.28	0	75	
1N3582A	S		2-32	RD						.002	12.28	-55	100	
1N3582B	S		2-32	RD						.002	12.28	-55	150	
1N3583	S			RD						.001	12.28	0	75	
1N3583A	S			RD						.001	12.28	-55	100	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3583B	S			RD						.001	12.28	-55	150
1N3584	S			RD						.005	12.28	0	75
1N3584A	S			RD						.005	12.28	-55	100
1N3584B	S			RD						.005	12.28	-55	150
1N3585	S	MR1240SB	3-44	R	50	1.25	400	25	8000				
1N3586	S	MR1241SB	3-44	R	100	1.25	400	25	8000				
1N3587	S	MR1243SB	3-44	R	200	1.25	400	25	8000				
1N3588	S	MR1245SB	3-44	R	300	1.25	400	25	8000				
1N3589	S	MR1247SB	3-44	R	400	1.25	400	25	8000				
1N3590	S			R	500	1.25	400	25	8000				
1N3591	S			R	600	1.25	400	25	8000				
1N3592	G			HS	30	.35	2M	4*	.04				
1N3593	S			HS	40	1	10M	25N	10				
1N3594	S			CS	60	1	50M	.1M	6				
1N3595	S			HC	125	1	200M	1M	3				
1N3596	S			HS	20	1	30M	.1*	4				
1N3597	S			CS	150	1.2	400M	.1*	.5				
1N3598	S			HS	50	.85	10M	.1*	4				
1N3599	S			CS	150	1	100M	.1*	50				
1N3600	S			CS	50	1	200M	100*	6				
1N3601	S			HS	75	1	10M	.1*	5				
1N3602	S			HS	50	1	20M	.1*	5				
1N3603	S			HS	30	1	30M	.1*	5				
1N3604	S			CS	75	1	50M	.05*	2				
1N3605	S			HS	40	.55	.1M	.05*	2				
1N3606	S			HS	75	.55	.1M	.05*	2				
1N3607	S			CS	75	1	50M	.05*	2				
1N3608	S			HS	40	.55	.1M	.05*	2				
1N3609	S			HS	75	.55	.1M	.05*	2				
1N3611	S	1N4003	3-23	HC	200	1	750M	10*					
1N3612	S	1N4004	3-23	HC	400	1	750M	10*					
1N3613	S	1N4005	3-23	HC	600	1	750M	10*					
1N3614	S	1N4006	3-23	HC	800	1	750M	10*					
1N3615	S	MR1120	3-28	R	50	1.2	16	3.0	300				
1N3616	S	MR1121	3-28	R	100	1.2	16	2.5	300				
1N3617	S	MR1122	3-28	R	150	1.2	16	2.25	300				
1N3618	S	MR1122	3-28	R	200	1.2	16	2.0	300				
1N3619	S	MR1123	3-28	R	300	1.2	16	1.75	300				
1N3620	S	MR1124	3-28	R	400	1.2	16	1.5	300				
1N3621	S	MR1125	3-28	R	500	1.2	16	1.25	300				
1N3622	S	MR1126	3-28	R	600	1.2	16	1.0	300				
1N3623	S	MR1128	3-28	R	800	1.2	16	.75	300				
1N3624	S	MR1130	3-28	R	1000	1.2	16	.6	300				
1N3625	S			MS	225	1	40M	.5*	.5				
1N3626	G			MS	50	.5	10M	1M	.45				
1N3627 thru 1N3628	Varactor Diodes, see table on page 1-99												
1N3629	S			R	100	1.0	.75	.01	30				
1N3630	S			R	200	1.0	.75	.01	30				
1N3631	S			R	300	1.0	.75	.01	30				
1N3632	S			R	400	1.0	.75	.01	30				
1N3633	S			R	500	1.0	.75	.01	30				
1N3634	S			R	600	1.0	.75	.01	30				
1N3635	S			R	700	1.0	.75	.01	30				
1N3636	S			R	800	1.0	.75	.01	30				
1N3637	S			R	900	1.0	.75	.01	30				
1N3638	S			R	1000	1.0	.75	.01	30				
1N3639	S	1N4003	3-23	R	200	1.2	.75	.2	40				
1N3640	S	1N4004	3-23	R	400	1.2	.75	.2	40				
1N3641	S	1N4005	3-23	R	600	1.2	.75	.2	40				
1N3642	S	1N4006	3-23	R	800	1.2	.5	.2	40				
1N3643	S			GP	1000	5	250M	5*					
1N3644	S			GP	1500	5	250M	5*					
1N3645	S			GP	1000	5	250M	5*					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3646 — 1N3686A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3646	S			GP	2500	5	250M	5*					
1N3647	S			GP	3000	5	250M	5*					
1N3648	S			R	10K	23	.35	.5	30				
1N3649	S	MR1128	3-28	R	800	1.1	1	.005	25				
1N3650	S	MR1130	3-28	R	1000	1.1	1	.005	25				
1N3653	S			CS	90	1	400M	25N	4				
1N3654	S			CS	90	1	50M	25N	4				
1N3656	S			HC	200	1.2	500M	.01M					
1N3657	S			HC	400	1.2	500M	.01M					
1N3658	S			HC	600	1.2	500M	.01M					
1N3659	S			R	50	1.4	25	5.0	400				
1N3660	S			R	100	1.4	25	4.5	400				
1N3661	S			R	200	1.4	25	4.0	400				
1N3662	S			R	300	1.4	25	3.5	400				
1N3663	S			R	400	1.4	25	3.0	400				
1N3664	S			R	500	1.4	25	2.5	400				
1N3665	S			R	600	1.4	25	2.0	400				
1N3666	G			HC	80	1	200M	25*	.3				
1N3667	S			R	500	1.2	1.5	1.2	30				
1N3668	S			HS	30	1	5M	.1*	.15				
1N3669	S			HS	70	1.1	400M	.25*	.2				
1N3670	S	MR1128	3-28	R	700	2.05	12	3.0	200				
1N3670A	S	MR1128	3-28	R	700	1.5	12	.9	240				
1N3671	S	MR1128	3-28	R	800	2.05	12	2.0	200				
1N3671A	S	MR1128	3-28	R	800	1.3	12	.8	240				
1N3672	S	MR1130	3-28	R	900	2.05	12	2.0	200				
1N3672A	S	MR1130	3-28	R	900	1.15	12	.7	240				
1N3673	S	MR1130	3-28	R	1000	2.05	12	1.0	200				
1N3673A	S	MR1130	3-28	R	1000	1	12	.6	240				
1N3675	S		2-21	ZD							6.8	20	750M
1N3675A	S		2-21	ZD							6.8	10	750M
1N3675B	S		2-21	ZD							6.8	5	750M
1N3676	S		2-21	ZD							7.5	20	750M
1N3676A	S		2-21	ZD							7.5	10	750M
1N3676B	S		2-21	ZD							7.5	5	750M
1N3677	S		2-21	ZD							8.2	20	750M
1N3677A	S		2-21	ZD							8.2	10	750M
1N3677B	S		2-21	ZD							8.2	5	750M
1N367B	S		2-21	ZD							9.1	20	750M
1N3678A	S		2-21	ZD							9.1	10	750M
1N3678B	S		2-21	ZD							9.1	5	750M
1N3679	S		2-21	ZD							10	20	750M
1N3679A	S		2-21	ZD							10	10	750M
1N3679B	S		2-21	ZD							10	5	750M
1N3680	S		2-21	ZD							11	20	750M
1N3680A	S		2-21	ZD							11	10	750M
1N3680B	S		2-21	ZD							11	5	750M
1N3681	S		2-21	ZD							12	20	750M
1N3681A	S		2-21	ZD							12	10	750M
1N3681B	S		2-21	ZD							12	5	750M
1N3682	S		2-21	ZD							13	20	750M
1N3682A	S		2-21	ZD							13	10	750M
1N3682B	S		2-21	ZD							13	5	750M
1N3683	S		2-21	ZD							15	20	750M
1N3683A	S		2-21	ZD							15	10	750M
1N3683B	S		2-21	ZD							15	5	750M
1N3684	S		2-21	ZD							16	20	750M
1N3684A	S		2-21	ZD							16	10	750M
1N3684B	S		2-21	ZD							16	5	750M
1N3685	S		2-21	ZD							18	20	750M
1N3685A	S		2-21	ZD							18	10	750M
1N3685B	S		2-21	ZD							18	5	750M
1N3686	S		2-21	ZD							20	20	750M
1N3686A	S		2-21	ZD							20	10	750M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max $t_{rr} < 0.3\mu s$), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3686B	S		2-21	ZD							20	5	750M
1N3687	S		2-21	ZD							22	20	750M
1N3687A	S		2-21	ZD							22	10	750M
1N3687B	S		2-21	ZD							22	5	750M
1N3688	S		2-21	ZD							24	20	750M
1N3688A	S		2-21	ZD							24	10	750M
1N3688B	S		2-21	ZD							24	5	750M
1N3689	S		2-21	ZD							27	20	750M
1N3689A	S		2-21	ZD							27	10	750M
1N3689B	S		2-21	ZD							27	5	750M
1N3690	S		2-21	ZD							30	20	750M
1N3690A	S		2-21	ZD							30	10	750M
1N3690B	S		2-21	ZD							30	5	750M
1N3691	S		2-21	ZD							33	20	750M
1N3691A	S		2-21	ZD							33	10	750M
1N3691B	S		2-21	ZD							33	5	750M
1N3692	S		2-21	ZD							36	20	750M
1N3692A	S		2-21	ZD							36	10	750M
1N3692B	S		2-21	ZD							36	5	750M
1N3693	S		2-21	ZD							39	20	750M
1N3693A	S		2-21	ZD							39	10	750M
1N3693B	S		2-21	ZD							39	5	750M
1N3694	S		2-21	ZD							43	20	750M
1N3694A	S		2-21	ZD							43	10	750M
1N3694B	S		2-21	ZD							43	5	750M
1N3695	S		2-21	ZD							47	20	750M
1N3695A	S		2-21	ZD							47	10	750M
1N3695B	S		2-21	ZD							47	5	750M
1N3696	S		2-21	ZD							51	20	750M
1N3696A	S		2-21	ZD							51	10	750M
1N3696B	S		2-21	ZD							51	5	750M
1N3697	S		2-21	ZD							56	20	750M
1N3697A	S		2-21	ZD							56	10	750M
1N3697B	S		2-21	ZD							56	5	750M
1N369B	S		2-21	ZD							62	20	750M
1N3698A	S		2-21	ZD							62	10	750M
1N369BB	S		2-21	ZD							62	5	750M
1N3699	S		2-21	ZD							68	20	750M
1N3699A	S		2-21	ZD							68	10	750M
1N3699B	S		2-21	ZD							68	5	750M
1N3700	S		2-21	ZD							75	20	750M
1N3700A	S		2-21	ZD							75	10	750M
1N3700B	S		2-21	ZD							75	5	750M
1N3701	S		2-21	ZD							82	20	750M
1N3701A	S		2-21	ZD							82	10	750M
1N3701B	S		2-21	ZD							82	5	750M
1N3702	S		2-21	ZD							91	20	750M
1N3702A	S		2-21	ZD							91	10	750M
1N3702B	S		2-21	ZD							91	5	750M
1N3703	S		2-21	ZD							100	20	750M
1N3703A	S		2-21	ZD							100	10	750M
1N3703B	S		2-21	ZD							100	5	750M
1N3704	S			ZD							110	20	750M
1N3704A	S			ZD							110	10	750M
1N3704B	S			ZD							110	5	750M
1N3705	S		2-21	ZD							120	20	750M
1N3705A	S		2-21	ZD							120	10	750M
1N3705B	S		2-21	ZD							120	5	750M
1N3706	S		2-21	ZD							130	20	750M
1N3706A	S		2-21	ZD							130	10	750M
1N3706B	S		2-21	ZD							130	5	750M
1N3707	S		2-21	ZD							150	20	750M
1N3707A	S		2-21	ZD							150	10	750M
1N3707B	S		2-21	ZD							150	5	750M

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3708 — 1N3783

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3708	S		2-21	ZD							160	20	750M
1N3708A	S		2-21	ZD							160	10	750M
1N3708B	S		2-21	ZD							160	5	750M
1N3709	S		2-21	ZD							180	20	750M
1N3709A	S		2-21	ZD							180	10	750M
1N3709B	S		2-21	ZD							180	5	750M
1N3710	S		2-21	ZD							200	20	750M
1N3710A	S			ZD							200	10	750M
1N3710B	S		2-21	ZD							200	5	750M
1N3711	S			R	6000	11	.15	.025	5				
1N3722	S			CS	50	1	20M	.1*	10				
1N3723	S			R	1000	2.2	.75	.005	12				
1N3724	S			R	1200	2.2	.75	.005	12				
1N3725	S			R	1400	2.2	.75	.005	12				
1N3726	S			R	1600	2.2	.75	.005	12				
1N3727	S			R	1800	2.2	.75	.005	12				
1N3728	S			HC	550	1.2	400M	.1*					
1N3729	S			MS	600	1	5M	.1*	.5				
1N3730	S			CS	80	1	750M	.1*	15				
1N3731	S			HS	80	1	100M	5*	3				
1N3732	S			ZD							5.1	5	1W
1N3735	S			R	100	1.3	250	16	4500				
1N3736	S	MR1233SB	3-41	R	200	1.3	250	16	4500				
1N3737	S	MR1235SB	3-41	R	300	1.3	250	16	4500				
1N3738	S	MR1237SB	3-41	R	400	1.3	250	16	4500				
1N3739	S			R	500	1.3	250	13	4500				
1N3740	S			R	600	1.3	250	12	4500				
1N3741	S			R	800	1.3	250	9	4500				
1N3742	S			R	1000	1.3	250	7	4500				
1N3743	S			R	1200	1.3	250	7	4500				
1N3744	S			R	1400	1.3	250	7	4500				
1N3748	S			R	200	1.5	.5		20				
1N3749	S			R	400	1.5	.5		20				
1N3750	S			R	600	1.5	.5		20				
1N3751	S			R	800	1.5	.5		20				
1N3752	S			R	1000	1.5	.5		20				
1N3753	G			HC	55	1	150M	5*					
1N3754	S			R	100	1.2	.15	.3	15				
1N3755	S			R	200	1.2	.15	.3	15				
1N3756	S			R	400	1.2	.15	.3	15				
1N3757	S			R	200	1	1		30				
1N3758	S			R	400	1	1		30				
1N3759	S			R	600	1	1		30				
1N3760	S			R	800	1	1		30				
1N3761	S			R	1000	1	1		30				
1N3762	S			R	5300	12	.065	.005	15				
1N3763	S			RD						.002	20	-55	150
1N3764	S			R	3000	6.5	.2	.1	8				
1N3765	S			R	700	1.8	35	5	400				
1N3766	S			R	800	1.8	35	4	400				
1N3767	S			R	900	1.8	35	3	400				
1N3768	S			R	1000	1.8	35	2	400				
1N3769	G			HC	90	.5	25M	5*					
1N3770		Varactor Diodes, see table on page 1-99											
1N3773	G			HS	25	.35	2M	4*	40				
1N3774	S			ZD							1.15	2	.34W
1N3775	S			R	1500	2.2	3.3	.1	15				
1N3776	S			ZD							10		6W
1N3777	S			HS	40	1	10M	.1*	4				
1N3779	S			RD						.015	6.7	-55	25
1N3780	S			RD						01	6.7	-55	25
1N3781	S			RD						.005	6.7	-55	25
1N3782	S			RD						.002	6.7	-55	25
1N3783	S			RD						.001	6.7	-55	25

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs) **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3784	S			RD						.0005	6.7	-55	25	
1N3785	S		2-22	ZD							6.8	20	1.5W	
1N3785A	S		2-22	ZD							6.8	10	1.5W	
1N3785B	S		2-22	ZD							6.8	5	1.5W	
1N3786	S		2-22	ZD							7.5	20	1.5W	
1N3786A	S		2-22	ZD							7.5	10	1.5W	
1N3786B	S		2-22	ZD							7.5	5	1.5W	
1N3787	S		2-22	ZD							8.2	20	1.5W	
1N3787A	S		2-22	ZD							8.2	10	1.5W	
1N3787B	S		2-22	ZD							8.2	5	1.5W	
1N3788	S		2-22	ZD							9.1	20	1.5W	
1N3788A	S		2-22	ZD							9.1	10	1.5W	
1N3788B	S		2-22	ZD							9.1	5	1.5W	
1N3789	S		2-22	ZD							10	20	1.5W	
1N3789A	S		2-22	ZD							10	10	1.5W	
1N3789B	S		2-22	ZD							10	5	1.5W	
1N3790	S		2-22	ZD							11	20	1.5W	
1N3790A	S		2-22	ZD							11	10	1.5W	
1N3790B	S		2-22	ZD							11	5	1.5W	
1N3791	S		2-22	ZD							12	20	1.5W	
1N3791A	S		2-22	ZD							12	10	1.5W	
1N3791B	S		2-22	ZD							12	5	1.5W	
1N3792	S		2-22	ZD							13	20	1.5W	
1N3792A	S		2-22	ZD							13	10	1.5W	
1N3792B	S		2-22	ZD							13	5	1.5W	
1N3793	S		2-22	ZD							15	20	1.5W	
1N3793A	S		2-22	ZD							15	10	1.5W	
1N3793B	S		2-22	ZD							15	5	1.5W	
1N3794	S		2-22	ZD							16	20	1.5W	
1N3794A	S		2-22	ZD							16	10	1.5W	
1N3794B	S		2-22	ZD							16	5	1.5W	
1N3795	S		2-22	ZD							18	20	1.5W	
1N3795A	S		2-22	ZD							18	10	1.5W	
1N3795B	S		2-22	ZD							18	5	1.5W	
1N3796	S		2-22	ZD							20	20	1.5W	
1N3796A	S		2-22	ZD							20	10	1.5W	
1N3796B	S		2-22	ZD							20	5	1.5W	
1N3797	S		2-22	ZD							22	20	1.5W	
1N3797A	S		2-22	ZD							22	10	1.5W	
1N3797B	S		2-22	ZD							22	5	1.5W	
1N3798	S		2-22	ZD							24	20	1.5W	
1N3798A	S		2-22	ZD							24	10	1.5W	
1N3798B	S		2-22	ZD							24	5	1.5W	
1N3799	S		2-22	ZD							27	20	1.5W	
1N3799A	S		2-22	ZD							27	10	1.5W	
1N3799B	S		2-22	ZD							27	5	1.5W	
1N3800	S		2-22	ZD							30	20	1.5W	
1N3800A	S		2-22	ZD							30	10	1.5W	
1N3800B	S		2-22	ZD							30	5	1.5W	
1N3801	S		2-22	ZD							33	20	1.5W	
1N3801A	S		2-22	ZD							33	10	1.5W	
1N3801B	S		2-22	ZD							33	5	1.5W	
1N3802	S		2-22	ZD							36	20	1.5W	
1N3802A	S		2-22	ZD							36	10	1.5W	
1N3802B	S		2-22	ZD							36	5	1.5W	
1N3803	S		2-22	ZD							39	20	1.5W	
1N3803A	S		2-22	ZD							39	10	1.5W	
1N3803B	S		2-22	ZD							39	5	1.5W	
1N3804	S		2-22	ZD							43	20	1.5W	
1N3804A	S		2-22	ZD							43	10	1.5W	
1N3804B	S		2-22	ZD							43	5	1.5W	
1N3805	S		2-22	ZD							47	20	1.5W	
1N3805A	S		2-22	ZD							47	10	1.5W	
1N3805B	S		2-22	ZD							47	5	1.5W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3806 — 1N3830

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N3806	S		2-22	ZD							51	20	1.5W	
1N3806A	S		2-22	ZD							51	10	1.5W	
1N3806B	S		2-22	ZD							51	5	1.5W	
1N3807	S		2-22	ZD							56	20	1.5W	
1N3807A	S		2-22	ZD							56	10	1.5W	
1N3807B	S		2-22	ZD							56	5	1.5W	
1N3808	S		2-22	ZD							62	20	1.5W	
1N3808A	S		2-22	ZD							62	10	1.5W	
1N3808B	S		2-22	ZD							62	5	1.5W	
1N3809	S		2-22	ZD							68	20	1.5W	
1N3809A	S		2-22	ZD							68	10	1.5W	
1N3809B	S		2-22	ZD							68	5	1.5W	
1N3810	S		2-22	ZD							75	20	1.5W	
1N3810A	S		2-22	ZD							75	10	1.5W	
1N3810B	S		2-22	ZD							75	5	1.5W	
1N3811	S		2-22	ZD							82	20	1.5W	
1N3811A	S		2-22	ZD							82	10	1.5W	
1N3811B	S		2-22	ZD							82	5	1.5W	
1N3812	S		2-22	ZD							91	20	1.5W	
1N3812A	S		2-22	ZD							91	10	1.5W	
1N3812B	S		2-22	ZD							91	5	1.5W	
1N3813	S		2-22	ZD							100	20	1.5W	
1N3813A	S		2-22	ZD							100	10	1.5W	
1N3813B	S		2-22	ZD							100	5	1.5W	
1N3814	S		2-22	ZD							110	20	1.5W	
1N3814A	S		2-22	ZD							110	10	1.5W	
1N3814B	S		2-22	ZD							110	5	1.5W	
1N3815	S		2-22	ZD							120	20	1.5W	
1N3815A	S		2-22	ZD							120	10	1.5W	
1N3815B	S		2-22	ZD							120	5	1.5W	
1N3816	S		2-22	ZD							130	20	1.5W	
1N3816A	S		2-22	ZD							130	10	1.5W	
1N3816B	S		2-22	ZD							130	5	1.5W	
1N3817	S		2-22	ZD							150	20	1.5W	
1N3817A	S		2-22	ZD							150	10	1.5W	
1N3817B	S		2-22	ZD							150	5	1.5W	
1N3818	S		2-22	ZD							160	20	1.5W	
1N3818A	S		2-22	ZD							160	10	1.5W	
1N3818B	S		2-22	ZD							160	5	1.5W	
1N3819	S		2-22	ZD							180	20	1.5W	
1N3819A	S		2-22	ZD							180	10	1.5W	
1N3819B	S		2-22	ZD							180	5	1.5W	
1N3820	S		2-22	ZD							200	20	1.5W	
1N3820A	S		2-22	ZD							200	10	1.5W	
1N3820B	S		2-22	ZD							200	5	1.5W	
1N3821	S		2-23	ZD							3.3	10	1W	
1N3821A	S		2-23	ZD							3.3	5	1W	
1N3822	S		2-23	ZD							3.6	10	1W	
1N3822A	S		2-23	ZD							3.6	5	1W	
1N3823	S		2-23	ZD							3.9	10	1W	
1N3823A	S		2-23	ZD							3.9	5	1W	
1N3824	S		2-23	ZD							4.3	10	1W	
1N3824A	S		2-23	ZD							4.3	5	1W	
1N3825	S		2-23	ZD							4.7	10	1W	
1N3825A	S		2-23	ZD							4.7	5	1W	
1N3826	S		2-23	ZD							5.1	10	1W	
1N3826A	S		2-23	ZD							5.1	5	1W	
1N3827	S		2-23	ZD							5.6	10	1W	
1N3827A	S		2-23	ZD							5.6	5	1W	
1N3828	S		2-23	ZD							6.2	10	1W	
1N3828A	S		2-23	ZD							6.2	5	1W	
1N3829	S		2-23	ZD							6.8	10	1W	
1N3829A	S		2-23	ZD							6.8	5	1W	
1N3830	S		2-23	ZD							7.5	10	1W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3830A	S			ZD							7.5	5	1W
1N3864	S			HC	125	1.5	200M	1N	.9				
1N3865	G			HC	80		100M	15*	.5				
1N3866	S			R	200	1.5	1	.05	25				
1N3867	S			R	400	1.5	1	.05	25				
1N3868	S			R	600	1.5	1	.05	25				
1N3869	S			R	1000	3	.5	.05	10				
1N3870	S			R	1500	3	.5	.05	10				
1N3871	S			R	2500	6	.25	.05	5				
1N3872	S			CS	90	1	150M	.1*	15				
1N3873	S			CS	50	1.14	.2A	.1*	4				
1N3874	S			R	50	1.5	6	3	75				
1N3875	S			R	100	1.5	6	3	75				
1N3876	S			R	200	1.5	6	3	75				
1N3877	S			R	300	1.5	6	3	75				
1N3878	S			R	400	1.5	6	3	75				
1N3879	S		3-20	R	50	1.5	6	3	75				
1N3880	S		3-20	R	100	1.5	6	3	75				
1N3881	S		3-20	R	200	1.5	6	3	75				
1N3882	S		3-20	R	300	1.5	6	3	75				
1N3883	S		3-20	R	400	1.5	6	3	75				
1N3884	S			R	50	1.5	12	3	150				
1N3885	S			R	100	1.5	12	3	150				
1N3886	S			R	200	1.5	12	3	150				
1N3887	S			R	300	1.5	12	3	150				
1N3888	S			R	400	1.5	12	3	150				
1N3889	S		3-20	R	50	1.5	12	3	150				
1N3890	S		3-20	R	100	1.5	12	3	150				
1N3891	S		3-20	R	200	1.5	12	3	150				
1N3892	S		3-20	R	300	1.5	12	3	150				
1N3893	S		3-20	R	400	1.5	12	3	150				
1N3894	S			HC	400	1	400M	.2*					
1N3895	S			HC	350	1	200M	.5*					
1N3896	S			ZD							.77	5	250M
1N3897	S			ZD							1.5	5	250M
1N3898	S			ZD							2.1	5	250M
1N3899	S			R	50	1.5	20	6	225				
1N3900	S			R	100	1.5	20	6	225				
1N3901	S			R	200	1.5	20	6	225				
1N3902	S			R	300	1.5	20	6	225				
1N3903	S			R	400	1.5	20	6	225				
1N3904	S			R	50	1.5	20	6	225				
1N3905	S			R	100	1.5	20	6	225				
1N3906	S			R	200	1.5	20	6	225				
1N3907	S			R	300	1.5	20	6	225				
1N3908	S			R	400	1.5	20	6	225				
1N3909	S			R	50	1.5	30	10	300				
1N3910	S			R	100	1.5	30	10	300				
1N3911	S			R	200	1.5	30	10	300				
1N3912	S			R	300	1.5	30	10	300				
1N3913	S			R	400	1.5	30	10	300				
1N3914	S			R	50	1.5	30	10	300				
1N3915	S			R	100	1.5	30	10	300				
1N3916	S			R	200	1.5	30	10	300				
1N3917	S			R	300	1.5	30	10	300				
1N3918	S			R	400	1.5	30	10	300				
1N3919	S			R	1000	2	5	.5	100				
1N3920	S			R	1500	2	5	.5	100				
1N3921	S			R	2000	2	5	.5	100				
1N3922	S			R	2500	2	5	.5	100				
1N3923	S			R	3000	2	5	.5	100				
1N3924	S			R	1000	2	10	.5	100				
1N3925	S			R	1500	2	10	.5	100				
1N3926	S			R	2000	2	10	.5	100				

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N3927 — 1N3994

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3927	S			R	2500	2	10	.5	100				
1N3928	S			R	3000	2	10	.5	100				
1N3929	S			GP	1000	2	1A	10*					
1N3930	S			GP	1500	2	1A	10*					
1N3931	S			GP	2000	2	1A	10*					
1N3932	S			GP	1500	2	1A	10*					
1N3933	S			GP	3000	2	1A	10*					
1N3934	S			R	1200	2.5	1	.4	50				
1N3938	S			R	200	1.1	2	.2	30				
1N3939	S			R	400	1.1	2	.2	30				
1N3940	S			R	600	1.1	2	.2	30				
1N3941	S			R	800	1.5	2	.2	30				
1N3942	S			R	1000	1.5	2	.2	30				
1N3943	S			GP	3	2.5	300M	100*					
1N3944	G			GP	15	.75	10M	2.5*	12				
1N3945 thru 1N3947		Varactor Diodes, see table on page 1-99											
1N3949	S			ZO							20.0	5	10W
1N3950	S			ZO							20.0	5	1.5W
1N3951	S			ZO							25.0	5	1.5W
1N3952	S			GP	130	.74	10M	25N					
1N3953	G			MS	40	.5	35M	50*	300				
1N3954	S			CS	50	1	200M	.1*	4				
1N3955	S			R	100	1.3	70	15	1200				
1N3956	S			HS	40	.55	100*	.05*	2				
1N3957	S			GP	1000	1	400M	10*					
1N3958	S			R	100	1.3	3.5	.4	35				
1N3959	S			R	200	1.3	3.5	.4	35				
1N3960	S			R	300	1.3	3.5	.4	35				
1N3961	S			R	400	1.3	3.5	.4	35				
1N3962	S			R	500	1.3	3.5	.4	35				
1N3963	S			R	600	1.3	3.5	.4	35				
1N3964	S			R	200	1.6	22	1	200				
1N3965	S			R	400	1.6	22	1	200				
1N3966	S			R	600	1.6	22	1	200				
1N3967	S			R	800	1.6	22	1	200				
1N3968	S			R	200	1.6	50	2	600				
1N3969	S			R	400	1.6	50	2	600				
1N3970	S			R	600	1.6	50	2	600				
1N3971	S			R	800	1.6	50	2	600				
1N3972	S			R	200	1.5	104	5	1500				
1N3973	S			R	400	1.5	104	5	1500				
1N3974	S			R	600	1.5	104	5	1500				
1N3975	S			R	800	1.5	104	5	1500				
1N3976	S			R	200	1.5	250	10	4000				
1N3977	S			R	400	1.5	250	10	4000				
1N3978	S			R	600	1.5	250	10	4000				
1N3979	S			R	800	1.5	250	10	4000				
1N3981	S			HC	200	1	900M	.01M					
1N3982	S			HC	400	1	900M	.01M					
1N3983	S			HC	600	1	900M	.01M					
1N3984	S			ZO							5.5	5	10W
1N3985	S			ZO							6	5	10W
1N3986	S			ZO							6.2	5	10W
1N3987	S			R	700	1.4	6	.9	150				
1N3988	S	MR1128	3-30	R	800	1.4	6	.8	150				
1N3989	S	MR1130	3-30	R	900	1.4	6	.7	150				
1N3990	S	MR1130	3-30	R	1000	1.4	6	.6	150				
1N3991	G			GP	35	.55	30M	1M	1				
1N3992	S			HC	4000	5	250M	5*					
1N3993	S		2-24	ZD							3.9	10	10W
1N3993A	S		2-24	ZO							3.9	5	10W
1N3994	S		2-24	ZO							4.3	10	10W

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **NC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N3994A	S		2-24	ZD							4.3	5	10W
1N3995	S		2-24	ZD							4.7	10	10W
1N3995A	S		2-24	ZD							4.7	5	10W
1N3996	S		2-24	ZD							5.1	10	10W
1N3996A	S		2-24	ZD							5.1	5	10W
1N3997	S		2-24	ZD							5.6	10	10W
1N3997A	S		2-24	ZD							5.6	5	10W
1N3998	S		2-24	ZD							6.2	10	10W
1N3998A	S		2-24	ZD							6.2	5	10W
1N3999	S		2-24	ZD							6.8	10	10W
1N3999A	S		2-24	ZD							6.8	5	10W
1N4000	S		2-24	ZD							7.5	10	10W
1N4000A	S		2-24	ZD							7.5	5	10W
1N4001	S		3-23	R	50	1.6	1	.03	30				
1N4002	S		3-23	R	100	1.6	1	.03	30				
1N4003	S		3-23	R	200	1.6	1	.03	30				
1N4004	S		3-23	R	400	1.6	1	.03	30				
1N4005	S		3-23	R	600	1.6	1	.03	30				
1N4006	S		3-23	R	800	1.6	1	.03	30				
1N4007	S		3-23	R	1000	1.6	1	.03	30				
1N4008	G			GP	12	.5	10M	.1M	70				
1N4009	S			HS	25	1	30M	.1M	4				
1N4010	S	1N827	2-32	RD						.0005	6.2	25	100
1N4011	S			R	1000	1.1	.5	.2	30				
1N4012	S			R	700	1.3	12	1	200				
1N4013	S			R	800	1.3	12	1	200				
1N4014	S			R	900	1.3	12	1	200				
1N4015	S			R	1000	1.3	12	1	200				
1N4016	S			ZD							8.2	20	5W
1N4016A	S			ZD							8.2	10	5W
1N4016B	S			ZD							8.2	5	5W
1N4017	S			ZD							9.1	20	5W
1N4017A	S			ZD							9.1	10	5W
1N4017B	S			ZD							9.1	5	5W
1N4018	S			ZD							10	20	5W
1N4018A	S			ZD							10	10	5W
1N4018B	S			ZD							10	5	5W
1N4019	S			ZD							11	20	5W
1N4019A	S			ZD							11	10	5W
1N4019B	S			ZD							11	5	5W
1N4020	S			ZD							12	20	5W
1N4020A	S			ZD							12	10	5W
1N4020B	S			ZD							12	5	5W
1N4021	S			ZD							13	20	5W
1N4021A	S			ZD							13	10	5W
1N4021B	S			ZD							13	5	5W
1N4022	S			ZD							15	20	5W
1N4022A	S			ZD							15	10	5W
1N4022B	S			ZD							15	5	5W
1N4023	S			ZD							16	20	5W
1N4023A	S			ZD							16	10	5W
1N4023B	S			ZD							16	5	5W
1N4024	S			ZD							18	20	5W
1N4024A	S			ZD							18	10	5W
1N4024B	S			ZD							18	5	5W
1N4025	S			ZD							20	20	5W
1N4025A	S			ZD							20	10	5W
1N4025B	S			ZD							20	5	5W
1N4026	S			ZD							22	20	5W
1N4026A	S			ZD							22	10	5W
1N4026B	S			ZD							22	5	5W
1N4027	S			ZD							24	20	5W
1N4027A	S			ZD							24	10	5W
1N4027B	S			ZD							24	5	5W

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3 μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

1N4028 — 1N4059

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4028	S			ZD							27	20		5W
1N4028A	S			ZD							27	10		5W
1N4028B	S			ZD							27	5		5W
1N4029	S			ZD							30	20		5W
1N4029A	S			ZD							30	10		5W
1N4029B	S			ZD							30	5		5W
1N4030	S			ZD							33	20		5W
1N4030A	S			ZD							33	10		5W
1N4030B	S			ZD							33	5		5W
1N4031	S			ZD							36	20		5W
1N4031A	S			ZD							36	10		5W
1N4031B	S			ZD							36	5		5W
1N4032	S			ZD							39	20		5W
1N4032A	S			ZD							39	10		5W
1N4032B	S			ZD							39	5		5W
1N4033	S			ZD							43	20		5W
1N4033A	S			ZD							43	10		5W
1N4033B	S			ZD							43	5		5W
1N4034	S			ZD							47	20		5W
1N4034A	S			ZD							47	10		5W
1N4034B	S			ZD							47	5		5W
1N4035	S			ZD							51	20		5W
1N4035A	S			ZD							51	10		5W
1N4035B	S			ZD							51	5		5W
1N4036	S			ZD							56	20		5W
1N4036A	S			ZD							56	10		5W
1N4036B	S			ZD							56	5		5W
1N4037	S			ZD							62	20		5W
1N4037A	S			ZD							62	10		5W
1N4037B	S			ZD							62	5		5W
1N4038	S			ZD							68	20		5W
1N4038A	S			ZD							68	10		5W
1N4038B	S			ZD							68	5		5W
1N4039	S			ZD							75	20		5W
1N4039A	S			ZD							75	10		5W
1N4039B	S			ZD							75	5		5W
1N4040	S			ZD							82	20		5W
1N4040A	S			ZD							82	10		5W
1N4040B	S			ZD							82	5		5W
1N4041	S			ZD							91	20		5W
1N4041A	S			ZD							91	10		5W
1N4041B	S			ZD							91	5		5W
1N4042	S			ZD							100	20		5W
1N4042A	S			ZD							100	10		5W
1N4042B	S			ZD							100	5		5W
1N4043	S			CS	25	1	30M	.1*	2					
1N4044	S	MR1230SB	3-41	R	50	1.35	275	15	5000					
1N4045	S	MR1231SB	3-41	R	100	1.35	275	15	5000					
1N4046	S	MR1232SB	3-41	R	150	1.35	275	15	5000					
1N4047	S	MR1233SB	3-41	R	200	1.35	275	15	5000					
1N4048	S	MR1234SB	3-41	R	250	1.35	275	15	5000					
1N4049	S	MR1235SB	3-41	R	300	1.35	275	15	5000					
1N4050	S	MR1237SB	3-41	R	400	1.35	275	15	5000					
1N4051	S			R	500	1.35	275	15	5000					
1N4052	S			R	600	1.35	275	15	5000					
1N4053	S			R	700	1.35	275	15	5000					
1N4054	S			R	800	1.35	275	15	5000					
1N4055	S			R	900	1.35	275	15	5000					
1N4056	S			R	1000	1.35	275	15	5000					
1N4057	S			RD						.005	12.4	-55	100	
1N4057A	S			RD						.002	12.4	-55	100	
1N4058	S			RD						.005	14.6	-55	100	
1N4058A	S			RD						.002	14.6	-55	100	
1N4059	S			RD						.005	16.8	-55	100	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4059A	S			RD						.002	16.8	-55	100
1N4060	S			RD						.005	18.5	-55	100
1N4060A	S			RD						.002	18.5	-55	100
1N4061	S			RD						.005	21	-55	100
1N4061A	S			RD						.002	21	-55	100
1N4062	S			RD						.005	23	-55	100
1N4062A	S			RD						.002	23	-55	100
1N4063	S			RD						.005	27	-55	100
1N4063A	S			RD						.002	27	-55	100
1N4064	S			RD						.005	30	-55	100
1N4064A	S			RD						.002	30	-55	100
1N4065	S			RD						.005	33	-55	100
1N4065A	S			RD						.002	33	-55	100
1N4066	S			RD						.005	37	-55	100
1N4066A	S			RD						.002	37	-55	100
1N4067	S			RD						5	43	-55	100
1N4067A	S			RD						2	43	-55	100
1N4068	S			RD						5	47	-55	100
1N4068A	S			RD						2	47	-55	100
1N4069	S			RD						5	51	-55	100
1N4069A	S			RD						2	51	-55	100
1N4070	S			RD						5	56	-55	100
1N4070A	S			RD						2	56	-55	100
1N4071	S			RD						5	62	-55	100
1N4071A	S			RD						2	62	-55	100
1N4072	S			RD						5	68	-55	100
1N4072A	S			RD						2	68	-55	100
1N4073	S			RD						5	75	-55	100
1N4073A	S			RD						2	75	-55	100
1N4074	S			RD						5	82	-55	100
1N4074A	S			RD						2	82	-55	100
1N4075	S			RD						.005	87	-55	100
1N4075A	S			RD						.002	87	-55	100
1N4076	S			RD						.005	91	-55	100
1N4076A	S			RD						.002	91	-55	100
1N4077	S			RD						.002	100	-55	100
1N4077A	S			RD						.002	100	-55	100
1N4078	S			RD						.005	105	-55	100
1N4078A	S			RD						.002	105	-55	100
1N4079	S			RD						.005	110	-55	100
1N4079A	S			RD						.002	110	-55	100
1N4080	S			RD						.005	120	-55	100
1N4080A	S			RD						.002	120	-55	100
1N4081	S			RD						.005	130	-55	100
1N4081A	S			RD						.002	130	-55	100
1N4082	S			RD						.005	140	-55	100
1N4082A	S			RD						.002	140	-55	100
1N4083	S			RD						.005	150	-55	100
1N4083A	S			RD						.002	150	-55	100
1N4084	S			RD						.005	175	-55	100
1N4084A	S			RD						.002	175	-55	100
1N4085	S			RD						.005	200	-55	100
1N4085A	S			RD						.002	200	-55	100
1N4086	S			HC	70	1	200M	.25M	200				
1N4087	S			CS	50	.975	30M	90N	2.5				
1N4088	G			HC	30	1	100M	.2M					
1N4089	S			R	400	1.2	400	.2	75				
1N4091	Varactor Diodes, see table on page 1-99												
1N4092	S			GP		1	5M	1•					
1N4093	S												
1N4094	S	1N2624B	2-32	RD							9.6		
1N4095	S	1N751	2-10	ZD							5	10	275M
1N4096	S	1N3004B	2-18	ZD							90	5	3W
1N4097	S	1N3005B	2-18	ZD							100	5	3W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4098 — 1N4159

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		t_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4098	S	1N3011B	2-18	ZD							150	5	3W
1N4099	S		2-25	ZD						6.46	7.14		250M
1N4100	S		2-25	ZD						7.125	7.875		250M
1N4101	S		2-25	ZD						7.79	8.61		250M
1N4102	S		2-25	ZD						8.265	9.135		250M
1N4103	S		2-25	ZD						8.645	9.555		250M
1N4104	S		2-25	ZD						9.5	10.5		250M
1N4105	S		2-25	ZD						10.45	11.55		250M
1N4106	S		2-25	ZD						11.4	12.6		250M
1N4107	S		2-25	ZD						12.35	13.65		250M
1N4108	S		2-25	ZD						13.3	14.7		250M
1N4109	S		2-25	ZD						14.25	15.75		250M
1N4110	S		2-25	ZD						15.2	16.8		250M
1N4111	S		2-25	ZD						16.15	17.85		250M
1N4112	S		2-25	ZD						17.1	18.9		250M
1N4113	S		2-25	ZD						18.05	19.95		250M
1N4114	S		2-25	ZD						19	21		250M
1N4115	S		2-25	ZD						20.9	23.1		250M
1N4116	S		2-25	ZD						22.8	25.2		250M
1N4117	S		2-25	ZD						23.75	26.25		250M
1N4118	S		2-25	ZD						25.65	28.35		250M
1N4119	S		2-25	ZD						26.6	29.4		250M
1N4120	S		2-25	ZD						28.5	31.5		250M
1N4121	S		2-25	ZD						31.35	34.65		250M
1N4122	S		2-25	ZD						34.2	37.8		250M
1N4123	S		2-25	ZD						37.05	40.95		250M
1N4124	S		2-25	ZD						40.85	45.15		250M
1N4125	S		2-25	ZD						44.65	49.35		250M
1N4126	S		2-25	ZD						48.45	53.55		250M
1N4127	S		2-25	ZD						53.2	58.8		250M
1N4128	S		2-25	ZD						57	63		250M
1N4129	S		2-25	ZD						58.9	65.1		250M
1N4130	S		2-25	ZD						64.6	71.4		250M
1N4131	S		2-25	ZD						71.25	78.75		250M
1N4132	S		2-25	ZD						77.9	86.1		250M
1N4133	S		2-25	ZD						82.65	91.35		250M
1N4134	S		2-25	ZD						86.45	95.55		250M
1N4135	S		2-25	ZD						95	105		250M
1N4136	S	MR1213SL	3-35	R	200	1.6	70	16	750				
1N4137	S	MR1217SL	3-35	R	400	1.6	70	12	750				
1N4138	S	MR1219SL	3-35	R	600	1.6	70	8	750				
1N4139	S	1N4719	3-24	R	50	1	3	.1	300				
1N4140	S	1N4720	3-24	R	100	1	3	.1	300				
1N4141	S	1N4721	3-24	R	200	1	3	.1	300				
1N4142	S	1N4722	3-24	R	400	1	3	.1	300				
1N4143	S	1N4723	3-24	R	600	1	3	.1	300				
1N4144	S	1N4724	3-24	R	800	1	3	.1	300				
1N4145	S	1N4725	3-24	R	1000	1	3	.1	300				
1N4146	S			R	1200	1	3	.1	300				
1N4147	S			CS	30	1	30M	.1*	10				
1N4148	S			HS	75	1	10M	25N	4				
1N4149	S			HS	75	1	10M	25N	4				
1N4150	S			CS	50	1	200M	.1*	6				
1N4151	S			CS	50	1	50M	50N	2				
1N4152	S			HS	30	.88	20M	50N	2				
1N4153	S			HS	50	.88	20M	50N	2				
1N4154	S			CS	25	1	30M	.1*	4				
1N4155	S			MS	400	1	100M	.1*	10				
1N4156	S			CS	20	1.84	.1A	50N					
1N4157	S			CS	20	2.66	.1A	50N					
1N4158	S			ZD							6.8	20	1W
1N4158A	S	1N4736	2-28	ZD							6.8	10	1W
1N4158B	S	1N4736A	2-28	ZD							6.8	5	1W
1N4159	S			ZD							7.5	20	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≧ 2D mA @ ≦ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4159A	S	1N4737	2-28	ZD							7.5	10	1W	
1N4159B	S	1N4737A	2-28	ZD							7.5	5	1W	
1N4160	S			ZD							8.2	20	1W	
1N4160A	S	1N4738	2-28	ZD							8.2	10	1W	
1N4160B	S	1N4738A	2-28	ZD							8.2	5	1W	
1N4161	S			ZD							9.1	20	1W	
1N4161A	S	1N4739	2-28	ZD							9.1	10	1W	
1N4161B	S	1N4739A	2-28	ZD							9.1	5	1W	
1N4162	S			ZD							10	20	1W	
1N4162A	S	1N4740	2-28	ZD							10	10	1W	
1N4162B	S	1N4740A	2-28	ZD							10	5	1W	
1N4163	S			ZD							11	20	1W	
1N4163A	S	1N4741	2-28	ZD							11	10	1W	
1N4163B	S	1N4741A	2-28	ZD							11	5	1W	
1N4164	S			ZD							12	20	1W	
1N4164A	S	1N4742	2-28	ZD							12	10	1W	
1N4164B	S	1N4742A	2-28	ZD							12	5	1W	
1N4165	S			ZD							13	20	1W	
1N4165A	S	1N4743	2-28	ZD							13	10	1W	
1N4165B	S	1N4743A	2-28	ZD							13	5	1W	
1N4166	S			ZD							15	20	1W	
1N4166A	S	1N4744	2-28	ZD							15	10	1W	
1N4166B	S	1N4744A	2-28	ZD							15	5	1W	
1N4167	S			ZD							16	20	1W	
1N4167A	S	1N4745	2-28	ZD							16	10	1W	
1N4167B	S	1N4745A	2-28	ZD							16	5	1W	
1N4168	S			ZD							18	20	1W	
1N4168A	S	1N4746	2-28	ZD							18	10	1W	
1N4168B	S	1N4746A	2-28	ZD							18	5	1W	
1N4169	S			ZD							20	20	1W	
1N4169A	S	1N4747	2-28	ZD							20	10	1W	
1N4169B	S	1N4747A	2-28	ZD							20	5	1W	
1N4170	S			ZD							22	20	1W	
1N4170A	S	1N4748	2-28	ZD							22	10	1W	
1N4170B	S	1N4748A	2-28	ZD							22	5	1W	
1N4171	S			ZD							24	20	1W	
1N4171A	S	1N4749	2-28	ZD							24	10	1W	
1N4171B	S	1N4749A	2-28	ZD							24	5	1W	
1N4172	S			ZD							27	20	1W	
1N4172A	S	1N4750	2-28	ZD							27	10	1W	
1N4172B	S	1N4750A	2-28	ZD							27	5	1W	
1N4173	S			ZD							30	20	1W	
1N4173A	S	1N4751	2-28	ZD							30	10	1W	
1N4173B	S	1N4751A	2-28	ZD							30	5	1W	
1N4174	S			ZD							33	20	1W	
1N4174A	S	1N4752	2-28	ZD							33	10	1W	
1N4174B	S	1N4752A	2-28	ZD							33	5	1W	
1N4175	S			ZD							36	20	1W	
1N4175A	S	1N4753	2-28	ZD							36	10	1W	
1N4175B	S	1N4753A	2-28	ZD							36	5	1W	
1N4176	S			ZD							39	20	1W	
1N4176A	S	1N4754	2-28	ZD							39	10	1W	
1N4176B	S	1N4754A	2-28	ZD							39	5	1W	
1N4177	S			ZD							43	20	1W	
1N4177A	S	1N4755	2-28	ZD							43	10	1W	
1N4177B	S	1N4755A	2-28	ZD							43	5	1W	
1N4178	S			ZD							47	20	1W	
1N4178A	S	1N4756	2-28	ZD							47	10	1W	
1N4178B	S	1N4756A	2-28	ZD							47	5	1W	
1N4179	S			ZD							51	20	1W	
1N4179A	S	1N4757	2-28	ZD							51	10	1W	
1N4179B	S	1N4757A	2-28	ZD							51	5	1W	
1N4180	S			ZD							56	20	1W	
1N4180A	S	1N4758	2-28	ZD							56	10	1W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4180B — 1N4201B

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4180B	S	1N4758A	2-28	ZD							56	5	1W	
1N4181	S			ZD							62	20	1W	
1N4181A	S	1N4759	2-28	ZD							62	10	1W	
1N4181B	S	1N4759A	2-28	ZD							62	5	1W	
1N4182	S			ZD							68	20	1W	
1N4182A	S	1N4760	2-28	ZD							68	10	1W	
1N4182B	S	1N4760A	2-28	ZD							68	5	1W	
1N4183	S			ZD							75	20	1W	
1N4183A	S	1N4761	2-28	ZD							75	10	1W	
1N4183B	S	1N4761A	2-28	ZD							75	5	1W	
1N4184	S			ZD							82	20	1W	
1N4184A	S	1N4762	2-28	ZD							82	10	1W	
1N4184B	S	1N4762A	2-28	ZD							82	5	1W	
1N4185	S			ZD							91	20	1W	
1N4185A	S	1N4763	2-28	ZD							91	10	1W	
1N4185B	S	1N4763A	2-28	ZD							91	5	1W	
1N4186	S			ZD							100	20	1W	
1N4186A	S	1N4764	2-28	ZD							100	10	1W	
1N4186B	S	1N4764A	2-28	ZD							100	5	1W	
1N4187	S			ZD							110	20	1W	
1N4187A	S			ZD							110	10	1W	
1N4187B	S			ZD							110	5	1W	
1N4188	S			ZD							120	20	1W	
1N4188A	S			ZD							120	10	1W	
1N4188B	S			ZD							120	5	1W	
1N4189	S			ZD							130	20	1W	
1N4189A	S			ZD							130	10	1W	
1N4189B	S			ZD							130	5	1W	
1N4190	S			ZD							150	20	1W	
1N4190A	S			ZD							150	10	1W	
1N4190B	S			ZD							150	5	1W	
1N4191	S			ZD							160	20	1W	
1N4191A	S			ZD							160	10	1W	
1N4191B	S			ZD							160	5	1W	
1N4192	S			ZD							180	20	1W	
1N4192A	S			ZD							180	10	1W	
1N4192B	S			ZD							180	5	1W	
1N4193	S			ZD							200	20	1W	
1N4193A	S			ZD							200	10	1W	
1N4193B	S			ZD							200	5	1W	
1N4194	S	1N2970	2-18	ZD							6.8	20	10W	
1N4194A	S	1N2970A	2-18	ZD							6.8	10	10W	
1N4194B	S	1N2970B	2-18	ZD							6.8	5	10W	
1N4195	S	1N2971	2-18	ZD							7.5	20	10W	
1N4195A	S	1N2971A	2-18	ZD							7.5	10	10W	
1N4195B	S	1N2971B	2-18	ZD							7.5	5	10W	
1N4196	S	1N2972	2-18	ZD							8.2	20	10W	
1N4196A	S	1N2972A	2-18	ZD							8.2	10	10W	
1N4196B	S	1N2972B	2-18	ZD							8.2	5	10W	
1N4197	S	1N2973	2-18	ZD							9.1	20	10W	
1N4197A	S	1N2973A	2-18	ZD							9.1	10	10W	
1N4197B	S	1N2973B	2-18	ZD							9.1	5	10W	
1N4198	S	1N2974	2-18	ZD							10	20	10W	
1N4198A	S	1N2974A	2-18	ZD							10	10	10W	
1N4198B	S	1N2974B	2-18	ZD							10	5	10W	
1N4199	S	1N2975	2-18	ZD							11	20	10W	
1N4199A	S	1N2975A	2-18	ZD							11	10	10W	
1N4199B	S	1N2975B	2-18	ZD							11	5	10W	
1N4200	S	1N2976	2-18	ZD							12	20	10W	
1N4200A	S	1N2976A	2-18	ZD							12	10	10W	
1N4200B	S	1N2976B	2-18	ZD							12	5	10W	
1N4201	S	1N2977	2-18	ZD							13	20	10W	
1N4201A	S	1N2977A	2-18	ZD							13	10	10W	
1N4201B	S	1N2977B	2-18	ZD							13	5	10W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4202	S	1N2978	2-18	ZD							14	20	10W	
1N4202A	S	1N2978A	2-18	ZD							14	10	10W	
1N4202B	S	1N2978B	2-18	ZD							14	5	10W	
1N4203	S	1N2979	2-18	ZD							15	20	10W	
1N4203A	S	1N2979A	2-18	ZD							15	10	10W	
1N4203B	S	1N2979B	2-18	ZD							15	5	10W	
1N4204	S	1N2980	2-18	ZD							16	20	10W	
1N4204A	S	1N2980A	2-18	ZD							16	10	10W	
1N4204B	S	1N2980B	2-18	ZD							16	5	10W	
1N4205	S	1N2981	2-18	ZD							17	20	10W	
1N4205A	S	1N2981A	2-18	ZD							17	10	10W	
1N4205B	S	1N2981B	2-18	ZD							17	5	10W	
1N4206	S	1N2982	2-18	ZD							18	20	10W	
1N4206A	S	1N2982A	2-18	ZD							18	10	10W	
1N4206B	S	1N2982B	2-18	ZD							18	5	10W	
1N4207	S	1N2983	2-18	ZD							19	20	10W	
1N4207A	S	1N2983A	2-18	ZD							19	10	10W	
1N4207B	S	1N2983B	2-18	ZD							19	5	10W	
1N4208	S	1N2984	2-18	ZD							20	20	10W	
1N4208A	S	1N2984A	2-18	ZD							20	10	10W	
1N4208B	S	1N2984B	2-18	ZD							20	5	10W	
1N4209	S	1N2985	2-18	ZD							22	20	10W	
1N4209A	S	1N2985A	2-18	ZD							22	10	10W	
1N4209B	S	1N2985B	2-18	ZD							22	5	10W	
1N4210	S	1N2986	2-18	ZD							24	20	10W	
1N4210A	S	1N2986A	2-18	ZD							24	10	10W	
1N4210B	S	1N2986B	2-18	ZD							24	5	10W	
1N4211	S	1N2987	2-18	ZD							25	20	10W	
1N4211A	S	1N2987A	2-18	ZD							25	10	10W	
1N4211B	S	1N2987B	2-18	ZD							25	5	10W	
1N4212	S	1N2988	2-18	ZD							27	20	10W	
1N4212A	S	1N2988A	2-18	ZD							27	10	10W	
1N4212B	S	1N2988B	2-18	ZD							27	5	10W	
1N4213	S	1N2989	2-18	ZD							30	20	10W	
1N4213A	S	1N2989A	2-18	ZD							30	10	10W	
1N4213B	S	1N2989B	2-18	ZD							30	5	10W	
1N4214	S	1N2990	2-18	ZD							33	20	10W	
1N4214A	S	1N2990A	2-18	ZD							33	10	10W	
1N4214B	S	1N2990B	2-18	ZD							33	5	10W	
1N4215	S	1N2991	2-18	ZD							36	20	10W	
1N4215A	S	1N2991A	2-18	ZD							36	10	10W	
1N4215B	S	1N2991B	2-18	ZD							36	5	10W	
1N4216	S	1N2992	2-18	ZD							39	20	10W	
1N4216A	S	1N2992A	2-18	ZD							39	10	10W	
1N4216B	S	1N2992B	2-18	ZD							39	5	10W	
1N4217	S	1N2993	2-18	ZD							43	20	10W	
1N4217A	S	1N2993A	2-18	ZD							43	10	10W	
1N4217B	S	1N2993B	2-18	ZD							43	5	10W	
1N4218	S	1N2994	2-18	ZD							45	20	10W	
1N4218A	S	1N2994A	2-18	ZD							45	10	10W	
1N4218B	S	1N2994B	2-18	ZD							45	5	10W	
1N4219	S	1N2995	2-18	ZD							47	20	10W	
1N4219A	S	1N2995A	2-18	ZD							47	10	10W	
1N4219B	S	1N2995B	2-18	ZD							47	5	10W	
1N4220	S	1N2996	2-18	ZD							50	20	10W	
1N4220A	S	1N2996A	2-18	ZD							50	10	10W	
1N4220B	S	1N2996B	2-18	ZD							50	5	10W	
1N4221	S	1N2997	2-18	ZD							51	20	10W	
1N4221A	S	1N2997A	2-18	ZD							51	10	10W	
1N4221B	S	1N2997B	2-18	ZD							51	5	10W	
1N4222	S	1N2998	2-18	ZD							52	20	10W	
1N4222A	S	1N2998A	2-18	ZD							52	10	10W	
1N4222B	S	1N2998B	2-18	ZD							52	5	10W	
1N4223	S	1N2999	2-18	ZD							56	20	10W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4223A — 1N4253

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z(min)	V_Z (nom) V_Z(max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4223A	S	1N2999A	2-18	ZD							56	10	10W	
1N4223B	S	1N2999B	2-18	ZD							56	5	10W	
1N4224	S	1N3000	2-18	ZD							62	20	10W	
1N4224A	S	1N3000A	2-18	ZD							62	10	10W	
1N4224B	S	1N3000B	2-18	ZD							62	5	10W	
1N4225	S	1N3001	2-18	ZD							68	20	10W	
1N4225A	S	1N3001A	2-18	ZD							68	10	10W	
1N4225B	S	1N3001B	2-18	ZD							68	5	10W	
1N4226	S	1N3002	2-18	ZD							75	20	10W	
1N4226A	S	1N3002A	2-18	ZD							75	10	10W	
1N4226B	S	1N3002B	2-18	ZD							75	5	10W	
1N4227	S	1N3003	2-18	ZD							82	20	10W	
1N4227A	S	1N3003A	2-18	ZD							82	10	10W	
1N4227B	S	1N3003B	2-18	ZD							82	5	10W	
1N4228	S	1N3004	2-18	ZD							91	20	10W	
1N4228A	S	1N3004A	2-18	ZD							91	10	10W	
1N4228B	S	1N3004B	2-18	ZD							91	5	10W	
1N4229	S	1N3005	2-18	ZD							100	20	10W	
1N4229A	S	1N3005A	2018	ZD							100	10	10W	
1N4229B	S	1N3005B	2-18	ZD							100	5	10W	
1N4230	S	1N3006	2-18	ZD							105	20	10W	
1N4230A	S	1N3006A	2-18	ZD							105	10	10W	
1N4230B	S	1N3006B	2-18	ZD							105	5	10W	
1N4231	S	1N3007	2-18	ZD							110	20	10W	
1N4231A	S	1N3007A	2-18	ZD							110	10	10W	
1N4231B	S	1N3007B	2-18	ZD							110	5	10W	
1N4232	S	1N3008	2-18	ZD							120	20	10W	
1N4232A	S	1N3008A	2-18	ZD							120	10	10W	
1N4232B	S	1N3008B	2-18	ZD							120	5	10W	
1N4233	S	1N3009	2-18	ZD							130	20	10W	
1N4233A	S	1N3009A	2-18	ZD							130	10	10W	
1N4233B	S	1N3009B	2-18	ZD							130	5	10W	
1N4234	S	1N3010	2-18	ZD							140	20	10W	
1N4234A	S	1N3010A	2-18	ZD							140	10	10W	
1N4234B	S	1N3010B	2-18	ZD							140	5	10W	
1N4235	S	1N3011	2-18	ZD							150	20	10W	
1N4235A	S	1N3011A	2-18	ZD							150	10	10W	
1N4235B	S	1N3011B	2-18	ZD							150	5	10W	
1N4236	S	1N3012	2-18	ZD							160	20	10W	
1N4236A	S	1N3012A	2-18	ZD							160	10	10W	
1N4236B	S	1N3012B	2-18	ZD							160	5	10W	
1N4237	S	1N3013	2-18	ZD							175	20	10W	
1N4237A	S	1N3013A	2-18	ZD							175	10	10W	
1N4237B	S	1N3013B	2-18	ZD							175	5	10W	
1N4238	S	1N3014	2-18	ZD							180	20	10W	
1N4238A	S	1N3014A	2-18	ZD							180	10	10W	
1N4238B	S	1N3014B	2-18	ZD							180	5	10W	
1N4239	S	1N3015	2-18	ZD							200	20	10W	
1N4239A	S	1N3015A	2-18	ZD							200	10	10W	
1N4239B	S	1N3015B	2-18	ZD							200	5	10W	
1N4240	S			ZD						4.9	5.1		10W	
1N4241	S			ZD						5.9	6.1		10W	
1N4242	S			HS	40	1	10M	.1N	2					
1N4243	S			HS	40	1	10M	.1N	2					
1N4244	S			HS	10	1	20M	.1*	.75					
1N4245	S	1N4003	3-23	R	200	1.64	1	.05	25					
1N4246	S	1N4004	3-23	R	400	1.64	1	.05	25					
1N4247	S	1N4005	3-23	R	600	1.64	1	.05	25					
1N4248	S	1N4006	3-23	R	800	1.64	1	.05	25					
1N4249	S	1N4007	3-23	R	1000	1.64	1	.05	25					
1N4250	S	1N4006	3-23	R	800		.5	.05	10					
1N4251	S	1N4007	3-23	R	1000		.5	.05	10					
1N4252	S			R	1200		.5	.05	10					
1N4253	S			R	1500		.5	.05	10					

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4254	S			R	1500	4.8	.25	.05	6.25					
1N4255	S			R	2000	4.8	.25	.05	6.25					
1N4256	S			R	2500	4.8	.25	.05	6.25					
1N4257	S			R	3000	4.8	.25	.05	6.25					
1N4258	S	1N2970	2-18	ZD							6.8	20	10W	
1N4258A	S	1N2970A	2-18	ZD							6.8	10	10W	
1N4258B	S	1N2970B	2-18	ZD							6.8	5	10W	
1N4259	S	1N2971	2-18	ZD							7.5	20	10W	
1N4259A	S	1N2971A	2-18	ZD							7.5	10	10W	
1N4259B	S	1N2971B	2-18	ZD							7.5	5	10W	
1N4260	S	1N2972	2-18	ZD							8.2	20	10W	
1N4260A	S	1N2972A	2-18	ZD							8.2	10	10W	
1N4260B	S	1N2972B	2-18	ZD							8.2	5	10W	
1N4261	S	1N2973	2-18	ZD							9.1	20	10W	
1N4261A	S	1N2973A	2-18	ZD							9.1	10	10W	
1N4261B	S	1N2973B	2-18	ZD							9.1	5	10W	
1N4262	S	1N2974	2-18	ZD							10	20	10W	
1N4262A	S	1N2974A	2-18	ZD							10	10	10W	
1N4262B	S	1N2974B	2-18	ZD							10	5	10W	
1N4263	S	1N2975	2-18	ZD							11	20	10W	
1N4263A	S	1N2975A	2-18	ZD							11	10	10W	
1N4263B	S	1N2975B	2-18	ZD							11	5	10W	
1N4264	S	1N2976	2-18	ZD							12	20	10W	
1N4264A	S	1N2976A	2-18	ZD							12	10	10W	
1N4264B	S	1N2976B	2-18	ZD							12	5	10W	
1N4265	S	1N2977	2-18	ZD							13	20	10W	
1N4265A	S	1N2977A	2-18	ZD							13	10	10W	
1N4265B	S	1N2977B	2-18	ZD							13	5	10W	
1N4266	S	1N2979	2-18	ZD							15	20	10W	
1N4266A	S	1N2979A	2-18	ZD							15	10	10W	
1N4266B	S	1N2979B	2-18	ZD							15	5	10W	
1N4267	S	1N2980	2-18	ZD							16	20	10W	
1N4267A	S	1N2980A	2-18	ZD							16	10	10W	
1N4267B	S	1N2980B	2-18	ZD							16	5	10W	
1N4268	S	1N2982	2-18	ZD							18	20	10W	
1N4268A	S	1N2982A	2-18	ZD							18	10	10W	
1N4268B	S	1N2982B	2-18	ZD							18	5	10W	
1N4269	S	1N2984	2-18	ZD							20	20	10W	
1N4269A	S	1N2984A	2-18	ZD							20	10	10W	
1N4269B	S	1N2984B	2-18	ZD							20	5	10W	
1N4270	S	1N2985	2-18	ZD							22	20	10W	
1N4270A	S	1N2985A	2-18	ZD							22	10	10W	
1N4270B	S	1N2985B	2-18	ZD							22	5	10W	
1N4271	S	1N2986	2-18	ZD							24	20	10W	
1N4271A	S	1N2986A	2-18	ZD							24	10	10W	
1N4271B	S	1N2986B	2-18	ZD							24	5	10W	
1N4272	S	1N2988	2-18	ZD							27	20	10W	
1N4272A	S	1N2988A	2-18	ZD							27	10	10W	
1N4272B	S	1N2988B	2-18	ZD							27	5	10W	
1N4273	S	1N2989	2-18	ZD							30	20	10W	
1N4273A	S	1N2989A	2-18	ZD							30	10	10W	
1N4273B	S	1N2989B	2-18	ZD							30	5	10W	
1N4274	S	1N2990	2-18	ZD							33	20	10W	
1N4274A	S	1N2990A	2-18	ZD							33	10	10W	
1N4274B	S	1N2990B	2-18	ZD							33	5	10W	
1N4275	S	1N2991	2-18	ZD							36	20	10W	
1N4275A	S	1N2991A	2-18	ZD							36	10	10W	
1N4275B	S	1N2991B	2-18	ZD							36	5	10W	
1N4276	S	1N2992	2-18	ZD							39	20	10W	
1N4276A	S	1N2992A	2-18	ZD							39	10	10W	
1N4276B	S	1N2992B	2-18	ZD							39	5	10W	
1N4277	S	1N2993	2-18	ZD							43	20	10W	
1N4277A	S	1N2993A	2-18	ZD							43	10	10W	
1N4277B	S	1N2993B	2-18	ZD							43	5	10W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4278 — 1N4300B

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4278	S	1N2995	2-18	ZD							47	20	10W	
1N4278A	S	1N2995A	2-18	ZD							47	10	10W	
1N4278B	S	1N2995B	2-18	ZD							47	5	10W	
1N4279	S	1N2997	2-18	ZD							51	20	10W	
1N4279A	S	1N2997A	2-18	ZD							51	10	10W	
1N4279B	S	1N2997B	2-18	ZD							51	5	10W	
1N4280	S	1N2999	2-18	ZD							56	20	10W	
1N4280A	S	1N2999A	2-18	ZD							56	10	10W	
1N4280B	S	1N2999B	2-18	ZD							56	5	10W	
1N4281	S	1N3000	2-18	ZD							62	20	10W	
1N4281A	S	1N3000A	2-18	ZD							62	10	10W	
1N4281B	S	1N3000B	2-18	ZD							62	5	10W	
1N4282	S	1N3001	2-18	ZD							68	20	10W	
1N4282A	S	1N3001A	2-18	ZD							68	10	10W	
1N4282B	S	1N3001B	2-18	ZD							68	5	10W	
1N4283	S	1N3002	2-18	ZD							75	20	10W	
1N4283A	S	1N3002A	2-18	ZD							75	10	10W	
1N4283B	S	1N3002B	2-18	ZD							75	5	10W	
1N4284	S	1N3003	2-18	ZD							82	20	10W	
1N4284A	S	1N3003A	2-18	ZD							82	10	10W	
1N4284B	S	1N3003B	2-18	ZD							82	5	10W	
1N4285	S	1N3004	2-18	ZD							91	20	10W	
1N4285A	S	1N3004A	2-18	ZD							91	10	10W	
1N4285B	S	1N3004B	2-18	ZD							91	5	10W	
1N4286	S	1N3005	2-18	ZD							100	20	10W	
1N4286A	S	1N3005A	2-18	ZD							100	10	10W	
1N4286B	S	1N3005B	2-18	ZD							100	5	10W	
1N4287	S	1N3007	2-18	ZD							110	20	10W	
1N4287A	S	1N3007A	2-18	ZD							110	10	10W	
1N4287B	S	1N3007B	2-18	ZD							110	5	10W	
1N4288	S	1N3008	2-18	ZD							120	20	10W	
1N4288A	S	1N3008A	2-18	ZD							120	10	10W	
1N4288B	S	1N3008B	2-18	ZD							120	5	10W	
1N4289	S	1N3009	2-18	ZD							130	20	10W	
1N4289A	S	1N3009A	2-18	ZD							130	10	10W	
1N4289B	S	1N3009B	2-18	ZD							130	5	10W	
1N4290	S	1N3011	2-18	ZD							150	20	10W	
1N4290A	S	1N3011A	2-18	ZD							150	10	10W	
1N4290B	S	1N3011B	2-18	ZD							150	5	10W	
1N4291	S	1N3012	2-18	ZD							160	20	10W	
1N4291A	S	1N3012A	2-18	ZD							160	10	10W	
1N4291B	S	1N3012B	2-18	ZD							160	5	10W	
1N4292	S	1N3014	2-18	ZD							180	20	10W	
1N4292A	S	1N3014A	2-18	ZD							180	10	10W	
1N4292B	S	1N3014B	2-18	ZD							180	5	10W	
1N4293	S	1N3015	2-18	ZD							200	20	10W	
1N4293A	S	1N3015A	2-18	ZD							200	10	10W	
1N4293B	S	1N3015B	2-18	ZD							200	5	10W	
1N4295	S	1N945B	2-32	RD						.012	10	-55	150	
1N4295A	S	1N945B	2-32	RD						.012	10	-55	150	
1N4296	S	1N2624B	2-32	ZD							10	2	1W	
1N4296A	S	1N2624B	2-32	ZD							10	1	1W	
1N4297	S			RD						.01	8.8	0	75	
1N4297A	S			RD						.01	8.8	-55	100	
1N4297B	S			RD						.01	8.8	-55	150	
1N4298	S			RD						.005	8.8	0	75	
1N4298A	S			RD						.005	8.8	-55	100	
1N4298B	S			RD						.005	8.8	-55	150	
1N4299	S			RD						.01	11.3	0	75	
1N4299A	S			RD						.01	11.3	-55	100	
1N4299B	S			RD						.01	11.3	-55	150	
1N4300	S			RD						.005	11.3	0	75	
1N4300A	S			RD						.005	11.3	-55	100	
1N4300B	S			RD						.005	11.3	-55	150	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4301	S			RD						.01	8.8	0	75
1N4301A	S			RD						.01	8.8	-55	100
1N4301B	S			RD						.01	8.8	-55	150
1N4302	S			RD						.005	8.8	0	75
1N4302A	S			RD						.005	8.8	-55	100
1N4302B	S			RD						.005	8.8	-55	150
1N4303	S			RD						.01	11.3	0	75
1N4303A	S			RD						.01	11.3	-55	100
1N4303B	S			RD						.01	11.3	-55	150
1N4304	S			RD						.005	11.3	0	75
1N4304A	S			RD						.005	11.3	-55	100
1N4304B	S			RD						.005	11.3	-55	150
1N4305	S			HS	75	.575	.25M	.1*	2				
1N4306	S			SP	50	1	50M	50N	2				
1N4307	S			SP	50	1	50M	50N	2				
1N4308	S			CS	80	1	200M	.1*	2				
1N4309	S			CS	40	1	400M	.1*	2				
1N4310	S			CS	60	1	400M	.1*	2				
1N4311	S			CS	80	1	300M	.1*	2				
1N4312	S			CS	120	1	200M	.1*	2				
1N4313	S			CS	80	1	100M	.1*	4				
1N4314	S			CS	80	1	200M	.1*	2				
1N4315	S			CS	40	1	400M	.1*	2				
1N4316	S			CS	60	1	400M	.1*	2				
1N4317	S			CS	80	1	300M	.1*	2				
1N4318	S			CS	120	1	200M	.1*	2				
1N4319	S			CS	80	1	100M	.1*	4				
1N4321	S	1N2996A	2-18	ZD							50	10	3W
1N4322	S			CS	50	1	.2A	.1*	6				
1N4323	S	1N3016	2-19	ZD							6.8	20	1W
1N4323A	S	1N3016A	2-19	ZD							6.8	10	1W
1N4323B	S	1N3016B	2-19	ZD							6.8	5	1W
1N4324	S	1N3017	2-19	ZD							7.5	20	1W
1N4324A	S	1N3017A	2-19	ZD							7.5	10	1W
1N4324B	S	1N3017B	2-19	ZD							7.5	5	1W
1N4325	S	1N3018	2-19	ZD							8.2	20	1W
1N4325A	S	1N3018A	2-19	ZD							8.2	10	1W
1N4325B	S	1N3018B	2-19	ZD							8.2	5	1W
1N4326	S	1N3019	2-19	ZD							9.1	20	1W
1N4326A	S	1N3019A	2-19	ZD							9.1	10	1W
1N4326B	S	1N3019B	2-19	ZD							9.1	5	1W
1N4327	S	1N3020	2-19	ZD							10	20	1W
1N4327A	S	1N3020A	2-19	ZD							10	10	1W
1N4327B	S	1N3020B	2-19	ZD							10	5	1W
1N4328	S	1N3021	2-19	ZD							11	20	1W
1N4328A	S	1N3021A	2-19	ZD							11	10	1W
1N4328B	S	1N3021B	2-19	ZD							11	5	1W
1N4329	S	1N3022	2-19	ZD							12	20	1W
1N4329A	S	1N3022A	2-19	ZD							12	10	1W
1N4329B	S	1N3022B	2-19	ZD							12	5	1W
1N4330	S	1N3023	2-19	ZD							13	20	1W
1N4330A	S	1N3023A	2-19	ZD							13	10	1W
1N4330B	S	1N3023B	2-19	ZD							13	5	1W
1N4331	S	1N3024	2-19	ZD							15	20	1W
1N4331A	S	1N3024A	2-19	ZD							15	10	1W
1N4331B	S	1N3024B	2-19	ZD							15	5	1W
1N4332	S	1N3025	2-19	ZD							16	20	1W
1N4332A	S	1N3025A	2-19	ZD							16	10	1W
1N4332B	S	1N3025B	2-19	ZD							16	5	1W
1N4333	S	1N3026	2-19	ZD							18	20	1W
1N4333A	S	1N3026A	2-19	ZD							18	10	1W
1N4333B	S	1N3026B	2-19	ZD							18	5	1W
1N4334	S	1N3027	2-19	ZD							20	20	1W
1N4334A	S	1N3027A	2-19	ZD							20	10	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4334B — 1N4355B

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4334B	S	1N3027B	2-19	ZD							20	5	1W	
1N4335	S	1N3028	2-19	ZD							22	20	1W	
1N4335A	S	1N3028A	2-19	ZD							22	10	1W	
1N4335B	S	1N3028B	2-19	ZD							22	5	1W	
1N4336	S	1N3029	2-19	ZD							24	20	1W	
1N4336A	S	1N3029A	2-19	ZD							24	10	1W	
1N4336B	S	1N3029B	2-19	ZD							24	5	1W	
1N4337	S	1N3030	2-19	ZD							27	20	1W	
1N4337A	S	1N3030A	2-19	ZD							27	10	1W	
1N4337B	S	1N3030B	2-19	ZD							27	5	1W	
1N4338	S	1N3031	2-19	ZD							30	20	1W	
1N4338A	S	1N3031A	2-19	ZD							30	10	1W	
1N4338B	S	1N3031B	2-19	ZD							30	5	1W	
1N4339	S	1N3032	2-19	ZD							33	20	1W	
1N4339A	S	1N3032A	2-19	ZD							33	10	1W	
1N4339B	S	1N3032B	2-19	ZD							33	5	1W	
1N4340	S	1N3033	2-19	ZD							36	20	1W	
1N4340A	S	1N3033A	2-19	ZD							36	10	1W	
1N4340B	S	1N3033B	2-19	ZD							36	5	1W	
1N4341	S	1N3034	2-19	ZD							39	20	1W	
1N4341A	S	1N3034A	2-19	ZD							39	10	1W	
1N4341B	S	1N3034B	2-19	ZD							39	5	1W	
1N4342	S	1N3035	2-19	ZD							43	20	1W	
1N4342A	S	1N3035A	2-19	ZD							43	10	1W	
1N4342B	S	1N3035B	2-19	ZD							43	5	1W	
1N4343	S	1N3036	2-19	ZD							47	20	1W	
1N4343A	S	1N3036A	2-19	ZD							47	10	1W	
1N4343B	S	1N3036B	2-19	ZD							47	5	1W	
1N4344	S	1N3037	2-19	ZD							51	20	1W	
1N4344A	S	1N3037A	2-19	ZD							51	10	1W	
1N4344B	S	1N3037B	2-19	ZD							51	5	1W	
1N4345	S	1N3038	2-19	ZD							56	20	1W	
1N4345A	S	1N3038A	2-19	ZD							56	10	1W	
1N4345B	S	1N3038B	2-19	ZD							56	5	1W	
1N4346	S	1N3039	2-19	ZD							62	20	1W	
1N4346A	S	1N3039A	2-19	ZD							62	10	1W	
1N4346B	S	1N3039B	2-19	ZD							62	5	1W	
1N4347	S	1N3040	2-19	ZD							68	20	1W	
1N4347A	S	1N3040A	2-19	ZD							68	10	1W	
1N4347B	S	1N3040B	2-19	ZD							68	5	1W	
1N4348	S	1N3041	2-19	ZD							75	20	1W	
1N4348A	S	1N3041A	2-19	ZD							75	10	1W	
1N4348B	S	1N3041B	2-19	ZD							75	5	1W	
1N4349	S	1N3042	2-19	ZD							82	20	1W	
1N4349A	S	1N3042A	2-19	ZD							82	10	1W	
1N4349B	S	1N3042B	2-19	ZD							82	5	1W	
1N4350	S	1N3043	2-19	ZD							91	20	1W	
1N4350A	S	1N3043A	2-19	ZD							91	10	1W	
1N4350B	S	1N3043B	2-19	ZD							91	5	1W	
1N4351	S	1N3044	2-19	ZD							100	20	1W	
1N4351A	S	1N3044A	2-19	ZD							100	10	1W	
1N4351B	S	1N3044B	2-19	ZD							100	5	1W	
1N4352	S	1N3045	2-19	ZD							110	20	1W	
1N4352A	S	1N3045A	2-19	ZD							110	10	1W	
1N4352B	S	1N3045B	2-19	ZD							110	5	1W	
1N4353	S	1N3046	2-19	ZD							120	20	1W	
1N4353A	S	1N3046A	2-19	ZD							120	10	1W	
1N4353B	S	1N3046B	2-19	ZD							120	5	1W	
1N4354	S	1N3047	2-19	ZD							130	20	1W	
1N4354A	S	1N3047A	2-19	ZD							130	10	1W	
1N4354B	S	1N3047B	2-19	ZD							130	5	1W	
1N4355	S	1N3048	2-19	ZD							150	20	1W	
1N4355A	S	1N3048A	2-19	ZD							150	10	1W	
1N4355B	S	1N3048B	2-19	ZD							150	5	1W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4356	S	1N3049	2-19	ZD							160	20	1W
1N4356A	S	1N3049A	2-19	ZD							160	10	1W
1N4356B	S	1N3049B	2-19	ZD							160	5	1W
1N4357	S	1N3050	2-19	ZD							180	20	1W
1N4357A	S	1N3050A	2-19	ZD							180	10	1W
1N4357B	S	1N3050B	2-19	ZD							180	5	1W
1N4358	S	1N3051	2-19	ZD							200	20	1W
1N4358A	S	1N3051A	2-19	ZD							200	10	1W
1N4358B	S	1N3051B	2-19	ZD							200	5	1W
1N4359	S			SP	200								
1N4360	S	1N4370A	2-10	ZD						2.28	2.52		.25W
1N4361	S	1N4007	3-23	R	900	1.3	.5	.5	20				
1N4362	S			GP	100	.9	.1A	10N					
1N4363	S			CS	120	1	.2A	.1*	40				
1N4364	S	1N4002	3-23	R	100	1.5	.75	.1	20				
1N4365	S	1N4003	3-23	R	200	1.5	.75	.1	20				
1N4366	S	1N4004	3-23	R	300	1.5	.75	.1	20				
1N4367	S	1N4004	3-23	R	400	1.5	.75	.1	20				
1N4368	S	1N4005	3-23	R	500	1.5	.75	.1	20				
1N4369	S	1N4005	3-23	R	600	1.5	.75	.1	20				
1N4370	S		2-10	ZD							2.4	10	.4W
1N4370A	S		2-10	ZD							2.4	5	.4W
1N4371	S		2-10	ZD							2.7	10	.4W
1N4371A	S		2-10	ZD							2.7	5	.4W
1N4372	S		2-10	ZD							3.0	10	.4W
1N4372A	S		2-10	ZD							3.0	5	.4W
1N4373	S			HS	80	1	10M	5*	4				
1N4374	S			R	1500	1.75	.75	.1	15				
1N4375	S			HS	50	1	20M	10N	6				
1N4376	S			CS	10	1.1	50M	.1*	.75				
1N4377	S			R	25K	30	.75	.1	50				
1N4380	S			CS	50	1.4	570M	50N	1.8				
1N4381	G			HS	25	.35	2M	.1M	.1				
1N4382	S			CS	55	1	.3A	.1*	6.5				
1N4383	S	1N4003	3-23	R	200	1.3	1	.275	50				
1N4384	S	1N4004	3-23	R	400	1.3	1	.25	50				
1N4385	S	1N4005	3-23	R	600	1.3	1	.225	50				
1N4386													
1N4387		Varactor Diodes, see table on page 1-99											
1N4389	S			SP	5	1	2M	.1M					
1N4390	S			SP	20	1	5M	.2*	.5				
1N4391	S			SP	20	1	2M	.2*	.5				
1N4392	S			SP	15	1	2M	1*	.5				
1N4400	S			ZD							6.8	20	1W
1N4401	S			ZD							7.5	20	1W
1N4402	S			ZD							8.2	20	1W
1N4403	S			ZD							9.1	20	1W
1N4404	S			ZD							10	20	1W
1N4405	S			ZD							11	20	1W
1N4406	S			ZD							12	20	1W
1N4407	S			ZD							13	20	1W
1N4408	S			ZD							15	20	1W
1N4409	S			ZD							16	20	1W
1N4410	S			ZD							18	20	1W
1N4411	S			ZD							20	20	1W
1N4412	S			ZD							22	20	1W
1N4413	S			ZD							24	20	1W
1N4414	S			ZD							27	20	1W
1N4415	S			ZD							30	20	1W
1N4416	S			ZD							33	20	1W
1N4417	S			ZD							36	20	1W
1N4418	S			ZD							39	20	1W
1N4419	S			ZD							43	20	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4420 — 1N4483

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4420	S			ZD							47	20	1W
1N4421	S			ZD							51	20	1W
1N4422	S			ZD							56	20	1W
1N4423	S			ZD							62	20	1W
1N4424	S			ZD							68	20	1W
1N4425	S			ZD							75	20	1W
1N4426	S			ZD							82	20	1W
1N4427	S			ZD							91	20	1W
1N4428	S			ZD							100	20	1W
1N4429	S			ZD							110	20	1W
1N4430	S			ZD							120	20	1W
1N4431	S			ZD							130	20	1W
1N4432	S			ZD							150	20	1W
1N4433	S			ZD							160	20	1W
1N4434	S			ZD							180	20	1W
1N4435	S			ZD							200	20	1W
1N4436	S			R	200	1.2	10	1	100				
1N4437	S			R	400	1.2	10	1	100				
1N4438	S			R	600	1	10	1	100				
1N4439	S			R	800	1.2	10	1	100				
1N4440	S			R	1000	1.2	10	1	100				
1N4441	S			R	1500	4	.025	.001	3				
1N4442	S			CS	30	1	.1A	1N	1				
1N4443	S			CS	50	1	.1A	2N	.6				
1N4444	S			CS	50	1	.1A	50N	7				
1N4445	S			CS	100	1	.1A	50N	4				
1N4446	S			CS	75	1	20M	25N	4				
1N4447	S			CS	75	1	20M	25N	4				
1N4448	S			CS	75	.72	5M	25N	4				
1N4449	S			CS	75	.73	5M	25N	4				
1N4450	S			CS	30	.92	.1A	50N	4				
1N4451	S			CS	30	.875	.1A	50N	10				
1N4452	S			CS	30	1.2	1A	50N	50				
1N4453	S			CS	20	.92	.1A	50N					
1N4454	S			CS	75	1	10M	.1*	2				
1N4455	S			GP	50	.7	5M	.1*					
1N4456	S			CS	35	1	.15A	.2*	1.5				
1N4457	S			CS	50	1	.2A	.2*	1.5				
1N4458	S			R	800	1.5	5	.5	150				
1N4459	S			R	1000	1.5	5	.5	150				
1N4460	S			ZD							6.2	5	1.5W
1N4461	S			ZD							6.8	5	1.5W
1N4462	S			ZD							7.5	5	1.5W
1N4463	S			ZD							8.2	5	1.5W
1N4464	S			ZD							9.1	5	1.5W
1N4465	S			ZD							10	5	1.5W
1N4466	S			ZD							11	5	1.5W
1N4467	S			ZD							12	5	1.5W
1N4468	S			ZD							13	5	1.5W
1N4469	S			ZD							15	5	1.5W
1N4470	S			ZD							16	5	1.5W
1N4471	S			ZD							18	5	1.5W
1N4472	S			ZD							20	5	1.5W
1N4473	S			ZD							22	5	1.5W
1N4474	S			ZD							24	5	1.5W
1N4475	S			ZD							27	5	1.5W
1N4476	S			ZD							30	5	1.5W
1N4477	S			ZD							33	5	1.5W
1N4478	S			ZD							36	5	1.5W
1N4479	S			ZD							39	5	1.5W
1N4480	S			ZD							43	5	1.5W
1N4481	S			ZD							47	5	1.5W
1N4482	S			ZD							51	5	1.5W
1N4483	S			ZD							56	5	1.5W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4484	S			ZD							62	5	1.5W	
1N4485	S			ZD							68	5	1.5W	
1N4486	S			ZD							75	5	1.5W	
1N4487	S			ZD							82	5	1.5W	
1N4488	S			ZD							91	5	1.5W	
1N4489	S			ZD							100	5	1.5W	
1N4490	S			ZD							110	5	1.5W	
1N4491	S			ZD							120	5	1.5W	
1N4492	S			ZD							130	5	1.5W	
1N4493	S			ZD							150	5	1.5W	
1N4494	S			ZD							160	5	1.5W	
1N4495	S			ZD							180	5	1.5W	
1N4496	S			ZD							200	5	1.5W	
1N4497	S			R	1600	3	.75	.1	35					
1N4498	S			R	3000	5	.75	.1	35					
1N4499	S			ZD							6.2	5	1W	
1N4500	S			CS	80	1	.3A	.1*	4					
1N4501	S			RD						.01	7.4	-55	100	
1N4502	G			GP	20	.3	3M	10*						
1N4503	S			ZD							33	10	3W	
1N4504	S			ZD							200	10	3W	
1N4505	S			R	6000	8.5	.1	.1	20					
1N4506	S			R	200	1.4	12	2.5	240					
1N4507	S			R	400	1.4	12	2.5	240					
1N4508	S			R	600	1.4	12	2.5	240					
1N4509	S			R	800	1.4	12	2	240					
1N4510	S			R	1000	1.4	12	1.75	240					
1N4511	S			R	1200	1.4	12	1.5	240					
1N4512	S			GP	10	.777	5M	10N						
1N4513	S			R	2000	4.5	.25	.1	20					
1N4514	S			R	800	1	1.1	.1	50					
1N4517	S			R	200	1.2	2	.1	100					
1N4523	G			CS	15	1	.1A	30*	8					
1N4524	G			CS	10	.65	10M	12*	3					
1N4525	S			R	200	1.4	35	3.5	500					
1N4526	S			R	400	1.4	35	3.5	500					
1N4527	S			R	600	1.4	35	3.5	500					
1N4528	S			R	800	1.4	35	3	500					
1N4529	S			R	1000	1.4	35	2.5	500					
1N4530	S			R	1200	1.4	35	2	500					
1N4531	S			HS	75	1	10M	25N	4					
1N4532	S			HS	75	1	10M	.1*	2					
1N4533	S			CS	40	.88	20M	50N	2					
1N4534	S			CS	50	.88	20M	50N	2					
1N4535	S			ZD							3.45	5	.5W	
1N4536	S			CS	25	1	30M	.1*	2					
1N4537	S			R	1500	1.85	3	.3	15					
1N4538	S			R	2000	1.85	3	.3	15					
1N4539	S			R	2500	1.85	3	.3	15					
1N4540	S			R	3000	1.85	3	.3	15					
1N4541	S			GP	225	1	.4A	20N						
1N4542	S			GP	400	1	.4A	20N						
1N4543	S			GP	600	1	.4A	20N						
1N4544	S			GP	800	1	.4A	20N						
1N4546	S			R	25K	30	1	.1	50					
1N4547	S			GP	25	1	25M	10N						
1N4548	S			CS	25	1	30M	.1*	4					
1N4549	S		2-15	ZD							3.9	20	50W	
1N4549A	S		2-15	ZD							3.9	10	50W	
1N4549B	S		2-15	ZD							3.9	5	50W	
1N4550	S		2-15	ZD							4.3	20	50W	
1N4550A	S		2-15	ZD							4.3	10	50W	
1N4550B	S		2-15	ZD							4.3	5	50W	
1N4551	S		2-15	ZD							4.7	20	50W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4551A — 1N4576

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4551A	S		2-15	ZD							4.7	10	50W	
1N4551B	S		2-15	ZD							4.7	5	50W	
1N4552	S		2-15	ZD							5.1	20	50W	
1N4552A	S		2-15	ZD							5.1	10	50W	
1N4552B	S		2-15	ZD							5.1	5	50W	
1N4553	S		2-15	ZD							5.6	20	50W	
1N4553A	S		2-15	ZD							5.6	10	50W	
1N4553B	S		2-15	ZD							5.6	5	50W	
1N4554	S		2-15	ZD							6.2	20	50W	
1N4554A	S		2-15	ZD							6.2	10	50W	
1N4554B	S		2-15	ZD							6.2	5	50W	
1N4555	S		2-15	ZD							6.8	20	50W	
1N4555A	S		2-15	ZD							6.8	10	50W	
1N4555B	S		2-15	ZD							6.8	5	50W	
1N4556	S		2-15	ZD							7.5	20	50W	
1N4556A	S		2-15	ZD							7.5	10	50W	
1N4556B	S		2-15	ZD							7.5	5	50W	
1N4557	S		2-15	ZD							3.9	20	50W	
1N4557A	S		2-15	ZD							3.9	10	50W	
1N4557B	S		2-15	ZD							3.9	5	50W	
1N4558	S		2-15	ZD							4.3	20	50W	
1N4558A	S		2-15	ZD							4.3	10	50W	
1N4558B	S		2-15	ZD							4.3	5	50W	
1N4559	S		2-15	ZD							4.7	20	50W	
1N4559A	S		2-15	ZD							4.7	10	50W	
1N4559B	S		2-15	ZD							4.7	5	50W	
1N4560	S		2-15	ZD							5.1	20	50W	
1N4560A	S		2-15	ZD							5.1	10	50W	
1N4560B	S		2-15	ZD							5.1	5	50W	
1N4561	S		2-15	ZD							5.6	20	50W	
1N4561A	S		2-15	ZD							5.6	10	50W	
1N4561B	S		2-15	ZD							5.6	5	50W	
1N4562	S		2-15	ZD							6.2	20	50W	
1N4562A	S		2-15	ZD							6.2	10	50W	
1N4562B	S		2-15	ZD							6.2	5	50W	
1N4563	S		2-15	ZD							6.8	20	50W	
1N4563A	S		2-15	ZD							6.8	10	50W	
1N4563B	S		2-15	ZD							6.8	5	50W	
1N4564	S		2-15	ZD							7.5	20	50W	
1N4564A	S		2-15	ZD							7.5	10	50W	
1N4564B	S		2-15	ZD							7.5	5	50W	
1N4565	S		2-32	RD						.01	6.4	0	75	
1N4565A	S		2-32	RD						.01	6.4	-55	100	
1N4566	S		2-32	RD						.005	6.4	0	75	
1N4566A	S		2-32	RD						.005	6.4	-55	100	
1N4567	S		2-32	RD						.002	6.4	0	75	
1N4567A	S		2-32	RD						.002	6.4	-55	100	
1N4568	S		2-32	RD						.001	6.4	0	75	
1N4568A	S		2-32	RD						.001	6.4	-55	100	
1N4569	S		2-32	RD						.0005	6.4	0	75	
1N4569A	S		2-32	RD						.0005	6.4	-55	100	
1N4570	S		2-32	RD						.01	6.4	0	75	
1N4570A	S		2-32	RD						.01	6.4	-55	100	
1N4571	S		2-32	RD						.005	6.4	0	75	
1N4571A	S		2-32	RD						.005	6.4	-55	100	
1N4572	S		2-32	RD						.002	6.4	0	75	
1N4572A	S		2-32	RD						.002	6.4	-55	100	
1N4573	S		2-32	RD						.001	6.4	0	75	
1N4573A	S		2-32	RD						.001	6.4	-55	100	
1N4574	S		2-32	RD						.0005	6.4	0	75	
1N4574A	S		2-32	RD						.0005	6.4	-55	100	
1N4575	S			RD						.01	6.4	0	75	
1N4575A	S			RD						.01	6.4	-55	100	
1N4576	S			RD						.005	6.4	0	75	

R—Rectifier, **RD**—Reference Diode, **ZD**—Zener Diode, **GP**—General Purpose, **HC**—High Conductance (≥ 20 mA @ ≤ 1 V), **HS**—High Speed Switch (Max t_{rr} < 0.3μs), **CS**—High Conductance, High Speed Switch, **MS**—Medium Speed Switch, **PA**—Parametric Amplifier, **SP**—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4576A	S			RD						.005	6.4	-55	100
1N4577	S			RD						.002	6.4	0	75
1N4577A	S			RD						.002	6.4	-55	100
1N4578	S			RD						.001	6.4	0	75
1N4578A	S			RD						.001	6.4	-55	100
1N4579	S			RD						.0005	6.4	0	75
1N4579A	S			RD						.0005	6.4	-55	100
1N4580	S			RD						.01	6.4	0	75
1N4580A	S			RD						.01	6.4	-55	100
1N4581	S			RD						.005	6.4	0	75
1N4581A	S			RD						.005	6.4	-55	100
1N4582	S			RD						.002	6.4	0	75
1N4582A	S			RD						.002	6.4	-55	100
1N4583	S			RD						.0001	6.4	0	75
1N4583A	S			RD						.0001	6.4	-55	100
1N4584	S			RD						.0005	6.4	0	75
1N4584A	S			RD						.0005	6.4	-55	100
1N4585	S			R	800	1.3	1	.2	50				
1N4586	S			R	1000	1.3	1	.2	50				
1N4587	S			R	100	1.35	150	9.5	3000				
1N4588	S			R	200	1.35	150	9.5	3000				
1N4589	S			R	300	1.35	150	9	3000				
1N4590	S			R	400	1.35	150	9	3000				
1N4591	S			R	500	1.35	150	8	3000				
1N4592	S			R	600	1.35	150	6.5	3000				
1N4593	S			R	800	1.35	150	5.5	3000				
1N4594	S			R	1000	1.35	150	4.5	3000				
1N4595	S			R	1200	1.35	150	4	3000				
1N4596	S			R	1400	1.35	150	3.5	3000				
1N4597	S			R	5000	5	.025		1				
1N4598													
1N4599	Varactor Diodes, see table on page 1-99												
1N4606	S			CS	70	1	.2A	.25*	6				
1N4607	S			CS	70	.95	250M	.25*	10				
1N4608	S			CS	70	.96	350M	.25*	10				
1N4609	Varactor Diodes, see table on page 1-99												
1N4610	S			HS	55	1.1	.3A	.1*	2				
1N4611	S			RD						.005	6.6	-50	100
1N4611A	S			RD						.002	6.6	-50	100
1N4611B	S			RD						.001	6.6	-50	100
1N4611C	S			RD						.0005	6.6	-50	100
1N4612	S			RD						.005	6.6	-50	100
1N4612A	S			RD						.002	6.6	-50	100
1N4612B	S			RD						.001	6.6	-50	100
1N4612C	S			RD						.0005	6.6	-50	100
1N4613	S			RD						.005	6.6	-50	100
1N4613A	S			RD						.002	6.6	-50	100
1N4613B	S			RD						.001	6.6	-50	100
1N4613C	S			RD						.0005	6.6	-50	100
1N4614	S			ZD							1.8		.25W
1N4615	S			ZD							2		.25W
1N4616	S			ZD							2.2		.25W
1N4617	S			ZD							2.4		.25W
1N4618	S			ZD							2.7		.25W
1N4619	S			ZD							3		.25W
1N4620	S			ZD							3.3		.25W
1N4621	S			ZD							3.6		.25W
1N4622	S			ZD							3.9		.25W
1N4623	S			ZD							4.3		.25W
1N4624	S			ZD							4.7		.25W
1N4625	S			ZD							5.1		.25W
1N4626	S			ZD							5.6		.25W
1N4627	S			ZD							6.2		.25W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4628 — 1N4729A

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4628	S			ZD							6.8		.6W
1N4629	S			ZD							7.5		.6W
1N4630	S			ZD							8.2		.6W
1N4631	S			ZD							9.1		.6W
1N4632	S			ZD							10		.6W
1N4633	S			ZD							11		.6W
1N4634	S			ZD							12		.6W
1N4635	S			ZD							13		.6W
1N4636	S			ZD							15		.6W
1N4637	S			ZD							16		.6W
1N4638	S			ZD							18		.6W
1N4639	S			ZD							20		.6W
1N4640	S			ZD							22		.6W
1N4641	S			ZD							24		.6W
1N4642	S			ZD							27		.6W
1N4643	S			ZD							30		.6W
1N4644	S			ZD							33		.6W
1N4645	S			ZD							36		.6W
1N4646	S			ZD							39		.6W
1N4647	S			ZD							43		.6W
1N4648	S			ZD							47		.6W
1N4649	S			ZD							3.3		1W
1N4650	S			ZD							3.6		1W
1N4651	S			ZD							3.9		1W
1N4652	S			ZD							4.3		1W
1N4653	S			ZD							4.7		1W
1N4654	S			ZD							5.1		1W
1N4655	S			ZD							5.6		1W
1N4656	S			ZD							6.2		1W
1N4657	S			ZD							6.8		1W
1N4658	S			ZD							7.5		1W
1N4659	S			ZD							8.2		1W
1N4660	S			ZD							9.1		1W
1N4661	S			ZD							10		1W
1N4662	S			ZD							11		1W
1N4663	S			ZD							12		1W
1N4664	S			ZD							13		1W
1N4665	S			ZD							15		1W
1N4666	S			ZD							16		1W
1N4667.	S			ZD							18		1W
1N4668	S			ZD							20		1W
1N4669	S			ZD							22		1W
1N4670	S			ZD							24		1W
1N4671	S			ZD							27		1W
1N4672	S			ZD							30		1W
1N4673	S			ZD							33		1W
1N4674	S			ZD							36		1W
1N4675	S			ZD							39		1W
1N4676	S			ZD							43		1W
1N4677	S			ZD							47		1W
1N4718	S			HS	50	1.2	.75A	50•	180				
1N4719	S			R	50	1	3	1.5	300				
1N4720	S			R	100	1	3	1.5	300				
1N4721	S			R	200	1	3	1.5	300				
1N4722	S			R	400	1	3	1.5	300				
1N4723	S			R	600	1	3	1.5	300				
1N4724	S			R	800	1	3	1.5	300				
1N4725	S			R	1000	1	3	1.5	300				
1N4726	S			HS	20	.85	10M	.1•					
1N4727	S			HS	20	.85	10M	.1•					
1N4728	S		2-28	ZD							3.3	10	1W
1N4728A	S		2-28	ZD							3.3	5	1W
1N4729	S		2-28	ZD							3.6	10	1W
1N4729A	S		2-28	ZD							3.6	5	1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	Isurge (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4730	S		2-28	ZD							3.9	10		1W
1N4730A	S		2-28	ZD							3.9	5		1W
1N4731	S		2-28	ZD							4.3	10		1W
1N4731A	S		2-28	ZD							4.3	5		1W
1N4732	S		2-28	ZD							4.7	10		1W
1N4732A	S		2-28	ZD							4.7	5		1W
1N4733	S		2-28	ZD							5.1	10		1W
1N4733A	S		2-28	ZD							5.1	5		1W
1N4734	S		2-28	ZD							5.6	10		1W
1N4734A	S		2-28	ZD							5.6	5		1W
1N4735	S		2-28	ZD							6.2	10		1W
1N4735A	S		2-28	ZD							6.2	5		1W
1N4736	S		2-28	ZD							6.8	10		1W
1N4736A	S		2-28	ZD							6.8	5		1W
1N4737	S		2-28	ZD							7.5	10		1W
1N4737A	S		2-28	ZD							7.5	5		1W
1N4738	S		2-28	ZD							8.2	10		1W
1N4738A	S		2-28	ZD							8.2	5		1W
1N4739	S		2-28	ZD							9.1	10		1W
1N4739A	S		2-28	ZD							9.1	5		1W
1N4740	S		2-28	ZD							10	10		1W
1N4740A	S		2-28	ZD							10	5		1W
1N4741	S		2-28	ZD							11	10		1W
1N4741A	S		2-28	ZD							11	5		1W
1N4742	S		2-28	ZD							12	10		1W
1N4742A	S		2-28	ZD							12	5		1W
1N4743	S		2-28	ZD							13	10		1W
1N4743A	S		2-28	ZD							13	5		1W
1N4744	S		2-28	ZD							15	10		1W
1N4744A	S		2-28	ZD							15	5		1W
1N4745	S		2-28	ZD							16	10		1W
1N4745A	S		2-28	ZD							16	5		1W
1N4746	S		2-28	ZD							18	10		1W
1N4746A	S		2-28	ZD							18	5		1W
1N4747	S		2-28	ZD							20	10		1W
1N4747A	S		2-28	ZD							20	5		1W
1N4748	S		2-28	ZD							22	10		1W
1N4748A	S		2-28	ZD							22	5		1W
1N4749	S		2-28	ZD							24	10		1W
1N4749A	S		2-28	ZD							24	5		1W
1N4750	S		2-28	ZD							27	10		1W
1N4750A	S		2-28	ZD							27	5		1W
1N4751	S		2-28	ZD							30	10		1W
1N4751A	S		2-28	ZD							30	5		1W
1N4752	S		2-28	ZD							33	10		1W
1N4752A	S		2-28	ZD							33	5		1W
1N4753	S		2-28	ZD							36	10		1W
1N4753A	S		2-28	ZD							36	5		1W
1N4754	S		2-28	ZD							39	10		1W
1N4754A	S		2-28	ZD							39	5		1W
1N4755	S		2-28	ZD							43	10		1W
1N4755A	S		2-28	ZD							43	5		1W
1N4756	S		2-28	ZD							47	10		1W
1N4756A	S		2-28	ZD							47	5		1W
1N4757	S		2-28	ZD							51	10		1W
1N4757A	S		2-28	ZD							51	5		1W
1N4758	S		2-28	ZD							56	10		1W
1N4758A	S		2-28	ZD							56	5		1W
1N4759	S		2-28	ZD							62	10		1W
1N4759A	S		2-28	ZD							62	5		1W
1N4760	S		2-28	ZD							68	10		1W
1N4760A	S		2-28	ZD							68	5		1W
1N4761	S		2-28	ZD							75	10		1W
1N4761A	S		2-28	ZD							75	5		1W

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4762 — 1N4830

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4762	S		2-28	ZD							82	10		1W
1N4762A	S		2-28	ZD							82	5		1W
1N4763	S		2-28	ZD							91	10		1W
1N4763A	S		2-28	ZD							91	5		1W
1N4764	S		2-28	ZD							100	10		1W
1N4764A	S		2-28	ZD							100	5		1W
1N4765	S		2-32	RD						.01	9.1	0		75
1N4765A	S		2-32	RD						.01	9.1	-55		100
1N4766	S		2-32	RD						.005	9.1	0		75
1N4766A	S		2-32	RD						.005	9.1	-55		100
1N4767	S		2-32	RD						.002	9.1	0		75
1N4767A	S		2-32	RD						.002	9.1	-55		100
1N4768	S		2-32	RD						.001	9.1	0		75
1N4768A	S		2-32	RD						.001	9.1	-55		100
1N4769	S		2-32	RD						.0005	9.1	0		75
1N4769A	S		2-32	RD						.0005	9.1	-55		100
1N4770	S		2-32	RD						.01	9.1	0		75
1N4770A	S		2-32	RD						.01	9.1	-55		100
1N4771	S		2-32	RD						.005	9.1	0		75
1N4771A	S		2-32	RD						.005	9.1	-55		100
1N4772	S		2-32	RD						.002	9.1	0		75
1N4772A	S		2-32	RD						.002	9.1	-55		100
1N4773	S		2-32	RD						.001	9.1	0		75
1N4773A	S		2-32	RD						.001	9.1	-55		100
1N4774	S		2-32	RD						.0005	9.1	0		75
1N4774A	S		2-32	RD						.0005	9.1	-55		100
1N4775	S		2-32	RD						.01	8.5	0		75
1N4775A	S		2-32	RD						.01	8.5	-55		100
1N4776	S		2-32	RD						.005	8.5	0		75
1N4776A	S		2-32	RD						.005	8.5	-55		100
1N4777	S		2-32	RD						.002	8.5	0		75
1N4777A	S		2-32	RD						.002	8.5	-55		100
1N4778	S		2-32	RD						.001	8.5	0		75
1N4778A	S		2-32	RD						.001	8.5	-55		100
1N4779	S		2-32	RD						.0005	8.5	0		75
1N4779A	S		2-32	RD						.0005	8.5	-55		100
1N4780	S		2-32	RD						.01	8.5	0		75
1N4780A	S		2-32	RD						.01	8.5	-55		100
1N4781	S		2-32	RD						.005	8.5	0		75
1N4781A	S		2-32	RD						.005	8.5	-55		100
1N4782	S		2-32	RD						.002	8.5	0		75
1N4782A	S		2-32	RD						.002	8.5	-55		100
1N4783	S		2-32	RD						.001	8.5	0		75
1N4783A	S		2-32	RD						.001	8.5	-55		100
1N4784	S		2-32	RD						.0005	8.5	0		75
1N4784A	S		2-32	RD						.0005	8.5	-55		100
1N4786 thru 1N4815	Varactor Diodes, see table on page 1-99													
1N4816	S			R	50	1.3	1.5	.25	50					
1N4817	S			R	100	1.3	1.5	.25	50					
1N4818	S			R	200	1.3	1.5	.25	50					
1N4819	S			R	300	1.3	1.5	.25	50					
1N4820	S			R	400	1.3	1.5	.25	50					
1N4821	S			R	500	1.3	1.5	.25	50					
1N4822	S			R	600	1.3	1.5	.25	50					
1N4823	S			R	100	1.25	1	1	35					
1N4824	S			R	200	1.25	1	1	35					
1N4825	S			R	400	1.25	1	1	35					
1N4826	S			R	600	1.25	1	1	35					
1N4827	G			HS	30	1	40M	15*	.2					
1N4828	S			GP	20	1.1	.1A	.1*						
1N4829	S			GP	20	1.87	.1A	.1*						
1N4830	S			GP	20	2.69	.1A	.1*						

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4831	S			ZD							9.1	20	1.2W	
1N4831A	S			ZD							9.1	10	1.2W	
1N4831B	S			ZD							9.1	5	1.2W	
1N4832	S			ZD							10	20	1.2W	
1N4832A	S			ZD							10	10	1.2W	
1N4832B	S			ZD							10	5	1.2W	
1N4833	S			ZD							11	20	1.2W	
1N4833A	S			ZD							11	10	1.2W	
1N4833B	S			ZD							11	5	1.2W	
1N4834	S			ZD							12	20	1.2W	
1N4834A	S			ZD							12	10	1.2W	
1N4834B	S			ZD							12	5	1.2W	
1N4835	S			ZD							13	20	1.2W	
1N4835A	S			ZD							13	10	1.2W	
1N4835B	S			ZD							13	5	1.2W	
1N4836	S			ZD							15	20	1.2W	
1N4836A	S			ZD							15	10	1.2W	
1N4836B	S			ZD							15	5	1.2W	
1N4837	S			ZD							16	20	1.2W	
1N4837A	S			ZD							16	10	1.2W	
1N4837B	S			ZD							16	5	1.2W	
1N4838	S			ZD							18	20	1.2W	
1N4838A	S			ZD							18	10	1.2W	
1N4838B	S			ZD							18	5	1.2W	
1N4839	S			ZD							20	20	1.2W	
1N4839A	S			ZD							20	10	1.2W	
1N4839B	S			ZD							20	5	1.2W	
1N4840	S			ZD							22	20	1.2W	
1N4840A	S			ZD							22	10	1.2W	
1N4840B	S			ZD							22	5	1.2W	
1N4841	S			ZD							24	20	1.2W	
1N4841A	S			ZD							24	10	1.2W	
1N4841B	S			ZD							24	5	1.2W	
1N4842	S			ZD							27	20	1.2W	
1N4842A	S			ZD							27	10	1.2W	
1N4842B	S			ZD							27	5	1.2W	
1N4843	S			ZD							30	20	1.2W	
1N4843A	S			ZD							30	10	1.2W	
1N4843B	S			ZD							30	5	1.2W	
1N4844	S			ZD							33	20	1.2W	
1N4844A	S			ZD							33	10	1.2W	
1N4844B	S			ZD							33	5	1.2W	
1N4845	S			ZD							36	20	1.2W	
1N4845A	S			ZD							36	10	1.2W	
1N4845B	S			ZD							36	5	1.2W	
1N4846	S			ZD							39	20	1.2W	
1N4846A	S			ZD							39	10	1.2W	
1N4846B	S			ZD							39	5	1.2W	
1N4847	S			ZD							43	20	1.2W	
1N4847A	S			ZD							43	10	1.2W	
1N4847B	S			ZD							43	5	1.2W	
1N4848	S			ZD							47	20	1.2W	
1N4848A	S			ZD							47	10	1.2W	
1N4848B	S			ZD							47	5	1.2W	
1N4849	S			ZD							51	20	1.2W	
1N4849A	S			ZD							51	10	1.2W	
1N4849B	S			ZD							51	5	1.2W	
1N4850	S			ZD							56	20	1.2W	
1N4850A	S			ZD							56	10	1.2W	
1N4850B	S			ZD							56	5	1.2W	
1N4851	S			ZD							62	20	1.2W	
1N4851A	S			ZD							62	10	1.2W	
1N4851B	S			ZD							62	5	1.2W	
1N4852	S			ZD							68	20	1.2W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4852A — 1N4894

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4852A	S			ZD							68	10	1.2W	
1N4852B	S			ZD							68	5	1.2W	
1N4853	S			ZD							75	20	1.2W	
1N4853A	S			ZD							75	10	1.2W	
1N4853B	S			ZD							75	5	1.2W	
1N4854	S			ZD							82	20	1.2W	
1N4854A	S			ZD							82	10	1.2W	
1N4854B	S			ZD							82	5	1.2W	
1N4855	S			ZD							91	20	1.2W	
1N4855A	S			ZD							91	10	1.2W	
1N4855B	S			ZD							91	5	1.2W	
1N4856	S			ZD							100	20	1.2W	
1N4856A	S			ZD							100	10	1.2W	
1N4856B	S			ZD							100	5	1.2W	
1N4857	S			ZD							110	20	1.2W	
1N4857A	S			ZD							110	10	1.2W	
1N4857B	S			ZD							110	5	1.2W	
1N4858	S			ZD							120	20	1.2W	
1N4858A	S			ZD							120	10	1.2W	
1N4858B	S			ZD							120	5	1.2W	
1N4859	S			ZD							130	20	1.2W	
1N4859A	S			ZD							130	10	1.2W	
1N4859B	S			ZD							130	5	1.2W	
1N4860	S			ZD							150	20	1.2W	
1N4860A	S			ZD							150	10	1.2W	
1N4860B	S			ZD							150	5	1.2W	
1N4861	S			GP	50	1.2	.1A	2N	1					
1N4862	S			GP	50	1.1	.1A	5N	1					
1N4863	S			HS	50	1.2	.1A	50N	7					
1N4864	S			HS	80	1.1	.1A	.1m	9					
1N4865	S			R	1500	2.4	1.25	.6	150					
1N4866	S			R	2500	3.6	1.25	.6	150					
1N4867	S			R	3000	4.8	1.25	.6	150					
1N4868	S			R	5000	8.4	1.25	.6	150					
1N4869	S			R	7500	12	1.25	.6	150					
1N4870	S			R	10K	16	1.25	.6	150					
1N4871	S			R	12K	18	1.25	.6	150					
1N4872	S			R	15K	23	1.25	.6	150					
1N4873	S			R	20K	30	1.25	.6	150					
1N4874	S			R	25K	38	1.25	.6	150					
1N4875	S			R	30K	46	1.25	.6	150					
1N4876	S			R	40K	60	1.25	.6	150					
1N4877	S			R	50K	76	1.25	.6	150					
1N4878	S			R	100	1.3	100	5	1500					
1N4879	S			R	100	1.3	160	10	2200					
1N4880	S			R	100	1.2	250	10	4000					
1N4881	S			ZD							20	10	3W	
1N4882	S			ZD							36	10	3W	
1N4883	S			ZD							12	5	3W	
1N4884	S			ZD							20	5	3W	
1N4885 1N4886	Varactor Diodes, see table on page 1-99													
1N4887	S			R	75K	115	1.25	.6	150					
1N4888	S			SP	12	1	20M	50N						
1N4889	S			ZD							62	5	5W	
1N4890	S			RD						.001	6.35	25	100	
1N4890A	S			RD						.001	6.35	-55	100	
1N4891	S			RD						.0005	6.35	25	100	
1N4891A	S			RD						.0005	6.35	-55	100	
1N4892	S			RD						.001	6.35	25	100	
1N4892A	S			RD						.001	6.35	-55	100	
1N4893	S			RD						.0005	6.35	25	100	
1N4893A	S			RD						.0005	6.35	-55	100	
1N4894	S			RD						.001	6.35	25	100	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES			
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D
					SIGNAL DIODES					REFERENCE DIODES			
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C
1N4894A	S			RD						.001	6.35	-55	100
1N4895	S			RD						.0005	6.35	25	100
1N4895A	S			RD						.0005	6.35	-55	100
1N4896	S			RD						.01	12.8	25	100
1N4896A	S			RD						.01	12.8	-55	100
1N4897	S			RD						.005	12.8	25	100
1N4897A	S			RD						.005	12.8	-55	100
1N4898	S			RD						.002	12.8	25	100
1N4898A	S			RD						.002	12.8	-55	100
1N4899	S			RD						.001	12.8	25	100
1N4899A	S			RD						.001	12.8	-55	100
1N4900	S			RD						.01	12.8	25	100
1N4900A	S			RD						.01	12.8	-55	100
1N4901	S			RD						.005	12.8	25	100
1N4901A	S			RD						.005	12.8	-55	100
1N4902	S			RD						.002	12.8	25	100
1N4902A	S			RD						.002	12.8	-55	100
1N4903	S			RD						.001	12.8	25	100
1N4903A	S			RD						.001	12.8	-55	100
1N4904	S			RD						.01	12.8	25	100
1N4904A	S			RD						.01	12.8	-55	100
1N4905	S			RD						.005	12.8	25	100
1N4905A	S			RD						.005	12.8	-55	100
1N4906	S			RD						.002	12.8	25	100
1N4906A	S			RD						.002	12.8	-55	100
1N4907	S			RD						.001	12.8	25	100
1N4907A	S			RD						.001	12.8	-55	100
1N4908	S			RD						.01	12.8	25	100
1N4908A	S			RD						.01	12.8	-55	100
1N4909	S			RD						.005	12.8	25	100
1N4909A	S			RD						.005	12.8	-55	100
1N4910	S			RD						.002	12.8	25	100
1N4910A	S			RD						.002	12.8	-55	100
1N4911	S			RD						.001	12.8	25	100
1N4911A	S			RD						.001	12.8	-55	100
1N4912	S			RD						.01	12.8	25	100
1N4912A	S			RD						.01	12.8	-55	100
1N4913	S			RD						.005	12.8	25	100
1N4913A	S			RD						.005	12.8	-55	100
1N4914	S			RD						.002	12.8	25	100
1N4914A	S			RD						.002	12.8	-55	100
1N4915	S			RD						.001	12.8	25	100
1N4915A	S			RD						.001	12.8	-55	100
1N4916	S			RD						.01	19.2	25	100
1N4916A	S			RD						.01	19.2	-55	100
1N4917	S			RD						.005	19.2	25	100
1N4917A	S			RD						.005	19.2	-55	100
1N4918	S			RD						.002	19.2	25	100
1N4918A	S			RD						.002	19.2	-55	100
1N4919	S			RD						.01	19.2	25	100
1N4919A	S			RD						.01	19.2	-55	100
1N4920	S			RD						.005	19.2	25	100
1N4920A	S			RD						.005	19.2	-55	100
1N4921	S			RD						.002	19.2	25	100
1N4921A	S			RD						.002	19.2	-55	100
1N4922	S			RD						.01	19.2	25	100
1N4922A	S			RD						.01	19.2	-55	100
1N4923	S			RD						.005	19.2	25	100
1N4923A	S			RD						.005	19.2	-55	100
1N4924	S			RD						.002	19.2	25	100
1N4924A	S			RD						.002	19.2	-55	100
1N4925	S			RD						.01	19.2	25	100
1N4925A	S			RD						.01	19.2	-55	100
1N4926	S			RD						.005	19.2	25	100

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance ($\geq$ 20 mA @ $\leq$ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

1N4926A — 1N5030

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z(min)	V_Z (nom) V_Z(max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ (volts)	I_F	I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N4926A	S			RD						.005	19.2	-55	100	
1N4927	S			RD						.002	19.2	25	100	
1N4927A	S			RD						.002	19.2	-55	100	
1N4928	S			RD						.001	19.2	25	100	
1N4928A	S			RD						.001	19.2	-55	100	
1N4929	S			RD						.01	19.2	25	100	
1N4929A	S			RD						.01	19.2	-55	100	
1N4930	S			RD						.005	19.2	25	100	
1N4930A	S			RD						.005	19.2	-55	100	
1N4931	S			RD						.002	19.2	25	100	
1N4931A	S			RD						.002	19.2	-55	100	
1N4932	S			RD						.001	19.2	25	100	
1N4932A	S			RD						.001	19.2	-55	100	
1N4933	S			R	50	1.2	1	.3	30					
1N4934	S			R	100	1.2	1	.3	30					
1N4935	S			R	200	1.2	1	.3	30					
1N4936	S			R	400	1.2	1	.3	30					
1N4937	S			R	600	1.2	1	.3	30					
1N4938	S			CS	200	1	.1A	.1*	50					
1N5008	S			ZD							3.3	10	2.5W	
1N5008A	S			ZD							3.3	5	2.5W	
1N5009	S			ZD							3.6	10	2.5W	
1N5009A	S			ZD							3.6	5	2.5W	
1N5010	S			ZD							3.9	10	2.5W	
1N5010A	S			ZD							3.9	5	2.5W	
1N5011	S			ZD							4.3	10	2.5W	
1N5011A	S			ZD							4.3	5	2.5W	
1N5012	S			ZD							4.7	10	2.5W	
1N5012A	S			ZD							4.7	5	2.5W	
1N5013	S			ZD							5.1	10	2.5W	
1N5013A	S			ZD							5.1	5	2.5W	
1N5014	S			ZD							5.6	10	2.5W	
1N5014A	S			ZD							5.6	5	2.5W	
1N5015	S			ZD							6.2	10	2.5W	
1N5015A	S			ZD							6.2	5	2.5W	
1N5016	S			ZD							6.8	10	2.5W	
1N5016A	S			ZD							6.8	5	2.5W	
1N5017	S			ZD							7.5	10	2.5W	
1N5017A	S			ZD							7.5	5	2.5W	
1N5018	S			ZD							8.2	10	2.5W	
1N5018A	S			ZD							8.2	5	2.5W	
1N5019	S			ZD							9.1	10	2.5W	
1N5019A	S			ZD							9.1	5	2.5W	
1N5020	S			ZD							10	10	2.5W	
1N5020A	S			ZD							10	5	2.5W	
1N5021	S			ZD							11	10	2.5W	
1N5021A	S			ZD							11	5	2.5W	
1N5022	S			ZD							12	10	2.5W	
1N5022A	S			ZD							12	5	2.5W	
1N5023	S			ZD							13	10	2.5W	
1N5023A	S			ZD							13	5	2.5W	
1N5024	S			ZD							14	10	2.5W	
1N5024A	S			ZD							14	5	2.5W	
1N5025	S			ZD							15	10	2.5W	
1N5025A	S			ZD							15	5	2.5W	
1N5026	S			ZD							16	10	2.5W	
1N5026A	S			ZD							16	5	2.5W	
1N5027	S			ZD							17	10	2.5W	
1N5027A	S			ZD							17	5	2.5W	
1N5028	S			ZD							18	10	2.5W	
1N5028A	S			ZD							18	5	2.5W	
1N5029	S			ZD							19	10	2.5W	
1N5029A	S			ZD							19	5	2.5W	
1N5030	S			ZD							20	10	2.5W	

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs)
CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

TYPE	MATERIAL	REPLACEMENT	PAGE NUMBER	IDENTIFICATION	RECTIFIERS					ZENER DIODES				
					V_R (volts)	V_F (volts)	I_O (Amps)	I_R (mA)	I_{surge} (Amps)	V_Z (min)	V_Z (nom) V_Z (max)	Tol V_Z %	P_D	
					SIGNAL DIODES					REFERENCE DIODES				
					PRV (volts)	V_F @ I_F (volts)		I_R	t_{rr} (μS)	TC %/°C	V_Z	T(min) °C	T(max) °C	
1N5030A	S			ZD							20	5	2.5W	
1N5031	S			ZD							22	10	2.5W	
1N5031A	S			ZD							22	5	2.5W	
1N5032	S			ZD							24	10	2.5W	
1N5032A	S			ZD							24	5	2.5W	
1N5033	S			ZD							25	10	2.5W	
1N5033A	S			ZD							25	5	2.5W	
1N5034	S			ZD							27	10	2.5W	
1N5034A	S			ZD							27	5	2.5W	
1N5035	S			ZD							30	10	2.5W	
1N5035A	S			ZD							30	5	2.5W	
1N5036	S			ZD							33	10	2.5W	
1N5036A	S			ZD							33	5	2.5W	
1N5037	S			ZD							36	10	2.5W	
1N5037A	S			ZD							36	5	2.5W	
1N5038	S			ZD							39	10	2.5W	
1N5038A	S			ZD							39	5	2.5W	
1N5039	S			ZD							43	10	2.5W	
1N5039A	S			ZD							43	5	2.5W	
1N5040	S			ZD							45	10	2.5W	
1N5040A	S			ZD							45	5	2.5W	
1N5041	S			ZD							47	10	2.5W	
1N5041A	S			ZD							47	5	2.5W	
1N5042	S			ZD							50	10	2.5W	
1N5042A	S			ZD							50	5	2.5W	
1N5043	S			ZD							51	10	2.5W	
1N5043A	S			ZD							51	5	2.5W	
1N5044	S			ZD							52	10	2.5W	
1N5044A	S			ZD							52	5	2.5W	
1N5045	S			ZD							56	10	2.5W	
1N5045A	S			ZD							56	5	2.5W	
1N5046	S			ZD							62	10	2.5W	
1N5046A	S			ZD							62	5	2.5W	
1N5047	S			ZD							68	10	2.5W	
1N5047A	S			ZD							68	5	2.5W	
1N5048	S			ZD							75	10	2.5W	
1N5048A	S			ZD							75	5	2.5W	
1N5049	S			ZD							82	10	2.5W	
1N5049A	S			ZD							82	5	2.5W	
1N5050	S			ZD							91	10	2.5W	
1N5050A	S			ZD							91	5	2.5W	
1N5051	S			ZD							100	10	2.5W	
1N5051A	S			ZD							100	5	2.5W	
1N5139 thru 1N5155	Varactor Diodes, see table on page 1-99													

R—Rectifier, RD—Reference Diode, ZD—Zener Diode, GP—General Purpose, HC—High Conductance (≥ 20 mA @ ≤ 1 V), HS—High Speed Switch (Max t_{rr} < 0.3 μs), CS—High Conductance, High Speed Switch, MS—Medium Speed Switch, PA—Parametric Amplifier, SP—Special Purpose.

VARACTOR DIODES

Index and Short-Form Specifications

The following table provides a numerical index and short-form specifications for varactor diodes with EIA-registered type number.

KEY

TYPE	PAGE NUMBER	CAPACITANCE					BV$_R$	Q @ f		Max R$_S$	GUARANTEED MULTIPLIER PERFORMANCE					
		C$_J$ C$_T$* pF	C Tol %	C (max) / C (min)	Voltage Range V$_1$ Volts	Voltage Range V$_2$ Volts	Volts		GHz	Ohms	P$_D$ @ 25°C Watts	P$_{in}$ Watts	f$_{in}$ GHz	Min P$_{out}$ Watts	f$_{out}$ GHz	Min η %
Numerical Listing of Registered Type Numbers																
	Page number in this book on which the device is fully characterized															
		Nominal Capacitance usually C$_J$ (junction capacitance) With *, specified value is C$_T$ (total capacitance) C$_T$ = C$_J$ + C$_C$														
			Tolerance of capacitance listed in preceding column													
				Effective tuning Ratio (Capacitance at Voltage V$_1$ divided by capacitance at Voltage V$_2$)												
					Voltage range over which the tuning range is measured											
							Reverse Breakdown Voltage									
								Figure of Merit at this specified frequency								
										Maximum Series Resistance						
											Power Dissipation at 25°C					
												Input Power				
													Input Frequency			
														Minimum Output Power at output frequency		
															Output frequency	
																Minimum efficiency (P$_{out}$/P$_{in}$ X 100)

1N950 — 1N3555 VARACTOR DIODES INDEX

TYPE	PAGE NUMBER	CAPACITANCE					BV$_R$	Q @ f		Max R$_S$	P$_D$ @ 25°C	MULTIPLIER PERFORMANCE				
		C$_J$ C$_T$* pF	C Tol %	C (max) / C (min)	Voltage Range V$_1$ Volts	Voltage Range V$_2$ Volts	Volts		GHz	Ohms	Watts	P$_{in}$ Watts	f$_{in}$ GHz	Min P$_{out}$ Watts	f$_{out}$ GHz	Min η %
1N950		35		2.51	4	130	130	7.0	0.05							
1N951		50		2.4	4	80	80	7.0	0.05	4.5						
1N952		70		2.43	4	60	60	7.0	0.05	2.1						
1N953		100		2.4	4	25	25	7.0	0.05	1.5						
1N954		35		2.51	4	25	25	7.0	0.05							
1N955		50		2.4	4	25	25	7.0	0.05	5.0						
1N956		70		2.43	4	25	25	7.0	0.05	2.1						
1N2627		2.75		1.75	0	5	5.0	10	1.0							
1N2628		2.5		1.5	0	5	5.0	14	1.0							
1N3182		33					20	65	0.05	3.0	0.163					
1N3488		56					15	7.0	0.05							
1N3551		50		1.22	4			30	0.05							
1N3552		20		1.22	0	4		25	0.05							
1N3554		12					100									
1N3555		20					100	60	0.05							

VARACTOR DIODES INDEX (continued)

TYPE	PAGE NUMBER	CAPACITANCE					BVR	Q @ f		Max RS	PD @ 25°C	MULTIPLIER PERFORMANCE				
		CJ CT*	C Tol	C (max) C (min)	Voltage Range V1	V2						Pin	fin	Min Pout	fout	Min η
		pF	%		Volts	Volts	Volts		GHz	Ohms	Watts	Watts	GHz	Watts	GHz	%
1N3556		47					100	50	0.10							
1N3557		24					210	75	0.05							
1N3627		21.3		2.45	4	20	20	25	0.05							
1N3628		50		2.5	4	20	20	30	0.05							
1N3770		2.0					5.5									
1N3945		20		1.5	4	20	20	7.0	0.05		0.50					
1N3946		71					9.0	7.0	0.05		0.50					
1N3947		70					9.0	9.0	0.05							
1N4091		4.2		2.5			6.0				0.30					
1N4386	12-5	50					250	75	0.05	1.5	25	50	0.05	32.5	0.15	65
1N4387	12-7	35					150	150	0.05	1.5	20	30	0.15	15	0.45	50
1N4388	12-8	20					100	200	0.05	2.0	10	20	0.5	11	1.0	55
1N4598		22		4.04	4	90	90	50	0.05		0.25					
1N4599		47		5	2	100	110	100	0.05	100	0.50					
1N4609		22		2.64	4	35	35	60	0.05		0.25					
1N4786		6.8	20	2.56	0	4	25	15	0.05		0.50					
1N4786A		6.8	10	2.56	0	4	25	15	0.05		0.50					
1N4786B		6.8	5	2.56	0	4	25	15	0.05		0.50					
1N4786C		6.8	2	2.56	0	4	25	15	0.05		0.50					
1N4786D		6.8	1	2.56	0	4	25	15	0.05		0.50					
1N4787		8.2	20	2.56	0	4	25	15	0.05		0.50					
1N4787A		8.2	10	2.56	0	4	25	15	0.05		0.50					
1N4787B		8.2	5	2.56	0	4	25	15	0.05		0.50					
1N4787C		8.2	2	2.56	0	4	25	15	0.05		0.50					
1N4787D		8.2	1	2.56	0	4	25	15	0.05		0.50					
1N4788		10	20	2.50	0	4	25	15	0.05		0.50					
1N4788A		10	10	2.50	0	4	25	15	0.05		0.50					
1N4788B		10	5	2.50	0	4	25	15	0.05		0.50					
1N4788C		10	2	2.50	0	4	25	15	0.05		0.50					
1N4788D		10	1	2.50	0	4	25	15	0.05		0.50					
1N4789		12	20	2.49	0	4	25	15	0.05		0.50					
1N4789A		12	10	2.49	0	4	25	15	0.05		0.50					
1N4789B		12	5	2.49	0	4	25	15	0.05		0.50					
1N4789C		12	2	2.49	0	4	25	15	0.05		0.50					
1N4789D		12	1	2.49	0	4	25	15	0.05		0.50					
1N4790		15	20	2.49	0	4	25	15	0.05		0.50					
1N4790A		15	10	2.49	0	4	25	15	0.05		0.50					
1N4790B		15	5	2.49	0	4	25	15	0.05		0.50					
1N4790C		15	2	2.49	0	4	25	15	0.05		0.50					
1N4790D		15	1	2.49	0	4	25	15	0.05		0.50					
1N4791		18	20	2.48	0	4	20	15	0.05		0.50					
1N4791A		18	10	2.48	0	4	20	15	0.05		0.50					
1N4791B		18	5	2.48	0	4	20	15	0.05		0.50					
1N4791C		18	2	2.48	0	4	20	15	0.05		0.50					
1N4791D		18	1	2.48	0	4	20	15	0.05		0.50					
1N4792		22	20	2.46	0	4	20	15	0.05		0.50					
1N4792A		22	10	2.46	0	4	20	15	0.05		0.50					
1N4792B		22	5	2.46	0	4	20	15	0.05		0.50					
1N4792C		22	2	2.46	0	4	20	15	0.05		0.50					
1N4792D		22	1	2.46	0	4	20	15	0.05		0.50					
1N4793		27	20	2.46	0	4	20	15	0.05		0.50					
1N4793A		27	10	2.46	0	4	20	15	0.05		0.50					
1N4793B		27	5	2.46	0	4	20	15	0.05		0.50					
1N4793C		27	2	2.46	0	4	20	15	0.05		0.50					
1N4793D		27	1	2.46	0	4	20	15	0.05		0.50					
1N4794		33	20	2.46	0	4	20	15	0.05		0.50					
1N4794A		33	10	2.46	0	4	20	15	0.05		0.50					
1N4794B		33	5	2.46	0	4	20	15	0.05		0.50					
1N4794C		33	2	2.46	0	4	20	15	0.05		0.50					
1N4794D		33	1	2.46	0	4	20	15	0.05		0.50					
1N4795		39	20	2.44	0	4	20	15	0.05		0.50					
1N4795A		39	10	2.44	0	4	20	15	0.05		0.50					
1N4795B		39	5	2.44	0	4	20	15	0.05		0.50					
1N4795C		39	2	2.44	0	4	20	15	0.05		0.50					
1N4795D		39	1	2.44	0	4	20	15	0.05		0.50					
1N4796		47	20	2.43	0	4	20	15	0.05		0.50					

1N4796A – 1N4809A VARACTOR DIODES INDEX (continued)

TYPE	PAGE NUMBER	CAPACITANCE					BVR	Q @ f		Max RS	PD @ 25°C	MULTIPLIER PERFORMANCE				
		CJ CT*	C Tol	C (max) C (min)	Voltage Range V1	Voltage Range V2						Pin	fin	Min Pout	fout	Min η
		pF	%		Volts	Volts	Volts		GHz	Ohms	Watts	Watts	GHz	Watts	GHz	%
1N4796A		47	10	2.43	0	4	20	15	0.05		0.50					
1N4796B		47	5	2.43	0	4	20	15	0.05		0.50					
1N4796C		47	2	2.43	0	4	20	15	0.05		0.50					
1N4796D		47	1	2.43	0	4	20	15	0.05		0.50					
1N4797		56	20	2.42	0	4	15	15	0.05		0.50					
1N4797A		56	10	2.42	0	4	15	15	0.05		0.50					
1N4797B		56	5	2.42	0	4	15	15	0.05		0.50					
1N4797C		56	2	2.42	0	4	15	15	0.05		0.50					
1N4797D		56	1	2.42	0	4	15	15	0.05		0.50					
1N4798		68	20	2.40	0	4	15	15	0.05		0.50					
1N4798A		68	10	2.40	0	4	15	15	0.05		0.50					
1N4798B		68	5	2.40	0	4	15	15	0.05		0.50					
1N4798C		68	2	2.40	0	4	15	15	0.05		0.50					
1N4798D		68	1	2.40	0	4	15	15	0.05		0.50					
1N4799		82	20	2.36	0	4	15	15	0.05		0.50					
1N4799A		82	10	2.36	0	4	15	15	0.05		0.50					
1N4799B		82	5	2.36	0	4	15	15	0.05		0.50					
1N4799C		82	2	2.36	0	4	15	15	0.05		0.50					
1N4799D		82	1	2.36	0	4	15	15	0.05		0.50					
1N4800		100	20	2.33	0	4	15	15	0.05		0.50					
1N4800A		100	10	2.33	0	4	15	15	0.05		0.50					
1N4800B		100	5	2.33	0	4	15	15	0.05		0.50					
1N4800C		100	2	2.33	0	4	15	15	0.05		0.50					
1N4800D		100	1	2.33	0	4	15	15	0.05		0.50					
1N4801		6.8	20	2.56	0	4	100	15	0.05		0.50					
1N4801A		6.8	10	2.56	0	4	100	15	0.05		0.50					
1N4801B		6.8	5	2.56	0	4	100	15	0.05		0.50					
1N4801C		6.8	2	2.56	0	4	100	15	0.05		0.50					
1N4801D		6.8	1	2.56	0	4	100	15	0.05		0.50					
1N4802		8.2	20	2.58	0	4	100	15	0.05		0.50					
1N4802A		8.2	10	2.58	0	4	100	15	0.05		0.50					
1N4802B		8.2	5	2.58	0	4	100	15	0.05		0.50					
1N4802C		8.2	2	2.58	0	4	100	15	0.05		0.50					
1N4802D		8.2	1	2.58	0	4	100	15	0.05		0.50					
1N4803		10	20	2.50	0	4	100	15	0.05		0.50					
1N4803A		10	10	2.50	0	4	100	15	0.05		0.50					
1N4803B		10	5	2.50	0	4	100	15	0.05		0.50					
1N4803C		10	2	2.50	0	4	100	15	0.05		0.50					
1N4803D		10	1	2.50	0	4	100	15	0.05		0.50					
1N4804		12	20	2.49	0	4	100	15	0.05		0.50					
1N4804A		12	10	2.49	0	4	100	15	0.05		0.50					
1N4804B		12	5	2.49	0	4	100	15	0.05		0.50					
1N4804C		12	2	2.49	0	4	100	15	0.05		0.50					
1N4804D		12	1	2.49	0	4	100	15	0.05		0.50					
1N4805		15	20	2.49	0	4	100	15	0.05		0.50					
1N4805A		15	10	2.49	0	4	100	15	0.05		0.50					
1N4805B		15	5	2.49	0	4	100	15	0.05		0.50					
1N4805C		15	2	2.49	0	4	100	15	0.05		0.50					
1N4805D		15	1	2.49	0	4	100	15	0.05		0.50					
1N4806		18	20	2.48	0	4	90	15	0.05	0.50						
1N4806A		18	10	2.48	0	4	90	15	0.05	0.50						
1N4806B		18	5	2.48	0	4	90	15	0.05	0.50						
1N4806C		18	2	2.48	0	4	90	15	0.05	0.50						
1N4806D		18	1	2.48	0	4	90	15	0.05	0.50						
1N4807		22	20	2.46	0	4	90	15	0.05		0.50					
1N4807A		22	10	2.46	0	4	90	15	0.05		0.50					
1N4807B		22	5	2.46	0	4	90	15	0.05		0.50					
1N4807C		22	2	2.46	0	4	90	15	0.05		0.50					
1N4807D		22	1	2.46	0	4	90	15	0.05		0.50					
1N4808		27	20	2.46	0	4	65	15	0.05		0.50					
1N4808A		27	10	2.46	0	4	65	15	0.05		0.50					
1N4808B		27	5	2.46	0	4	65	15	0.05		0.50					
1N4808C		27	2	2.46	0	4	65	15	0.05		0.50					
1N4808D		27	1	2.46	0	4	65	15	0.05		0.50					
1N4809		33	20	2.46	0	4	60	15	0.05		0.50					
1N4809A		33	10	2.46	0	4	60	15	0.05		0.50					

VARACTOR DIODES INDEX (continued) 1N4809B – 1N5155

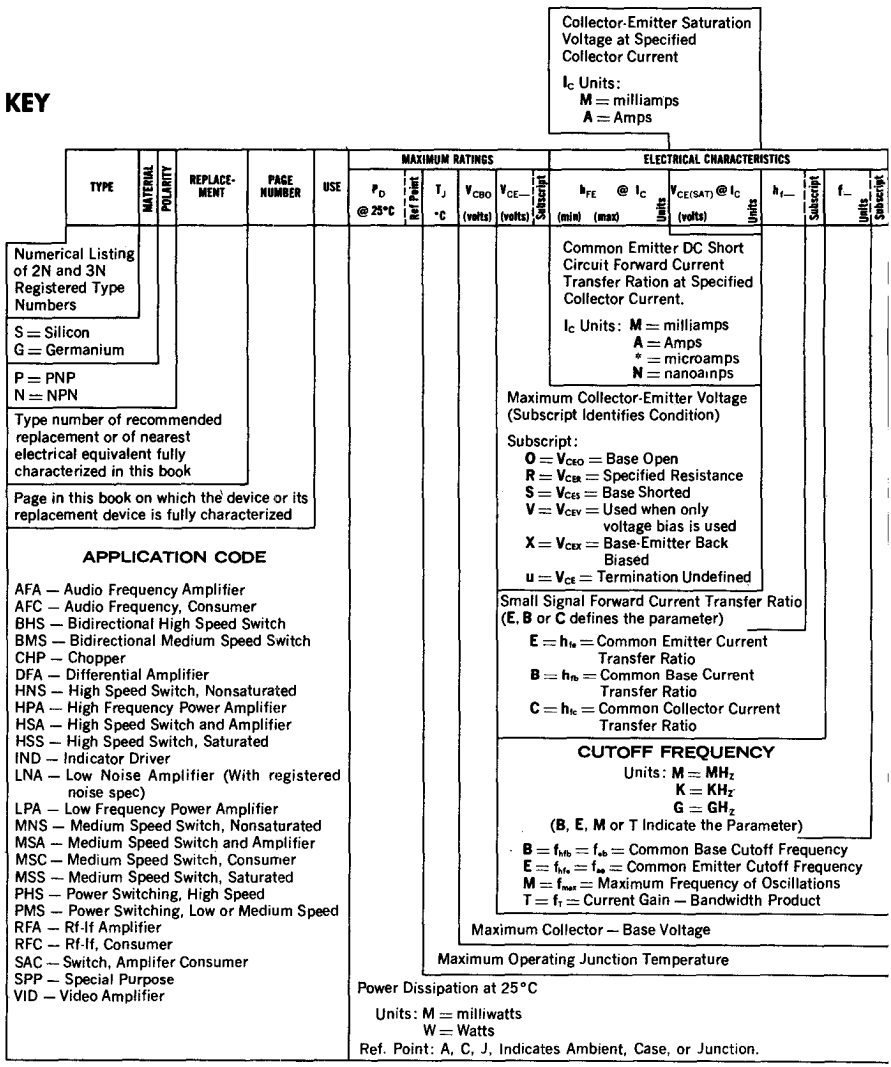
TYPE	PAGE NUMBER	CAPACITANCE					BV$_R$	Q @ f		Max R_S	P_D @ 25°C	MULTIPLIER PERFORMANCE				
		C_J C_T*	C Tol	C (max) C (min)	Voltage Range V_1	V_2						P_{in}	f_{in}	Min P_{out}	f_{out}	Min η
		pF	%		Volts	Volts	Volts		GHz	Ohms	Watts	Watts	GHz	Watts	GHz	%
1N4809B		33	5	2.46	0	4	60	15	0.05		0.50					
1N4809C		33	2	2.46	0	4	60	15	0.05		0.50					
1N4809D		33	1	2.46	0	4	60	15	0.05		0.50					
1N4810		39	20	2.44	0	4	55	15	0.05		0.50					
1N4810A		39	10	2.44	0	4	55	15	0.05		0.50					
1N4810B		39	5	2.44	0	4	55	15	0.05		0.50					
1N4810C		39	2	2.44	0	4	55	15	0.05		0.50					
1N4810D		39	1	2.44	0	4	55	15	0.05		0.50					
1N4811		47	20	2.43	0	4	50	15	0.05		0.50					
1N4811A		47	10	2.43	0	4	50	15	0.05		0.50					
1N4811B		47	5	2.43	0	4	50	15	0.05		0.50					
1N4811C		47	2	2.43	0	4	50	15	0.05		0.50					
1N4811D		47	1	2.43	0	4	50	15	0.05		0.50					
1N4812		56	20	2.42	0	4	40	15	0.05		0.50					
1N4812A		56	10	2.42	0	4	40	15	0.05		0.50					
1N4812B		56	5	2.42	0	4	40	15	0.05		0.50					
1N4812C		56	2	2.42	0	4	40	15	0.05		0.50					
1N4812D		56	1	2.42	0	4	40	15	0.05		0.50					
1N4813		68	20	2.40	0	4	30	15	0.05		0.50					
1N4813A		68	10	2.40	0	4	30	15	0.05		0.50					
1N4813B		68	5	2.40	0	4	30	15	0.05		0.50					
1N4813C		68	2	2.40	0	4	30	15	0.05		0.50					
1N4813D		68	1	2.40	0	4	30	15	0.05		0.50					
1N4814		82	20	2.36	0	4	20	15	0.05		0.50					
1N4814A		82	10	2.36	0	4	20	15	0.05		0.50					
1N4814B		82	5	2.36	0	4	20	15	0.05		0.50					
1N4814C		82	2	2.36	0	4	20	15	0.05		0.50					
1N4814D		82	1	2.36	0	4	20	15	0.05		0.50					
1N4815		100	20	2.33	0	4	20	15	0.05		0.50					
1N4815A		100	10	2.33	0	4	20	15	0.05		0.50					
1N4815B		100	5	2.33	0	4	20	15	0.05		0.50					
1N4815C		100	2	2.33	0	4	20	15	0.05		0.50					
1N4815D		100	1	2.33	0	4	20	15	0.05		0.50					
1N4885		35		2.57	6	150	150			0.70	20					
1N4886		35		2.57	6	120	120			0.80	20					
1N5139	12-10	6.8*	10	2.9	4	60	60	350	0.05		0.4					
1N5139A	12-10	6.8*	5	2.9	4	60	60	350	0.05		0.4					
1N5140	12-10	10*	10	3.0	4	60	60	300	0.05		0.4					
1N5140A	12-10	10*	5	3.0	4	60	60	300	0.05		0.4					
1N5141	12-10	12*	10	3.0	4	60	60	300	0.05		0.4					
1N5141A	12-10	12*	5	3.0	4	60	60	300	0.05		0.4					
1N5142	12-10	15*	10	3.0	4	60	60	250	0.05		0.4					
1N5142A	12-10	15*	5	3.0	4	60	60	250	0.05		0.4					
1N5143	12-10	18*	10	3.0	4	60	60	250	0.05		0.4					
1N5143A	12-10	18*	5	3.0	4	60	60	250	0.05		0.4					
1N5144	12-10	22*	10	3.4	4	60	60	200	0.05		0.4					
1N5144A	12-10	22*	5	3.4	4	60	60	200	0.05		0.4					
1N5145	12-10	27*	10	3.4	4	60	60	200	0.05		0.4					
1N5145A	12-10	27*	5	3.4	4	60	60	200	0.05		0.4					
1N5146	12-10	33*	10	3.4	4	60	60	200	0.05		0.4					
1N5146A	12-10	33*	5	3.4	4	60	60	200	0.05		0.4					
1N5147	12-10	39*	10	3.4	4	60	60	200	0.05		0.4					
1N5147A	12-10	39*	5	3.4	4	60	60	200	0.05		0.4					
1N5148	12-10	47*	10	3.4	4	60	60	200	0.05		0.4					
1N5148A	12-10	47*	5	3.4	4	60	60	200	0.05		0.4					
1N5149	12-12	11.5*					80	800	0.05		10	20	0.5	11	1	55
1N5150	12-12	11.5*					80	800	0.05		14	37	0.5	24	1	65
1N5151	12-15	5.8*					75	1100	0.05	0.5	5.5	12	1	6	2	50
1N5152	12-15	5.8*					75	1100	0.05	0.5	5.5	12	1	6	2	50
1N5153	12-15	5.8*					75	1100	0.05	0.5	5.5	12	1	6	2	50
1N5154	12-18	2.1*					35	1700	0.05	0.9	3.5	5	2	2	6	40
1N5155	12-18	2.1*					35	1700	0.05	0.9	3.5	5	2	2	6	40

NUMERICAL INDEX

Numerical Listing of EIA-Registered 2N and 3N Type Numbers and Short-Form Specifications for Bi-Polar Transistors

This table serves two functions. It provides a complete listing of EIA-registered 2N and 3N type numbers, for device identification, and gives short-form specifications for bi-polar transistors. Type numbers for devices other than bi-polar transistors (i.e. thyristors, field-effect transistors, etc.), may be listed in blocks (2N — thru 2N —) with reference to subsequent tables where such devices are sequentially tabulated and short-form specifications are given.

KEY



TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N 21		P			MSS	.12W	A	85	100											
2N 22	G	P			MSS	145M	A	55	100	100	0						2	B		
2N 23	G	P			MSS	105M	A	55	40	50	0						2	B		
2N 24	G	P			AFA	145M	A	50	30	30	0						2.2	B		
2N 25	G	P			RFA	200M	A	60	50	50	0						2.5	B	3M	B
2N 26	G	P			MNS	90M	A	55	30	40	0									
2N 27		N			AFA	50M	A	85	35								.95	B	1M	B
2N 28		N			AFA	50M	A	85	30								.94	B	.5M	B
2N 29		N			AFA	50M	A	85	35								.96	B	1M	B
2N 30	G	P			AFA	100M	A	40	35										3M	B
2N 31	G	P			AFA	100M	A	40	35										3M	B
2N 32	G	P			MSA	50M	A		40											
2N 32A	G	P			MSA	50M	A		40											
2N 33	G	P			RFC	30M	A		8.5											
2N 34	G	P	2N1191	7-30	AFC	50M	A		25											
2N 34A	G	P			AFC	50M	A		25											
2N 35	G	P			AFC	50M	A		25											
2N 36	G	P	2N1191	7-30	AFA	50M	A	50	20											
2N 37	G	P	2N1191	7-30	AFA	50M	A	20									30	E		
2N 38	G	P	2N1191	7-30	AFA	50M	A										15	E		
2N 38A	G	P			AFA	50M	A	20	20											
2N 41	G	P			AFC	50M	A		25											
2N 43	G	P			AFA	240M	A	85	45	30	0	34		20M			30	E	500K	B
2N 43A	G	P	2N525	7-17	AFA	240M	A	85	45	30	0	34	65	20M			30	E	500K	B
2N 44	G	P	2N524	7-17	AFA	240M	A	85	45	30	0	18	43	20M					500K	B
2N 45	G	P	2N524	7-17	AFA	240M	A	85	45	30	0	18		20M					500K	B
2N 46	G	P			AFC	50M	A		25											
2N 47	G	P	2N1191	7-30	AFC	50M			35											
2N 48	G	P			AFC	50M			35											
2N 49	G	P	2N1191	7-30	AFC	50M			35											
2N 50	G				MSA	50M	A	50	15											
2N 51	G				MSA	.1W	A	50	50											
2N 52	G				MSA	.12W	A	50	50											
2N 53	G				MSA	.1W	A	50	50											
2N 54	G	P	2N1191	7-30	AFA	.2W	A	60	45											
2N 55	G	P	2N1191	7-30	AFA	.2W	A	60	45											
2N 56	G	P	2N1191	7-30	AFA	.2W	A	60	45											
2N 57	G	P			LPA	20W	C		60											
2N 59	G	P	2N1193	7-30	AFA	180M	A	85	25	25	0									
2N 59A	G	P			AFA	180M	A	85	40	40	0									
2N 59B	G	P			AFA	180M	A	85	50	50	0									
2N 59C	G	P			AFA	180M	A	85	60	60	0									
2N 60	G	P	2N1193	7-30	AFA	180M	A	85	25	25	0									
2N 60A	G	P			AFA	180M	A	85	40	40	0									
2N 60B	G	P			AFA	180M	A	85	50	50	0									
2N 60C	G	P			AFA	180M	A	85	60	60	0									
2N 61	G	P	2N1192	7-30	AFA	180M	A	85	25	25	0									
2N 61A	G	P			AFA	180M	A	85	40	40	0									
2N 61B	G	P			AFA	180M	A	85	50	50	0									
2N 61C	G	P			AFA	180M	A	85	60	60	0									
2N 62	G	P	2N1191	7-30	AFC	50M			35											
2N 63	G	P	2N1191	7-30	AFA	102M	A	85	44	44	S									
2N 64	G	P	2N1191	7-30	AFA	102M	A	85	30	30	S									
2N 65	G	P	2N1193	7-30	AFA		A	85	24	24	S									
2N 66		P			LPA	27.5W	C	80	60	40										
2N 67		P			MSS	.1W	A	85	50											
2N 68		P			LPA	2W	A	70	25											
2N 71		P			LPA	1W	A	60	75	50	U									
2N 72	G	P			MSA	50M	A		40											
2N 73		P			CHP	.2W	A			50	U									
2N 74		P			MSS	.2W	A			50	U									
2N 75		P			MSS	.2W	A			20	U									
2N 76	G	P	2N319	7-6	AFA	5M	J	60	20										500K	B
2N 77	G	P	2N1191	7-30	AFC	35M	A		25											
2N 78	G	N			RFA	65M	A	85	15	15	0	45	135	1M			.97	B	5M	B
2N 78A	G	N			RFA	65M	A	85	20	15	0	45	135	1M			.97	B	5M	B
2N 79	G	P	2N1191	7-30	AFC	35M	A		35											
2N 80	G	P			AFA	50M	A		25											
2N 81	G	P	2N1191	7-30	AFA	50M	A	100		20	0						20	E		
2N 82	G	P	2N1191	7-30	AFA	35M	A	71	20			20	60	1M						
2N 94	G	N			RFC	150M	A	85	20	20	R	20	80	1M			7.5		2M	B
2N 94A	G	N			RFC	150M	A	85	20	20	R	20	80	1M			5.0		5M	B
2N 95		N			LPA	2.5W	A	70	25											
2N 96	G	P			AFC	50M	A		30										500K	B
2N 97	G	N			AFA	50M	A	75	30								5	E	.5M	B
2N 97A	G	N			AFA	50M	A	85	40								5	E	.5M	B
2N 98	G	N			AFA	50M	A	75	40								19	E	.8M	B

2N98A — 2N166

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f}—	Subscript	f— Units	Subscript
2N 98A	G	N			AFA	50M	A	85	40								24	E	.8M	B
2N 99	G	N			AFA	50M	A	75	40								19	E	2M	B
2N 100		N			AFA	25M	A	50	25								99	E	2.5M	B
2N 101	G	P			LPA	1W	A	70	25											
2N 102	G	N			LPA	1W	A	70	25											
2N 103	G	N			AFA	50M	A	75	35								1.5	E		
2N 104	G	P	2N650	7-20	AFC	150M	A	70	30											
2N 105	G	P			AFC	35M	A	50	35											
2N 106	G	P	2N1191	7-30	AFA	102M	A	85	6											
2N 107	G	P	2N464	7-15	AFC	50M	A	60	12	6	0						.95	B		
2N 108	G	P			AFA	50M	A													
2N 109	G	P	2N1192	7-30	AFC	165M	A	71	35	25	0	65	115	50M	.15	50M	50	E		
2N 110	G	P			MSS	.2W	A	85	50						2.5	18M				
2N 111	G	P			RFA	150M	A	85	30	15	0	15		1M						
2N 111A	G	P			RFA	150M	A	85	30	15	0	15		1M						
2N 112	G	P			RFA	150M	A	85	30	15	0	15		1M						
2N 112A	G	P			RFA	150M	A	85	30	15		15		1M						
2N 113	G	P			RFA	96M	A	85	10											
2N 114	G	P			RFA	96M	A	85	10											
2N 115	G	P			PMS	50W	C	75	32	32	R		110	30M						
2N 117	S	N			HSA	150M	C	150	30								.9	B	1M	B
2N 118	S	N			HSA	150M	C	150	30								.95	B	2M	B
2N 118A	S	N			HSA	150M	C	150	45											
2N 119	S	N			HSA	150M	C	150	30								.974	B	2M	B
2N 120	S	N			RFA	150M	C	175	45			76	333				.987	B		
2N 122	S	N			LPA	8.75W	C	150	120			3		100M						
2N 123	G	P			HSA	50M	J	85	20	15	0						.98	B	5M	B
2N 124	G	N			MSS	50M	A	75	10			12	24	5M	.3	5M			3M	U
2N 125	G	N			MSS	50M	A	75	10			24	48	5M	.3	5M			5M	U
2N 126	G	N			MSS	50M	A	75	10			48	100	5M	.3	5M			5M	U
2N 127	G	N			MSS	50M	A	75	10			100	200	5M	.3	5M			5M	U
2N 128	G	P			RFA	30M	A	85	10	4.5	U						19	E	45M	M
2N 129	G	P			RFA	30M	A	85	10	4.5	U						11.5	E	30M	M
2N 130	G	P	2N1191	7-30	AFA	85M	A	85	44											
2N 130A	G	P	2N650	7-20	AFA	100M	A	85	45	40	0						14	E		
2N 131	G	P	2N1192	7-30	AFA	85M	A	85	30											
2N 131A	G	P	2N651	7-20	AFA	100M	A	85	45	30	0						27	E		
2N 132	G	P	2N1192	7-30	AFA	85M	A	85	24											
2N 132A	G	P	2N651	7-20	AFA	100M	A	85	35	20	0									
2N 133	G	P	2N1192	7-30	AFA	85M	A	85	30											
2N 133A	G	P	2N651	7-20	LNA	100M	A	85	35	20	0									
2N 135	G	P			RFA	100M	A	85	20	12	R						20	E	4.5M	B
2N 136	G	P			RFA	100M	A	85	20	12	R						40	E	6.5M	B
2N 137	G	P			RFA	100M	A	85	10	6	R						60	E	10M	B
2N 138	G	P			AFA	50M	A	50	24											
2N 138A	G	P			AFA	150M	A	85	45	30	0	10		50M						
2N 138B	G	P			AFA	100M	A	85	45											
2N 139	G	P			AFC	80M	A	70	16											
2N 140	G	P			AFC	80M	A	70	16											
2N 141	G	P			LPA	1.5W	A	25	60	30										
2N 142	G	N			LPA	1.5W	A	25	60	30										
2N 143	G	P			LPA	1W	A	25	60	30										
2N 144	G	N			LPA	1W	A	25	60	30										
2N 145	G	N			RFA	65M	A	75		20	U									
2N 146	G	N			RFA	65M	A	75		20	U									
2N 147	G	N			RFA	65M	A	75		20	U									
2N 148	G	N			RFA	65M	A	75		16	U									
2N 148A	G	N			RFA	65M	A	75		32	U									
2N 149	G	N			RFA	65M	A	75		16	U									
2N 149A	G	N			RFA	65M	A	75		32	U									
2N 150	G	N			RFA	65M	A	75		16	U									
2N 150A	G	N			RFA	65M	A	75		32	U									
2N 155	G	P	2N176	6-16	LPA	1.5W	A	85	30			24		.5A	.65	.5A				
2N 156	G	P	2N176	6-16	LPA	1.5W	A	85	30			24		.5A	.6	1A			145K	B
2N 157	G	P	2N1531	6-56	LPA	1.5W	A	85	60			20		.5A					100K	B
2N 157A	G	P	2N1532	6-56	LPA	1.5W	A	85	90			20		.5A					100K	B
2N 158	G	P	2N2139	6-74	LPA	1.5W	A	85	60			21		.5A	.75	1A			145K	B
2N 158A	G	P	2N2141	6-74	LPA	1.5W	A	95	80	60	0	21		.5A	.75	1A			4K	E
2N 160	S	N			AFA	.15W	A		40			9	19							
2N 160A	S	N			AFA	.15W	A		40			9	19							
2N 161	S	N			AFA	.15W	A		40			19	39							
2N 161A	S	N			AFA	.15W	A		40			19	39							
2N 162	S	N			AFA	.15W	A		40			19	199							
2N 162A	S	N			AFA	.15W	A		40			19	199							
2N 163	S	N			AFA	.15W	A		40			39	199							
2N 163A	S	N			AFA	.15W	A		40			39	199							
2N 166	G	N			RFC	25M	A	50		6	0									

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N 167	G	N			HSA	75M	A	85	30	30	0						.952	B	5M	B
2N 167A	G	N			HSA	75M	A	85	30	30	0	17	90	8M			.952	B	5M	B
2N 168	G	N			RFC	55M	A	75	15	15	0						20	E		
2N 168A	G	N			RFC	65M	A	85	15	15	0						20	E		
2N 169	G	N			RFC	65M	A	85	15	15	0						30	E		
2N 169A	G	N			AFC	65M	A	85	25	25	0						30	E		
2N 170	G	N			RFC	25M	A	50		6	0									
2N 172	G	N			RFA	65M	A	75		16	U									
2N 173	G	P		6-21	LPA	10W	C	95	60	50	S	35	70	5A	1	12A				
2N 174	G	P		6-13	PMS	100W	C	95	80	70	S	25	50	5A	.9	12A				
2N 174A	G	P			PMS	100W	C	95	80	70	S	40	80	1.2A	.7	12A			100K	B
2N 175	G	P	2N1192	7-30	AFC	50M	A	71	10											
2N 176	G	P		6-16	AFC	90W	C	80	40	30	R	25		.5A	.4	3A			4	E
2N 178	G	P		6-18	AFA	40W	C	90	30	30	R	35	45	.5A	.6	3A			5	E
2N 179	G	P	2N176	6-16	AFA															
2N 180	G	P	2N1192	7-30	AFA	.15W	A	75	30											
2N 181	G	P	2N1192	7-30	AFA	.25W	A	75	30											
2N 182	G	N			MSS	.1W	A	75	25											
2N 183	G	N			MSS	.1W	A	75	25											
2N 184	G	N			MSS	.1W	A	75	25											
2N 185	G	P	2N650	7-20	AFA	150M	A	50	20								35	E		
2N 186	G	P	2N1191	7-30	AFC	100M	A	85	25	25	R								800K	B
2N 186A	G	P	2N1191	7-30	AFC	200M	A	85	25	25	R								800K	B
2N 187	G	P	2N1191	7-30	AFC	100M	A	85	25	25	R								1M	B
2N 187A	G	P	2N1191	7-30	AFC	200M	A	85	25	25	R								1M	B
2N 188	G	P	2N1191	7-30	AFC	100M	A	85	25	25	R								1.2M	B
2N 188A	G	P	2N1191	7-30	AFC	200M	A	85	25	25	R								1.2M	B
2N 189	G	P	2N1191	7-30	AFC	75M	A	85	25	25	R								800K	B
2N 190	G	P	2N1191	7-30	AFC	75M	A	85	25	25	R								1M	B
2N 191	G	P	2N1192	7-30	AFC	75M	A	85	25	25	R								1.2M	B
2N 192	G	P	2N1193	7-30	AFC	75M	A	85	25	25	R								1.5M	B
2N 193	G	N			RFC	150M	A	85	18	18	R						4.0		2M	B
2N 194	G	N			RFC	50M	A	75	15	15	R						4.8		2M	B
2N 194A	G	N			RFC	50M	A	75	20	20	R						5.0		2M	B
2N 206	G	P	2N1191	7-30	AFC	75M	A		30											
2N 207	G	P	2N1193	7-30	LNA	50M	A	65	12	12	V						35	E		
2N 207A	G	P	2N1190	7-28	LNA	50M	A	65	12	12	V						35	E		
2N 207B	G	P			LNA	50M	A	65	12	12	V						35	E		
2N 211	G	N			RFC	50M	A	75	10	10	R						3.8		2M	E
2N 212	G	N			RFC	150M	A	85	18	18		10		1M			10	E	4M	B
2N 213	G	N			AFC	50M	A	75	40	25	R				0.6	100M	70	E		
2N 213A	G	N			AFC	150M	A	85	40	25	R				1.0	100M	100	E	10K	E
2N 214	G	N			AFC	125M	A	75	40			50	100	35M					600K	B
2N 215	G	P	2N1189	7-28	AFC	150M	A	70	30											
2N 216	G	N			RFC	50M	A	75	15								3.9	E	2M	B
2N 217	G	P	2N1192	7-30	AFC	150M	A	71	35	25	0	65	115	50M	.15	50M				
2N 218	G	P			AFC	80M	A	70	16											
2N 219	G	P			AFC	80M	A	70	16											
2N 220	G	P	2N1189	7-30	AFC	50M	A	71	10											
2N 223	G	P	2N1193	7-30	AFC	100M	A	65		18	V						39	E		
2N 224	G	P	2N1192	7-30	AFC	250M	A	75	25			60	120	100M	.25	100M				
2N 225	G	P	2N1193	7-30	AFC	250M	A	75	25			60	120	100M	.25	100M				
2N 226	G	P	2N1192	7-30	AFC	250M	A	75	30			35	105	100M	.25	100M				
2N 227					AFC	250M	A	75	30			35	105	100M	.25	100M				
2N 228	G	P			AFC	50M	A	75	25			50	100	35M					600K	B
2N 229	G	N			AFC	50M	A	75	10										550K	B
2N 230	G	P			LPA	15W	C	85	60	30	U	60	106	.5A	.8	2A			12K	E
2N 231	G	P			RFC	9M	A	55	4.5	4.5	V						19	E	30M	M
2N 232	G	P			RFC	9M	A	55	4.5	4.5	V						9	E	20M	M
2N 233	G	N			RFC	50M	A	75	10								3.0	E		
2N 233A	G	N			RFC	50M	A	75	10								3.5	E		
2N 234	G	P	2N554	6-18	LPA			90		25	R									
2N 234A	G	P	2N555	6-18	LPA	25W		90		25	R									
2N 235	G	P	2N350A	6-26	LPA			90		40	U				.8	1A				
2N 235A	G	P	2N3611	6-110	LPA	25W		90		40	U				.8	1A				
2N 2358	G	P	2N3613	6-110	LPA	25W		85	50	35	R				.8	1A			5K	E
2N 236	G	P	2N350A	6-26	LPA			95		35	R				1	3A				
2N 236A	G	P	2N351A	6-26	LPA	25W		95		35	R				1	3A				
2N 236B	G	P	2N376A	6-26	LPA	25W		95	50	35	R				1	3A			5K	E
2N 237	G	P			AFA	150M	A	55	45								.98	B	500K	B
2N 238	G	P	2N1192	7-30	AFA	50M	A	60	20											
2N 240	G	P			MSS	25M	A	85	6	6	S				.1	8M	16	E	25M	T
2N 241	G	P	2N321	7-6	AFC	100M	A	85	25	25	R								1.3M	B
2N 241A	G	P	2N321	7-6	AFC	200M	A	85	25	25	R								1.3M	B
2N 242	G	P		6-20	AFA	20W	C	85	45	45	R								5K	B
2N 243	S	N			AFA	750M	C	150	60								.9	B		

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units Subscript
2N 244	S	N			AFA	750M	C	150	60								.961	B		
2N 247	G	P			RFC	80M	A		40											
2N 248	G	P			AFA			75	25											
2N 249	G	P			AFA	350M	A	60	25								30	E		
2N 250	G	P	2N3611	6-110	LPA	12W	C	80	30			30		500M					8K	E
2N 250A	G	P	2N3611	6-110	LPA	90W	C	100	40	35	V	25	100	3A	.7	3A			200K	T
2N 251	G	P	2N1530	6-56	LPA	12W	C	80	60			30		500M					8K	E
2N 251A	G	P	2N3616	6-113	LPA	90W	C	100	60	55	V	25	100	3A	.7	3A			200K	T
2N 252	G	P			RFA	30M	C	55		16	0									
2N 253	G	N			RFA	65M	C	75		12	0									
2N 254	G	N			RFA	65M	C	75		20	0									
2N 255	G	P	2N554	6-18	LPA	1.5W	A	85	15											
2N 255A	G	P			LPA	20W	C	85	15	15	R									
2N 256	G	P	2N555	6-18	LPA	1.5W	A	85	30											
2N 256A	G	P			LPA	20W	C	85	30	25	R									
2N 257	G	P	2N3611	6-110	LPA	25W	C	85	40										7K	
2N 258	S	P			AFA	250M	A	160	30	30	0						15	E		
2N 259	S	P			AFA	250M	A	160	30	30	0						32	E		
2N 260	S	P			AFA	.2W	A	150	10											
2N 260A	S	P			AFA	.2W	A	150	30											
2N 261	S	P			AFA	.2W	A	150	75											
2N 262	S	P			AFA	.2W	A	150	10											
2N 262A	S	P			AFA	.2W	A	150	30											
2N 263																				
2N 264	S	N			AFA	125M	A	150	45	30	0	20	55	10M	1.5	10M	.95	B	10M	B
2N 265	G	P	2N1175	7-33	AFC	75M	A	85		25	R								1.5M	B
2N 266	G	P			AFC	75M	A	85		18	R								800K	B
2N 267	G	P			RFC	80M	A		40											
2N 268	G	P	2N1530	6-56	LPA	25W	C	85	80										6K	
2N 268A	G	P	2N1536	6-56	PMS	10W	C	90	80	60	V	20		2A	1	2A				
2N 269	G	P			MNS	120M	A	85	25	24	0									
2N 270	G	P	2N1193	7-30	AFC	150M	A	50	25											
2N 271	G	P			RFA	150M	A	85	30	10	0									
2N 271A	G	P			RFA	150M	A	85	30	10	0									
2N 272	G	P			AFA	150M	A	85	30	24	0						60	E		
2N 273	G	P			AFA	150M	A	85	45	25	S	30		50M						
2N 274	G	P			RFC	120M	A	100	40	40	0	20	175	1.5M			20	E		
2N 277	G	P		6-21	LPA	70W	C	95	40	40	S	35	70	5A						
2N 278	G	P		6-21	LPA	70W	C	95	50	45	S	35	70	5A	1	12A				
2N 279	G	P	2N650	7-20	AFA	125M	A	75		20							20	E		
2N 280	G	P	2N650	7-20	AFA	125M	A	75		20							30	E		
2N 281	G	P	2N651	7-20	AFA	167M	C	75	16	16		45	120						.35M	B
2N 282	G	P			AFA															
2N 283	G	P	2N650	7-20	MSA	125M	A	75	20	20							30	E		
2N 284	G	P			MSA	125M	A	75	32	32		15							.35M	B
2N 284A	G	P			MSA	125M	A	75	60	60		15							.35M	B
2N 285	G	P	2N3617	6-113	LPA	25W	C	95		35	R				.5	1A				
2N 285A	G	P	2N3617	6-113	LPA	25W	C	95		35	R				.5	1A				
2N 290	G	P			LPA	55W	C	95	70											
2N 291	G	P	2N1191	7-30	AFA	180M	A	50	25								30	E		
2N 292	G	N			RFC	65M	A	85	15	15	0	6	44							
2N 293	G	N			RFC	65M	A	85	15	15	0	6	55							
2N 296	G	P	2N1531	6-36	AFA	20W	C	85	60			19		1A	1.0	1A			4K	B
2N 297	G	P	2N297A	6-24	LPA	35W	C	95	60	50	S	40	100	.5A	1	2A			5K	E
2N 297A	G	P		6-24	LPA	35W	C	95	60	50	S	40	100	.5A	1	2A			5K	E
2N 299	G	P			RFA	20M	A	85	5	4.5	V								90M	M
2N 300	G	P			VID	20M	A	85	5	4.5	V						11	E	85M	M
2N 301	G	P	2N3611	6-110	LPA	11W	A	85	40											
2N 301A	G	P	2N3612	6-110	LPA	11W	A	85	60											
2N 302	G	P			RFA	150M	A	85	30	10	0						45	E	7M	B
2N 303	G	P			RFA	150M	A	85	30	10	0						75	E	14M	B
2N 306	G	N			AFA	50M	A	75	20	15	R				.5	.1A	25	E	.6M	B
2N 307	G	P		6-20	LPA	25W	C	75	35	35	R	20		.2A	1	.2A			3K	E
2N 307A	G	P		6-20	LPA	25W	C	75	35	35	R	20		.2A	.8	1A			3.5K	E
2N 308	G	P			RFA	30M	A	55		20	0									
2N 309	G	P			RFA	30M	A	55		20	0									
2N 310	G	P			RFA	30M	A	55		30	0									
2N 311	G	P			PMS	75M	A	85	15	15	0	25	75	10M	.075	10M				
2N 312	G	P			PMS	75M	A	85	15	15	0	25	75	10M	.075	10M				
2N 315	G	P			MSA	100M	A	85	20	15	0	15	30	100M	.15	100M				
2N 315A	G	P			MSA	150M	A	100	30	20	0	20	50	100M	.15	100M				
2N 315B	G	P			MSA	150M	A	100	30	20	0	20	50	100M	.15	100M				
2N 316	G	P			MSA	100M	A	85	20	10	0	20	50	200M	.18	200M				
2N 316A	G	P			MSA	150M	A	100	30	15	0	20	50	200M	.18	200M				
2N 317	G	P			MSA	100M	A	85	20	6	0	20	60	400M	.2	400M				
2N 317A	G	P			MSA	150M	A	100	25	10	0	20	60	400M	.2	400M				
2N 318	G	P			SPP	50M	A		12											

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	h_{f-}	Subscript	f_-	Units Subscript
2N 319	G	P			AFC	225M	A	85		20	R								
2N 320	G	P	2N319	7-6	AFC	225M	A	85		20	R								
2N 321	G	P	2N319	7-6	AFC	225M	A	85		20	R								
2N 322	G	P	2N319	7-6	AFC	140M	A	60	18	18	R	34	65	20M					1M B
2N 323	G	P	2N319	7-6	AFC	140M	A	60	18	18	R	53	125	20M					1.5M B
2N 324	G	P	2N319	7-6	AFC	140M	A	60	18	18	R	72	198	20M					2M B
2N 325	G	P	2N3611	6-110	AFA	12W	C	85	35	35	S	30	60	500M	0.6	500M			150K B
2N 326	G	N			AFA	7W	C	85	35	35	S	30	60	500M	0.6	500M			150K B
2N 327	S	P			AFA	350M	A	160	50								9	E	
2N 327A	S	P			DFA	385M	A	160	50	40	0	9	22	3M	.3	5M			
2N 327B	S	P			DFA	385M	A	200	50	40	0	9	22	3M	.3	5M			
2N 328	S	P			AFA	350M	A	160	35								18	E	
2N 328A	S	P			DFA	385M	A	160	50	35	0	18	44	3M	.5	10M			
2N 328B	S	P			DFA	385M	A	200	50	35	0	18	44	3M	.5	10M			
2N 329	S	P			AFA	350M	A	160	30								36	E	
2N 329A	S	P			DFA	385M	A	160	50	30	0	36	88	3M	.6	15M			
2N 329B	S	P			DFA	385M	A	200	50	30	0	36	88	3M	.6	15M			
2N 330	S	P			AFA	350M	A	160	45								9	E	
2N 330A	S	P			DFA	385M	A	160	50	30	0								
2N 331	G	P		7-8	AFC	200M	A	71	30										
2N 332	S	N			RFA	150M	A	175	45			9	20				.9	B	
2N 332A	S	N			AFC	500M	A	175	45	45	0				1	5M	.9	B	2.5M B
2N 333	S	N			RFA	150M	A	175	45			18	40				.948	B	
2N 333A	S	N			AFC	500M	A	175	45	45	0				1	5M	.948	B	2.5M B
2N 334	S	N			RFA	150M	A	175	45			18	86				.948	B	
2N 334A	S	N			AFC	500M	A	175	45	45	0				1	5M	.948	B	8M B
2N 334B	S	N			AFC	500M	A	175	60	60	0	15	85	1M	1	5M	18	E	8M B
2N 335	S	N			RFA	150M	A	175	45			36	86				.973	B	
2N 335A	S	N			AFC	500M	A	175	45	45	0				1	5M	.973	B	2.5M B
2N 335B	S	N			AFC	500M	A	175	60	60	0	28	90	1M	1	5M	37	E	2.5M B
2N 336	S	N			RFA	150M	A	175	45			76	333				.987	B	
2N 336A	S	N			AFC	500M	A	175	45	45	0				1	5M	.987	B	2.5M B
2N 337	S	N			MSA	125M	C	150	45			20	55	10M					10M B
2N 337A	S	N			AFC	500M	A	175	45			20	55	10M			19	E	15M B
2N 338	S	N			MSA	125M	C	150	45			45	150	10M					20M B
2N 338A	S	N			AFC	500M	A	175	45			45	150	10M			39	E	25M B
2N 339	S	N			AFA	1W	C	150	55	55	0						.9	B	
2N 339A	S	N			RFA	3W	A	200	60	60	0	20	80				25	E	10M T
2N 340	S	N			AFA	1W	C	150	85	85	0						.9	B	
2N 340A	S	N			RFA	3W	A	200	85	85	0	20	80				25	E	10M T
2N 341	S	N			AFA	1W	C	150	125	85	0						.9	B	
2N 341A	S	N			RFA	3W	A	200	125	125	0	20	80				25	E	10M T
2N 342	S	N			AFA	1W	C	150	60	60	0						.9	B	
2N 342A	S	N			AFA	1W	C	150	85	85	0						.9	B	
2N 342B	S	N			AFA	750M	A	175	85	85	0						9	E	
2N 343	S	N			AFA	1W	C	150	60	60	0						.966	B	
2N 343A	S	N			AFA	1W	C	150	60	60	0						.966	B	
2N 343B	S	N			AFA	750M	A	175	65	65	0						28	E	
2N 344	G	P			RFC	20M	A	55	5	5	V						11	E	30M M
2N 345	G	P			RFC	20M	A	55	5	5	V						25	E	30M M
2N 346	G	P			RFC	20M	A	55	5	5	V						10	E	60M M
2N 350A	G	P		6-26	LPA	90W	J	100	50	40	S	20	60	.7A	1.75	3A			5K E
2N 351A	G	P		6-26	LPA	90W	J	100	50	40	S	25	90	.7A	1.75	4A			5K E
2N 352	G	P	2N1536	6-36	LPA	25W	C	100		40	R	30	140	1A					10K E
2N 353	G	P	2N1536	6-36	LPA	30W	C	100		40	R	40	150	1A					7K E
2N 354	S	P			RFA	150M	A	140	25	25	U						9	E	8M M
2N 355	S	P			MSS	150M	A	140	10	10	U				.15	5M	9	E	8M M
2N 356	G	N			MSA	100M	A	85	20	18	0	20	50	100M	.2	100M			
2N 356A	G	N			MSA	150M	A	100	30	20	0	20	50	100M	.2	100M			
2N 357	G	N			MSA	100M	A	85	20	15	0	20	50	200M	.2	200M			
2N 357A	G	N			MSA	150M	A	100	30	20	0	25	75	200M	.2	200M			
2N 358	G	N			MSA	100M	A	85	20	12	0	20	50	300M	.2	300M			
2N 358A	G	N			MSA	150M	A	100	30	15	0	25	75	300M	.2	300M			
2N 359	G	P	2N652	7-20	AFC	170M	A	85	25	18	R	100	300	50M					
2N 360	G	P	2N1192	7-30	AFC	170M	A	85	32	30	R	50	150	50M					
2N 361	G	P	2N1191	7-30	AFC	170M	A	85	32	30	R	25	75	50M					
2N 362	G	P	2N1192	7-30	AFC	170M	A	85	25	18	0						50	E	
2N 363	G	P	2N1192	7-30	AFC	170M	A	85	32	28	0						25	E	
2N 364	G	N			MSA	150M	A	100	30								9	E	1M B
2N 365	G	N			MSA	150M	A	100	30								19	E	1M B
2N 366	G	N			MSA	150M	A	100	30								49	E	1M B
2N 367	G	P	2N1191	7-30	MSA	100M	A	75	30								9	E	300K B
2N 368	G	P	2N1191	7-30	MSA	100M	A	75	30								19	E	400K B
2N 369	G	P	2N1191	7-30	MSA	100M	A	75	30								49	E	500K B
2N 370	G	P	2N3324	9-66	RFC	80M	A	71	24										

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N 371	G	P	2N3324	9-66	RFC	80M	A	71	24											
2N 372	G	P	2N3324	9-66	RFC	80M	A	71	24											
2N 373	G	P			RFC	80M	A	71	25											
2N 374	G	P	2N3325	9-66	RFC	80M	A	71	25											
2N 375	G	P		6-28	LPA	58W	C	95	80	60	S	35	90	1A	1	2A			7K	E
2N 376A	G	P		6-26	LPA	90W	J	100	50	40	S	35	120	.7A	1.75	5A			5K	E
2N 377	G	N			MSS	150M	A	100	25	20	V	20	60	30M		200M			5M	B
2N 377A	G	N			MSS	150M	A	100	40	40	V	20	60	30M						
2N 378	G	P		6-31	PMS	50W	C	100	20			40	80	2A	1	2A			5K	E
2N 379	G	P		6-31	PMS	50W	C	100	40			20	70	2A	1	2A			5K	E
2N 380	G	P		6-31	PMS	50W	C	100	30			30	70	2A	1	2A			5K	E
2N 381	G	P		7-10	AFA	.2W	A	100	50	25	R	35	65	20M			35	E		
2N 382	G	P		7-10	AFA	.2W	A	100	50	25	R	60	95	20M			70	E		
2N 383	G	P		7-10	AFA	.2W	A	100	50	25	R	75	120	20M			90	E		
2N 384	G	P	2N3325	9-66	RFC	120M	A	100	40	40	O	20	175	1.5M						
2N 385	G	N			MSS	150M	A	100	25	25	R	30	110	30M					4M	B
2N 385A	G	N			MSS	150M	A	100	40	40	V	30	110	30M					4M	B
2N 386	G	P	2N1531	6-56	LPA	500M	C	100	60	60	V	20		2.5A					7K	E
2N 387	G	P	2N1531	6-56	LPA	500M	C	100	80	80	V	20		2.5A					6K	E
2N 388	G	N			MSS	150M	A	100	25	20	R	60	180	30M					5M	B
2N 388A	G	N			MSS	150M	A	100	40	40	V	60	200	.30M					5M	B
2N 389	S	N	2N3445	6-103	LPA	85W	C	200		60	R	12	60	1A						
2N 389A	S	N			LPA	85W	C	200		60	R	12	60	1A	.75	1A			1M	T
2N 392	G	P	2N1550	6-63	LPA	48W	C	95	60	40	R	60	150	3A	.5	3A				
2N 393	G	P	2N967	8-50	MSS	25M	A	100	6	6	S	20		50M	.07	8M	40	E	25M	T
2N 394	G	P			HSA	150M	A	85	10	10	O	20	150	10M					4M	B
2N 394A	G	P			HSA	150M	A	85	10	30	O	30	120	10M					4M	B
2N 395	G	P			HSA	200M	A	100	30	15	R	20	150	10M	.2	50M			3M	B
2N 396	G	P			HSA	200M	A	100	30	20	R	30	150	10M	.2	50M			5M	B
2N 396A	G	P			HSA	200M	A	100	30	20	O	30	150	10M	.2	50M			5M	B
2N 397	G	P			HSA	200M	A	100	30	15	R	40	150	10M	.2	50M			10M	B
2N 398	G	P		7-12	IND	50M	A	55	105	105	S	20		5M						
2N 398A	G	P		7-12	AFA	150M	A	100	105	105	S	20		5M	.35	5M	20	E		
2N 3988	G	P	2N2043	7-39	IND	250M	A	100	105	105	S	20		5M	.25	5M	40	E	1M	B
2N 399	G	P	2N351A	6-26	LPA	25W	C	90		35	R				1	1.2A				
2N 400	G	P	2N350A	6-26	LPA	35W	C	95	25	20	O	40	300	.5A	.8	1A	25	E	3K	E
2N 401	G	P	2N3611	6-110	LPA	25W	C	90		35	R				1	1.2A				
2N 402	G	P	2N1191	7-30	AFA	180M	A	85	25	20	O									
2N 403	G	P	2N1191	7-30	AFA	180M	A	85	25	20	O									
2N 404	G	P			MSS	150M	A	85	25											
2N 404A	G	P			MSS	150M	A	100	40	35	O	30		12M	0.15	12M			4M	B
2N 405	G	P	2N322	7-7	AFC	150M	A	71	20											
2N 406	G	P	2N322	7-7	AFC	150M	A	71	20											
2N 407	G	P	2N324	7-7	AFC	150M	A	71	20											
2N 408	G	P	2N324	7-7	AFC	150M	A	71	20											
2N 409	G	P			RFC	80M	A	71	13											
2N 410	G	P			RFC	80M	A	71	13											
2N 411	G	P			RFC	80M	A	71	13											
2N 412	G	P			RFC	80M	A	71	13											
2N 413	G	P			RFA	150M	A	85	30	18	O									
2N 413A	G	P			RFA	150M	A	85	30	15	O									
2N 414	G	P			RFA	150M	A	85	30	15	O									
2N 414A	G	P			RFA	150M	A	85	30	15	O									
2N 414B	G	P			RFA	.2W	A	100	30	24	V						40	E	4M	B
2N 414C	G	P			RFA	.2W	A	100	30	24	V						40	E	4M	B
2N 415	G	P			RFA	150M	A	85	30	10	O									
2N 415A	G	P			RFA	150M	A	85	30	10	O									
2N 416	G	P			RFA	150M	A	85	30	12	O									
2N 417	G	P			RFA	150M	A	85	30	10	O									
2N 418	G	P	2N1537	6-56	PMS	25W	C	100	100	75	R	40		4A	2	4A				
2N 419	G	P			LPA	35W	C	95	25	20	O	50	350	.5A	.8	1.5A	25	E	3K	E
2N 420	G	P	2N1535	6-56	PMS	25W	C	100	65	40	R	40		4A	2	4A				
2N 420A	G	P	2N1537	6-56	PMS	25W	C	100	90	65	R	40		4A	2	4A				
2N 422	G	P	2N651	7-20	LNA	150M	A	85	35	20	O									
2N 422A	G	P			LNA	175M	A	100	35	20	O						30	E	1.5M	B
2N 424	S	N	2N3446	6-103	LPA	85W	C	200		80	R	12	60	1A						
2N 424A	S	N			LPA	85W	C	200		80	R	12	60	1A	.75	1A			1M	T
2N 425	G	P			MSA	175M	A	85	30	20	O	20	40		.32	100M			2.5M	B
2N 426	G	P			MSA	175M	A	85	30	10	O	30	60		.32	100M			3M	B
2N 427	G	P			MSA	175M	A	85	30	15	O	40	80		.32	150M			5M	B
2N 428	G	P			MSA	175M	A	85	30	12	O	60			.32	200M			10M	B
2N 428A	G	P			MSS	.15W	A	100	30	18	O	80			.32	.2A			10M	B
2N 438	G	N			MSS	.1W	A	85	30	25	O	20		50M					2.5M	B
2N 438A	G	N			MSS	.15W	A	85	30	25	O	20		50M					2.5M	B
2N 439	G	N			MSS	.1W	A	85	30	20	O	30		50M					5M	B
2N 439A	G	N			MSS	.15W	A	85	30	20	O	30		50M					5M	B
2N 440	G	N			MSS	.1W	A	85	30	15	O	40		50M					10M	B

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N 440A	G	N			MSS	.15W	A	85	30	15	0	40		50M		50M			10M		B
2N 441	G	P		6-32	LPA	50W	C	95	40	40	S	20	40	5A							
2N 442	G	P		6-32	LPA	50W	C	95	50	45	S	20	40	5A							
2N 443	G	P		6-32	LPA	50W	C	95	60	50	S	20	40	5A	1	12A					
2N 444	G	N			AFA	100M	A	85	15	15	0								.5M		B
2N 444A	G	N			AFA	150M	A	100	40	25	0	20	40	20M			15	E	.5M		B
2N 445	G	N			AFA	100M	A	85	15	12	0								.5M		B
2N 445A	G	N			AFA	150M	A	100	30	18	0	40	160	20M			35	E	2M		B
2N 446	G	N			MSA	100M	A	85	15	10	0								5M		B
2N 446A	G	N			MSA	150M	A	100	30	15	0	60	250	20M			60	E	5M		B
2N 447	G	N			MSA	100M	A	85	15	6	0								5M		B
2N 447A	G	N			MSA	150M	A	100	30	12	0	80	300	20M			85	E	9M		B
2N 447B	G	N			MSA	150M	A	100	25	12	0	80	300	20M			150	E	9M		B
2N 448	G	N			RFC	65M	A	85	15	15	0	8	51	1M							
2N 449	G	N			RFC	65M	A	85	15	15	0	34		1M							
2N 450	G	P			HSA	150M	A	85	20	12	0	30		10M	.2	10M			5M		B
2N 456	G	P	2N456A	6-35	LPA	50W	C	95	40	40	X				1	5A					
2N 456A	G	P		6-35	LPA	150W	C		40	40	0	30	90	5A	.5	5A			4K		E
2N 456B	G	P	2N1553	6-36	LPA	150W	C	100	40	30	0	30	90	5A	.5	5A			200K		T
2N 457	G	P	2N457A	6-35	LPA	50W		95	60	60	X				1	5A					
2N 457A	G	P		6-35	LPA	150W	C		60	60	0	30	90	5A	.5	5A			4K		E
2N 457B	G	P	2N1553	6-63	LPA	150W	C	100	60	40	0	30	90	5A	.5	5A			200K		T
2N 458	G	P	2N458A	6-35	LPA	50W		95	80	80	X				1	5A					
2N 458A	G	P		6-35	LPA	150W	C		80	80	0	30	90	5A	.5	5A			4K		E
2N 458B	G	P	2N1555	6-63	LPA	150W	C	100	80	45	0	30	90	5A	.5	5A			200K		T
2N 459	G	P		6-31	PMS	50W	C	100	60			20	70	2A	1	2A			5K		E
2N 459A	G	P		6-31	PMS	106W	C	110	105	60	0	40	70	2A	.3	2A			5K		E
2N 460	G	P		7-14	AFA	.2W	A	100	45			16	32								
2N 461	G	P		7-14	AFA	.2W	A	100	45			32	100								
2N 462	G	P			BMS	150M	A	75	40			20		200M					500K		B
2N 463	G	P	2N1555	6-63	LPA	37.5W	C	100	60	60		20	60	2A					4K		E
2N 464	G	P		7-15	AFA	150M	A	85	45	40	0										
2N 465	G	P		7-15	AFA	150M	A	85	45	30	0										
2N 466	G	P		7-15	AFA	150M	A	85	35	20	0										
2N 467	G	P		7-15	AFA	150M	A	85	35	15	0										
2N 469	G	P			SPP	50M	A	75	6			10		1M							
2N 469A	G	P			SPP	50M	A	85	20	15	R						30	E			
2N 470	S	N			RFA	.2W	A	200	15	15	0				1.5	5M	10	E	8M		T
2N 471	S	N			AFA	.2W	A	200	30	30	0				1.5	5M	10	E	8M		T
2N 471A	S	N			AFA	.2W	A	200	30	30	0				1	5M	10	E	8M		T
2N 472	S	N			RFA	.2W	A	200	45	45	0				1.5	5M	10	E	8M		T
2N 472A	S	N			AFA	.2W	A	200	45	45	0				1	5M	10	E	8M		T
2N 473	S	N			AFA	.2W	A	200	15	15	0				1.5	5M	20	E	8M		T
2N 474	S	N			AFA	.2W	A	200	30	30	0				1.5	5M	20	E	8M		T
2N 474A	S	N			AFA	.2W	A	200	30	30	0	10			1	5M	20	E	8M		T
2N 475	S	N			AFA	.2W	A	200	45	45	0				1.5	5M	20	E	8M		T
2N 475A	S	N			AFA	.2W	A	200	45	45	0	10			1	5M	20	E	8M		T
2N 476	S	N			AFA	.2W	A	200	15	15	0				1.5	5M	30	E	12M		T
2N 477	S	N			AFA	.2W	A	200	30	30	0				1.5	5M	30	E	12M		T
2N 478	S	N			RFA	.2W	A	200	15	15	0				1.5	5M	40	E	20M		T
2N 479	S	N			RFA	.2W	A	200	30	30	0				1.5	5M	40	E	20M		T
2N 479A	S	N			AFA	.2W	A	200	30	30	0	10			1	5M	40	E	20M		T
2N 480	S	N			RFA	.2W	A	200	45	45	0				1.5	5M	40	E	20M		T
2N 480A	S	N			AFA	.2W	A	200	45	45	0	10			1	5M	40	E	20M		T
2N 481	G	P			RFA	150M	A	85	12	12	0										
2N 482	G	P			RFA	150M	A	85	12	12	0										
2N 483	G	P			RFA	150M	A	85	12	12	0										
2N 484	G	P			RFA	150M	A	85	12	12	0										
2N 485	G	P			RFA	150M	A	85	12	12	0										
2N 486	G	P			RFA	150M	A	85	12	12	0										
2N 487	G	P			AFC	100M	A	85	18	18	R	20		1M			10	E	10M		T
2N489 thru 2N494	Unijunction Transistors, see Table on Page 1-177																				
2N 495	S	P			RFA	150M	A	140	25	25	U						15	E	8M		M
2N 496	S	P			MSS	150M	A	140	10	10	U	15		15M	.15	5M	9	E	7.2M		T
2N 497	S	N	2N3498	8-161	AFA	4W	C	200	60	60	0	12	36	200M							
2N 497A	S	N			AFA	5W	C	200	60	60	0	12	36	200M							
2N 498	S	N	2N3498	8-161	AFA	4W	C	200	100	100	0	12	36	200M							
2N 498A	S	N			AFA	5W	C	200	100	100	0	12	36	200M							
2N 499	G	P	2N3328	9-66	RFA	30M	A	85	30	18	0								120M		T
2N 499A	G	P	2N3323	9-66	RFA	60M	A	100	30	18	0						20	E	120M		T
2N 500	G	P	2N3323	9-66	RFA	50M	A	85	20	15											
2N 501	G	P	2N960	8-48	HSS	60M	A	100	15	12	S	20		10M	.2	10M			90M		T
2N 501A	G	P	2N960	8-48	HSS	60M	A	100	15	12	S	30		10M	.2	10M			90M		T
2N 502	G	P	2N3283	9-44	RFA	60M	A	85	20	20	S						9	E	220M		T
2N 502A	G	P	2N3284	9-44	RFA	75M	A	100	30	30	S						15	E	220M		T

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N 502B	G	P			RFC	75M	A	100	30	30	S						20	E		
2N 503	G	P	2N3284	9-44	RFA	25M	A	85	20	20	S						9	E	168M	T
2N 504	G	P	2N3323	9-66	RFA	30M	A	85	35	25	S	20	200	10M			16	E	50M	M
2N 506	G	P			AFA	50M	A	85	40			25	50	50M	0.6	50M			600K	B
2N 507	G	N			AFA	50M	A	85	40			25	50	50M	0.6	50M			600K	B
2N 508	G	P	2N508	8-7	AFC	200M	A	100	18	18	R	99	198	20M					2.5M	B
2N 508A	G	P	2N1189	7-28	AFA	.2W	A	100	30	30	S	100	200	20M			75	E	2.5M	B
2N 509	G	P			RFA	225M	A	100	30								.96	B	400M	T
2N 511	G	P	2N1554	6-63	LPA	150W	C		40			20	60	10A	.5	10A			260K	T
2N 511A	G	P	2N1555	6-63	LPA	150W	C		60			20	60	10A	.5	10A			260K	T
2N 511B	G	P	2N1556	6-63	PMS	150W	C		80			20	60	10A	.5	10A			260K	T
2N 512	G	P	2N1558	6-63	LPA	150W	C		40			20	60	15A	.75	15A			280K	T
2N 512A	G	P	2N1559	6-63	LPA	150W	C		60			20	60	15A	.75	15A			260K	T
2N 512B	G	P	2N1560	6-63	PMS	150W	C		80			20	60	15A	.5	10A			260K	T
2N 513	G	P	2N1163	6-49	LPA	150W	C		40			20	60	20A	1.25	20A			300K	T
2N 513A	G	P	2N1165	6-49	LPA	150W	C		60			20	60	20A	1.25	20A			260K	T
2N 513B	G	P	2N1167	6-49	PMS	150W	C		80			20	60	20A	.5	10A			260K	T
2N 514	G	P	2N1163	6-49	PMS	80W	C	95	40	40	X				1.25	25A				
2N 514A	G	P	2N1165	6-49	PMS	80W	C	95	60	60	X				1.25	25A				
2N 514B	G	P	2N1167	6-49	PMS	80W	C	95	80	80	X				1.25	25A				
2N 515	G	N			RFC	50M	A	75	20	18	R						4	E	2M	B
2N 516	G	N			RFC	50M	A	75	20	18	R						4	E	2M	B
2N 517	G	N			RFC	50M	A	75	20	18	R						4	E	2M	B
2N 518	G	P			MSS	.15W	A	85	45	12	0	60		10M	.15	10M			10M	B
2N 519	G	P			MSA	100M	A	85	15	15	0						15	E	.5M	B
2N 519A	G	P			MSA	150M	A	100	25	18	0	20	50	20M			15	E	.5M	B
2N 520	G	P			MSA	100M	A	85	15	12	0						20	E	3M	B
2N 520A	G	P			MSA	150M	A	100	25	15	0	40	170	20M			40	E	3M	B
2N 521	G	P			MSA	100M	A	85	15	10	0						35	E	8M	B
2N 521A	G	P			MSA	150M	A	100	25	12	0	60	250	20M			70	E	8M	B
2N 522	G	P			MSA	100M	A	85	15	8	0						60	E	15M	B
2N 522A	G	P			MSA	150M	A	100	25	10	0	80	320	20M			100	E	15M	B
2N 523	G	P			MSA	100M	A	85	15	6	0						80	E	21M	B
2N 523A	G	P			MSA	150M	A	100	20	6	0	100	400	20M			125	E	21M	B
2N 524	G	P		7-17	AFA	225M	A	100	45	30	R	25	42	20M	.13	20M	16	E	800K	B
2N 524A	G	P		7-17	AFA	225M	A	100	45	30	R	25	42	20M	.13	20M	18	E	.8M	B
2N 525	G	P		7-17	AFA	225M	A	100	45	30	R	34	65	20M	.13	20M	30	E	1M	B
2N 525A	G	P		7-17	AFA	225M	A	100	45	30	R	34	65	20M	.13	20M	30	E	1M	B
2N 526	G	P		7-17	AFA	225M	A	100	45	30	R	53	90	20M	.13	20M	44	E	1.3M	B
2N 526A	G	P		7-17	AFA	225M	A	100	45	30	R	53	90	20M	.13	20M	44	E	1.3M	B
2N 527	G	P		7-17	AFA	225M	A	100	45	30	R	72	121	20M	.13	20M	60	E	1.5M	B
2N 527A	G	P			AFA	225M	A	100	45	30	R	72	121	20M	.13	20M	60	E	1.5M	B
2N 528	G	P				2.5W	C	100	40	40		20		.5A						
2N 529	G					100M	A	85	15	15	0									
2N 530	G					100M	A	85	15	15	0									
2N 531	G					100M	A	85	15	15	0									
2N 532	G					100M	A	85	15	15	0									
2N 533	G					100M	A	85	15	15	0									
2N 534	G	P	2N1189	7-28	AFA	25M	A	65	50	50	U						35	E		
2N 535	G	P	2N1192	7-30	LNA	50M	A	85	20	20	U						35	E		
2N 535A	G	P	2N1192	7-30	LNA	50M	A	85	20	20	U						35	E		
2N 535B	G	P			LNA	50M	A	85	20	20	U						35	E		
2N 536	G	P	2N1193	7-30	MSS	50M	A	85	20	20	U	100		30M	.13	10M			1M	B
2N 537	G	P			RFA			100	30						4	70M	.9	B		
2N 538	G	P	2N2140	6-74	PMS	34W	J	95	80	60		20	50	2A	.6	2A				
2N 538A	G	P	2N2140	6-74	PMS	34W	J	95	80	60		20	50	2A	.6	2A				
2N 539	G	P	2N2145	6-74	PMS	34W	J	95	80	55		30	75	2A	.6	2A				
2N 539A	G	P	2N2145	6-74	PMS	11W	J	95	80	55		30	75	2A	.6	2A				
2N 540	G	P	2N1551	6-63	PMS	34W	J	95	80	55		45	113	2A	.6	2A				
2N 540A	G	P	2N1551	6-63	PMS	34W	J	95	80	55		45	113	2A	.6	2A				
2N 541	S	N			VID	.2W	A	200	15	15	U				1.5	5M	80	E	10M	T
2N 541A	S	N			AFA	.2W	A	200	15	15	0	20			1	5M	80	E	8M	T
2N 542	S	N			VID	.2W	A	200	30	30	U				1.5	5M	80	E	10M	T
2N 542A	S	N			AFA	.2W	A	200	30	30	0	20			1	5M	80	E	10M	T
2N 543	S	N			VIO	.2W	A	200	50	50	U				1.5	5M	80	E	10M	T
2N 543A	S	N			AFA	.2W	A	200	45	45	0	20			1	5M	80	E	10M	T
2N 544	G	P			RFC	80M	A	71	34											
2N 545	S	N			RFA	5W	C	200	60	60	0	15	80	.5A	5	.5A				
2N 546	S	N			RFA	5W	C	200	30	30	0	15	80	.5A	3	.5A				
2N 547	S	N	2N3766	6-134	RFA	5W	C	200	60	60	0	20	80	.5A	5	.5A			4M	T
2N 548	S	N	MJ3101	6-152	RFA	5W	C	200	30	30	0	20	80	.5A	3	.5A			4M	T
2N 549	S	N			RFA	5W	C	200	60	60	0	20	80	.2A	4	.2A			4M	T
2N 550	S	N			RFA	5W	C	200	30	30	0	20	80	.2A	4	.2A			4M	T
2N 551	S	N			RFA	5W	C	200	60	60	0	20	80	50M	2	50M			3M	T
2N 552	S	N			RFA	5W	C	200	30	30	0	20	80	50M	2	50M			3M	T
2N 553	G	P	2N2144	6-74	PMS	35W	C	95	80			40	80	500M	.9	3A				
2N 554	G	P		6-18	LPA	10W	J	90												

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ (volts)	@ I_C Units	h_{f-}	Subscript	f_-	Units	Subscript
2N 555	G	P		6-18	LPA	10W	J	90	40										5K	B
2N 556	G	N	2N1551	6-63	MSS	100M	A	85	25	20	X	35	70	1M	0.5	200M					
2N 557	G	N			MSS	100M	A	85	20	20	X	20		1M	0.5	200M					
2N 558	G	N			MSS	100M	A	75	15	15	X	60		1M	.75	200M					
2N 559	G	P			HSS	.15W	A	100	15	15					.3	10M					
2N 560	S	N			HSS	500M	A	150		60	S	20			.5	10M					
2N 561	G	P			AFC	50W	A	100	80	50	O										
2N 563	G	P	2N650	7-20	MSA	150M	A	85	30	25	O	10	30								
2N 564	G	P	2N650	7-20	MSA	120M	A	85	30	25	O	10	30								
2N 565	G	P	2N651	7-20	MSA	150M	A	85	30	25	O	30	50								
2N 566	G	P	2N651	7-20	MSA	120M	A	85	30	25	O	30	50								
2N 567	G	P	2N651	7-20	MSA	150M	A	85	30	25	O	50	70								
2N 568	G	P	2N651	7-20	MSA	120M	A	85	30	25	O	50	70								
2N 569	G	P	2N1193	7-30	MSA	150M	A	85	30	20	O	70	100								
2N 570	G	P	2N1192	7-30	MSA	120M	A	85	30	20	O	70	100								
2N 571	G	P	2N1193	7-30	MSA	150M	A	85	30	10	O	100									
2N 572	G	P	2N1193	7-30	MSA	120M	A	85	30	10	O	100									
2N 573	G	P			AFA	.2W	A	100	40	25	O	30	300	50M							
2N 574	G	P	2N1550	6-63	PMS	180W	J	100	60	55	O	9	22	10A	.2	10A					
2N 574A	G	P	2N1551	6-63	PMS	180W	J	100	80	60	O	9	22	10A	.2	10A					
2N 575	G	P	2N1554	6-63	PMS	180W	J	100	60	50	O	19	42	10A	.5	25A					
2N 575A	G	P	2N1555	6-63	PMS	180W	J	100	80	55	O	19	42	10A	.5	25A					
2N 576	G	N			MSS	200M	A	100	20	20	R	20	60	400M	.4	400M			2M	B	
2N 576A	G	N			MSS	200M	A	100	40	20	R	20	60	400M	.4	400M			5M	B	
2N 577		P			SPP	25M	A	55	25												
2N 578	G	P			MSS	120M	A	71	20			10		400M	.3	400M			3M	B	
2N 579	G	P			MSS	120M	A	71	20			20		400M	.3	400M			5M	B	
2N 580	G	P			MSS	120M	A	71	20			30		400M	.3	400M			10M	B	
2N 581	G	P			MSS	80M	A	71	18			20		20M		20M			4M	B	
2N 582	G	P			MSS	120M	A	71	25			40		20M	.3	100M			14M	B	
2N 583	G	P			MSS	80M	A	71	18			20		20M		20M			4M	B	
2N 584	G	P			MSS	120M	A	71	25			40		20M	.3	100M			14M	B	
2N 585	G	P			MSS	120M	A	71	25			20		20M	.2	20M			3M	B	
2N 586	G	P	2N1191	7-30	MSS	250M	A	85	45			35		250M	.5	250M					
2N 587	G	N			MSS	150M	A	100	40	20	R	20		200M	.5	200M					
2N 588	G	P	2N3324	9-66	RFA	30M	A	85	15	15	S								200M	M	
2N 588A	G	P			RFA	60M	A	85	15	15	S	30		10M	.2	10M			200M	M	
2N 591	G	P	2N1192	7-30	AFC	50M	A	71	32	32	O										
2N 592	G	P			BMS	125M	A	85	20	20	O	20									
2N 593	G	P			BMS	125M	A	85	40	30	O	30									
2N 594	G	N			BMS	100M	A	85	20	20	O	20							1.5M	E	
2N 595	G	N			BMS	100M	A	85	15	15	O	35							3M	E	
2N 596	G	N			BMS	100M	A	85	10	10	O	50							5M	E	
2N 597	G	P	2N3427	7-41	MSS	250M	A	100	45	40	S	40		100M	.2	10M			3M	B	
2N 598	G	P	2N3427	7-41	MSS	250M	A	100	35	35	S	70	225	100M	.2	10M			5.6M	T	
2N 599	G	P	2N3428	7-41	MSS	250M	A	100	30	20	S	100		100M	.2	10M			10M	T	
2N 600	G	P	2N3427	7-41	PMS	750M	C	100	35	35	S	70	225	100M	.2	10M			5.6M	T	
2N 601	G	P	2N3428	7-41	PMS	750M	C	100	30	20	S	100		100M	.2	10M			10M	T	
2N 602	G	P			HSA	120M	A	85	20	20	O	20	80		.25	10M			10M	T	
2N 603	G	P			HSA	120M	A	85	30	20	O	30	100		.25	15M			30M	T	
2N 604	G	P			HSA	120M	A	85	30	20	O	40	140		.25	20M			50M	T	
2N 605	G	P			RFA	.12W	A	85	15	15	O										
2N 606	G	P			RFA	.12W	A	85	15	15	O										
2N 607	G	P			RFA	.12W	A	85	15	15	O										
2N 608	G	P			RFA	.12W	A	85	15	15	O										
2N 609	G	P	2N1193	7-30	AFA	180M	A	85	25	15	O										
2N 610	G	P	2N1193	7-30	AFA	180M	A	85	25	15	O										
2N 611	G	P	2N1192	7-30	AFA	180M	A	85	25	15	O										
2N 612	G	P	2N1191	7-30	AFA	180M	A	85	25	15	O										
2N 613	G	P	2N1191	7-30	AFA	180M	A	85	25	15	O										
2N 614	G	P			RFA	180M	A	85	20	15	O										
2N 615	G	P			RFA	180M	A	85	20	15	O										
2N 616	G	P			RFA	180M	A	85	15	12	O										
2N 617	G	P			RFA	180M	A	85	15	12	O										
2N 618	G	P		6-28	LPA	90W	C	95	80	60	S	60	140	1A	.8	2A			5K	E	
2N 619	S	N			AFA	175M	A	160	50	40	O	9	22	5M	.5	8M			200K	B	
2N 620	S	N			AFA	175M	A	160	50	35	O	18	44	5M	.4	8M			250K	B	
2N 621	S	N			AFA	175M	A	160	50	30	O	36	68	5M	.3	8M			300K	B	
2N 622	S	N			DFA	385M	A	160	50	30	O								300K	B	
2N 624	G	P			RFA	100M	A	100	30	20	S						20	E	20M	E	
2N 625	G	N			MSS	1500M	C	100	40	30	S	20		500M	1.0	500M					
2N 627	G	P			LPA	90W	C	100	40	30	S	10	30	10A	1	10A			5K	E	
2N 628	G	P			LPA	90W	C	100	60	45	S	10	30	10A	1	10A			5K	E	
2N 629	G	P			LPA	90W	C	100	80	60	S	10	30	10A	1	10A			5K	E	
2N 630	G	P			LPA	90W	C	100	100	75	S	10	30	10A	1	10A			5K	E	
2N 631	G	P	2N1194	7-30	AFA	167M	A	85	25	20	R										
2N 632	G	P	2N1193	7-30	AFA	167M	A	85	36	20	R										

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N 633	G	P	2N1192	7-30	AFA	167M	A	85	35	30	R								
2N 634	G	N			HSA	150M	A	85	20	20	0	15		200M				5M	B
2N 634A	G	N			MSA	2.5M	J	85	25	20	R	40	120	10M	.2	10M		5M	B
2N 635	G	N			HSA	150M	A	85	20	20	0	25		200M				10M	B
2N 635A	G	N			MSA	2.5M	J	85	25	20	R	80	240	10M	.2	10M		10M	B
2N 636	G	N			HSA	150M	A	85	20	20	0	35		200M				15M	B
2N 636A	G	N			MSA	2.5M	J	85	25	15	R	100	300	10M	.15	10M		15M	B
2N 637	G	P	2N1535	6-56	PMS	60W	C	100		35	R	30	60	3A	1.5	3A			
2N 637A	G	P	2N1537	6-56	PMS	60W	C	100		65	R	30	60	3A	1.5	3A			
2N 637B	G	P	2N1538	6-56	PMS	60W	C	100		75	R	30	60	3A	1.5	3A			
2N 638	G	P	2N1530	6-56	PMS	60W	C	100		35	R	20	40	3A	2	3A			
2N 638A	G	P	2N1532	6-56	PMS	60W	C	100		65	R	20	40	3A	2	3A			
2N 638B	G	P	2N1533	6-56	PMS	60W	C	100		75	R	20	40	3A	2	3A			
2N 639	G	P	2N1530	6-56	PMS	37W	C	100		35	R	15		3A	2.5	3A			
2N 639A	G	P	2N1532	6-56	PMS	37W	C	100		65	R	15		3A	2.5	3A			
2N 639B	G	P	2N1533	6-56	PMS	37W	C	100		75	R	15		3A	2.5	3A			
2N 640	G	P			AFC	80M	A	71	34										
2N 641	G	P			AFC	80M	A	71	34										
2N 642	G	P			AFC	80M	A	71	34										
2N 643	G	P	2N2955	8-119	MSS	120M	A	71	30			20						20M	T
2N 644	G	P	2N2955	8-119	MSS	120M	A	71	30			20						20M	T
2N 645	G	P	2N2955	8-119	MSS	120M	A	71	30			20						20M	T
2N 646	G	N			AFC	100M	A	85	25	25	0	50	150	30M					
2N 647	G	N			AFC	100M	A	71	25	25	0								
2N 649	G	N			AFC	100M	A	71	20	18	0								
2N 650	G	P		7-20	AFA	.2W	A	100	45	30	R	30		10M	.25	50M	30	E	.75M	E
2N 650A	G	P		7-20	AFA	.2W	A	100	45	30	R	33		10M	.25	50M	30	E	.75M	B
2N 651	G	P		7-20	AFA	.2W	A	100	45	30	R	45		10M	.25	50M	50	E	1M	E
2N 651A	G	P		7-20	AFA	.2W	A	100	45	30	R	45		10M	.25	50M	50	E	1M	B
2N 652	G	P		7-20	AFA	.2W	A	100	45	30	R	80		10M	.25	50M	100	E		
2N 652A	G	P		7-20	AFA	.2W	A	100	45	30	R	80		10M	.25	50M	100	E		
2N 653	G	P		7-20	AFA	.2W	A	100	30	25	R	20		10M			30	E		
2N 654	G	P		7-20	AFA	.2W	A	100	30	25	R	40		10M			50	E		
2N 655	G	P		7-20	AFA	.2W	A	100	30	25	R	70		10M			100	E		
2N 656	S	N	2N3498	8-161	AFA	4W	C	200	60	60	0	30	90	200M					
2N 656A	S	N			AFA	5W	C	200	60	60	0	30	90	200M					
2N 657	S	N	2N3498	8-161	AFA	4W	C	200	100	100	0	30	90	200M					
2N 657A	S	N			AFA	5W	C	200	100	100	0	30	90	200M					
2N 658	G	P			MSA	167M	A	85	25	16	0	25	80		3.45	150M		2.5M	B
2N 659	G	P			MSA	167M	A	85	25	14	0	40	110		3.5	250M		5M	B
2N 660	G	P			MSA	167M	A	85	25	11	0	60	150		3.5	400M		10M	B
2N 661	G	P			MSA	167M	A	85	25	9	0	80			3.5	550M		15M	B
2N 662	G	P			MSA	167M	A	85	25	11	0	30			3.4	180M		4M	B
2N 663	G	P	2N2143	6-74	PMS	35W	C	100	50	25	0	25	75	500M	1	3A		15K	E
2N 665	G	P		6-38	PMS	35W	C	95	80	40	0	40	80	500M	.9	3A		20K	E
2N 669	G	P		6-16	LPA	62.5W	C	100	40	30	S		250	.5A				3K	E
2N 670	G	P	2N3428	7-41	AFA	300M	A	85	40	40	V	40	250	1A	.35	1A		500K	B
2N 671	G	P	2N3428	7-41	AFA	800M	C	85	40	40	V	40	250	1A	.35	1A		500K	B
2N 672	G	P	2N3428	7-40	AFA	300M	A	85	25	25	S				.2	400M			
2N 673	G	P	2N3428	7-40	AFA	800M	C	85	25	25	S				.2	400M			
2N 674	G	P	2N3428	7-40	AFA	300M	A	85	75	75	V	40	250	1A	.35	1A		400K	B
2N 675	G	P	2N3428	7-40	AFA	800M	C	85	75	75	V	40	250	1A	.35	1A		400K	B
2N 677	G	P	2N1553	6-63	LPA	90W	C	100	50	30	S	20	60	10A	1	10A			
2N 677A	G	P	2N1554	6-63	LPA	90W	C	100	60	40	S	20	60	10A	1	10A			
2N 677B	G	P	2N1555	6-63	LPA	90W	C	100	90	70	S	20	60	10A	1	10A			
2N 677C	G	P	2N1556	6-63	LPA	90W	C	100	100	80	S	20	60	10A	1	10A			
2N 678	G	P	2N1557	6-63	LPA	90W	C	100	50	20	0	50	100	10A	1	10A			
2N 678A	G	P	2N1558	6-63	LPA	90W	C	100	60	30	0	50	100	10A	1	10A			
2N 678B	G	P	2N1559	6-63	LPA	90W	C	100	90	60	0	50	100	10A	1	10A			
2N 678C	G	P	2N1560	6-63	LPA	90W	C	100	100	70	0	50	100	10A	1	10A			
2N 679	G	N			MSS	150M	A	85	25	20	X	20		30M	.3	100M		2M	B
2N 680	G	P	2N1191	7-30	AFA	150M	A	75	20	20	S	18	165	50M	.75	50M	15	E		
2N681 thru 2N692	Thyristors, see Table on Page 1-161																			
2N 694	G	P			RFA	.1W	A	100	30	15	0	10		2M			.9	8	340M	T
2N 695	G	P			HSS	75M	A	100	15	15	S	25		10M	1	50M				
2N 696	S	N	2N2218	8-74	MSA	600M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N 696A	S	N	2N2218	8-74	MSA	800M	A	300	60	35	0	20	60	150M	1.5	150M	15	E	40M	T
2N 697	S	N		8-12	MSA	600M	A	175	60	40	R	40	120	150M	1.5	150M			40M	T
2N 697A	S	N	2N2218	8-74	MSA	800M	A	300	60	35	0	40	120	150M	1.5	150M	25	E	50M	T
2N 698	S	N	2N3498	8-161	MSA	800M	A	200	120	80	R	20	60	150M	1.2	50M	15	E	40M	T
2N 699	S	N	2N3498	8-161	MSA	600M	A	175	120	80	R	40	120	150M	5	150M	35	E	50M	T
2N 699A	S	N			MSA	800M	A	300	120	80	R	40	120	150M	5	150M	35	E	50M	T
2N 699B	S	N	2N3498	8-161	MSA	870M	A	200	120	100	R	40	120	150M	1.2	50M	35	E	60M	T
2N 700	G	P		9-9	RFA	75M	A	100	25	20	S	1.5		2M			4	E	270M	T
2N 700A	G	P		9-9	RFA	75M	A	100	25	25	0	1.5		6M			4	E	360M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N 702	S	N	2N835	8-35	HSS	300M	A	175	25	25	0	20	60	10M	.5	10M			70M	T
2N 703	S	N	2N835	8-35	HSS	300M	A	175	25	25	0	40	100	10M	.5	10M			70M	T
2N 705	G	P		8-13	HSS	300M	C	100	15	15	S	25		10M	.3	10M				
2N 705A	G	P			HSS	150M	A	100	15	15	S	25		10M	.3	10M				
2N 706	S	N		8-15	HSS	300M	A	175	25	20	R	20		10M	.6	10M			200M	T
2N 706A	S	N		8-15	HSA	300M	A	175	25	20	R	20	60	10M	.6	10M			200M	T
2N 706B	S	N		8-15	HSS	300M	A	175	25	15	0	20	60	10M	.4	10M			200M	T
2N 706C	S	N	2N835	8-35	HSS	360M	A	200	40	20	R	20	60	10M	.4	10M			200M	T
2N 707	S	N		9-11	HPA	300M	A	175	56	28	R	9		10M	.6	10M				
2N 707A	S	N		9-11	RFA	500M	A	175	70	40	0	9	50	10M	.6	10M			70M	T
2N 708	S	N		8-17	HSS	360M	A	200	40	20	R	30	120	10M	.4	10M			300M	T
2N 708A	S	N	2N834	8-35	HSS	360M	A	200	50	30	R	40	120	10M	.15	10M			300M	T
2N 709	S	N			HSS	300M	A	200	15	6	0	20	120	10M	.3	3M			600M	T
2N 709A	S	N			HSS	300M	A	200	15	6	0	30	90	10M	.3	3M			800M	T
2N 710	G	P		8-18	HSS	300M	C	100	15	15	S	25		10*	.5	10M				
2N 710A	G	P			HSS	150M	A	100	15	15	S	25		10M	.5	10M				
2N 711	G	P		8-19	HSS	150M	A	100	12	12	S	20	250	10M	.5	10M			150M	T
2N 711A	G	P		8-19	HSS	150M	A	100	15	7	0	25	150	10M	.55	50M			150M	T
2N 711B	G	P		8-19	HSS	150M	A	100	18	7	0	30	150	10M	.25	10M			150M	T
2N 715	S	N	2N2221	8-74	RFA	500M	A	175	50	35	0	10	50	15M	1.2	15M			70M	E
2N 716	S	N	2N2221	8-74	RFA	500M	A	175	70	40	0	10	50	15M	1.2	15M			70M	E
2N 717	S	N	2N2221	8-74	RFA	400M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N 718	S	N		8-12	RFA	400M	A	175	60	40	R	40	120	150M	1.5	150M			50M	T
2N 718A	S	N		8-22	RFA	500M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N 719	S	N	2N3498	8-161	RFA	400M	A	175	120	80	R	20	60	150M	5	150M	15	E	40M	T
2N 719A	S	N	2N3498	8-161	RFA	500M	A	200	120	80	R	20	60	150M	1.2	50M	15	E	40M	T
2N 720	S	N	2N3498	8-161	RFA	400M	A	175	120	80	R	40	120	150M	5	150M	35	E	50M	T
2N 720A	S	N	2N3498	8-161	MSA	500M	A	200	120	100	R	40	120	150M	5	150M	30	E	50M	T
2N 721	S	P	2N2837	8-111	RFA	400M	A	175	50	50	R	20	45	150M	1.5	150M	15	E	50M	T
2N 721A	S	P			RFA	500M	A	200	50	50	R	20	45	150M	.5	150M	15	E	50M	T
2N 722	S	P		8-24	RFA	400M	A	175	50	50	R	30	90	150M	1.5	150M	25	E	60M	T
2N 722A	S	P	2N2837	8-111	RFA	500M	A	200	50	50	R	30	90	150M	.5	150M	25	E	60M	T
2N 725	G	P			HSA	150M	A		15	12	S	20		10M						
2N 726	S	P	2N3250	8-141	AFA	300M	A	175	25	20	0	15	45	10M	.6	10M	15	E	140M	T
2N 727	S	P	2N3250	8-141	AFA	300M	A	175	25	20	0	30	120	10M	.6	10M	30	E	140M	T
2N 728	S	N	2N2539	8-107	HSS	4M	A	175	15	15	0	20	200	10M	.7	10M			100M	T
2N 729	S	N	2N2539	8=107	HSS	4M	A	175	30	30	0	20	200	10M	.7	10M			100M	T
2N 730	S	N	2N2218	8-74	AFA	500M	A	175	60	40	R	20	60	150M	1.5	150M			40M	T
2N 731	S	N	2N2221	8-74	AFA	500M	A	175	60	40	R	40	120	150M	1.5	150M			50M	T
2N 734	S	N	2N2221	8-74	AFA	500M	A	175	80	60	0	15	50	5M	1	10M	20	E		
2N 734A	S	N			AFA	.5W	A	200	80	60	0	15	50	5M	.5	10M	20	E	30M	T
2N 735	S	N	2N2221	8-74	AFA	500M	A	175	80	60	0	30	100	5M	1	10M	40	E		
2N 735A	S	N			AFA	.5W	A	200	80	60	0	30	100	5M	.5	10M	40	E	60M	T
2N 736	S	N	2N2222	8-74	AFA	500M	A	175	80	60	0	60	200	5M	1	10M	80	E		
2N 736A	S	N	2N2222	8-74	AFA	500M	A	175	80	60	0	60	200	5M	.6	10M	80	E	100M	T
2N 736B	S	N			AFA	.5W	A	200	80	60	0	60	200	5M	.5	10M	80	E	100M	T
2N 738	S	N			AFA	500M	A	175	125	80	0	15	50	5M	1	10M	20	E		
2N 738A	S	N			AFA	.5W	A	200	125	80	0	15	50	5M	.5	10M	20	E	30M	T
2N 739	S	N			AFA	500M	A	175	125	80	0	30	100	5M	1	10M	40	E		
2N 739A	S	N			AFA	.5W	A	200	125	80	0	30	100	5M	.5	10M	40	E	60M	T
2N 740	S	N			AFA	.5W	A	200	125	80	0	60	200	5M			80	E		
2N 740A	S	N			AFA	.5W	A	200	125	80	0	60	200	5M	.5	10M	80	E	100M	T
2N 741	G	P		9-13	RFA	150M	A	100	15	15	S	10		5M			20	E		
2N 741A	G	P		9-13	RFA	150M	A	100	20	20	S	10		5M			20	E	300M	T
2N 742	S	N	2N2218	8-74	MSS	.5W	A	200	60	60	0	25		10M	.5	10M				
2N 742A	S	N	2N2218	8-74	MSS	.5W	A	200	60	60	0	25		10M	.5	10M				
2N 743	S	N	2N835	8-35	HSS	300M	A	175	20	12	0	20	60	10M	.35	10M			300M	T
2N 743A	S	N			HSS	.36W	A	200	40	15	0	20	60	10M					500M	T
2N 744	S	N		8-26	HSS	300M	A	175	20	12	0	40	120	10M	.35	10M			300M	T
2N 744A	S	N			HSS	.36W	A	200	40	15	0	40	120	10M					500M	T
2N 745	S	N			AFA	.15W	A	175	45	30	0	20	55	10M			19	E	10M	B
2N 746	S	N			AFA	.15W	A	175	45	30	0	45	150	10M			39	E	10M	B
2N 747	S	N			MSS	200M	A	175	25	25	0	30	90	10M	.6	5M				
2N 748	S	N			MSS	200M	A	175	30	30	0	20	40	10M	.5	5M				
2N 749	S	N			RFA	200M	A	175	45	25	0	15	55	10M			30	E	50M	B
2N 751	S	N			RFA	200M	A	175	20	20	0	30	150	10M			10	E	20M	B
2N 752	S	N	2N2221	8-74	VID	.5W	A	200	85	45	0				1.2	15M	40	E	200M	T
2N 753	S	N		8-15	HSA	300M	A	175		20	R	40	120	10M	.6	10M			200M	T
2N 754	S	N	2N2218	8-74	RFA	.3W	A	175	60	60	R	20	80	5M	.8	10M			30M	T
2N 755	S	N	2N2218	8-74	RFA	.3W	A	175	100	80	R	20	80	5M	.8	10M			30M	T
2N 756	S	N			AFA	.5W	A	200	45	45	0				1	10M	12	E	50M	B
2N 756A	S	N			AFA	.5W	A	200	60	60	0				1	10M	12	E	50M	B
2N 757	S	N			AFA	.5W	A	200	45	45	0				1	10M	18	E	50M	B
2N 757A	S	N			AFA	.5W	A	200	60	60	0				1	10M	18	E	50M	B
2N 758	S	N			AFA	.5W	A	200	45	45	0				1	10M	18	E	50M	B
2N 758A	S	N			AFA	.5W	A	200	60	60	0				1	10M	18	E	50M	B
2N 758B	S	N			AFA	.5W	A	200	60	60	0	12		1M	.5	10M	18	E	50M	B

2N759 — 2N837

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$t_{—}$	Units	Subscript
2N 759	S	N			AFA	.5W	A	200	45	45	0					1	10M	36	E	50M	B
2N 759A	S	N			AFA	.5W	A	200	60	60	0					1	10M	36	E	50M	B
2N 759B	S	N			AFA	.5W	A	200	60	60	0	25		1M	.5	10M	36	E	50M	B
2N 760	S	N			AFA	.5W	A	200	45	45	0					1	10M	76	E	50M	B
2N 760A	S	N			AFA	.5W	A	200	60	60	0					1	10M	76	E	50M	B
2N 760B	S	N			AFA	.5W	A	200	60	60	0	50		1M	.5	10M	76	E	50M	B
2N 761	S	N			AFA	.5W	A	200	50	30	0	20	55	10M	1	10M	19	E	50M	B
2N 762	S	N			AFA	.5W	A	200	50	30	0	45	150	10M	1	10M	39	E	50M	B
2N764 thru 2N767	Thyristors, see Table on Page 1-161																			
2N 768	G	P	2N961	8-48	HSS	35M	A	100	12	10	S	25		2M	.13	2M			125M	T
2N 769	G	P	2N961	8-48	HSS	35M	A	100	12	7	0	25		20M	.25	10M			100M	T
2N 770	S	N			HSS	150M	A	150	20	15	0	12	60	20M	.25	10M			75M	T
2N 771	S	N			HSS	150M	A	150	20	15	0	30	150	20M	.25	10M			100M	T
2N 772	S	N			HSS	150M	A	150	25	25	0	20		10M	.25	10M			75M	T
2N 773	S	N			RFA	150M	A	150	20	15	0	4	16	1.5M			6	E		
2N 774	S	N			RFA	150M	A	150	20	15	0	7	30	1.5M			11	E		
2N 775	S	N			RFA	150M	A	150	20	15	0	20	80	1.5M			28	E		
2N 776	S	N			RFA	150M	A	150	20	15	0	4	16	1.5M			6	E		
2N 777	S	N			RFA	150M	A	150	20	15	0	7	30	1.5M			11	E		
2N 778	S	N			RFA	150M	A	150	20	15	0	20	80	1.5M			28	E		
2N 779	G	P	2N964	8-48	HSS	60M	A	100	15	15	S	50	200	10M	.16	10M			320M	T
2N 779A	G	P	2N964	8-48	HSS	60M	A	100	15	15	S	50	200	10M	.125	10M			320M	T
2N 779B	G	P	2N964	8-48	HSS	150M	A	100	15	15	S	50	200	10M	.125	10M			320M	T
2N 780	S	N	2N2220	8-74	AFA	1W	C	175	45	45		35	140	500*	1	10M			60M	T
2N 781	G	P			HSS	150M	A	100	15	15	S	25		10M	.16	10M				
2N 782	G	P			HSS	150M	A	100	12	12	S	20		10M	.20	10M				
2N 783	S	N	2N834	8-35	HSS	300M		175	40	20	R	20	60	10M	.25	10M			200M	T
2N 784	S	N	2N834	8-35	HSS	300M	A	175	30	15	R	25		10M	.19	10M			200M	T
2N 784A	S	N	2N834	8-35	HSS	350M	A	200	40	20	R	25	150	10M	.65	100M			300M	T
2N 785	G	P			LNA	50M	A	85	12	12	S						40	E		
2N 789	S	N			AFA	150M	A	175	45	30	0				1	5M	9	E	1M	B
2N 790	S	N			AFA	150M	A	175	45	30	0				1	5M	18	E	2M	B
2N 791	S	N			AFA	150M	A	175	45	30	0				1	5M	18	E	8M	B
2N 792	S	N			AFA	150M	A	175	45	30	0				1	5M	36	E	2M	B
2N 793	S	N			AFA	150M	A	175	45	30	0				1	5M	76	E	2M	B
2N 794	G	P			HSS	120M	A	85	13			30		10M	.3	10M			25M	T
2N 795	G	P			HSS	120M	A	85	13			30		10M	.5	40M			35M	T
2N 796	G	P			HSS	120M	A	85	13			50		10M	.5	40M			50M	T
2N 797	G	N			HSS	150M	A	100	20	7	0	40		10M	.14	10M			600M	T
2N 799	G	P			MSS	75M	A	85	25	12	0	30		12M	.15	12M			4M	B
2N 800	G	P			MSS	75M	A	85	25	12	0	30			.15	12M			4M	B
2N 801	G	P			MSS	75M	A	85	30	18	0	30	60							
2N 802	G	P			MSS	75M	A	85	30	18	0	30	60							
2N 803	G	P			MSS	75M	A	85	30	15	0	40	80							
2N 804	G	P			MSS	75M	A	85	30	15	0	40	80							
2N 805	G	P			MSS	75M	A	85	30	12	0	60								
2N 806	G	P			MSS	75M	A	85	30	12	0	60								
2N 807	G	P			MSS	70M	A	85	25	14	V	40		20M	.2	20M			14M	B
2N 808	G	P			MSS	70M	A	85	25	14	V	40		20M	.2	20M			14M	B
2N 809	G	P			RFA	75M	A	85	30	15	0	25	110	25M			30	E	3M	B
2N 810	G	P			RFA	75M	A	85	30	15	0	25	110	25M			30	E	3M	B
2N 811	G	P			RFA	75M	A	85	30	12	0	45	180	45M			50	E	5M	B
2N 812	G	P			RFA	75M	A	85	30	12	0	45	180	45M			50	E	5M	B
2N 813	G	P			RFA	75M	A	85	30	10	0	55	220	55M			70	E	15M	B
2N 814	G	P			RFA	75M	A	85	30	10	0	55	220	55M			70	E	15M	B
2N 815	G	N			MSS	75M	A	85	25	15	0	60	180	30M	.75	200M				
2N 816	G	N			MSS	75M	A	85	25	15	0	60	180	30M	.75	200M				
2N 817	G	N			MSS	75M	A	85	30	15	0	20		50M	.25	50M				
2N 818	G	N			MSS	75M	A	85	30	15	0	20		50M	.25	50M				
2N 819	G	N			MSS	75M	A	85	30	20	0	30		50M	.25	50M				
2N 820	G	N			MSS	75M	A	85	30	20	0	30		50M	.25	50M				
2N 821	G	N			MSS	75M	A	85	30	25	0	40		50M	.25	50M				
2N 822	G	N			MSS	75M	A	85	30	25	0	40		50M	.25	50M				
2N 823	G	N			MSS	75M	A	85	25	12	0	40		20M	.15	12M			4M	B
2N 824	G	P			RFA	70M	A	85	30	18	0								2M	B
2N 825	G	P			MSS	70M	A	85	30	20	0	20	40						2.5M	B
2N 826	G	P			MSS	70M	A	85	30	20	0	20	40						2.5M	B
2N 827	G	P		8-28	HSS	150M	A	100	20	20	S	100		10M	.25	10M			250M	T
2N 828	G	P		8-30	HSS	150M	A	100	15	15	S	25		10M	.2	10M			300M	T
2N 828A	G	P		8-32	HSS	150M	A	100	15	15	S	25		10M	.2	10M			300M	T
2N 829	G	P		8-32	HSS	150M	A	100	15	15	S	50		10M	.2	10M			300M	T
2N 834	S	N		8-35	HSS	300M		175	40	30	S	25		10M	.25	10M			350M	T
2N 834A	S	N			HSS	360M	A	200	40	30	S	25		10M	.25	10M			500M	T
2N 835	S	N		8-35	HSS	.3W	A	175	25	20	0	20		10M	.3	10M			300M	T
2N 837	G	P			HSS	150M	A	100	12	12	S	30		10M	.25	10M				

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N 838	G	P		8-37	HSS	150M	A	100	30	30	S	30		10M	.18	10M			300M	T
2N 839	S	N	2N2222	8-74	RFA	.3W	A	175	45	45	0	15	50	10M	2	10M	20	E	30M	T
2N 840	S	N	2N2221	8-74	RFA	.3W	A	175	45	45	0	30	100	10M	2	10M	40	E	30M	T
2N 841	S	N	2N2222	8-74	RFA	.3W	A	175	45	45	0	60	400	10M	2	10M	80	E	40M	T
2N 842	S	N	2N2221	8-74	RFA	.3W	A	175	45	45	0	20	55	10M	1.2	10M	20	E	30M	T
2N 843	S	N	2N2222	8-74	RFA	.3W	A	175	45	45	0	45	150	10M	1.2	10M	40	E	40M	T
2N 844	S	N			VID	.3W	A	175	60	60	R	40	120	5M	.8	10M			50M	T
2N 845	S	N			VID	.3W	A	175	100	80	R	40	120	5M	.8	10M			50M	T
2N 846	G	P	2N960	8-48	HSS	60M	A	100	15	15	S	25	125	10M	.18	10M			320M	T
2N 846A	G	P	2N960	8-48	HSS	60M	A	100	15	15	S	25	125	10M	.14	10M			320M	T
2N 846B	G	P	2N960	8-48	HSS	150M	A	100	15	15	S	25	125	10M	.14	10M			320M	T
2N 847	S	N			MSS	.2W	A	175	20	15	0				1.5	10M				
2N 848	S	N			MSS	.2W	A	175	40	25	0				1.5	10M				
2N 849	S	N	2N835	8-35	HSS	300M	A	175	25	15	0	20	60	10M	.6	10M			600M	T
2N 850	S	N	2N834	8-35	HSS	300M	A	175	25	15	0	40	120	10M	.6	10M			600M	T
2N 851	S	N	2N835	8-35	HSS	300M	A	175	20	12	0	20	60	10M					300M	T
2N 852	S	N	2N834	8-35	HSS	300M	A	175	20	12	0	40	120	10M					300M	T
2N 858	S	P			MSS	150M	A	140	40	40	0	10	60	5M	.15	5M	15	E	5M	T
2N 859	S	P			MSS	150M	A	140	40	40	0	25	100	5M	.15	5M	30	E	6M	T
2N 860	S	P			MSS	150M	A	140	25	25	0	10	40	5M	.15	5M	15	E	6.5M	T
2N 861	S	P			MSS	150M	A	140	25	25	0	25	75	5M	.15	5M	30	E	7.5M	T
2N 862	S	P			MSS	150M	A	140	15	15	0	12	48	5M	.15	5M	20	E	8M	T
2N 863	S	P			MSS	150M	A	140	15	15	0	25	100	5M	.15	5M	40	E	10M	T
2N 864	S	P			MSS	150M	A	140	6	6	0	20	100	5M	.1	5M	25	E	16M	T
2N 865	S	P			MSS	150M	A	140	10	6	0	45	125	5M	.1	5M	100	E	24M	T
2N 866	S	N			MSS	500M	A	175	30	20	R	15	45	150M	1.5	150M			40M	T
2N 867	S	N			MSS	500M	A	175	30	20	R	30	90	150M	1.5	150M			50M	T
2N 869	S	P		8-39	RFA	360M	A	200	25	18	0	20	120	10M	1	10M			100M	T
2N 869A	S	P	2N3250	8-39	MSS	360M	A	200	25	18	0	40	120	30M	.15	10M			400M	T
2N 870	S	N			RFA	500M	A	200	100	80	R	40	120	150M	1.2	50M	30	E	50M	T
2N 871	S	N			RFA	500M	A	200	100	80	R	100	300	150M	1.2	50M	50	E	60M	T
2N876 thru 2N901	Thyristors, see Table on Page 1-161																			
2N 902	S	N			AFA	150M	A	175	45	30	0				1	5M	9	E	1M	
2N 903	S	N			AFA	150M	A	175	45	30	0				1	5M	18	E	2M	
2N 904	S	N			AFA	150M	A	175	45	30	0				1	5M	18	E	8M	
2N 905	S	N			AFA	150M	A	175	45	30	0				1	5M	36	E	2M	
2N 906	S	N			AFA	150M	A	175	45	30	0				1	5M	76	E	2M	
2N 907	S	N			RFA	.15W	A	175	45	30	0	20	55	10M			19	E	12M	T
2N 908	S	N			RFA	.15W	A	175	45	30	0	45	150	10M			39	E	25M	T
2N 909	S	N	2N2222	8-74	RFA	400M	A	175	60	30	R	110	350	50M	.5	10M	40	E	50M	T
2N 910	S	N			AFA	500M	A	200	100	80	R	75		10M	.4	10M	76	E	60M	T
2N 911	S	N			AFA	500M	A	200	100	80	R	35		10M	.4	10M	36	E	50M	T
2N 912	S	N			AFA	500M	A	200	100	80	R	15		10M	.4	10M	18	E	40M	T
2N 914	S	N		8-41	HSS	360M	A	200	40	20	R	30	120	10M	.7	200M			300M	T
2N 914A	S	N			HSS	360M	A	200	40	20	R	30	120	10M	.4	200M			300M	T
2N 915	S	N		8-43	RFA	360M	A	200	70	50	0	50	200	10M	1	10M	50	E	250M	T
2N 916	S	N		8-45	RFA	360M	A	200	45	25	0	50	200	10M	.5	10M	50	E	300M	T
2N 916A	S	N			RFA	360M	A	200	45	25	0	50	200	10M	.5	10M	50	E	300M	T
2N 917	S	N			RFA	200M	A	200	30	15	0	20	200	3M	.5	3M			500M	T
2N 917A	S	N			RFA	200M	A	200	30	15	0	20	200	3M	.4	10M			600M	T
2N 918	S	N		9-15	RFA	200M	A	200	30	15	0	20		3M	.4	10M			600M	T
2N 919	S	N	2N834	8-35	HSS	.36W	A	200	25	15	0	20	60	10M	.2	10M			200M	T
2N 920	S	N	2N834	8-35	HSS	.36W	A	200	25	15	0	40	120	10M	.2	10M			200M	T
2N 921	S	N	2N834	8-35	HSS	.36W	A	200	50	20	0	20	60	10M	.3	10M			200M	T
2N 922	S	N	2N834	8-35	HSS	.36W	A	200	50	20	0	40	120	10M	.3	10M			200M	T
2N 923	S	P			AFA	.25W	A	200	40	25	0				.5	5M	12	E	.8M	B
2N 924	S	P			AFA	.25W	A	200	40	25	0				.5	5M	24	E	.8M	B
2N 925	S	P			AFA	.25W	A	200	50	40	0				.5	5M	10	E	.8M	B
2N 926	S	P			AFA	.25W	A	200	50	40	0				.5	5M	20	E	.8M	B
2N 927	S	P			AFA	.25W	A	200	70	60	0				.5	5M	8	E	.8M	B
2N 928	S	P			AFA	.25W	A	200	70	60	0				.5	5M	18	E	.8M	B
2N 929	S	N		8-46	AFA	600M	C	175	45	45	0	40	120	10*	1	10M	150	E	1M	E
2N 929A	S	N			AFA	.5W	A	200	60	45	0	40	120	10*	.5	10M	60	E	45M	T
2N 930	S	N		8-46	AFA	600M	C	175	45	45	0	100	300	10*	1	10M	150	E	1M	E
2N 930A	S	N			AFA	.5W	A	200	60	45	0	100	300	10*	.5	10M	150	E	45M	T
2N 934	G	P	2N965	8-48	HSS	150M	A	85	13	12		40		40M	.3	40M			35M	T
2N 935	S	P			AFA	.25W	A	160	50	40	0	9	22		.3	5M				
2N 936	S	P			AFA	.25W	A	160	50	35	0	18	44		.5	5M				
2N 937	S	P			AFA	.25W	A	160	50	30	0	36	88		.6	5M				
2N 938	S	P			AFA	.25W	A	175	40	35	0				.3	5M	9	E	1M	B
2N 939	S	P			AFA	.25W	A	175	40	35	0				.3	5M	18	E	2M	B
2N 940	S	P			AFA	.25W	A	175	40	35	0				.3	5M	36	E	2M	B
2N 941	S	P			CHP	.25W	A	175	25	8	U	10		1M			25	E	16M	T
2N 942	S	P			CHP	.25W	A	175	25	8	U	10		1M			25	E	10M	T
2N 943	S	P			CHP	.25W	A	175	40	18	0	10			.003		25	E	1M	B

2N944 — 2N1015E

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N 944	S	P			CHP	.25W	A	175	40	18	O	10			.004		25	E	1M	B
2N 945	S	P			CHP	.25W	A	175	50	50	O	10			.005		25	E	1M	B
2N 946	S	P			CHP	.25W	A	175	80	80	O	10			.005		25	E	1M	B
2N 947	S	N	2N834	8-35	MSA	360M	A	150	20	15	R	20		10M	.4	5M			200M	T
2N948 thru 2N951	Thyristors, see Table on Page 1-161																			
2N 955	G	N			HSS	150M	A	100	12	8	O	30		30M	.5	30M				
2N 955A	G	N			HSS	150M	A	100	12	8	O	30		30M	.3	30M				
2N 956	S	N	2N2222	8-74	RFA	500M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M	T
2N 957	S	N	2N2501	8-104	RFA	250M	A	150	40	20	O	45		10M	1.5	10M			200M	T
2N 958	S	N			HSS	.25W	C	150	25	15	O	20		10M	.2	10M			200M	T
2N 959	S	N			HSS	.25W	C	150	25	15	O	40		10M	.2	10M			200M	T
2N 960	G	P		8-48	HSS	150M	A	100	15	15	S	20		10M	.2	10M			300M	T
2N 961	G	P		8-48	HSS	150M	A	100	12	12	S	20		10M	.2	10M			300M	T
2N 962	G	P		8-48	HSS	150M	A	100	12	12	S	20		10M	.2	10M			300M	T
2N 963	G	P		8-48	HSS	150M	A	100	12	12	S	20		10M	.2	10M			250M	T
2N 964	G	P		8-48	HSS	150M	A	100	15	15	S	40		10M	.18	10M			300M	T
2N 964A	G	P		8-48	HSS	150M	A	100	15	15	S	40		10M	.18	10M			300M	T
2N 965	G	P		8-48	HSS	150M	A	100	12	12	S	40		10M	.18	10M			300M	T
2N 966	G	P		8-48	HSS	150M	A	100	12	12	S	40		10M	.18	10M			300M	T
2N 967	G	P		8-50	HSS	150M	A	100	12	12	S	40		10M	.2	10M			250M	T
2N 968	G	P		8-59	HSS	150M	A	100	15	15	S	17		10M	.25	10M			300M	T
2N 969	G	P		8-59	HSS	150M	A	100	12	12	S	17		10M	.25	10M			300M	T
2N 970	G	P		8-59	HSS	150M	A	100	12	12	S	17		10M	.25	10M			300M	T
2N 971	G	P		8-59	HSS	150M	A	100	7	7	S	17		10M	.25	10M			300M	T
2N 972	G	P		8-59	HSS	150M	A	100	15	15	S	40		10M	.25	10M			300M	T
2N 973	G	P		8-59	HSS	150M	A	100	12	12	S	40		10M	.25	10M			300M	T
2N 974	G	P		8-59	HSS	150M	A	100	12	12	S	40		10M	.25	10M			300M	T
2N 975	G	P		8-59	HSS	150M	A	100	7	7	S	40		10M	.25	10M			300M	T
2N 976	G	P	2N964	8-48	HSS	100M	A	100	15	10	O	30		20M	.17	20M			249M	T
2N 977	G	P	2N964	8-48	HSS	150M	A	100	15	10	O	50		40M	.2	40M			400M	T
2N 978	S	P	2N2837	8-111	RFA	330M	A	150	30	20	O	15	60	150M	1.5	150M			40M	T
2N 979	G	P			HSS	60M	A	100	20	15	O	30		10M	.25	10M			100M	T
2N 980	G	P			HSS	60M	A	100	20	12	O	30		10M	.25	10M			100M	T
2N 981	S	N			AFA	.5W	A	200	80	80	O				3	10M	36	E	50M	B
2N 982	G	P			HSS	60M	A	100	20	15	O	50		10M	.125	10M				
2N 983	G	P			HSS	60M	A	100	15	15	O	40		10M	.15	10M				
2N 984	G	P			HSS	60M	A	100	15	10	O	50		10M	.18	10M				
2N 985	G	P		8-62	HSS	150M	A	100	15	7	O	40		10M	.15	10M			300M	T
2N 986	S	N			SPP	500M	A	200	100	80	R									
2N 987	G	P			RFA	.1W	A	100	40	40	O	40	250	1M			40	E		
2N 988	S	N	2N2221	8-74	RFA	.3W	A	175	20	10	O	20	120	10M	.5	10M			300M	T
2N 989	S	N	2N2221	8-74	RFA	.3W	A	175	20	10	O	20	120	10M	.5	10M			300M	T
2N 990	G	P			RFC	67M	A	75	20	20	R	40		1M			40	E	44M	T
2N 991	G	P			RFC	67M	A	75	20	20	R	40		1M			40	E	44M	T
2N 992	G	P			RFC	67M	A	75	20	20	R	40		1M			40	E		
2N 993	G	P			RFC	67M	A	75	20	20	R	40		1M			40	E	44M	T
2N 994	G	P			HSS	200M	A	150	15	6	O	45	140	10M	.18	10M				
2N 995	S	P		8-39	RFA	360M	A	200	20	15	O	35	140	20M	.2	20M			100M	T
2N 995A	S	P	2N3250	8-141	RFA	360M	A	200	20	15	O	35	140	20M	.2	20M			100M	T
2N 996	S	P	2N3248	8-137	RFA	360M	A	200	15	12	O	35		20M	.3	60M			100M	T
2N 997	S	N			AFA	500M	A	175	75	40	O			100*	1.6	100M				
2N 998	S	N			SPP	500M	A	200	100	60	O				1.2	50M	1000	E		
2N 999	S	N			SPP	500M	A	200	60	60	O				1.6	100M				
2N1000	G	N			MSA	150M	A	100	40	25	O	40		10M	.25	100M			7M	E
2N1003	G	P			RFA	120M	A	100	35	20	U						10	E		
2N1004	G	P			VID	120M	A	100	35	20	U						10	E		
2N1005	S	N			AFA	150M	A	175	15	15	O	10	25	10M	.6	10M				
2N1006	S	N			AFA	150M	A	175	15	15	O	25	150	10M	.6	10M				
2N1007	G	P			LPA	35W	C	95	25	20	O	50	250	1A	1	2A	25	E	60K	T
2N1008	G	P		7-24	AFA	.3W	C	85	20	15	R				.25	.1A	40	E		
2N1008A	G	P		7-24	AFA	.3W	C	85	40	35	R				.25	.1A	40	E		
2N1008B	G	P		7-24	AFA	.3W	C	85	60	55	R				.25	.1A	40	E		
2N1009	G	P			AFA	.4W	C	85	35	35	R				.25	.1A	40	E	7.5K	E
2N1010	G	N			AFC	20M	A	55	10	10	O									
2N1011	G	P		6-40	LPA	35W	C	95	80	80	S	30	75	3A	1.5	3A	20	E	5K	E
2N1012	G	N			MSA	150M	A	100	40	22	O	40		100M	.2	100M			3M	E
2N1014	G	P	2N1552	6-63	LPA	50W	C	100	100	65	O	20	50	4A	.8	4A			.5M	B
2N1015	S	N	2N3713	6-117	PMS	150W	C	150	30	30	V	10		2A	1.5	2A				
2N1015A	S	N			PMS	150W	C	150	60	60	V	10		2A	1.5	2A				
2N1015B	S	N			PMS	150W	C	150	100	100	V	10		2A	1.5	2A				
2N1015C	S	N			PMS	150W	C	150	150	150	V	10		2A	1.5	2A				
2N1015D	S	N			PMS	150W	C	150	200	200	V	10		2A	1.5	2A				
2N1015E	S	N			PMS	150W	C	150	250	250	V	10		2A	1.5	2A				

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N1015F	S	N			PMS	150W	C	150	300	300	V	10		2A	1.5	2A				
2N1016	S	N	2N3713	6-117	PMS	150W	C	150	30	30	V	10		5A	2.5	5A				
2N1016A	S	N			PMS	150W	C	150	60	60	V	10		5A	2.5	5A				
2N1016B	S	N			PMS	150W	C	150	100	100	V	10		5A	2.5	5A				
2N1016C	S	N			PMS	150W	C	150	150	150	V	10		5A	2.5	5A				
2N1016D	S	N			PMS	150W	C	150	200	200	V	10		5A	2.5	5A				
2N1016E	S	N			PMS	150W	C	150	250	250	V	10		5A	2.5	5A				
2N1016F	S	N			PMS	150W	C	150	300	300	V	10		5A	2.5	5A				
2N1017	G	P			MSA	150M	A	85	30	10	O	70			2.6	200M			15M	B
2N1018	G	P			MSS	200M	A	100	30	6	O	70		70M	2.6	200M			20M	B
2N1021	G	P		6-42	LPA	50W	C	95	100	100	X	23	70	1A	1	5A				
2N1021A	G	P	2N1021	6-42	LPA	150W	C	100	100	50	O	30	90	5A	.5	5A			200K	T
2N1022	G	P		6-42	LPA	50W	C	95	120	120	X	23	70	5A	1	5A				
2N1022A	G	P	2N1022	6-42	LPA	150W	C	100	120	55	O	30	90	5A	.5	5A			200K	T
2N1023	G	P	2N3323	9-66	RFA	120M	A	100	40	40	O	20	175	1.5M						
2N1024	S	P			AFA	.25W	A	175	18	15	U						9	E	1M	B
2N1025	S	P			AFA	.25W	A	175	40	35	U						9	E	1M	B
2N1026	S	P			AFA	.25W	A	175	40	35	U						18	E	2M	B
2N1027	S	P			AFA	.25W	A	175	18	15	U						18	E	4M	B
2N1028	S	P			AFA	.25W	A	175	12	10	U						9	E	7.2M	T
2N1029	G	P	2N1553	6-63	LPA	90W	C	100	50	20	O	20	60	10A	1	10A				
2N1029A	G	P	2N1554	6-63	LPA	90W	C	100	60	30	O	20	60	10A	1	10A				
2N1029B	G	P	2N1555	6-63	LPA	90W	C	100	90	60	O	20	60	10A	1	10A				
2N1029C	G	P	2N1556	6-63	LPA	90W	C	100	100	70	O	20	60	10A	1	10A				
2N1030	G	P	2N1557	6-63	LPA	90W	C	100	50	20	O	50	100	10A	1	10A				
2N1030A	G	P	2N1558	6-63	LPA	90W	C	100	60	30	O	50	100	10A	1	10A				
2N1030B	G	P	2N1559	6-63	LPA			100	90	60	O	50	100	10A	1	10A				
2N1030C	G	P	2N1560	6-63	LPA			100	100	70	O	50	100	10A	1	10A				
2N1031	G	P	2N1553	6-63	LPA	90W	C	100	50	30	S	20	60	10A	1	10A	10	E	2K	E
2N1031A	G	P	2N1554	6-63	LPA	90W	C	100	60	40	S	20	60	10A	1	10A	10	E	2K	E
2N1031B	G	P	2N1555	6-63	LPA	90W	C	100	90	70	S	20	60	10A	1	10A	10	E	2K	E
2N1031C	G	P	2N1556	6-63	LPA	90W	C	100	100	80	S	20	60	10A	1	10A	10	E	2K	E
2N1032	G	P	2N1557	6-63	LPA	90W	C	100	50	30	S	50	100	10A	1	10A	25	E	2K	E
2N1032A	G	P			LPA	90W	C	100	60	40	S	50	100	10A	1	10A	25	E	2K	E
2N1032B	G	P			LPA	90W	C	100	90	70	S	50	100	10A	1	10A	25	E	2K	E
2N1032C	G	P			LPA	90W	C	100	100	80	S	50	100	10A	1	10A	25	E	2K	E
2N1034	S	P			AFA	250M	A	160	50	40	O				.5	8M	9	E	150K	B
2N1035	S	P			AFA	250M	A	160	50	35	O				.4	8M	18	E	200K	B
2N1036	S	P			AFA	250M	A	160	50	30	O				.3	8M	34	E	300K	B
2N1037	S	P			AFA	250M	A	160	50	35	O				.5	8M	9	E	150K	B
2N1038	G	P	2N2138	6-74	LPA	20W	C	95	40	40	V	20	60	1A	.25	1A	18	E	8K	E
2N1039	G	P	2N2139	6-74	LPA	20W	C	95	60	60	V	20	60	1A	.25	1A	18	E	8K	E
2N1040	G	P	2N2140	6-74	LPA	20W	C	95	80	80	V	20	60	1A	.25	1A	18	E	8K	E
2N1041	G	P	2N2141	6-74	LPA	20W	C	95	100	100	V	20	60	1A	.25	1A	18	E	8K	E
2N1042	G	P	2N2143	6-74	LPA	20W	C	100	40	40	V	20	60	3A	.75	3A	2	E	250K	T
2N1043	G	P	2N2144	6-74	LPA	20W	C	100	60	60	V	20	60	3A	.25	1A			250K	T
2N1044	G	P	2N2145	6-74	LPA	20W	C	100	80	80	V	20	60	3A	.25	1A			250K	T
2N1045	G	P	2N2146	6-74	LPA	20W	C	100	100	100	V	20	60	3A	.25	1A			250K	T
2N1046	G	P	2N2832	6-87	HPA	50W	C	100	100	50	O	40		5A	.2	500M			15M	T
2N1046A	G	P	2N2832	6-87	HPA	50W	C	100	130	50	O	40		5A	.4	5A			15M	T
2N1046B	G	P	2N2833	6-87	HPA	50W	C	100	130	50	O	20		10A	.4	5A			15M	T
2N1047	S	N			LPA	40W	C	200	80			12	36	500M	7.5	500M				
2N1047A	S	N			LPA	40W	C	200	80	80	O	12	36	500M	7.5	500M			75K	E
2N1047B	S	N			LPA	40W	C	200	80	80	O	12	36	500M	2	500M			125K	E
2N1047C	S	N			LPA	40W	C	200	80	80	O	12	36	500M	1	500M			125K	E
2N1048	S	N			LPA	40W	C	200	120			12	36	500M	7.5	500M				
2N1048A	S	N			LPA	40W	C	200	120	120	O	12	36	500M	7.5	500M			75K	E
2N1048B	S	N			LPA	40W	C	200	120	120	O	12	36	500M	2	500M			125K	E
2N1048C	S	N			LPA	40W	C	200	120	120	O	12	36	500M	1	500M			125K	E
2N1049	S	N			LPA	40W	C	200	80			30	90	500M	7.5	500M				
2N1049A	S	N			LPA	40W	C	200	80	80	O	30	90	500M	7.5	500M			75K	E
2N1049B	S	N			LPA	40W	C	200	80	80	O	30	90	500M	2	500M			125K	E
2N1049C	S	N			LPA	40W	C	200	80	80	O	30	90	500M	1	500M			125K	E
2N1050	S	N			LPA	40W	C	200	120			30	90	500M	7.5	500M				
2N1050A	S	N			LPA	40W	C	200	120	120	O	30	90	500M	7.5	500M			75K	E
2N1050B	S	N			LPA	40W	C	200	120	120	O	30	90	500M	2	500M			125K	E
2N1050C	S	N			LPA	40W	C	200	120	80	O	30	90	500M	1	500M			125K	E
2N1051	S	N			RFA	.5W	A	150	40	40	O	25		50M	3	50M	30	E	80M	T
2N1052	S	N			RFA	6M	A	200	200	200	V	20	80	.2A	5	.2A				
2N1054	S	N			VID	.8W	A	200	125	115	O	20		.2A			15	E	8M	T
2N1055	S	N			RFA	5.5M	A	200	100	100	O	20	80	50M	2	50M			3M	T
2N1056	G	P	2N2043	7-39	AFA	240M	A	100	70	50	R	18	43	20M	.13	20M			500K	B
2N1057	G	P	2N1924	7-37	AFA	240M	A	100	45	45	V	34	90	20M	.13	20M			500K	B
2N1058	G	N				50M		75	20	20	R						10	8	4M	B
2N1059	G	N			AFA	180M		75	40	15	R			10M					10K	E
2N1060	S	N	2N2501	8-104	HSS	.25W	A	150	40	40	O	17		5M	.3	5M				
2N1065	G	P			AFA	.12W	A	85	40	20	O	20	80		.25	10M			10M	T

2N1066 — 2N1138B

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units	Subscript
2N1066	G	P	2N3323	9-66	RFA	120M	A	100	40	40	0	20	175	1.5M							
2N1067	S	N	2N3766	6-134	PMS	5W	C	175	60	30	0	15	75	200M	2	200M			.75M	B	
2N1068	S	N	2N3766	6-134	PMS	10W	C	175	60	30	0	15	75	750M	2	200M			.75M	B	
2N1069	S	N	2N3766	6-134	PMS	50W	C	175	60	45	0	20	50	1.5A	1.33	1.5A			.5M	B	
2N1070	S	N	2N3766	6-134	PMS	50W	C	175	60	45	0	20	50	1.5A	.5	1.5A			.5M	B	
2N1072	S	N	2N3766	6-134	PHS	2W	A	150	75	30	0	20		.75A	2	.75A					
2N1073	G	P		6-44	LPA			110	40	40	R	20	60	5A	1	5A					
2N1073A	G	P		6-44	LPA			110	80	80	R	20	60	5A	1	5A					
2N1073B	G	P		6-44	LPA			110	120	120	R	20	60	5A	1	5A					
2N1074	S	N			AFA	250M	A	160	50	40	0						9	E	200K	B	
2N1075	S	N			AFA	250M	A	160	50	35	0						18	E	250K	B	
2N1076	S	N			AFA	250M	A	160	50	30	0						36	E	300K	B	
2N1077	S	N			AFA	250M	A	160	50	35	0				1	8M	9	E	200K	B	
2N1078	G	P			LPA	20W	C	85	60	60	S	40		.5A	1	1A					
2N1079	S	N			HPA	60W	C	200	60	60	S	20	80	1A	3	1A	20	E	10M	T	
2N1080	S	N			HPA	60W	C	200	60	60	S	20	80	2A	5	2A	20	E	10M	T	
2N1081	S	N			MSS	6M	A	200	40	40	0	20	100	.5A	4	.5A					
2N1082	S	N			RFA	.2W	A	200	25	25	S	10	50	10M			10	E	17M	T	
2N1086	G	N			RFC	65M	A	85	9	9	0	17	195	1M							
2N1086A	G	N			RFC	65M	A	85	9	9	0	17	195	1M							
2N1087	G	N			RFC	65M	A	85	9	9	0	17	195	1M							
2N1090	G	N			MSS	120M	A	85	25			30		20M	.2	20M			5M	B	
2N1091	G	N			MSS	120M	A	85	25			40		20M	.3	200M			10M	B	
2N1092	S	N			PMS	2W	A	175	60	30	0	15	75	200M	2	200M			.75M	B	
2N1093	G	P			AFA	150M	A	95	30	15	0	50	150	20M	.2	20M	40	E	5M	B	
2N1094	G	P			RFA	.15W	A	100	30	15	0	15		4M			.96	B	560M	T	
2N1097	G	P	2N1414	7-33	AFC	200M	A	100	18	18	R	34	90	20M					1M	B	
2N1098	G	P	2N1414	7-33	AFC	200M	A	100	18	18	R	25	90	20M					1M	B	
2N1099	G	P		6-21	LPA	50W	C	95	80	70	S	35	70	5A	.7	12A					
2N1100	G	P		6-13	LPA	50W	C	95	100	65	0	25	50	5A	.7	12A					
2N1101	G	N			AFA	180M		75	20	15	R	25	50	35M	0.5	100M			10K	E	
2N1102	G	N			AFA	180M		75	40	25	R	25	50	35M	0.5	100M			10K	E	
2N1103	S	N			AFA	125M	A	150	45	35	0	30	65	10M	1.5	10M	20	E	10M	B	
2N1104	S	N			AFA	125M	A	150	45	35	0	45	150	10M	1.5	10M	40	E	20M	B	
2N1105	S	N			AFA	800M	A	200	60	60	0	12	36	200M	5	200M					
2N1106	S	N			AFA	800M	A	200	100	100	0	12	36	200M	5	200M					
2N1107	G	P			RFA	30M	C		16										40M	B	
2N1108	G	P			RFA	30M	C		16										35M	B	
2N1109	G	P			RFA	30M	C		16										35M	B	
2N1110	G	P			RFA	30M	C		16										35M	B	
2N1111	G	P			RFA	30M	C		16										35M	B	
2N1114	G	N			MSS	150M		100	25	15	R	40	180	20M					7M	B	
2N1115	G	P			MSA	150M	A	85	20	15	0				.35	60M			5M	B	
2N1115A	G	P			MSA	150M	A	85	20	15	0				.35	60M			5M	B	
2N1116	S	N			RFA	600M	C	200	60	60	0	40	150	.5A	5	.5A			6M	T	
2N1117	S	N			RFA	600M	C	200	60	60	0	40	150	.2A	4	.2A			4M	T	
2N1118	S	P			RFA	150M	A	140	25	25	U						15	E	8M	M	
2N1118A	S	P			RFA	150M	A	140	25	25	U		25	15M			15	E	8M	M	
2N1119	S	P			MSS	150M	A	140	10	10	U	15		15M	.15	5M			7.2M	T	
2N1120	G	P		6-47	LPA	45W	C	95	80	70	S	20	50	10A	1	10A	30	E	3K	E	
2N1121	G	N			RFC	65M	C	85	15	15	0	34		1M							
2N1122	G	P	2N961	8-48	HSS	25M	A	100	12	11	S	25		10M	.1	8M	35	E	40M	&	
2N1122A	G	P	2N960	8-48	HSS	25M	A	100	15	14	S	25		10M	.1	8M	35	E	40M	&	
2N1123	G	P	2N3427	8-41	MSS	10M	C	100	45	40	S	40		100M	.2	10M			3M	B	
2N1124	G	P	2N651	7-20	AFS	300M	A	85	40	35	V				.2	100M	40	E	400K	B	
2N1125	G	P	2N651	7-20	HSA	300M	A	85	40	40	V	50	150	500M	.3	500M			1M	B	
2N1126	G	P	2N651	7-20	MSA	1W	C	85	40	35	V				.2	100M	40	E	400K	B	
2N1127	G	P	2N3428	7-41	MSA	1W	C	85	40	40	V	50	150	500M	.3	500M			1M	B	
2N1128	G	P	2N1192	7-30	AFA	150M	A	85	25	18	S						70	E			
2N1129	G	P	2N3427	7-41	AFA	150M	A	85	25	25	V	100	200	100M	.25	100M					
2N1130	G	P	2N1193	7-30	AFA	150M	A	85	30			50	165	100M	.25	100M					
2N1131	S	P		8-64	MSA	600M	A	175	50	35	0	20	45	150M	1.5	150M	15	E	50M	T	
2N1131A	S	P	2N2800	8-111	MSA	.6W	A	175	60	40	0	20	45	.15A	1.5	.15A	15	E	50M	T	
2N1132	S	P		8-24	MSA	600M	A	175	50	35	0	30	90	150M	1.5	150M	25	E	60M	T	
2N1132A	S	P		8-24	MSA	.6W	A	175	60	40	0	30	90	.15A	1.5	.15A	25	E	60M	T	
2N1132B	S	P		8-24	MSA	.6W	A	175	70	45	0	30	90	.15A	1.5	.15A	25	E	60M	T	
2N1135	S	P			MSS	100M	A	140	12	12	0								5.6M	T	
2N1135A	S	P			MSS	100M	A	140	12	12	0								5.6M	T	
2N1136	G	P	2N1540	6-60	LPA			100	60	35	R	50	100	3A	1	3A			4K	E	
2N1136A	G	P	2N1542	6-60	LPA			100	90	65	R	50	100	3A	1	3A			4K	E	
2N1136B	G	P	2N1543	6-60	LPA			100	100	75	R	50	100	3A	1	3A			4K	E	
2N1137	G	P	2N1544	6-60	LPA			100	60	25	0	75	150	3A	1	3A					
2N1137A	G	P	2N1547	6-60	LPA			100	90	55	0	75	150	3A	1	3A					
2N1137B	G	P	2N1548	6-60	LPA			100	100	65	0	75	150	3A	1	3A					
2N1138	G	P	2N1545	6-60	LPA			100	60	25	0	100	200	3A	1	3A					
2N1138A	G	P	2N1547	6-60	LPA			100	90	55	0	100	200	3A	1	3A					
2N1138B	G	P	2N1548	6-60	LPA			100	100	65	0	100	200	3A	1	3A					

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_{—}$ Units	Subscript
2N1139	S	N	2N835	8-35	HSS	6.6M	A	175	15	15	0	20	200	10M	.7	10M			100M	T
2N1141	G	P		9-16	RFA	750M	C	100	35			10		10M	2	50M	12	E		
2N1141A	G	P			RFA	750M	C	100	35	25	S	15		10M	2	50M	.94	B	500M	T
2N1142	G	P		9-16	RFA	750M	C	100	30			10		10M	2	50M	.980	B	600M	B
2N1142A	G	P			RFA	750M	C	100	30	25	S	15		10*	2	50M	.94	B	400M	T
2N1143	G	P		9-16	RFA	750M	C	100	25			10		10M	2	50M	.980	B	480M	B
2N1143A	G	P			RFA	750M	C	100	30	25	S	15		10M	2	50M	.94	B	400M	T
2N1144	G	P	2N321	7-6	AFC	175M	A	85	16	16	R	34	90	20M					1M	B
2N1145	G	P	2N1414	7-33	AFC	175M	A	85	16	16	R	25	90	20M					1M	B
2N1146	G	P			PMS	87W	C	95	40	20	0	60	150	5A	1	15A			.15M	E
2N1146A	G	P			PMS	87W	C	95	60	30	0	60	150	5A	1	15A			.15M	E
2N1146B	G	P			PMS	87W	C	95	80	40	0	60	150	5A	1	15A			.15M	E
2N1146C	G	P			PMS	87W	C	95	100	50	0	60	150	5A	1	15A			.15M	E
2N1147	G	P			PMS	87W	C	95	40	20	0	60	150	5A	1	15A			.15M	E
2N1147A	G	P			PMS	87W	C	95	60	30	0	60	150	5A	1	15A			.15M	E
2N1147B	G	P			PMS	87W	C	95	80	40	0	60	150	5A	1	15A			.15M	E
2N1147C	G	P			PMS	87W	C	95	100	50	0	60	150	5A	1	15A			.15M	E
2N1149	S	N			AFA	150M		175	45			9	20	25M			.9	B	4M	B
2N1150	S	N			AFA	150M		175	45			18	40	25M			.948	B	5M	B
2N1151	S	N			AFA	150M		175	45			18	90	25M			.948	B	8M	B
2N1152	S	N			AFA	150M		175	45			36	90	25M			.973	B	6M	B
2N1153	S	N			AFA	150M		175	45			76	333	25M			.987	B	7M	B
2N1154	S	N			AFA	750M		150	50			9		60M			.9	B		
2N1155	S	N			AFA	750M		150	80			9		50M			.9	B		
2N1156	S	N			AFA	750M		150	120			9		40M			.9	B		
2N1157	G	P	MP501	6-168	PMS	187W	J	100	60	45	0	38	84	10A	.8	40A			75K	T
2N1157A	G	P	MP502	6-168	PMS	187W	J	100	80	50	0	38	84	10A	.8	40A			75K	T
2N1158	G	P	2N1143	9-16	RFA	60M	A	100	20	20	S						5.7	E		
2N1158A	G	P	2N1142	9-16	RFA	75M	A	100	20	20	S						9	E		
2N1159	G	P	2N3616	6-113	PMS	35W	C	95	80	60	0	30	75	3A	1	3A				
2N1160	G	P	2N3616	6-113	PMS	35W	C	95	80	60	0	20	50	5A	1	5A				
2N1162	G	P		6-49	PMS	90W	C	100	50	35	S	15	65	25A	.8	25A			1K	E
2N1162A	G	P		6-49	PMS	90W	C	100	50	35	S	15	65	25A	.8	25A			3K	E
2N1163	G	P		6-49	PMS	90W	C	100	50	35	S	15	65	25A	.8	25A			1K	E
2N1163A	G	P		6-49	PMS	90W	C	100	50	35	S	15	65	25A	.8	25A			3K	E
2N1164	G	P		6-49	PMS	90W	C	100	80	60	S	15	65	25A	.8	25A			1K	E
2N1164A	G	P		6-49	PMS	90W	C	100	80	60	S	15	65	25A	.8	25A			3K	E
2N1165	G	P		6-49	PMS	90W	C	100	80	60	S	15	65	25A	.8	25A			1K	E
2N1165A	G	P		6-49	PMS	90W	C	100	80	60	S	15	65	25A	.8	25A			3K	E
2N1166	G	P		6-49	PMS	90W	C	100	100	75	S	15	65	25A	.8	25A			1K	E
2N1166A	G	P		6-49	PMS	90W	C	100	100	75	S	15	65	25A	.8	25A			3K	E
2N1167	G	P		6-49	PMS	90W	C	100	100	75	S	15	65	25A	.8	25A			1K	E
2N1167A	G	P		6-49	PMS	90W	C	100	100	75	S	15	65	25A	.8	25A			3K	E
2N1168	G	P	2N3614	6-110	LPA	45W	C	95	50	30	R									
2N1169	G	N			BMS	120M	A	71	40	20	0	20		200M	.3	200M			4.5M	B
2N1170	G	N			BMS	120M	A	71	40	20	0	20		200M	.3	200M			4.5M	B
2N1171	G	P			MMS	170M	A	85	30	12		30		30M					10M	B
2N1172	G	P	2N2137	6-74	PMS			95	40	30	0	30	90	100M						
2N1173	G	N			MSS	.25W	A	100	35	20	0	50	200	10M	.075	10M	50	E		
2N1174	G	P			MSS	.25W	A	100	35	20	0	50	200	10M	.075	10M	50	E		
2N1175	G	P		7-33	AFA	200M	A	85	35	25	R	70	140	20M					1.5M	B
2N1176	G	P	2N1189	7-28	AFA	.3W	C	85	10	10	R				.3	.1A	20	E		
2N1177	G	P	2N2957	8-119	RFA	80M	A	71	30											
2N1178	G	P	2N2955	8-119	RFA	80M	A	71	30											
2N1179	G	P	2N2956	8-119	RFA	80M	A	71	30											
2N1180	G	P	2N2956	8-119	RFA	80M	A	71	30											
2N1182	G	P	2N2140	6-74	PMS	106W	C	100	50	60	0	30	85	.5A	.9	2A			5K	E
2N1183	G	P	2N2139	6-74	PMS	7.5W	C	100	45	20	0	20	60	400M	.5	400M			500K	B
2N1183A	G	P	2N2140	6-74	PMS	7.5W	C	100	60	30	0	20	60	400M	.5	400M			500K	B
2N1183B	G	P	2N2141	6-74	PMS	7.5W	C	100	80	40	0	20	60	400M	.5	400M			500K	B
2N1184	G	P	2N2144	6-74	PMS	7.5W	C	100	45	20	0	40	120	400M	.5	400M			500K	B
2N1184A	G	P	2N2145	6-74	PMS	7.5W	C	100	60	30	0	40	120	400M	.5	400M			500K	B
2N1184B	G	P	2N2146	6-74	PMS	7.5W	C	100	80	40	0	40	120	400M	.5	400M			500K	B
2N1185	G	P	2N1185	7-25	AFA	200M	A	100	45	30	R	130		10M			190	E	1.7M	B
2N1186	G	P		7-25	AFA	200M	A	100	60	45	R	33		10M			30	E	.75M	B
2N1187	G	P		7-25	AFA	200M	A	100	60	45	R	45		10M			50	E	1M	B
2N1188	G	P		7-25	AFA	200M	A	100	60	45	R	80		10M			100	E	1.2M	B
2N1189	G	P		7-28	AFA	200M	A	100	45	30	R	60		10M	.22	50M	75	E	1.7M	B
2N1190	G	P		7-28	AFA	200M	A	100	45	30	R	100		10M	.22	50M	125	E	2.2M	B
2N1191	G	P		7-30	AFA	200M	A	100	40	25	R	20	80	10M			30	E		
2N1192	G	P		7-30	AFA	200M	A	100	40	25	R	40	135	10M			50	E		
2N1193	G	P		7-30	AFA	200M	A	100	40	25	R	70	300	10M			100	E		
2N1194	G	P		7-30	AFA	200M	A	100	40	25	R	125	600	10M			190	E		
2N1195	G	P		9-16	RFA	225M	A	100	30								.96	B	400M	T
2N1196	S	P			RFA	.35W	A	200	70	70	0	5	30	2M			.85	B		
2N1197	S	P			RFA	.35W	A	200	70	70	0	5	30	2M			.85	B		
2N1198	G	N			HSA	65M	A	85	25	25	0	17	90	8M			.952	B	5M	B

2N1199—2N1274

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_{—}$	Units Subscript
2N1199	S	N	2N835	8-35	HSS	150M	A	150	20	15	0	12	60	20M	.25	10M			75M	T
2N1199A	S	N	2N835	8-35	HSS	150M	A	150	20	15	0	.12	60	20M	.25	10M			75M	T
2N1200	S	N			RFA	100M	A	150	20	15	0	7	200	1.5M				9	E	
2N1201	S	N			RFA	100M	A	150	20	15	0	7	200	1.5M				9	E	
2N1202	G	P	2N2145	6-74	PMS	34W	J	95	80	60		40	120	500M	.3	500M			200K	T
2N1203	G	P	2N2146	6-74	PMS	34W	J	95	120	70		25	75	2A	.6	2A			200K	T
2N1204	G	P		8-66	HSS	200M	A	100	20	15	0	15		400M	.5	200M			220M	T
2N1204A	G	P		8-66	HSS	200M	A	100	20	15	0	25		200M	.4	200M			220M	T
2N1206	S	N			RFA	3M	A	200	60	60	0	20	80					25	E	10M	T
2N1207	S	N			RFA	3M	A	200	125	125	0	20	80					25	E	10M	T
2N1208	S	N	2N3445	6-103	LPA	45W	C	200	60	60	0	15		2A	5	2A				
2N1209	S	N	2N3445	6-103	HPA	45W	C	200	45	45	0	20	80	2A	5	2A			3M	T
2N1210	S	N	2N3713	6-117	HPA	30W	C	175	60	60	0	15	75	2A	2	2A			3M	T
2N1211	S	N	2N3445	6-103	HPA	30W	C	175	80	80	V	15	75	2A	2	2A			3M	T
2N1212	S	N	2N3445	6-103	HPA	45W	C	200	60	60	0	12	36	1A	5	1A			3M	T
2N1213	G	P			BHS	75M	A	71	25											
2N1214	G	P			BHS	75M	A	71	25											
2N1215	G	P			BHS	75M	A	71	25											
2N1216	G	P			BHS	75M	A	71	25											
2N1217	G	N			HSA	75M	A	85	20	20	0	40	100	500*					6M	B
2N1218	G	N			LPA	20W	C	90	45	45	R	30	120	1A	1	1A			7K	E
2N1219	S	P			AFA	.25W	A	175	30	25	0	18		5M					5M	B
2N1220	S	P			AFA	.25W	A	175	30	25	0	9		5M					2M	B
2N1221	S	P			AFA	.25W	A	175	30	25	0							18	E	5M	B
2N1222	S	P			AFA	.25W	A	175	30	25	0							9	E	2M	B
2N1223	S	P			AFA	.25W	A	175	40	40	0							6	E		
2N1224	G	P			BHS	120M	A	85	40												
2N1225	G	P			RFC	120M	A	85	40												
2N1226	G	P			RFC	120M	A	85	60												
2N1227	G	P	2N3611	6-110	LPA	50W	C	95	35	20	0	50	350	.5A	.8	1.5A		25	E	3K	E
2N1228	S	P			MSA	.4W	A	160	15	15	0				.2	10M		14	E		
2N1229	S	P			MSA	.4W	A	160	15	15	0				.2	10M		28	E		
2N1230	S	P			MSA	.4W	A	160	35	35	0				.2	10M		14	E		
2N1231	S	P			MSA	.4W	A	160	35	35	0				.2	10M		28	E		
2N1232	S	P			MSA	.4W	A	160	60	60	0				.2	10M		14	E		
2N1233	S	P			MSA	.4W	A	160	60	60	0				.2	10M		28	E		
2N1234	S	P			MSA	.4W	A	160	110	110	0				.2	10M		14	E		
2N1235	S	N			LPA	85W	C	200	120	120	R	12	60	1A	5	1A			50K	E
2N1238	S	P			MSA	1W	A	160	15	15	0				.2	10M		14	E		
2N1239	S	P			MSA	1W	A	160	15	15	0				.2	10M		28	E		
2N1240	S	P			MSA	1W	A	160	35	35	0				.2	10M		14	E		
2N1241	S	P			MSA	1W	A	160	35	35	0				.2	10M		28	E		
2N1242	S	P			MSA	1W	A	160	60	60	0				.2	10M		14	E		
2N1243	S	P			MSA	1W	A	160	60	60	0				.2	10M		28	E		
2N1244	S	P			MSA	1W	A	160	110	110	0				.2	10M		14	E		
2N1245	G	P			LPA	20W	C	85	30	25	R	50		.5A							
2N1246	G	P			LPA	20W	C	85	30	25	R	50		.5A							
2N1247	S	N			AFA	30M	A	150	6	6	0	15		5*							
2N1248	S	N			AFA	30M	A	150	6	6	0	15		20*							
2N1249	S	N			AFA	30M	A	150	6	6	0	20		30*							
2N1250	S	N	2N3713	6-117	LPA	85W	C	200	60	60	0	15		2A	5	2A				
2N1251	G	N			AFA	150M		85	20	15	R				0.5	100M		70	E	7.5K	E
2N1252	S	N	2N2537	8-107	MSS	600M	A	175	30	20	R	15	45	150M	1.5	150M			40M	T
2N1252A	S	N	2N2537	8-107	MSA	800M	A	300	60	30	0	15	45	150M	1.5	150M			40M	T
2N1253	S	N	2N2537	8-107	MSS	600M	A	175	30	20	R	30	90	150M	1.5	150M			50M	T
2N1253A	S	N	2N2537	8-107	MSA	800M	A	300	60	30	0	30	90	150M	1.5	150M			50M	T
2N1254	S	P			HSS	275M	A	200	30	30	0	25	50	10M	.3	10M			30M	T
2N1255	S	P			HSS	275M	A	200	30	30	0	40	80	10M	.3	10M			50M	T
2N1256	S	P			HSS	275M	A	200	40	40	0	25	50	10M	.3	10M			30M	T
2N1257	S	P			HSS	275M	A	200	40	40	0	40	80	10M	.3	10M			50M	T
2N1258	S	P			HSS	275M	A	200	30	30	0	75	150	10M	.6	10M			50M	T
2N1259	S	P			HSS	275M	A	200	50	50	0	25	100	10M	.3	10M			40M	T
2N1260	S	N			LPA	85W	C	200	120	120	R	12	60	1A	10	1A			50K	E
2N1261	G	P	2N1531	6-56	PMS	34W	J	95	80	45		20	50	2A	.6	2A			200K	T
2N1262	G	P	2N1531	6-56	PMS	34W	J	95	80	45		30	75	2A	.6	2A			200K	T
2N1263	G	P	2N3617	6-113	PMS	34W	J	95	80	45		45	113	2A	.6	2A			200K	T
2N1264	G	P	2N1191	7-30	RFC	50M	A	75	20									15	E		
2N1265	G	P	2N1192	7-30	RFC	50M	A	85	12	10	R				0.5	100M		25	E	600K	B
2N1266	G	P	2N1191	7-30	RFC	80M	A	85	10									10	E		
2N1267	S	N			RFA	150M	A	150	20	15	0	4	16	1.5M				6	E		
2N1268	S	N			RFA	150M	A	150	20	15	0	7	30	1.5M				11	E		
2N1269	S	N			RFA	150M	A	150	20	15	0	20	80	1.5M				28	E		
2N1270	S	N			RFA	150M	A	150	20	15	0	4	16	1.5M				6	E		
2N1271	S	N			RFA	150M	A	150	20	15	0	7	30	1.5M				11	E		
2N1272	S	N			RFA	150M	A	150	20	15	0	20	80	1.5M				28	E		
2N1273	G	P	2N1191	7-30	AFC	250M	A	100	15	15	R	27	165	50M	1	100M		20	E		
2N1274	G	P	2N1191	7-30	AFC	250M	A	100	25	25	R	27	165	50M	1	100M		20	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N1275	S	P			DFA	250M	A	160	100	80	0	9	25	1M	.3	5M			100K	B
2N1276	S	N	2N2501	8-104	AFC	150M	A	150	40	30	0				1	5M	9	E	15M	B
2N1277	S	N			AFC	150M	A	150	40	30	0				1	5M	18	E	15M	B
2N1278	S	N	2N2501	8-104	AFC	150M	A	150	40	30	0				1	5M	37	E	15M	B
2N1279	S	N	2N2501	8-104	AFC	150M	A	150	40	30	0				1	5M	76	E	15M	B
2N1280	G	P			MSS	.2W	A	85	16	16	D	40		20M					5M	B
2N1281	G	P			MSS	.2W	A	85	16	12	D	60		20M					7M	B
2N1282	G	P			MSS	.2W	A	85	16	6	D	70		20M					10M	B
2N1284	G	P			MSS	.15W	A	85	20	15	D	30	150	10M	.2	10M			5M	B
2N1285	G	P			RFA	240M	A	71	40	40	V	30	100	1.5M						
2N1287	G	P	2N651	7-20	AFC	.3W	C	85	25	25	R				.5	20M	40	E		
2N1287A	G	P	2N652	7-20	AFC	.3W	C	85	25	25	R				.5	20M	60	E		
2N1288	G	N			HSA	75M	A	100	15	10	R	50	300	10M	.3	10M				
2N1289	G	N			HSA	75M	A	85	20	15	D	50	300	10M	.3	10M			40M	B
2N1291	G	P	2N1529	6-56	LPA	20W	C	85	35	30	S	40		.5A	1	1A				
2N1292	G	N			LPA	25W	C	100	35	30	S	30		.5A	1	1A				
2N1293	G	P	2N1531	6-56	LPA	20W	C	85	60	60	S	40		.5A	1	1A				
2N1294	G	N			LPA	25W	C	100	60	45	S	30		.5A	1	1A				
2N1295	G	P	2N1532	6-56	LPA	20W	C	85	80	80	S	40		.5A	1	1A				
2N1296	G	N			LPA	25W	C	100	80	60	S	30		.5A	1	1A				
2N1297	G	P	2N1533	6-56	LPA	20W	C	85	100	100	S	40		.5A	1	1A				
2N1298	G	N			LPA	25W	C	100	100	80	S	30		.5A	1	1A				
2N1299	G	N			MSS	150M		100	40	20	R	35	110	50M	.17	15M			4M	B
2N1300	G	P			HSS	150M	A	85	13	12	D	30		10M					25M	T
2N1301	G	P			HSS	150M	A	85	13	12	D	30		10M					35M	T
2N1302	G	N			MSS	150M	A	85	25			20		10M	.2	10M			3M	B
2N1303	G	P	2N1192	7-30	MSS	150M	A	85	30			20		10M	.2	10M			3M	B
2N1304	G	N			MSS	150M	A	85	25			40	200	10M	.2	10M			5M	B
2N1305	G	P			MSS	150M	A	85	30			40	200	10M	.2	10M			5M	B
2N1306	G	N			MSS	150M	A	85	25			60	300	10M	.2	10M			10M	B
2N1307	G	P			MSS	150M	A	85	30			60	300	10M	.2	10M			10M	B
2N1308	G	N			MSS	150M	A	85	25			80		10M	.2	10M			15M	B
2N1309	G	P			MSS	150M	A	85	30			80		10M	.2	10M			15M	B
2N1309A	G	P			MSS	.15W	A	85	35	15	D	80		10M	.2	10M			15M	B
2N1310	G	N			SPP	120M	A	85	90	90		20		5M						
2N1311	S	N			SPP	120M	A	85	75	75		15		5M						
2N1312	G	N			MSA	120M	A	85	50	50		20		20M		20M				
2N1313	G	P			MSS	18W	A	100	30	15	D	40	125		.28	.3A			6M	B
2N1314	G	P	2N3611	6-110	LPA	125W	C	90	40	40	R	20	55	1A						
2N1315	G	P	2N3611	6-110	LPA	125W	C	90	32	16		45	135	1A						
2N1316	G	P			MSS	.2W	A	85	30	15	D	50	200						10M	B
2N1317	G	P			MSS	.2W	A	85	20	12	D	45	180						10M	B
2N1318	G	P			MSS	.2W	A	85	10	6	D	40	150						10M	B
2N1319	G	P			BMS	120M	A	71	20	20	V	15		.4A	.3	.4A			3M	T
2N1320	G	P			LPA	20W	C	85	35	30	S	40		.5A	1	1A				
2N1321	G	N			LPA	25W	C	100	35	30	S	30		.5A	1	1A				
2N1322	G	P			LPA	20W	C	85	60	60	S	40		.5A	1	1A				
2N1323	G	N			LPA	25W	C	100	60	45	S	30		.5A	1	1A				
2N1324	G	P			LPA	20W	C	85	80	80	S	40		.5A	1	1A				
2N1325	G	N			LPA	25W	C	100	80	60	S	30		.5A	1	1A				
2N1326	G	P			LPA	20W	C	85	100	100	S	40		.5A	1	1A				
2N1327	G	N			LPA	25W	C	100	100	80	S	30		.5A	1	1A				
2N1328	G	P			LPA	20W	C	85	35	30	S	40		.5A	1	1A				
2N1329	G	N			LPA	25W	C	100	35	30	S	30		.5A	1	1A				
2N1330	G	N			LPA	25W	C	100	60	45	S	30		.5A	1	1A				
2N1331	G	P			LPA	20W	C	85	80	80	S	40		.5A	1	1A				
2N1332	G	N			LPA	25W	C	100	80	60	S	30		.5A	1	1A				
2N1333	G	P			LPA	20W	C	85	100	100	S	40		.5A	1	1A				
2N1334	G	N			LPA	25W	C	100	100	80	S	30		.5A	1	1A				
2N1335	S	N			HPA	.8W	A	175	120	45	D	10	150	30M					70M	T
2N1336	S	N			HPA	.8W	A	175	120	45	D	10	150	30M					70M	T
2N1337	S	N			HPA	.8W	A	175	120	45	D	10	150	30M					70M	T
2N1338	S	N			HPA	.8W	A	175	80	25	D	10	150	30M					70M	T
2N1339	S	N			HPA	.8W	A	175	120	50	D	10	150	30M					70M	T
2N1340	S	N			HPA	.8W	A	175	120	50	D	10	150	30M					70M	T
2N1341	S	N			HPA	.8W	A	175	120	50	D	10	150	30M					70M	T
2N1342	S	N			HPA	.8W	A	175	150	65	D	10	150	30M					70M	T
2N1343	G	P			MSA	.15W	A	85	20	16	D	15		50M					4M	B
2N1344	G	P			MSS	.15W	A	85	15	10	D	60		20M					7M	B
2N1345	G	P			MSS	.15W	A	85	10	8	D	30	100	.4A					10M	B
2N1346	G	P			MSS	.15W	A	85	12	10	D	40	250	.35M	.13	12M			10M	B
2N1347	G	P			MSS	.15W	A	85	20	12	D	30		10M	.2	10M			5M	B
2N1352	G	P	2N651	7-20	AFA	.15W	A	85	30	20	D	40	100							
2N1353	G	P			MSS	.2W	A	85	15	10	D	25	150	10M	.2	50M			1.5M	B
2N1354	G	P			MSS	.2W	A	85	30	15	D	25	150	10M	.2	50M			3M	B
2N1355	G	P			MSS	.2W	A	85	30	20	D	30	150	10M	.2	50M			5M	B
2N1356	G	P			MSS	.2W	A	100	30	20	D	40	140	10M	.2	50M			5M	B

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} - @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f}—	Subscript	f—	Units	Subscript
2N1357	G	P			MSS	.2W	A	85	30	15	0	40	150	10M	.2	50M			10M		B
2N1358	G	P	2N2929	9-28	PMS	90W		95	80	40	0	40	80	1.2A	.7	12A			100K		B
2N1358A	G	P		6-71	PMS	150W	C	100	100	60	0	40	80	1.2A	.7	12A			100K		B
2N1359	G	P		6-28	LPA	90W	J	100	50	40	S	35	90	1A	.1	2A			5K		E
2N1360	G	P		6-28	LPA	90W	J	100	50	40	S	60	140	1A	1	2A			5K		E
2N1361	G	P			MSS	.15W	A	100	25	20	0	40	100	25M					4M		B
2N1361A	G	P			MSS	.2W	A	100	25	20	0	40	100	25M					4M		B
2N1362	G	P		6-28	LPA	90W	J	100	100	75	S	35	90	1A	1	2A			5K		E
2N1363	G	P		6-28	LPA	90W	J	100	100	75	S	60	140	1A	1	2A			5K		E
2N1364	G	P		6-28	LPA	90W	J	100	120	100	S	35	90	1A	1	2A			5K		E
2N1365	G	P		6-28	LPA	90W	J	100	120	100	S	60	140	1A	1	2A			5K		E
2N1366	G	N			AFC	100M	A	85	18	18	R	20		1M			10	E	5M		T
2N1367	G	N			AFC	100M	A	85	18	18	R	10		1M			5	E	2.5M		T
2N1370	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	45	165	50M	1	100M	40	E			
2N1371	G	P	2N1192	7-30	AFC	250M	A	100	45	45	R	45	165	50M	1	100M	40	E			
2N1372	G	P	2N1191	7-30	AFC	250M	A	100	25	25	R	27	105	50M	1	100M	20	E			
2N1373	G	P	2N1191	7-30	AFC	250M	A	100	45	45	R	27	105	50M	1	100M	20	E			
2N1374	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	45	165	50M	1	100M	40	E			
2N1375	G	P	2N1192	7-30	AFC	250M	A	100	45	45	R	45	165	50M	1	100M	40	E			
2N1376	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	67	165	50M	1	100M	60	E			
2N1377	G	P	2N651	7-20	AFC	250M	A	100	45	45	R	67	165	50M	1	100M	60	E			
2N1378	G	P	2N1193	7-30	AFC	250M	A	100	12	12	R	85	330	50M	1	100M	75	E			
2N1379	G	P	2N1193	7-30	AFC	250M	A	100	25	25	R	85	330	50M	1	100M	75	E			
2N1380	G	P	2N1192	7-30	AFC	250M	A	100	12	12	R	27	330	50M	1	100M	20	E			
2N1381	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	27	330	50M	1	100M	20	E			
2N1382	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	45	165	50M	1	100M	40	E			
2N1383	G	P	2N1192	7-30	AFC	250M	A	100	25	25	R	27	165	50M	1	100M	20	E			
2N1384	G	P			HSS	240M	A	85	30	30	0	20		200M					20M		T
2N1385	G	P			RFA	750M	A	100	25	10	0	10		10M					250M		T
2N1386	S	N	2N2218	8-74	MSS	300M	A	175	25	25	0	30	90	10M	.6	5M					
2N1387	S	N	2N2218	8-74	MSS	300M	A	175	30	30	0	20	40	10M	.5	5M					
2N1388	S	N	2N2218	8-74	RFA	300M	A	175	45	25	0	15	55	10M			30	E	50M		B
2N1389	S	N	2N2218	8-74	VID	300M	A	175	50	50	0				.8	5M			24M		T
2N1390	S	N	2N2218	8-74	RFA	300M	A	175	20	20	0	30	150	10M			10	E	20M		B
2N1391	G	N			AFA	150M	A	100	25	18	0	40	160	20M			35	E	3M		E
2N1392	G	P			SPP	50M	A	85	20	20	R										
2N1393	G	P			SPP	50M	A	85	20	10	R										
2N1394	G	P			SPP	50M	A	85	10	6	R										
2N1395	G	P	2N2955	8-119	RFA	120M	A	100	40	40	0	50	175	1.5M					30M		B
2N1396	G	P	2N3323	9-66	RFA	120M	A	100	40	40	0	50	175	1.5M					30M		B
2N1397	G	P	2N3323	9-66	RFA	120M	A	100	40	40	0	50	175	1.5M					120M		B
2N1398	G	P			RFC	50M	A	85	30	20	0	10		.5M	.75	10M			140M		T
2N1399	G	P			RFC	50M	A	85	30	20	0	3.5		.5M	.75	10M			140M		T
2N1400	G	P			RFC	50M	A	85	30	20	0	5	12	.5M	.75	10M			100M		T
2N1401	G	P			RFC	50M	A	85	30	20	0	5		.5M	.75	10M			120M		T
2N1402	G	P			RFC	50M	A	85	30	20	0	3.5	12	1.5M	.75	10M			100M		T
2N1403	G	P			RFA	250M	A	100	15	12		25	250	7M	.75	10M			200M		T
2N1404	G	P			MSS	150M	A	85	25						.15	12M			4M		B
2N1404A	G	P			MSS	150M	A	85	25	15	0	30	200	12M	.15	12M			3M		T
2N1405	G	P			RFA	75M	A	100	30	20	0	10	200	2M			10	E	250M		T
2N1406	G	P			RFA	75M	A	100	30	20	0	10	200	2M			10	E	250M		T
2N1407	G	P			RFA	75M	A	100	30	20	0	10	200	2M			10	E	200M		T
2N1408	G	P		7-32	MSA	150M	A	100	50	50	S	10					10	E			
2N1411	G	P	2N962	8-48	MSS	25M	A	85	5	5	S	20		50M	.45	10M			25M		T
2N1412	G	P		6-53	PMS	70W	C	95	100	65	0	25	50	5A	.7	12A					
2N1413	G	P		7-33	MSA	200M	A	85	35	25	R	25	42	20M			20	E	800K		B
2N1414	G	P		7-33	MSA	200M	A	85	35	25	R	34	65	20M			30	E	1M		B
2N1415	G	P		7-33	MSA	200M	A	85	35	25	R	53	90	20M			44	E	1.3M		B
2N1416	G	P	2N1193	7-30	AFC	100M	A	65		18	U						39	E			
2N1417	S	N			AFA	.15W	A	150	15	15	0						30	E			
2N1418	S	N			AFA	.15W	A	150	30	30	0						30	E			
2N1419	G	P	2N1164	6-49	PMS	87W	C	95	80	40	0	40	100	25A	.7	25A					
2N1420	S	N		8-12	RFA	600M	A	175	60	30	R	100	300	150M	1.5	150M			50M		T
2N1420A	S	N	2N2219	8-74	RFA	800M	A	200	60	40	R	100	300	150M	1.5	150M			60M		T
2N1421	S	N			HPA	30W	C	200	60	60	S	20	80	1A	3	1A	20	E	10M		T
2N1422	S	N			HPA	30W	C	200	60	60	S	20	80	1A	3	1A	20	E	10M		T
2N1423	S	N			HPA	60W	C	200	60	60	S	20	80	2A	5	2A	20	E	10M		T
2N1424	S	N			HPA	60W	C	200	60	60	S	20	80	2A	5	2A	20	E	10M		T
2N1425	G	P			AFC	80M	A	85	24										10M		B
2N1426	G	P			AFC	80M	A	85	24								17	E	10M		B
2N1427	G	P	2N962	8-48	HSS	25M	A	100	6	6	S	20		50M	.2	50M	40	E	50M		T
2N1428	S	P			MSA	100M	A	140	6	6	0	12		5M	.1	5M	25	E	16M		T
2N1429	S	P			MSA	100M	A	140	6	6	0	12		5M	.1	5M	25	E	16M		T
2N1430	G	P			PMS	70W	C	110	120	100	0	30	90	5A	.4	10A			.6M		T
2N1431	G	N			AFA	180M	A	75	20	15	R	75	150	35M					10K		E
2N1432	G	P			AFA	100M	A	100	45	45	R						30	E			
2N1433	G	P			LPA			95	80	50	0	20	50	2A	1.5	2A			5K		E

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N1434	G	P			LPA			95	80	50	0	45	115	2A	1	2A			5K	E
2N1435	G	P			LPA			95	80	50	0	30	75	2A	.6	2A			5K	E
2N1436	G	P			HSS	50M	A	100	15	12	S	20		10M	.2	10M				
2N1437	G	P			LPA	23W	C	95	100	90		20		.5A	1	1A			4K	E
2N1438	G	P			LPA	23W	C	95	100	90		20		.5A	1	1A			4K	E
2N1439	S	P			AFA	.4W	A	200	50	50	0				.25	5M	9	E	.5M	B
2N1440	S	P			AFA	.4W	A	200	60	50	0				.25	5M	9	E	1M	B
2N1441	S	P			AFA	.4W	A	200	50	35	0				.25	5M	18	E	1M	B
2N1442	S	P			AFA	.4W	A	200	50	30	0				.25	5M	30	E	1M	B
2N1443	S	P			AFA	.4W	A	200	50	15	0				.25	5M	50	E	1M	B
2N1444	S	N			HSS	.5W	A	150	60	20	0	20		.25A	1.5	.25A				
2N1445	S	N			LPA	4W	C	200	120	120	0	20	80	200M	4	200M			75K	E
2N1446	G	P	2N1191	7-30	AFA	.2W	A	85	45	25	0	16	45	20M			16	E	.8M	B
2N1447	G	P	2N1191	7-30	AFA	.2W	A	85	45	25	0	35	65	20M			30	E	1.5M	B
2N1448	G	P	2N1192	7-30	AFA	.2W	A	85	45	25	0	50	90	20M			45	E	2M	B
2N1449	G	P	2N1189	7-28	AFA	.2W	A	85	45	25	0	70	125	20M			60	E	2.5M	B
2N1450	G	P	2N2955	8-119	MSS	.12W	A	85	30	20	0	20		10M	.25	10M				
2N1451	G	P	2N464	7-15	AFA	.2W	A	85	45	20	0	20	65	20M						
2N1452	G	P	2N1191	7-30	AFA	.2W	A	85	45	20	0	30	90	20M						
2N1453	G	P			LPA			90	30	20	0	40	90	1A	1	3A			5K	E
2N1454	G	P			LPA			90	30	20	0	70	150	1A	1	3A			5K	E
2N1455	G	P			LPA			90	60	40	0	40	90	1A	1	3A			5K	E
2N1456	G	P			LPA			90	60	40	0	70	150	1A	1	3A			5K	E
2N1457	G	P			LPA			90	80	60	0	40	90	1A	1	3A			5K	E
2N1458	G	P			LPA			90	80	60	0	70	150	1A	1	3A			5K	E
2N1461	G	P			LPA			90	30	20	0	40	90	1A	1	3A			5K	E
2N1462	G	P			LPA			90	30	20	0	70	150	1A	1	3A			5K	E
2N1463	G	P			LPA			90	60	40	0	40	90	1A	1	3A			5K	E
2N1464	G	P			LPA			90	60	40	0	70	150	1A	1	3A			5K	E
2N1465	G	P			LPA	20W	C	85	120	70	0	20		.5A	.75	1A			4K	E
2N1466	G	P			LPA	20W	C	85	120	70	0	20		.5A	.75	1A			4K	E
2N1469	S	P			AFA	.25W	A	175	40	35	U						36	E	2M	B
2N1470	S	N			LPA	55W	C	200	60	60	S	15		1A	3	1A				
2N1471	G	P			MSS	200M	A	85	12	15	R						100	E	3M	B
2N1472	S	N			HSS	150M	A	150	25	25	0	20		10M	.25	10M			75M	T
2N1473	G	N			MSS	167M	A	75	40	20	0	25	50	400M					4M	B
2N1474	S	P			AFA	.25W	A	175	60	60	U						12	E	1M	B
2N1474A	S	P			AFA	.25W	A	175	60	60	U						18	E	2M	B
2N1475	S	P			AFA	.25W	A	175	60	60	U						36	E	1M	B
2N1476	S	P			AFA	.25W	A	175	100	100	U						12	E	1M	B
2N1477	S	P			AFA	.25W	A	175	100	100	U						30	E	1M	B
2N1478	G	P	2N3427	7-41	MSS	250M	A	100	30	20	S	40		100M	.2	10M			3M	B
2N1479	S	N			PMS	5W	C	200	60	60	V	20	60	200M	1.4	200M				
2N1480	S	N			PMS	5W	C	200	100	100	V	20	60	200M	1.4	200M				
2N1481	S	N			PMS	5W	C	200	60	60	V	35	100	200M	1.4	200M				
2N1482	S	N			PMS	5W	C	200	100	100	V	35	100	200M	1.4	200M				
2N1483	S	N	2N3766	6-134	PMS	25W	C	200	60	60	V	20	60	750M	2	750M				
2N1484	S	N	2N3766	6-134	PMS	25W	C	200	100	100	V	20	60	750M	2	750M				
2N1485	S	N	2N3766	6-134	PMS	25W	C	200	60	60	V	35	100	750M	.75	750M				
2N1486	S	N	2N3766	6-134	PMS	25W	C	200	100	100	V	35	100	750M	.75	750M				
2N1487	S	N	2N3713	6-117	PMS	75W	C	200	60	60	V	15	45	200M	3	1.5A				
2N1488	S	N	2N3714	6-117	PMS	75W	C	200	100	100	V	15	45	200M	3	1.5A				
2N1489	S	N	2N3713	6-117	PMS	75W	C	200	60	60	V	25	75	1.5A	1	1.5A				
2N1490	S	N	2N3714	6-117	PMS	75W	C	200	100	100	V	25	75	1.5A	1	1.5A				
2N1491	S	N			RFA	3W	C	175	30								15	E		
2N1492	S	N			RFA	3W	C	175	60								15	E		
2N1493	S	N			RFA	3W	C	175	100			4					15	E		
2N1494	G	P		8-66	HSS	400M	A	100	20	15	0	15		400M	.5	200M			220M	T
2N1494A	G	P		8-66	HSS	400M	A	100	20	15	0	25		200M	.4	200M			220M	T
2N1495	G	P		8-66	HSS	250M	A	100	40	25	0	25		200M	.3	200M			150M	T
2N1495A	G	P		8-66	HSS	.25W	A	100	40	25	0	25		.2A	.3	.2A			150M	T
2N1496	G	P		8-48	HSS	500M	A	100	40	25	0	25		200M	.3	200M			150M	T
2N1499	G	P	2N960	8-48	HSS	25M	A	85	20	15	5	20		10M	.2	10M				
2N1499A	G	P	2N960	8-48	HSS	60M	A	100	20	20	S	30		10M	.2	10M			100M	T
2N1499B	G	P			HSS	75M	A	100	30	20	0	40		10M	.2	10M			150M	T
2N1500	G	P	2N962	8-48	HSS	60M	A	100	15	12	S	20		10M	.2	10M			120M	T
2N1501	G	P	2N2144	6-74	PMS	34W	J	95	60	40		25	100	2A	.6	2A			200K	T
2N1502	G	P	2N2143	6-74	PMS	34W	J	95	40	40		25	100	2A	.6	2A			200K	T
2N1504	G	P			LPA	25W	C	95	80	60	0	21		.5A	.75	1A			4K	E
2N1505	S	N			HPA	.8W	A	175	50	20	0	7	100	.1A	2	.15A			70M	T
2N1506	S	N			HPA	.8W	A	175	60	20	0	10	100	.1A	1.5	.15A			140M	T
2N1506A	S	N			HPA	.8W	A	200	80	50	0	10	100	.1A	.6	.15A			140M	T
2N1507	S	N	2N2219	8-74	MSA	600M	A	175	60	30	R	100	300	150M	1.5	150M			50M	T
2N1508	S	N			MSA	1W	A	175	100	55	0	20	60	600M	3.6	600M			50M	T
2N1509	S	N			MSA	1W	A	175	60	35	0	20	60	600M	3.6	600M			50M	T
2N1510	G	N			SPP	75M	A	85	75	70	R	8	90	1M	.8	4M				

2N1511—2N1554A

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N1511	S	N	2N3713	6-117	PMS	75W	C	200	60	60	V	4		6A	1.2	6A			.3M	T
2N1512	S	N			PMS	75W	C	200	100	100	V	7		6A	6	6A			.3M	T
2N1513	S	N			PMS	75W	C	200	60	60	V	7		6A	6	6A			.3M	T
2N1514	S	N			PMS	75W	C	200	100	100	V								.3M	T
2N1516	G	P			RFC	83M	A	75	25			20		1M						
2N1518	G	P	2N2153	6-74	PMS	50W	C	95	50	40		15	60	15A	.7	25A				
2N1519	G	P	2N2154	6-78	PMS	50W	C	95	80	60		15	60	15A	.7	25A				
2N1520	G	P	2N2153	6-78	PMS	50W	C	95	50	40		17	68	15A	.6	35A				
2N1521	G	P	2N2154	6-78	PMS	50W	C	95	80	60		17	68	15A	.6	35A				
2N1522	G	P	2N2153	6-78	PMS	50W	C	95	50	40	B	25	100	15A	.5	50A				
2N1523	G	P	2N2154	6-78	PMS	50W	C	95	80	60	B	25	100	15A	.5	50A				
2N1524	G	P	2N3325	9-66	RFC	80M	A	85	24								17	E		
2N1525	G	P	2N3325	9-66	RFC	80M	A	85	24								17	E		
2N1526	G	P	2N3325	9-66	RFC	80M	A	85	24								27	E		
2N1527	G	P	2N3325	9-66	RFC	80M	A	85	24								27	E		
2N1528	S	N	2N2218	8-74	VID	150M	A	175	25	25	S						10	E		
2N1529	G	P		6-56	LPA	90W	C	100	40	30	S	20	40	3A	1.5	3A				
2N1529A	G	P		6-56	LPA	90W	C	100	40	20	O	20	40	3A	1.5	3A			5K	E
2N1530	G	P		6-56	LPA	90W	C	100	60	45	S	20	40	3A	1.5	3A				
2N1530A	G	P		6-56	LPA	90W	C	100	60	30	O	20	40	3A	1.5	3A			5K	E
2N1531	G	P		6-56	LPA	90W	C	100	80	60	S	20	40	3A	1.5	3A				
2N1531A	G	P		6-56	LPA	90W	C	100	80	40	O	20	40	3A	1.5	3A			5K	E
2N1532	G	P		6-56	LPA	90W	C	100	100	75	S	20	40	3A	1.5	3A				
2N1532A	G	P		6-56	LPA	90W	C	100	100	50	O	20	40	3A	1.5	3A			5K	E
2N1533	G	P		6-56	LPA	90W	C	100	120	90	S	20	40	3A	1.5	3A				
2N1534	G	P		6-56	LPA	90W	C	100	40	30	S	35	70	3A	1.2	3A				
2N1534A	G	P		6-56	LPA	90W	C	100	40	20	O	35	70	3A	1.2	3A			5K	E
2N1535	G	P		6-56	LPA	90W	C	100	60	45	S	35	70	3A	1.2	3A				
2N1535A	G	P		6-56	LPA	90W	C	100	60	30	O	35	70	3A	1.2	3A			5K	E
2N1536	G	P		6-56	LPA	90W	C	100	80	60	S	35	70	3A	1.2	3A				
2N1536A	G	P		6-56	LPA	90W	C	100	80	40	O	35	70	3A	1.2	3A			5K	E
2N1537	G	P		6-56	LPA	90W	C	100	100	75	S	35	70	3A	1.2	3A				
2N1537A	G	P		6-56	LPA	90W	C	100	100	50	O	35	70	3A	1.2	3A			5K	E
2N1538	G	P		6-56	LPA	90W	C	100	120	90	S	35	70	3A	1.2	3A				
2N1539	G	P		6-60	LPA	90W	C	100	40	30	S	50	100	3A	.3	3A				
2N1539A	G	P		6-60	LPA	90W	C	100	40	20	O	50	100	3A	.3	3A			3K	E
2N1540	G	P		6-60	LPA	90W	C	100	60	45	S	50	100	3A	.3	3A				
2N1540A	G	P		6-60	LPA	90W	C	100	60	30	O	50	100	3A	.3	3A			3K	E
2N1541	G	P		6-60	LPA	90W	C	100	80	60	S	50	100	3A	.3	3A				
2N1541A	G	P		6-60	LPA	90W	C	100	80	40	O	50	100	3A	.3	3A			3K	E
2N1542	G	P		6-60	LPA	90W	C	100	100	75	S	50	100	3A	.3	3A				
2N1542A	G	P		6-60	LPA	90W	C	100	100	50	O	50	100	3A	.3	3A			3K	E
2N1543	G	P		6-60	LPA	90W	C	100	120	90	S	50	100	3A	.3	3A				
2N1544	G	P		6-60	LPA	90W	C	100	40	30	S	75	150	3A	.2	3A			1K	E
2N1544A	G	P		6-60	LPA	90W	C	100	40	30	S	75		3A	.2	3A			3K	E
2N1545	G	P		6-60	LPA	90W	C	100	60	45	S	75	150	3A	.2	3A			1K	E
2N1545A	G	P		6-60	LPA	90W	C	100	60	45	S	75		3A	.2	3A			3K	E
2N1546	G	P		6-60	LPA	90W	C	100	80	60	S	75	150	3A	.2	3A			1K	E
2N1546A	G	P		6-60	LPA	90W	C	100	80	60	S	75		3A	.2	3A			3K	E
2N1547	G	P		6-60	LPA	90W	C	100	100	75	S	75	150	3A	.2	3A			1K	E
2N1547A	G	P		6-60	LPA	90W	C	100	100	75	S	75		3A	.2	3A			3K	E
2N1548	G	P		6-60	LPA	90W	C	100	120	90	S	75	150	3A	.2	3A			1K	E
2N1549	G	P		6-68	LPA	90W	C	100	40	30	S	10	30	10A	1	10A				
2N1549A	G	P		6-63	LPA	90W	C	100	40	30	S	10	30	10A	1	10A			5K	E
2N1550	G	P		6-83	LPA	90W	C	100	60	45	S	10	30	10A	1	10A				
2N1550A	G	P		6-63	LPA	90W	C	100	60	45	S	10	30	10A	1	10A			5K	E
2N1551	G	P		6-63	LPA	90W	C	100	80	60	S	10	30	10A	1	10A				
2N1551A	G	P		6-63	LPA	90W	C	100	80	60	S	10	30	10A	1	10A			5K	E
2N1552	G	P		6-63	LPA	90W	C	100	100	75	S	10	30	10A	1	10A				
2N1552A	G	P		6-63	LPA	90W	C	100	100	75	S	10	30	10A	1	10A			5K	E
2N1553	G	P		6-63	LPA	90W	C	100	40	30	S	30	60	10A	.5	10A			1K	E
2N1553A	G	P		6-63	LPA	90W	C	100	40	20	O	30	60	10A	.5	10A			3K	E
2N1554	G	P		6-63	LPA	90W	C	100	60	45	S	30	60	10A	.5	10A			1K	E
2N1554A	G	P		6-63	LPA	90W	C	100	60	30	O	30	60	10A	.5	10A			3K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1555	G	P		6-63	LPA	90W	C	100	80	60	S	30	60	10A	.5	10A			1K	E
2N1555A	G	P		6-63	LPA	90W	C	100	80	40	O	30	60	10A	.5	10A			3K	E
2N1556	G	P		6-63	LPA	90W	C	100	100	75	S	30	60	10A	.5	10A			1K	E
2N1556A	G	P		6-63	LPA	90W	C	100	100	50	O	30	60	10A	.5	10A			3K	E
2N1557	G	P		6-63	LPA	90W	C	100	40	30	S	50	100	10A	.4	10A			1K	E
2N1557A	G	P		6-63	LPA	90W	C	100	40	20	O	50	100	10A	.5	10A			3K	E
2N1558	G	P		6-63	LPA	90W	C	100	60	45	S	50	100	10A	.4	10A			1K	E
2N1558A	G	P		6-63	LPA	90W	C	100	60	30	O	50	100	10A	.5	10A			3K	E
2N1559	G	P		6-63	LPA	90W	C	100	80	60	S	50	100	10A	.4	10A			1K	E
2N1559A	G	P		6-63	LPA	90W	C	100	80	40	O	50	100	10A	.5	10A			3K	E
2N1560	G	P		6-63	LPA	90W	C	100	100	75	S	50	100	10A	.4	10A			1K	E
2N1560A	G	P		6-63	LPA	90W	C	100	100	50	O	50	100	10A	.5	10A			3K	E
2N1561	G	P		9-21	RFA	250M	A	100	25	15	O				3	200M				
2N1562	G	P		9-21	RFA	250M	A	100	25	15	O				4	200M				
2N1564	S	N	2N2218	8-74	AFA	600M	A	175	80	60	O	15	50	5M	1	10M	20	E		
2N1565	S	N	2N2218	8-74	AFA	600M	A	175	80	60	O	30	100	5M	1	10M	40	E		
2N1566	S	N	2N2219	8-74	AFA	600M	A	175	80	60	O	60	200	5M	1	10M	80	E		
2N1566A	S	N	2N2219	8-74	AFA	600M	A	175	80	60	O	60	200	5M	.95	10M	80	E	100M	T
2N1572	S	N			AFA	600M	A	175	125	80	O	15	50	5M	1	10M	20	E		
2N1573	S	N			AFA	600M	A	175	125	80	O	30	100	5M	1	10M	40	E		
2N1574	S	N			AFA	600M	A	175	125	80	O	60	200	5M	1	10M	80	E		
2N1585	G	N			RFA	750M	A	100	25	10	O	20		10M						
2N1586	S	N			AFA	125M	A	85	15	10	O	5	27	1M	1.5	5M	9	E	5M	B
2N1587	S	N			AFA	125M	A	85	30	20	O	5	27	1M	1.5	5M	9	E	5M	B
2N1588	S	N			AFA	125M	A	85	60	40	O	5	27	1M	1.5	5M	9	E	5M	B
2N1589	S	N			AFA	125M	A	85	15	10	O	20	75	1M	1.5	5M	25	E	5M	B
2N1590	S	N			AFA	125M	A	85	30	20	O	20	75	1M	1.5	5M	25	E	5M	B
2N1591	S	N			AFA	125M	A	85	60	40	O	20	75	1M	1.5	5M	25	E	5M	B
2N1592	S	N			AFA	125M	A	85	15	10	O	40	210	1M	1.5	5M	70	E	5M	B
2N1593	S	N			AFA	125M	A	85	30	20	O	40	210	1M	1.5	5M	70	E	5M	B
2N1594	S	N			AFA	125M	A	85	60	40	O	40	210	1M	1.5	5M	70	E	5M	B
2N1595 thru 2N1604	Thyristors, see Table on Page 1-161																			
2N1605	G	N			MSS	150M	A	100	25	24	O	40		20M	.15	12M			4M	B
2N1605A	G	N			MSS	.2W	A	100	40	40		40		20M	.15	12M			4M	B
2N1606	S	P			HSS	100M	A	140	10	10	S	6	30	15M	.15	5M			7.2M	T
2N1607	S	P			HSS	100M	A	140	10	10	S	6	30	15M	.15	5M			10M	T
2N1608	S	P			HSS	100M	A	140	10	10	S	6	30	15M	.15	5M			25M	T
2N1609	G	P	2N2140	6-74	LPA			95	80	60	O	30	75	100M	1	500M				
2N1610	G	P	2N2145	6-74	LPA			95	80	60	O	50	125	100M	.6	500M				
2N1611	G	P	2N2138	6-74	LPA			95	60	40	O	30	75	100M	1	500M				
2N1612	G	P	2N2143	6-74	LPA			95	60	40	O	50	125	100M	.6	500M				
2N1613	S	N		8-22	MSA	800M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N1613A	S	N	2N2218	8-74	MSA	1000M	A	200	75	50	R	40	120	150M	1	150M	30	E	60M	T
2N1613B	S	N			MSA	1000M	A	200	120	55	R	40	120	150M	.2	150M	30	E	60M	T
2N1614	G	P	2N1924	7-37	MSA	240M	A	100	65	40	R	18	43	20M	.13	20M			500K	B
2N1615	S	N			RFA	5.5M	A	200	100	100	O	25		5M	5	50M			2M	T
2N1616	S	N	2N3487	6-107	HPA	60W	C	175	60	60	O	15	75	2A	2	2A			3M	T
2N1616A	S	N	2N3487	6-107	LPA	85W	C	200	60	60	O	20	60	2A	1	2A			3M	T
2N1617	S	N	2N3487	6-107	HPA	60W	C	175	80	80	V	15	75	2A	2	2A			3M	T
2N1617A	S	N	2N3487	6-107	LPA	85W	C	200	80	70	O	20	60	2A	1	2A			3M	T
2N1618	S	N	2N3488	6-107	HPA	60W	C	175	100	100	V	15	75	2A	2	2A			3M	T
2N1618A	S	N	2N3488	6-107	LPA	85W	C	200	100	80	O	20	60	2A	1	2A			3M	T
2N1620	S	N	2N3446	6-103	HPA	60W	C	175	100	100	V	15	75	2A	2	2A			3M	T
2N1622	G	N			AFA	.12W	A	85	90	90	S	40		5M		5M				
2N1623	S	P			AFA	250M	A	160	50	20	O	9	40	1M	.3	5M			100K	B
2N1624	G	N			MSS	.15W	A	100	25	20	R	60	180	30M					5M	B
2N1631	G	P	2N3325	9-66	RFC	80M	A	85	34								40	E		
2N1632	G	P	2N3325	9-66	RFC	80M	A	85	34								40	E		
2N1633	G	P			RFC	80M	A	85	34								27	E		
2N1634	G	P			RFC	80M	A	85	34								27	E		
2N1635	G	P			RFC	80M	A	85	34								40	E		
2N1636	G	P			RFC	80M	A	85	34								40	E		
2N1637	G	P	2N3325	9-66	RFC	80M	A	85	34								40	E		
2N1638	G	P	2N3325	9-66	RFC	80M	A	85	34								70	E		
2N1639	G	P	2N3325	9-66	RFC	80M	A	85	34								40	E		

2N1640—2N1711B

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units	Subscript
2N1640	S	P			CHP	250M	A	160	30	20	U	6		100*						
2N1641	S	P			CHP	250M	A	160	30	10	U	10		100*						
2N1642	S	P			CHP	250M	A	160	30	6	U	15		100*						
2N1643	S	P			AFA	250M	A	160	25	25	U	10	25	100*						
2N1644	S	N	2N2218	8-74	MSA	2000M	C	175	60	40	R	40	120	150M	1.5	150M			50M	T
2N1645	G	P			HPA	1W	A	100	35	20	O	20		.2A	4	.2A	25	E	450M	T
2N1646	G	N			HSS	150M	A	100	15	12	S	20		10M						
2N1647	S	N			HPA	.267W	C	175	80	80	V	15	45	.5A	3	1A			3M	T
2N1648	S	N			HPA	.267W	C	175	120	80	O	15	45	.5A	3	1A			2M	T
2N1649	S	N			HPA	.267W	C	175	80	80	V	30	90	.5A	3	1A			3M	T
2N1650	S	N			HPA	.267W	C	175	120	80	O	30		.5A	3	1A			2M	T
2N1651	G	P	2N2832	6-87	LPA	100W	C	110	60	60	S	35	140	10A	.65	25A	20	E		
2N1652	G	P	2N2833	6-87	LPA	100W	C	110	100	100	S	35	140	10A	.65	25A	20	E		
2N1653	G	P	2N2834	6-87	LPA	100W	C	110	120	120	S	35	140	10A	.65	25A	20	E		
2N1654	S	N			LPA	250M	A	160	100	80	O	20	45	1M	.3	5M			100K	B
2N1655	S	N			LPA	250M	A	160	125	100	O	10	22	1M	.3	5M			100K	B
2N1656	S	N			LPA	250M	A	160	125	100	O	20	45	1M	.3	5M			100K	B
2N1657	S	N			LPA		C	200	60	60	S	7.5	30	.85A	4.5	.85A			2M	B
2N1660	S	N			LPA	85W	C	200	60	60	R	45	135	1A	4	1A			25M	T
2N1661	S	N			LPA	85W	C	200	80	80	R	45	135	1A	4	1A			25M	T
2N1662	S	N			LPA	85W	C	200	100	100	R	45	135	1A	4	1A			25M	T
2N1663	S	N			HSS	150M	A	150	20	15	O	30	150	20M	.25	10M			100M	T
2N1664	G	P			AFA	.2W	A	100	45	40	R	45	120	10M	.5	.1A	50	E	.1M	B
2N1665	G	P			RFA	150M	A	85	15	12	O	5	100	10M					300M	T
2N1666	G	P	2N3616	6-113	PMS	30W	C	90	80	60	V	15	30	6A	.5	6A			2K	E
2N1667	G	P	2N3618	6-113	PMS	30W	C	90	60	48	X	35	80	6A	.5	6A			2K	E
2N1668	G	P	2N3616	6-113	PMS	30W	C	90	60	48	X	20	45	6A	.5	6A			2K	E
2N1669	G	P	2N3616	6-113	PMS	30W	C	90	80	60	X	20	65	6A	.5	6A			2K	E
2N1670	G	P			MSS	.12W	A	85	100			15		10M						
2N1671	Unijunction Transistor, see Table on Page 1-177																			
2N1672	G	N			SPP	120M	A	85	40	40	X	20		1M			15	E	2M	B
2N1672A	G	N			SPP	120M	A	85	40	40	X	20		1M			15	E	2M	B
2N1673	G	P			RFA	80M	A	85	35								20	E		
2N1674	S	N			AFA	.2W	A	200	45	45	O				1.5	5M	50	E	20M	T
2N1675	S	N			PHS	50W	C	150	100	100	S	25	100	1A	2.5	5A			120M	T
2N1676	S	P			CHP	100M	A	140	4.5	4.5	U				.1	5M			16M	T
2N1677	S	P			CHP	100M	A	140	4.5	4.5	U				.1	5M	25	E	16M	T
2N1678	G	P			MSS	120M	A	85	60	60	S	25		20M		20M			25M	B
2N1679	S	N			MSA	1W	A	175	100	55	O	40	120	600M	3.6	600M			50M	T
2N1680	S	N			MSA	1W	A	175	60	35	O	40	120	600M	3.6	600M			50M	T
2N1681	G	P			MSS	.18W	C	100	30	15	O	30	120	10M	.1	10M			5M	B
2N1682	S	N			MSA	500M	A	175	25	20	R	20		10M	.6	10M			200M	T
2N1683	G	P			HSS	150M	A	85	13	12	O	50		40M	12	1A			50M	T
2N1684	G	P			MSS	100M	A	100	25	25	X				.15	12M			4M	B
2N1685	G	P			MSS	100M	A	100	25	20	R	60	180	30M		100M			8M	B
2N1686 thru 2N1689	Thyristors, see Table on Page 1-161																			
2N1690	S	N			LPA	40W	C	200	80	80	O	20	60	500M	7.5	500M			90K	E
2N1691	S	N			LPA	40W	C	200	120	120	O	20	60	500M	7.5	500M			90K	E
2N1692	G	P		9-21	RFA	350M	A	100	25	15	O				5	200M				
2N1693	G	P		9-21	RFA	350M	A	100	25	25	S				4	200M				
2N1694	G	N			MSA	75M	A	85	20	20	O	17	50	1M					3M	B
2N1699	G	P			RFA	100M	A	100	40	-40	X	20	175	1.5M			20	E		
2N1700	S	N	2N2218	8-74	MSS	5W	C	200	60	60	V	20	80	100M	12.5	2.5A			.4M	B
2N1701	S	N	2N2218	8-74	MSS	25W	C	200	60	60	V	20	80	300M	20	5A			.35M	B
2N1702	S	N	2N2218	8-74	MSS	75W	C	200	60	60	V	15	60	800M	20	5A			.3M	B
2N1703	S	N	2N2218	8-74	MSS	75W	C	200	60	60	V	15	60	800M		10M			.3M	B
2N1704	S	N	2N2218	8-74	MSA	3.3M	J	175	45	45	O	50	200	1M	1	10M	40	E	5M	B
2N1705	G	P		7-35	AFC	.2W	A	100	18	12	R						70	E		
2N1706	G	P		7-35	AFC	.2W	A	100	25	18	R	60	120	20M			50	E		
2N1707	G	P		7-35	AFC	.2W	A	100	30	25	R	30	150	10M			40	E		
2N1708A	S	N			HSS	300M	A	175	40	20	R	30	120	10M	.22	10M		E	300M	T
2N1709	S	N			HPA	15W	C	175	75	30	O	7.5	75	.35A	5	1A			175M	T
2N1710	S	N			HPA	15W	C	175	60	30	O	4	100	.35A	5	1A			140M	T
2N1711	S	N		8-22	MSA	800M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M	T
2N1711A	S	N	2N2219A	8-80	RFA	1000M	A	200	75	50	R	100	300	150M	1	150M	50	E	70M	T
2N1711B	S	N	2N2219A	8-80	RFA	1000M	A	200	120	55	R	100	300	150M	.2	150M	50	E	70M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N1713	G	P			AFC	80M	A	85	30	12	0	20		1.5M			40	E	100M	B
2N1714	S	N			LPA	20W	C	175	90	60	0	20	60	200M	2	200M			16M	T
2N1715	S	N			LPA	20W	C	175	150	100	0	20	60	200M	2	200M			16M	T
2N1716	S	N			LPA	20W	C	175	90	60	0	40	120	200M	2	200M			16M	T
2N1717	S	N			LPA	20W	C	175	150	100	0	40	120	200M	2	200M			16M	T
2N1718	S	N			LPA	20W	C	175	90	60	0	20	60	200M	2	200M			16M	T
2N1719	S	N			LPA	20W	C	175	150	100	0	20	60	200M	2	200M			16M	T
2N1720	S	N			LPA	20W	C	175	90	60	0	40	120	200M	2	200M			16M	T
2N1721	S	N			LPA	20W	C	175	150	100	0	40	120	200M	2	200M			16M	T
2N1722	S	N	2N3446	6-103	LPA	30W	C	175	120	80	0	20	90	2A	1	2A			10M	T
2N1722A	S	N			LPA	50W	C	175	180	120	0	30	90	2A	.6	2A			10M	T
2N1723	S	N	2N3448	6-103	LPA	50W	C	175	120	80	0	50	150	2A	1	2A			10M	T
2N1724	S	N		6-67	LPA	50W	C	175	120	80	0	20	90	2A	1	2A			10M	T
2N1724A	S	N			LPA	50W	C	175	180	120	0	30	90	2A	.6	2A			10M	T
2N1725	S	N		6-67	LPA	50W	C	175	120	80	0	50	150	2A	1	2A			10M	T
2N1726	G	P	2N3323	9-66	RFC	60M	A	100	20	20	S	50		1M					100M	M
2N1727	G	P	2N3324	9-66	RFC	60M	A	100	20	20	S	20		1M					100M	M
2N1728	G	P	2N3324	9-66	RFC	60M	A	100	20	20	S	20		1M					100M	M
2N1729	G	P			MSS	150M	A	85	25	15	X	30		100M	.35	200M				
2N1730	G	N			MSS	150M	A	85	20	15	X	30		100M	.35	200M				
2N1731	G	P			AFA	150M	A	85	30	30	X	40		10M					5M	B
2N1732	G	N			AFA	150M	A	85	30	30	X	40		10M					5M	B
2N1742	G	P	2N3283	9-44	RFC	60M	A	125	20	20	S	10		2M						
2N1743	G	P	2N3284	9-44	RFC	60M	A	125	20	20	S	10		2M						
2N1744	G	P	2N3284	9-44	RFC	60M	A	125	20	20	S	10		2M						
2N1745	G	P	2N3285	9-44	RFC	60M	A	100	20	20	S	10		2M						
2N1746	G	P	2N3323	9-66	RFC	60M	A	100	20	20	S	10		1M					100M	M
2N1747	G	P	2N3324	9-66	RFC	60M	A	100	20	20	S	10		1M						
2N1748	G	P	2N3324	9-66	VAC	60M	A	100	25	25	S						30	E	80M	T
2N1748A	G	P	2N3323	9-66	VAC	60M	A	100	25	25	S						50	E	100M	T
2N1749	G	P	2N3323	9-66	VAC	75M	A	100	40	40	S						30	E	80M	T
2N1750	G	P			AFC	15M	A	75	14	6	S	18	40	500*					30M	M
2N1751	G	P	2N2832	6-87	LPA			110	80	80	S	30	90	20A	.5	20A	20	E	1.5M	B
2N1752	G	P	2N3325	9-66	AFC	60M	A	100	12	12	S						50	E	50M	M
2N1753	G	P			RFA	30M	A	85	30	18	D	50	220	100*						
2N1754	G	P	2N964	8-48	HSS	50M	A	85	13	13	S	20		10M	.2	10M				
2N1755	G	P	2N2137	6-74	PMS	28W	C	95	40	35	S	30	75	.5A	.7	3A			15K	E
2N1756	G	P	2N2138	6-74	PMS	28W	C	95	60	50	S	30	75	.5A	.7	3A				
2N1757	G	P	2N2139	6-74	PMS	28W	C	95	80	65	S	30	75	.5A	.7	3A			15K	E
2N1758	G	P	2N2140	6-74	PMS	28W	C	95	100	75	S	30	75	.5A	.7	3A			15K	E
2N1759	G	P	2N2142	6-74	PMS	28W	C	95	40	35	S	60	150	.5A	.5	3A			15K	E
2N1760	G	P	2N2143	6-74	PMS	28W	C	95	60	50	S	60	150	.5A	.5	3A			15K	E
2N1761	G	P	2N2144	6-74	PMS	28W	C	95	80	65	S	60	150	.5A	.5	3A			15K	E
2N1762	G	P	2N2145	6-74	PMS	28W	C	95	100	75	S	60	150	.5A	.5	3A			15K	E
2N1763	S	N			MSS	.3W	A	175	40	25	0				1.5	10M				
2N1764	S	N			MSS	.3W	A	175	20	15	0				1.5	10M				
2N1765	Thyristor, see Table on Page 1-161																			
2N1768	S	N	2N3713	6-117	MSS	40W	C	200	60	40	0	35	100	750M	.75	750M			600K	B
2N1769	S	N	2N3713	6-117	MSS	40W	C	200	100	55	0	35	100	750M	.75	750M			600K	B
2N1770 thru 2N1778	Thyristors, see Table on Page 1-161																			
2N1779	G	P			MSS	100M	A	100	25	20	R	20	60	30M						
2N1780	S	P			MSS	100M	A	100	25	25	R	30	110	30M					4M	B
2N1781	G	P			MSS	100M	A	100	25	25	X	40		20M	.15	12M			4M	B
2N1782	G	P			MSS	100M	A	100	30	20	X	30	150	10M	.20	50M			5M	B
2N1783	G	P			MSS	100M	A	100	30	15	0	20		10M	.32	200M	30	E	5M	B
2N1784	G	P			MSS	100M	A	100	30	20	0	20		10M	.32	200M			10M	B
2N1785	G	P	2N3324	9-66	RFC	45M	A	85	10	10	S	40		1M					50M	M
2N1786	G	P	2N3323	9-66	RFC	45M	A	85	10	10	S	15		1M					50M	M
2N1787	G	P	2N3324	9-66	RFC	45M	A	85	15	15	S	25		1M					50M	M
2N1788	G	P	2N3324	9-66	RFC	50M	A	100	35	35	S	50		1M					100M	M
2N1789	G	P	2N3325	9-66	RFC	60M	A	100	35	35	S	20		1M					100M	M
2N1790	G	P	2N3323	9-66	RFC	60M	A	100	35	35	S	40		1M					100M	M
2N1792 thru 2N1807	Thyristors, see Table on Page 1-161																			

2N1808—2N1916

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1808	G	N			MSA	150M	A	85	25						.15	12M			4M	B
2N1809	S	N			PMS	250W	C	175	50	50	V	10		10A	1.5	10A				
2N1810	S	N			PMS	250W	C	175	100	100	V	10		10A	1.5	10A				
2N1811	S	N			PMS	250W	C	175	150	150	V	10		10A	1.5	10A				
2N1812	S	N			PMS	250W	C	175	200	200	V	10		10A	1.5	10A				
2N1813	S	N			PMS	250W	C	175	250	250	V	10		10A	1.5	10A				
2N1814	S	N			PMS	250W	C	175	300	300	V	10		10A	1.5	10A				
2N1816	S	N			PMS	250W	C	175	50	50	V	10		15A	1.5	15A				
2N1817	S	N			PMS	250W	C	175	100	100	V	10		15A	1.5	15A				
2N1818	S	N			PMS	250W	C	175	150	150	V	10		15A	1.5	15A				
2N1819	S	N			PMS	250W	C	175	200	200	V	10		15A	1.5	15A				
2N1820	S	N			PMS	250W	C	175	250	250	V	10		15A	1.5	15A				
2N1821	S	N			PMS	250W	C	175	300	300	V	10		15A	1.5	15A				
2N1823	S	N			PMS	250W	C	175	50	50	V	10		20A	1.5	20A				
2N1824	S	N			PMS	250W	C	175	100	100	V	10		20A	1.5	20A				
2N1825	S	N			PMS	250W	C	175	150	150	V	10		20A	1.5	20A				
2N1826	S	N			PMS	250W	C	175	200	200	V	10		20A	1.5	20A				
2N1827	S	N			PMS	250W	C	175	250	250	V	10		20A	1.5	20A				
2N1828	S	N			PMS	250W	C	175	300	300	V	10		20A	1.5	20A				
2N1830	S	N			PMS	250W	C	175	50	50	V	10		25A	1.5	25A				
2N1831	S	N			PMS	250W	C	175	100	100	V	10		25A	1.5	25A				
2N1832	S	N			PMS	250W	C	175	150	150	V	10		25A	1.5	25A				
2N1833	S	N			PMS	250W	C	175	200	200	V	10		25A	1.5	25A				
2N1834	S	N			PMS	250W	C	175	250	250	V	10		25A	1.5	25A				
2N1835	S	N			PMS	250W	C	175	300	300	V	10		25A	1.5	25A				
2N1837	S	N	2N2218	8-74	HSS	800M	A	300	80	30	O	40	120	150M	.8	150M			140M	T
2N1837A	S	N	2N2218	8-74	HSS	.8W	A	175	80	30	O	40	120	.15A	.8	.15A			140M	T
2N1837B	S	N			HSS	.8W	A	200	80	30	O	40	120	.15A	.8	.15A			140M	T
2N1838	S	N	2N2218	8-74	HSS	.6W	A	175	45	20	O	40	150	.1A	1.4	.1A			90M	T
2N1839	S	N	2N2218	8-74	HSS	.6W	A	175	45	20	O	12	50	.1A	1.4	.15A			90M	T
2N1840	S	N	2N2218	8-74	HSS	.6W	A	175	25	15	O	10	100	.15A	1.4	.15A			90M	T
2N1841	S	N			HPA	2W	A	150	100	50	O	15	50	15M	1	1A			60M	E
2N1842 thru 2N1850	Thyristors, see Table on Page 1-161																			
2N1853	G	P			HSS	150M	A	85	18	6	O	30		6M	.2	6M				
2N1854	G	P			HSS	150M	A	85	18	6	O	40		20M	.2	20M			40M	T
2N1864	G	P	2N3324	9-66	RFC	60M	A	100	20	20	S	10		1M			20	E	50M	M
2N1865	G	P	2N3325	9-66	RFC	60M	A	100	20	20	S	40		1M						
2N1866	G	P	2N3323	9-66	RFC	60M	A	100	35	35	S	40		1M						
2N1867	G	P	2N3324	9-66	RFC	60M	A	100	35	35	S	10		1M						
2N1868	G	P	2N3325	9-66	RFC	60M	A	100	20	20	S	10		2M						
2N1869 thru 2N1885	Thyristors, see Table on Page 1-161																			
2N1886	S	N			HPA	20W	C	175	60	60	O	20	80	.5A	5	1A			2M	T
2N1889	S	N	2N3498	8-161	RFA	800M	A	200	100	80	R	40	120	150M	5	150M	30	E	50M	T
2N1890	S	N	2N3499	8-161	RFA	800M	A	200	100	80	R	100	300	150M	5	150M	50	E	60M	T
2N1891	G	N			BMS	150M	A	85	25	15	O	25		100M	.15	100M			5M	B
2N1892	G	P			MSS	150M	A	85	30	15	O	40	200	10M	.2	10M	30	E	5M	B
2N1893	S	N		8-70	RFA	800M	A	200	120	100	R	40	120	150M	5	150M	30	E	50M	T
2N1893A	S	N	2N3498	8-161	HPA	.8W	A	200	140	80	O	40	120	.15A	2	.15A	30	E	100M	T
2N1894	S	N			LPA			200	60	60	R	12	60	1A	5	1A				
2N1895	S	N			LPA			200	80	80	R	12	60	1A	10	1A				
2N1896	S	N			LPA			200	60	60	R	45	135	1A	4	1A			25M	T
2N1897	S	N			LPA			200	80	80	R	45	135	1A	4	1A			25M	T
2N1898	S	N			LPA			200	100	100	R	45	135	1A	4	1A			25M	T
2N1899	S	N			PHS	125W	C	150	140	50	O	10	30	10A	1	10A			50M	T
2N1900	S	N			HPA	125W	C	150	140	50	O	8		10A	2	10A			50M	T
2N1901	S	N			PHS	125W	C	150	140	50	O	20	60	10A	1	10A			50M	T
2N1902	S	N			PHS	125W	C	150	140	50	O	10	30	10A	1	10A			50M	T
2N1903	S	N			HPA	125W	C	150	140	50	O	8		10A	2	10A			50M	T
2N1904	S	N			PHS	125W	C	150	140	50	O	20	60	10A	1	10A			50M	T
2N1905	G	P	2N2832	6-87	LPA	30W	C	100	100	50	O	50	150	1A	1	5A	30	E		
2N1906	G	P	2N2832	6-87	LPA	30W	C	100	130	60	O	75	250	1A	5	5A	50	E		
2N1907	G	P	2N2832	6-87	HPA	60W	C	100	100	40	O				1	15A			10M	T
2N1908	G	P	2N2833	6-87	HPA	60W	C	100	130	50	O				1	15A			10M	T
2N1909 thru 2N1916	Thyristors, see Table on Page 1-161																			

2N1917—2N1995

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units Subscript
2N1917	S	P			CHP	.25W	A	175	25	8	O						25	E	16M	T
2N1918	S	P			CHP	.25W	A	175	25	8	O						25	E	10M	T
2N1919	S	P			CHP	.25W	A	175	40	18	O				.003				1M	B
2N1920	S	P			CHP	.25W	A	175	40	18	O				.004				1M	B
2N1921	S	P			CHP	.25W	A	175	50	50	O				.005				1M	B
2N1922	S	P			CHP	.25W	A	175	80	80	O				.005				1M	B
2N1923	S	N			AFA	750M	A	150	85	85	O	4	90		7	20M	28	E		
2N1924	G	P		7-37	AFA	225M	A	100	60	40	R	34	65	20M	.11	20M	30	E	1M	B
2N1925	G	P		7-37	AFA	225M	A	100	60	40	R	53	90	20M	.11	20M	44	E	1.3M	B
2N1926	G	P		7-37	AFA	225M	A	100	60	40	R	72	121	20M	.11	20M	60	E	1.5M	B
2N1929 thru 2N1935	Thyristors, see Table on Page 1-161																			
2N1936	S	N			LPA	150W	C	175	125	60	O	7	50	10A	.75	10A	15	E	4M	T
2N1937	S	N			LPA	150W	C	175	125	80	O	7	50	10A	.75	10A	15	E	4M	T
2N1940	G	P			HPA	3.5W	C	100	30	15	O	5		40M	1.8	200M				
2N1941	S	N			AFA	.6W	A	175	45	30	R	30	150	10M	1.5	5M	40	E	60M	T
2N1942	G	P			MSS	.2W	A	85	20	10	O	20	60	.2A					5M	B
2N1943	S	N			AFA	800M	A	200	60	60	O	30	90	200M	5	200M	12	E		
2N1944	S	N			MSS	.6W	A	175	20	20	R	150	450	1M			100	E	60M	T
2N1945	S	N			MSS	.6W	A	175	30	30	R	150	450	1M			100	E	60M	T
2N1946	S	N			MSS	.6W	A	175	40	40	R	150	450	1M			100	E	60M	T
2N1947	S	N			MSS	.6W	A	175	20	20	R	500	800	.1A			100	E	60M	T
2N1948	S	N			MSS	.6W	A	175	30	30	R	500	800	.1A			100	E	60M	T
2N1949	S	N			MSS	.6W	A	175	40	40	R	500	800	.1A			100	E	60M	T
2N1950	S	N			MSS	.6W	A	175	20	20	R	250	500	.1A			75	E	60M	T
2N1951	S	N			MSS	.6W	A	175	30	30	R	250	500	.1A			75	E	60M	T
2N1952	S	N			MSS	.6W	A	175	40	40	R	250	500	.1A			75	E	60M	T
2N1953	S	N			AFA	.6W	A	175	20	20	S	15	150	10M			28	E	40M	T
2N1954	G	P	2N651	7-20	MSS	200M	A	100	60	20	O	30	120	20M	.3	20M				
2N1955	G	P	2N1190	7-28	MSS	200M	A	100	60	18	O	50	200	20M	.175	20M				
2N1956	G	P	2N651	7-20	MSS	200M	A	100	60	16	O	30	120	20M	.175	20M				
2N1957	G	P	2N1187	7-28	MSS	200M	A	100	60	14	O	30	120	20M	.175	20M				
2N1958	S	N	2N2537	8-107	HSS	600M	A	175	60	40	R	20	60	150M	.45	150M			100M	T
2N1958A	S	N	2N2537	8-107	HSS	600M	A	175	60	40	R	20	60	150M	.45	150M			100M	T
2N1959	S	N	2N2537	8-107	HSS	600M	A	175	60	40	R	40	120	150M	.45	150M	1	E		
2N1959A	S	N	2N2537	8-107	HSS	600M	A	175	60	40	R	40	120	150M	.45	150M			100M	T
2N1960	G	P			HSS	150M	A	100	15	15		25		10M	.16	10M				
2N1961	G	P			HSS	150M	A	100	12	12	S	20		10M	.20	10M				
2N1962	S	N	2N834	8-35	HSS	400M	A	175	40	20	R	20	60	10M	.25	10M			200M	T
2N1963	S	N	2N834	8-35	HSS	400M	A	175	30	15	R	25		10M	.16	10M			200M	T
2N1964	S	N	2N2539	8-107	HSS	400M	A	175	60	40	R	20	60	150M	.45	150M			100M	T
2N1965	S	N	2N2539	8-107	HSS	.4W	A	175	60	40	R	40	120	.15A	.45	.15A			100M	T
2N1966	G	P			SPP	.12W	A	75	35	15	R									
2N1967	G	P			SPP	.12W	A	75	35	15	R									
2N1968	G	P			SFP	.12W	A	75	35	18	R									
2N1969	G	P			MSS	150M	A	85	30	15	O	50	200	200*					10M	8
2N1970	G	P		6-70	LPA	150W	C	100	100	50	8	17	40	5A	1	12A			5K	E
2N1971	G	P	2N2140	6-74	LPA			100	80	40	O	25	60	.5A	.9	3A			15K	E
2N1972	S	N	2N2219	8-74	RFA	600M	A	175	60	30	R	110	350	50M	2	50M	40	E	50M	T
2N1973	S	N	2N2219	8-74	AFA	800M	A	200	100	80	R	75		10M	1.2	50M	76	E	60M	T
2N1974	S	N	2N3498	8-161	AFA	800M	A	200	100	80	R	35		10M	1.2	50M	36	E	50M	T
2N1975	S	N	2N3498	8-161	AFA	800M	A	200	100	80	R	15		10M	1.2	50M	18	E	40M	T
2N1978	S	N			HPA	30W	C	200	60	40	R	20		500M	1.5	1A			40M	T
2N1980	G	P		6-70	LPA	170W	C	100	50	30	O	50	100	5A	.5	5A			3K	E
2N1981	G	P		6-70	LPA	170W	C	100	70	40	O	50	100	5A	.5	5A			3K	E
2N1982	G	P		6-70	LPA	170W	C	100	90	50	O	50	100	5A	.5	5A			3K	E
2N1983	S	N	2N2218	8-74	AFA	600M	A	150	50	25	O						70	E	40M	T
2N1984	S	N	2N2218	8-74	AFA	600M	A	150	50	25	O						35	E	40M	T
2N1985	S	N	2N2218	8-74	AFA	600M	A	150	50	25	O						15	E	40M	T
2N1986	S	N	2N2218	8-74	RFA	600M	A	150	50	25	O	60	240	150M	1.5	150M			40M	T
2N1987	S	N	2N2218	8-74	RFA	600M	A	150	50	25	O	20	80	150M	1.5	150M			40M	T
2N1988	S	N	2N2218A	8-80	VID	600M	A	150	100	45	O	35	120	30M	2	30M	20	E	40M	T
2N1989	S	N	2N2218A	8-80	VIO	600M	A	150	100	45	O	20	60	30M	2	30M	10	E	40M	T
2N1990	S	N			IND	600M	A	150	100			20		30M	.5	2M				
2N1991	S	P		8-64	RFA	600M	A	150	30	20	O	15	60	150M	1.5	150M			40M	T
2N1992	S	N			HSS	.35W	A	200	15	15	O	30	120	1M	.25	10M			300M	T
2N1993	G	N			MSS	150M	A	100	30	18	O	50	300	10M	0.2	10M			3M	B
2N1994	G	N			MSS	150M	A	85	30	15	O	15		10M	.25	200M			3M	B
2N1995	G	N			MSS	150M	A	85	25	15	O	25		10M	.25	200M			5M	B

2N1996 — 2N2076

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_O @25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N1996	G	N			MSS	150M	A	85	20	15	0	35		10M	.25	200M			8M	B
2N1997	G	P			MSS	250M	A	100	45	15	0	40	200	100M	.2	10M			3M	B
2N1998	G	P			MSS	250M	A	100	35	15	0	70	225	100M	.2	10M			5.6M	T
2N1999	G	P			MSS	250M	A	100	30	15	0	100	350	100M	.2	10M			10M	T
2N2000	G	P			MSS	300M	A	100	50	15	0	50	300	100M	.35	500M			2M	B
2N2001	G	P			MSS	300M	A	100	30	15	0	100		100M	.2	100M			6M	B
2N2002	S	P			CHP	.25W	A	200	30	5	0									
2N2003	S	P			CHP	.25W	A	200	30	5	0									
2N2004	S	P			CHP	.25W	A	175	50	15	0	12		1M			15	E	.5M	B
2N2005	S	P			CHP	.25W	A	200	50	15	0									
2N2006	S	P			CHP	.25W	A	200	60	35	0									
2N2007	S	P			CHP	.25W	A	200	60	35	0									
2N2008	S	N	2N3500	8-161	AFA	800M	A	200	175	110	0	30	90	10M	2.5	25M	20	E	40M	T
2N2009 thru 2N2014	Thyristors, see Table on Page 1-161																			
2N2015	S	N	2N3715	6-117	AFA	150W	C	200	100	50	0	15	50	5A	1.25	5A	12	E	12K	E
2N2016	S	N	2N3715	6-117	AFA	150W	C	200	130	65	0	15	50	5A	1.25	5A	12	E	12K	E
2N2017	S	N			AFA	1W	A	200	60	60	0	50	200	200M			30	E		
2N2018	S	N	2N3738	6-125	HPA	20W	C	175	150	150	V	20	60	.5A	6	1A			2M	T
2N2019	S	N	2N3738	6-125	HPA	20W	C	175	200	200	V	20	60	.5A	6	1A			2M	T
2N2020	S	N	2N3738	6-125	HPA	20W	C	175	150	125	0	40	90	.5A	6	1A			3M	T
2N2021	S	N	2N3738	6-125	HPA	20W	C	175	200	140	0	40	90	.5A	6	1A			3M	T
2N2022	G	P			HSS	.15W	A	100	15	12	S	25	150	10M	1.2	50M			250M	T
2N2023 thru 2N2031	Thyristors, see Table on Page 1-161																			
2N2032	S	N	2N3713	6-117	HPA	45W	C	200	45	45	0	20		2A	5	2A			3M	T
2N2033	S	N			PMS	5W	C	200	80	60	0	20	60	500M	.4	500M			1M	T
2N2034	S	N			PMS	14W	C	200	80	60	0	20	60	1A	.3	1A			1M	T
2N2035	S	N			PMS	17W	C	200	80	60	0	20	60	1.5A	.45	1.5A			1M	T
2N2036	S	N			PMS	17.5W	C	200	80	60	0	20	60	2A	1	2A			1M	T
2N2038	S	N			RFA	.6W	A	200	45	45	0	12	36	.2A	6	.2A			2M	T
2N2039	S	N			RFA	.6W	A	200	75	75	0	12	36	.2A	6	.2A			2M	T
2N2040	S	N			RFA	.6W	A	200	45	45	0	30	90	.2A	6	.2A			2M	T
2N2041	S	N			RFA	.6W	A	200	75	75	0	30	90	.2A	6	.2A			2M	T
2N2042A	G	P		7-39	AFA	200M	A	100	105	105	S	20	50	5M	.75	100M	20	E	.5M	B
2N2043A	G	P		7-39	AFA	200M	A	100	105	105	S	40	100	5M	.75	100M	45	E	.75M	B
2N2044 thru 2N2047	Thyristors, see Table on Page 1-161																			
2N2048	G	P	2N2955	8-119	HSS	150M	A	100	20	15	0	50	300	10M	.14	10M			150M	T
2N2048A	G	P			HSS	150M	A	100	30	20	0	50	300	10M	.14	10M			7.5K	E
2N2049	S	N	2N2219A	8-74	LNA	800M	A	200	75	50	R	100	300	150M	.4	10M	75	E	50M	T
2N2059	G	P			MSS	60M	A	100	10	8	S	20		10M	.2	10M			50M	T
2N2060	S	N		11-4	DFA	500M	A	200	100	80	R	50	150	10M	1.2	50M	50	E	60M	T
2N2060A	S	N		11-4	DFA	.5W	A	200	100	60	0	50	150	10M	.6	50M	50	E	60M	T
2N2061	G	P	2N3611	6-110	SAC	40W	C	85	20	10	0	10	60	.5A	2	.5A			2K	E
2N2061A	G	P			PMS	90W	C	100	20	15	0	20	60	2A	1	5A			5K	E
2N2062	G	P	2N3611	6-110	SAC	40W	C	85	20	10	0	20	200	2A	1	2A			2K	E
2N2062A	G	P			PMS	90W	C	100	20	15	0	50	140	2A	.7	5A			1K	E
2N2063	G	P	2N3611	6-110	SAC	35W	C	95	40	15	0	10	200	2A	2	2A			2K	E
2N2063A	G	P			PMS	90W	C	100	40	20	0	20	60	2A	1	5A			5K	E
2N2064	G	P	2N3611	6-110	SAC	35W	C	95	40	15	0	20	200	2A	1	2A			2K	E
2N2064A	G	P			PMS	90W	C	100	40	20	0	50	140	2A	.7	5A			1K	E
2N2065	G	P	2N3615	6-113	SAC	35W	C	95	80	25	0	10	200	2A	2	2A			2K	E
2N2065A	G	P			PMS	90W	C	100	80	40	0	20	60	2A	1	5A			5K	E
2N2066	G	P	2N3615	6-113	SAC	35W	C	95	80	25	0	20	200	2A	1	2A			2K	E
2N2066A	G	P			PMS	90W	C	100	80	40	0	50	140	2A	.7	5A			1K	E
2N2067	G	P	2N1536	6-56	SAC	28W	C	95	40	25	0	20	100	.5A	.7	1A			7K	E
2N2068	G	P	2N1531	6-56	SAC	28W	C	95	80	55	0	20	100	.5A	.7	1A			7K	E
2N2069	G	P	2N1539	6-56	SAC	70W	C	95	40	30	S	30	200	5A	1.5	12A			1.5K	E
2N2070	G	P	2N1541	6-56	SAC	70W	C	95	80	60	S	30	200	5A	1.5	12A			1.5K	E
2N2071	G	P			SAC	70W	C	95	40	30	S	30	200	5A	1.5	12A			1.5K	E
2N2072	G	P			SAC	70W	C	95	80	60	S	30	200	5A	1.5	12A			1.5K	E
2N2074	Thyristor, see Table on Page 1-161																			
2N2075	G	P		6-71	LPA	170W	C	110	80	80	S	20	40	5A	.7	12A			5K	E
2N2075A	G	P		6-71	LPA	170W	C	110	80	80	S	20	40	5A	.7	12A			5K	E
2N2076	G	P		6-71	LPA	170W	C	110	70	70	S	20	40	5A	.7	12A			5K	E

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N2076A	G	P		6-71	LPA	170W	C	110	70	70	S	20	40	5A	.7	12A			5K	E
2N2077	G	P		6-71	LPA	170W	C	110	50	50	S	20	40	5A	.9	12A			5K	E
2N2077A	G	P		6-71	LPA	170W	C	110	50	50	S	20	40	5A	.9	12A			5K	E
2N2078	G	P		6-71	LPA	170W	C	110	40	40	S	20	40	5A	.9	12A			5K	E
2N2078A	G	P		6-71	LPA	170W	C	110	40	40	S	20	40	5A	.9	12A			5K	E
2N2079	G	P		6-71	LPA	170W	C	110	80	80	S	35	70	5A	.7	12A			5K	E
2N2079A	G	P		6-71	LPA	170W	C	110	80	80	S	35	70	5A	.7	12A			5K	E
2N2080	G	P		6-71	LPA	170W	C	110	70	70	S	35	70	5A	.7	12A			5K	E
2N2080A	G	P		6-71	LPA	170W	C	110	70	70	S	35	70	5A	.7	12A			5K	E
2N2081	G	P		6-71	LPA	170W	C	110	50	50	S	35	70	5A	.9	12A			5K	E
2N2081A	G	P		6-71	LPA	170W	C	110	50	50	S	35	70	5A	.9	12A			5K	E
2N2082	G	P		6-71	LPA	170W	C	110	40	40	S	35	70	5A	.9	12A			5K	E
2N2082A	G	P		6-71	LPA	170W		110	40	40	S	35	70	5A	.9	12A			5K	E
2N2083	G	P			AFC	60M	A	85	30			25		1M					30M	T
2N2084	G	P			RFA	125M	A	100	40	20	0	40	250	1M			40	E		
2N2085	G	N			AFA	150M	A	100	33	23	X	50	300	10M		10M	20	E	6M	B
2N2086	S	N			HSS	600M	A	175	120	80	R	20		150M	.7	150M			150M	T
2N2087	S	N			HSS	600M	A	175	120	80	R	40	120	150M	.5	150M			150M	T
2N2089	G	P			RFC	.1W	A	85	20	20	R	40		1M			40	E	44M	T
2N2090	G	P			RFC	.1W	A	85	20	20	R	40		1M			40	E	44M	T
2N2091	G	P			RFC	.1W	A	85	20	20	R	40		1M			40	E	44M	T
2N2092	G	P			RFC	.1W	A	85	20	20	R	40		1M			40	E	44M	T
2N2093	G	P			RFC	.1W	A	85	25	25	R	40		1M			40	E	30M	T
2N2095	G	P			HPA	1W	A	100	30	15	0								500M	T
2N2096	G	P		8-66	PHS	250M	A	100	25	12	0	15		400M	.6	200M				
2N2097	G	P		8-66	PHS	250M	A	100	40	20	0	20		400M	.5	200M				
2N2098	G	P			HPA	1W	A	100	30	15	0								500M	T
2N2099	G	P		8-66	PHS	250M	A	100	25	12	0	15		400M	.6	200M				
2N2100	G	P		8-66	PHS	250M	A	100	40	20	0	20		400M	.5	200M				
2N2100A	G	P			PHS	300M	A	100	40	20	0	20		400M	.5	200M				
2N2101	S	N			LPA	75W	C	200	60	40	0	15	60	1A	5	1A			25K	T
2N2102	S	N			HNS	5W	C	200	120	80	R	35		10M	.5	150M	35	E		
2N2102A	S	N			HNS	1W	A	200	120	65	0	40	120	150M	.3	150M	30	E		
2N2104	S	P			HSA	3.5W	C	200	50	35	0	25	80	150M	1.5	150M			60M	T
2N2105	S	P			HSA	3.5W	C	200	50	35	0	15	40	150M	1.5	150M			50M	T
2N2106	S	N	2N2218	8-74	AFA	1W	A	150	60	60	R	12	36	200M	5	200M				
2N2107	S	N	2N2218	8-74	AFA	1W	A	150	60	60	R	30	90	200M	2	200M				
2N2108	S	N	2N2219	8-74	AFA	1W	A	150	60	60	R	75	200	200M	2	200M				
2N2109	S	N			PMS	250W	C	175	50	50	V	10		10A	1.5	10A				
2N2110	S	N			PMS	250W	C	175	100	100	V	10		10A	1.5	10A				
2N2111	S	N			PMS	250W	C	175	150	150	V	10		10A	1.5	10A				
2N2112	S	N			PMS	250W	C	175	200	200	V	10		10A	1.5	10A				
2N2113	S	N			PMS	250W	C	175	250	250	V	10		10A	1.5	10A				
2N2114	S	N			PMS	250W	C	175	300	300	V	10		10A	1.5	10A				
2N2116	S	N			PMS	250W	C	175	50	50	V	10		15A	1.5	15A				
2N2117	S	N			PMS	250W	C	175	100	100	V	10		15A	1.5	15A				
2N2118	S	N			PMS	250W	C	175	150	150	V	10		15A	1.5	15A				
2N2119	S	N			PMS	250W	C	175	200	200	V	10		15A	1.5	15A				
2N2120	S	N			PMS	250W	C	175	250	250	V	10		15A	1.5	15A				
2N2121	S	N			PMS	250W	C	175	300	300	V	10		15A	1.5	15A				
2N2123	S	N			PMS	250W	C	175	50	50	V	10		20A	1.5	20A				
2N2124	S	N			PMS	250W	C	175	100	100	V	10		20A	1.5	20A				
2N2125	S	N			PMS	250W	C	175	150	150	V	10		20A	1.5	20A				
2N2126	S	N			PMS	250W	C	175	200	200	V	10		20A	1.5	20A				
2N2127	S	N			PMS	250W	C	175	250	250	V	10		20A	1.5	20A				
2N2128	S	N			PMS	250W	C	175	300	300	V	10		20A	1.5	20A				
2N2130	S	N			PMS	250W	C	175	50	50	V	10		25A	1.5	25A				
2N2131	S	N			PMS	250W	C	175	100	100	V	10		25A	1.5	25A				
2N2132	S	N			PMS	250W	C	175	150	150	V	10		25A	1.5	25A				
2N2133	S	N			PMS	250W	C	175	200	200	V	10		25A	1.5	25A				
2N2134	S	N			PMS	250W	C	175	250	250	V	10		25A	1.5	25A				
2N2135	S	N			PMS	250W	C	175	300	300	V	10		25A	1.5	25A				
2N2137	G	P		6-74	LPA	62.5W	C	100	30	30	S	30	60	.5A	.5	2A			12K	E
2N2137A	G	P		6-74	LPA	62.5W	C	100	30	20	0	30	60	.5A	.5	2A			12K	E
2N2138	G	P		6-74	LPA	62.5W	C	100	45	45	S	30	60	.5A	.5	2A			12K	E
2N2138A	G	P		6-74	LPA	62.5W	C	100	45	30	0	30	60	.5A	.5	2A			12K	E
2N2139	G	P		6-74	LPA	62.5W	C	100	60	60	S	30	60	.5A	.5	2A			12K	E
2N2139A	G	P		6-74	LPA	62.5W	C	100	60	45	0	30	60	.5A	.5	2A			12K	E
2N2140	G	P		6-74	LPA	62.5W	C	100	75	75	S	30	60	.5A	.5	2A			12K	E

2N2140A — 2N2193A

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N2140A	G	P		6-74	LPA	62.5W	C	100	75	60	0	30	60	.5A	.5	2A			12K	E
2N2141	G	P		6-74	LPA	62.5W	C	100	90	90	S	30	60	.5A	.5	2A			12K	E
2N2141A	G	P		6-74	LPA	62.5W	C	100	90	65	0	30	60	.5A	.5	2A			12K	E
2N2142	G	P		6-74	LPA	62.5W	C	100	30	30	S	50	100	.5A	.5	2A			12K	E
2N2142A	G	P		6-74	LPA	62.5W	C	100	30	20	0	50	100	.5A	.5	2A			12K	E
2N2143	G	P		6-74	LPA	62.5W	C	100	45	45	S	50	100	.5A	.5	2A			12K	E
2N2143A	G	P		6-74	LPA	62.5W	C	100	45	30	0	50	100	.5A	.5	2A			12K	E
2N2144	G	P		6-74	LPA	62.5W	C	100	60	60	S	50	100	.5A	.5	2A			12K	E
2N2144A	G	P		6-74	LPA	62.5W	C	100	60	45	0	50	100	.5A	.5	2A			12K	E
2N2145	G	P		6-74	LPA	62.5W	C	100	75	75	S	50	100	.5A	.5	2A			12K	E
2N2145A	G	P		6-74	LPA	62.5W	C	100	75	60	0	50	100	.5A	.5	2A			12K	E
2N2146	G	P		6-74	LPA	62.5W	C	100	90	90	S	50	100	.5A	.5	2A			12K	E
2N2146A	G	P		6-74	LPA	62.5W	C	100	90	65	0	50	100	.5A	.5	2A			12K	E
2N2147	G	P	2N2832	6-87	LPA	12.5W	C	100	75	50	0	100	300	1A	1	4A	75	E	3M	T
2N2148	G	P	2N2837	6-87	LPA	12.5W	C	100	60	40	0	40	160	1A	1	4A	30	E	2M	T
2N2150	S	N			HFA	30W	C	175	125	80	0	20	60	1A	1	1A	20	E	10M	T
2N2151	S	N			HFA	30W	C	175	125	80	0	40	120	1A	1	1A	40	E	10M	T
2N2152	G	P		6-78	LPA	170W	C	110	45	45	S	50	100	5A	.1	5A			2K	E
2N2152A	G	P		6-78	LPA	170W	C	110	45	30	0	50	100	5A	.1	5A			2K	E
2N2153	G	P		6-78	LPA	170W	C	110	60	60	S	50	100	5A	.1	5A			2K	E
2N2153A	G	P		6-78	LPA	170W	C	110	60	45	0	50	100	5A	.1	5A			2K	E
2N2154	G	P		6-78	LPA	170W	C	110	75	75	S	50	100	5A	.1	5A			2K	E
2N2154A	G	P		6-78	LPA	170N	C	110	75	60	0	50	100	5A	.1	5A			2K	E
2N2155	G	P			LPA	170W	C	110	90	90	S	50	100	5A	.1	5A			2K	E
2N2155A	G	P			LPA	170W	C	110	90	65	0	50	100	5A	.1	5A			2K	E
2N2156	G	P		6-78	LPA	170W	C	110	45	45	S	80	160	5A	.1	5A			2K	E
2N2156A	G	P		6-78	LPA	170W	C	110	45	30	0	80	160	5A	.1	5A			2K	E
2N2157	G	P		6-78	LPA	170W	C	110	60	60	S	80	160	5A	.1	5A			2K	E
2N2157A	G	P		6-78	LPA	170W	C	110	60	45	0	80	160	5A	.1	5A			2K	E
2N2158	G	P		6-78	LPA	170W	C	110	75	75	S	80	160	5A	.1	5A			2K	E
2N2158A	G	P		6-78	LPA	170W	C	110	75	60	0	80	160	5A	.1	5A			2K	E
2N2159	G	P			LPA	170W	C	110	90	90	S	80	160	5A	.1	5A			2K	E
2N2159A	G	P			LPA	170W	C	110	90	65	0	80	160	5A	.1	5A			2K	E
2N2160	Unijunction Transistor, see Table on Page 1-177																			
2N2161	S	N			HSS	200M	A	150	55	35	0	60	160	10M	1.5	10M	75	E		
2N2162	S	P			CHP	150M	A	140	30	30	0								14M	T
2N2163	S	P			CHP	150M	A	140	15	15	0								14M	T
2N2164	S	P			CHP	150M	A	140	12	8	0								24M	T
2N2165	S	P			CHP	150M	A	140	30	30	0								10M	T
2N2166	S	P			CHP	150M	A	140	15	15	0								10M	T
2N2167	S	P			CHP	150M	A	140	12	8	0								16M	T
2N2168	G	P			HSS	60M	A	100	20	15	0	50		10M	.125	10M				
2N2169	G	P			HSS	60M	A	100	15	15	0	40		10M	.15	10M				
2N2170	G	P			HSS	60M	A	100	15	10	0	20		10M	.18	10M				
2N2171	G	P		7-10	AFA	.2W	A	100	50	25	R	110	250	20M			120	E		
2N2172	G	P			MSS	200M	A	85	20	15	0	30	150	10M	.2	10M	.97	B	5M	B
2N2173	G	P			HSS	240M	A	100	25	15	0	30		200M	.4	200M				
2N2175	S	P			AFA	.1W	A	175	6	6	0	30		20*					10M	T
2N2176	S	P			AFA	.1W	A	175	6	6	0	30		20*					10M	T
2N2177	S	P			AFA	.1W	A	160	6	6	0	15		5*			50	E	8M	B
2N2178	S	P			AFA	.1W	A	160	6	6	0	15		5*			50	E	8M	B
2N2180	G	P			HSS	50M	A	100	15	6	0	100		10M	.08	10M	120	E	60M	T
2N2181	S	P			CHP	150M	A	140	25	25	0	10		5M					6M	T
2N2182	S	P			CHP	150M	A	140	25	25	0	10		5M					6M	T
2N2183	S	P			CHP	150M	A	140	15	10	0	10		5M					6M	T
2N2184	S	P			CHP	150M	A	140	15	10	0	10		5M					6M	T
2N2185	S	P			CHP	150M	A	140	30	30	0								6.5M	T
2N2186	S	P			CHP	150M	A	140	30	30	0								6.5M	T
2N2187	S	P			CHP	150M	A	140	30	30	0								6.5M	T
2N2188	G	P	2N3323	9-66	RFA	125M	A	85	40	25	0	40	160	1.5M			40	E	60M	T
2N2189	G	P	2N3323	9-66	RFA	125M	A	85	40	25	0	60	180	1.5M			40	E	102M	T
2N2190	G	P	2N3323	9-66	RFA	125M	A	85	60	25	0	40	160	1.5M			40	E	60M	T
2N2191	G	P	2N3323	9-66	RFA	125M	A	85	60	25	0	60	180	1.5M			60	E	102M	T
2N2192	S	N		8-72	HSA	800M	A	200	60	40	0	100	300	150M	.35	150M				
2N2192A	S	N		8-72	HSA	800M	A	200	60	40	0	100	300	150M	.25	150M				
2N2192B	S	N		8-72	HSA	800M	A	200	60	40	0	100	300	150M	.18	150M				
2N2193	S	N		8-72	HSA	800M	A	200	80	50	0	40	120	150M	.35	150M				
2N2193A	S	N		8-72	HSA	800M	A	200	80	50	0	40	120	150M	.25	150M				

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units	Subscript
2N2193B	S	N		8-72	HSA	800M	A	200	80	50	O	40	120	150M	.18	150M					
2N2194	S	N		8-72	HSA	800M	A	200	60	40	O	20	60	150M	.35	150M					
2N2194A	S	N		8-72	HSA	800M	A	200	60	40	O	20	60	150M	.25	150M					
2N2194B	S	N		8-72	HSA	800M	A	200	60	40	O	20	60	150M	.18	150M					
2N2195	S	N	2N2218	8-74	HSA	800M	A	200	45	25	O	20		150M	.35	150M					
2N2195A	S	N	2N2218	8-74	HSA	800M	A	200	45	25	O	20		150M	.25	150M					
2N2195B	S	N	2N2218	8-74	HSA	800M	A	200	45	25	O	20		150M	.18	150M					
2N2196	S	N			LPA	2W	A	175	80	60	R	30	90	.2A	2	.2A	30	E			
2N2197	S	N			LPA	2W	A	175	80	60	R	75	200	.2A	2	.2A	30	E			
2N2198	S	N			RFA	5.5M	A	200	80	80	O	35	55	.1A	6	.2A			4M		T
2N2199	G	P			RFA	75M	A	100	15	10	O	9		3M				20	E	120M		T
2N2200	G	P			RFA	75M	A	100	15	10	O	9		3M						120M		T
2N2201	S	N	2N3738	6-125	AFA	1W	C	175	120	100	O	25	90	200M	1.7	200M	30	E			
2N2202	S	N	2N3738	6-125	AFA	1W	C	175	120	100	O	25	90	200M	1.7	200M	30	E			
2N2203	S	N	2N3738	6-125	AFA	1W	C	175	120	100	O	25	90	200M	1.7	200M	30	E			
2N2204	S	N	2N3738	6-125	AFA	1W	C	175	120	100	O	25	90	200M	1.7	200M	30	E			
2N2205	S	N	2N835	8-35	HSS	1W	C	175	25	12	O	20		10M	.22	10M	2	E			
2N2206	S	N	2N835	8-35	HSS	1W	C	175	25	12	O	40	120	10M	.22	10M	2	E			
2N2207	G	P			VID	.26W	A	75	70	50	R	36	370	10M					140M		B
2N2208	G	P			RFC	120M	A	85	40	10	O	15		1.5M			30	E			
2N2209	G	P			MSS	150M	A	85	30	12	O	50		24M	.15	12M			6M		B
2N2210	G	P	2N2095	6-71	LPA	75W	C	100	100	65		25	50	5A	.6	12A			5K		E
2N2211	G	P			LPA	90W	C	100	80	60	S	60	140	1A	.8	2A			5K		E
2N2212	G	P			HPA	100W	C	110	120	120	R	50	120	5A	1	5A	30	E	.45M		T
2N2214	S	N			HSS	.25W	C	150	25	15	O	25		10M	.2	10M			200M		T
2N2216	S	P	2N3498	8-161	HSA	3W	C	200	150	100	O	25	120	50M	5	50M			40M		T
2N2217	S	N	2N2218	8-74	HSA	.8W	A	175	60	30	O	20	60	150M	.4	150M			250M		T
2N2218	S	N		8-74	HSA	.8W	A	175	60	30	O	40	120	150M	.4	150M			250M		T
2N2218A	S	N		8-80	HSS	.8W	A	175	75	40	O	40	120	.15A	.3	.15A	30	E	250M		T
2N2219	S	N		8-74	HSA	.8W	A	175	60	30	O	100	300	150M	.4	150M			250M		T
2N2219A	S	N		8-80	HSS	.8W	A	175	75	40	O	100	300	.15A	.3	.15A	50	E	300M		T
2N2220	S	N	2N2222	8-74	HSA	.5W	A	175	60	30	O	20	60	150M	.4	150M			250M		T
2N2221	S	N		8-74	HSA	.5W	A	175	60	30	O	40	120	150M	.4	150M			250M		T
2N2221A	S	N		8-80	HSS	.5W	A	175	75	40	O	40	120	.15A	.3	.15A	30	E	250M		T
2N2222	S	N		8-74	HSA	.5W	A	175	60	30	O	100	300	150M	.4	150M			250M		T
2N2222A	S	N		8-80	HSS	.5W	A	175	75	40	O	100	300	.15A	.3	.15A	50	E	300M		T
2N2223	S	N		11-4	DFA	500M	A	200	100	80	R	50	200	10M	1.2	50M	40	E	50M		T
2N2223A	S	N		11-4	DFA	500M	A	200	100	80	R	50	200	10M	1.2	50M	40	E	50M		T
2N2224	S	N	2N2218	8-74	HSS	.8W	A	175	65	40	O	35	115	10M	.4	150M			250M		T
2N2225	G	P			MSS	200M	A	100	15	4	O	100	300	100M	.2	50M			25M		B
2N2226	S	N			LPA	150W	C	150	50	50	V	100	500	9A	3.5	9A	50	E	7K		E
2N2227	S	N			LPA	150W	C	150	100	100	V	100	500	9A	3.5	9A	50	E	7K		E
2N2228	S	N			LPA	150W	C	150	150	150	V	100	500	9A	3.5	9A	50	E	7K		E
2N2229	S	N			LPA	150W	C	150	200	200	V	100	500	9A	3.5	9A	50	E	7K		E
2N2230	S	N			LPA	150W	C	150	50	50	V	350		9A	3.5	9A	100	E	4K		E
2N2231	S	N			LPA	150W	C	150	100	100	V	350		9A	3.5	9A	100	E	4K		E
2N2232	S	N			LPA	150W	C	150	150	150	V	350		9A	3.5	9A	100	E	4K		E
2N2233	S	N			LPA	150W	C	150	200	200	V	350		9A	3.5	9A	100	E	4K		E
2N2234	S	N			PHS	12.5W	C	150	40	20	O	15	60	100M	.25	100M			50M		T
2N2235	S	N			PHS	12.5W	C	150	40	20	O	40	125	100M	.25	100M			100M		T
2N2236	S	N			HSS	575M	A	150	40	20	O	15	60	100M	.25	100M			50M		T
2N2237	S	N			HSS	575M	A	150	40	20	O	40	125	100M	.25	100M					
2N2238	G	P			RFA	.3W	A	100	30	30	S	10		10M				25	E	400M		T
2N2239	S	N	2N3766	6-134	AFA	1W	A	150	60	50	R	30	200	200M	3	200M					
2N2240	S	N			HSA	.6W	A	200	25	20	O	40	100	1M	1	50M			50M		T
2N2241	S	N			HSA	.6W	A	200	25	20	O	100	200	1M	1	50M			50M		T
2N2242	S	N	2N2501	8-104	HSA	360M	A	200	40	15	O	40	120	10M	.7	100M			250M		T
2N2243	S	N	2N2219	8-74	HSS	.8W	A	200	120	80	O	40	120	.15A	.35	.15A			50M		T
2N2243A	S	N			HSS	.8W	A	200	120	80	O	40	120	.15A	.25	.15A			50M		T
2N2244	S	N	2N835	8-35	AFA	.5W	A	200	20	20	D	5	15	2*	.2	1M	40	E	60M		T
2N2245	S	N	2N835	8-35	AFA	.5W	A	200	20	20	O	10	30	2*	.2	1M	80	E	60M		T
2N2246	S	N	2N835	8-35	AFA	.5W	A	200	20	20	O	5	15	2*	.2	1M	40	E	60M		T
2N2247	S	N	2N835	8-35	AFA	.5W	A	200	45	45	O	5	15	2*	.2	1M	40	E	60M		T
2N2248	S	N	2N836	8-35	AFA	.5W	A	200	45	45	O	10	30	2*	.2	1M	80	E	60M		T

2N2249—2N2333

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref. Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N2249	S	N	2N834	8-35	AFA	.5W	A	200	45	45	0	20	60	2*	.2	1M	150	E	60M	T
2N2250	S	N	2N835	8-35	LNA	.5W	A	200	25	20	0	5	15	2*	.2	1M	40	E	60M	T
2N2251	S	N	2N835	8-35	LNA	.5W	A	200	25	20	0	10	30	2*	.2	1M	80	E	60M	T
2N2252	S	N	2N834	8-35	LNA	.5W	A	200	25	20	0	20	60	2*	.2	1M	150	E	60M	T
2N2253	S	N	2N834	8-35	LNA	.5W	A	200	45	50	0	5	15	2*	.2	1M	40	E	60M	T
2N2254	S	N	2N834	8-35	LNA	.5W	A	200	45	50	0	10	30	2*	.2	1M	80	E	60M	T
2N2255	S	N	2N834	8-35	LNA	.5W	A	200	45	50	0	20	60	2*	.2	1M	150	E	60M	T
2N2256	S	N		8-84	HNS	300M	A	175	7	7	S	17		10M						
2N2257	S	N		8-84	HNS	300M	A	175	7	7	S	40		10M						
2N2258	G	P		8-84	HNS	150M	A	100	7	7	S	17		10M						
2N2259	G	P		8-84	HNS	150M	A	100	7	7	S	40		10M						
2N2260 thru 2N2262	Thyristors, see Table on Page 1-161																			
2N2266	G	P	2N2145	6-74	PMS	50W	J	125	100	55		40	120	500M	.75	5A			200K	T
2N2267	G	P	2N2145	6-74	PMS	50W	J	125	120	55		40	120	500M	.75	5A			200K	T
2N2268	G	P	2N2145	6-74	PMS	50W	J	125	100	55		40	120	500M	.75	5A			200K	T
2N2269	G	P	2N2145	6-74	PMS	50W	J	125	120	55		40	120	500M	.75	5A			200K	T
2N2270	S	N	2N2219	8-74	AFA	5W	C	200	60	45	0	30		1M	.9	150M	50	E		
2N2271		P			AFC	.25W	A	100	20	15	R	50	100	35M					10K	E
2N2272	S	N			HSS	360M	A	200	40	20	R	80	240	10M	.7	200M	3	E		
2N2273	G	P		9-24	RFA	100M	A		25	15	0	20	150	1M						
2N2274	S	P			CHP	150M	A	140	25	25	0	10		5M					6M	T
2N2275	S	P			CHP	150M	A	140	25	25	0	10		5M					6M	T
2N2276	S	P			CHP	150M	A	140	15	10	0	10		5M					6M	T
2N2277	S	P			CHP	150M	A	140	15	10	0	10		5M					6M	T
2N2278	S	P			CHP	150M	A	140	15	15	0								7.6M	T
2N2279	S	P			CHP	150M	A	140	15	15	0								7.6M	T
2N2280	S	P			CHP	150M	A	140	10	6	0				.1	5M			16M	T
2N2281	S	P			CHP	150M	A	140	10	6	0				.1	5M			16M	T
2N2282	G	P			HPA	5W	C	110	60	30	0	15		3A	.4	1A	40	E	20M	T
2N2283	G	P			HPA	5W	C	110	100	60	0	15		3A	.4	1A	40	E	20M	T
2N2284	G	P			HPA	5W	C	110	200	100	0	15		3A	.4	1A	40	E	20M	T
2N2285	G	P			LPA	100W	C	110	60	30	0	35	140	10A	.65	25A			.6M	T
2N2286	G	P			LPA	100W	C	110	100	60	0	35	140	10A	.65	25A			.6M	T
2N2287	G	P			LPA	100W	C	110	120	80	0	35	140	10A	.65	25A			.6M	T
2N2288	G	P	2N2526	6-83	LPA	60W	C	110	40	40	R	20	60	5A	1	5A	25	E	.45M	T
2N2289	G	P	2N2526	6-83	LPA	60W	C	110	80	80	R	20	60	5A	1	5A	25	E	.45M	T
2N2290	G	P	2N2526	6-83	LPA	60W	C	110	120	120	R	20	60	5A	1	5A	25	E	.45M	T
2N2291	G	P			LPA	60W	C	110	40	30	0	50	120	5A	1	5A	50	E	.45M	T
2N2292	G	P			LPA	60W	C	110	80	70	0	50	120	5A	1	5A	50	E	.45M	T
2N2293	G	P			LPA	60W	C	110	120	70	0	50	120	5A	1	5A	50	E	.45M	T
2N2294	G	P			PMS	70W	C	110	40	30	0	50	120	5A	1	5A	50	E	.45M	T
2N2295	G	P			PMS	70W	C	110	80	50	0	50	120	5A	1	5A	50	E	.45M	T
2N2296	G	P			PMS	70W	C	110	120	70	0	50	120	5A	1	5A	50	E	.45M	T
2N2297	S	N	2N3252	8-24	RFA	800M	A	200	80	35	0	40	120	150M	.2	150M			60M	T
2N2303	S	P	2N2801	8-35	RFA	600M	A	175	50	50	R	75	200	150M	1.5	150M	75	E	60M	T
2N2304	S	N	2N3766	6-134	LPA	25W	C	200	60	60	V	20	80	300M	.9	300M				
2N2305	S	N			LPA	75W	C	200	60	60	V	15	60	800M	1.2	600M				
2N2306	S	N			PHS	13W	C	175	75	50	0	12	75	.35A	2	1A			175M	T
2N2308	S	N			LPA	25W	C	200	100	80	0	20	60	1A	1	1A	15	E	30K	E
2N2309	S	N			LNA	600M	A	200	30	30	0	25	125	.2M			40	E		
2N2310	S	N			AFA	350M	A	200	60	60	0	12	36	200M	5	200M				
2N2311	S	N			AFA	350M	A	200	100	100	0	12	36	200M	5	200M				
2N2312	S	N			AFA	350M	A	200	60	60	0	30	90	200M	5	200M				
2N2313	S	N			AFA	350M	A	200	100	100	0	30	90	200M	5	200M				
2N2314	S	N			AFA	350M	A	200	60	40	R	20	60	150M	5	150M	15	E	40M	T
2N2315	S	N			AFA	350M	A	200	60	40	R	40	120	150M	1.5	150M	25	E	50M	T
2N2316	S	N			AFA	350M	A	200	120	80	R	40	120	150M	5	150M	30	E	50M	T
2N2317	S	N			AFA	350M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N2318	S	N	2N834	8-35	HSA	360M	A	200	30	25	S	15		.1M	.35	20M			300M	T
2N2319	S	N	2N834	8-35	HSA	300M	A	200	30	25	S	15		.1M	.35	20M			300M	T
2N2320	S	N	2N834	8-35	HSA	600M	A	200	30	25	S	15		.1M	.35	20M			300M	T
2N2322 thru 2N2329	Thyristors, see Table on Page 1-161																			
2N2330	S	N		8-87	CHP	.8W	A	150	30	20	0	50		10M					100M	T
2N2331	S	N		8-87	CHP	.5W	A	150	30	20	0	50		10M					100M	T
2N2332	S	P			CHP	.15W	A	200	15	15	0									
2N2333	S	P			CHP	.15W	A	200	15	5	0									

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N2334	S	P			CHP	.15W	A	200	30	15	0								
2N2335	S	P			CHP	.15W	A	200	30	15	0								
2N2336	S	P			CHP	.15W	A	200	50	35	0								
2N2337	S	P			CHP	.15W	A	200	50	35	0								
2N2338	S	N	2N3713	6-117	LPA	150W	C	200	60	40	0	7		6A	1.5	3A	12	E	15K	E
2N2339	S	N	MJ3101	6-152	LPA	40W	C	200	60	40	0	6		1.5A	1.5	.3A	12	E	.7M	T
2N2340	S	N			HPA	15W	C	175	50	40	0	10	40	750M	4	750M			550K	E
2N2341	S	N			HPA	15W	C	175	50	40	0	40	100	750M	4	750M			350K	E
2N2342	S	N			HPA	15W	C	175	100	40	0	10	40	750M	3	750M			550K	E
2N2343	S	N			HPA	15W	C	175	100	40	0	40	100	750M	2.5	750M			350K	E
2N2344 thru 2N2348	Thyristors, see Table on Page 1-161																			
2N2349	S	N			AFA	150M	A	200	40	24	0	120	250	10M	1.5	10M	60	E		
2N2350	S	N			HSA	400M	A	200	60	40	0	100	300	150M	.35	150M	2.5	E		
2N2350A	S	N			HSA	400M	A	200	60	40	0	100	300	150M	.25	150M	2.5	E		
2N2351	S	N			HSA	400M	A	200	80	50	0	40	120	150M	.35	150M	2.5	E		
2N2351A	S	N			HSA	400M	A	200	80	50	0	40	120	150M	.25	150M	2.5	E		
2N2352	S	N			HSA	400M	A	200	60	40	0	20	60	150M	.35	150M	2.5	E		
2N2352A	S	N			HSA	400M	A	200	60	40	0	20	60	150M	.25	150M	2.5	E		
2N2353	S	N			HSA	400M	A	200	45	25	0	20		150M	.35	150M	2.5	E		
2N2353A	S	N			HSA	400M	A	200	45	25	0	20		150M	.25	150M	2.5	E		
2N2354		N			AFC	.18W	A	85	20	15	R	50	150	35M						
2N2356	S	N			CHP	.6W	A	200	25	7	0								50M	T
2N2356A	S	N			CHP	.6W	A	200	25	7	0								50M	T
2N2357	G	P			PMS	170W	C	110	60	30	0	30	90	20A	.9	50A	20	E	.6M	T
2N2358	G	P			PMS	170W	C	110	100	60	0	30	90	20A	.9	50A	20	E	.6M	T
2N2359	G	P			PMS	170W	C	110	120	80	0	30	90	20A	.9	50A	20	E	.6M	T
2N2360	G	P	2N3283	9-44	RFC	60M	A	125	20	20	0	10		2M						
2N2361	G	P	2N3284	9-44	RFC	60M	A	125	20	20	0	10		2M						
2N2362	G	P	2N3284	9-44	RFC	60M	A	100	20	20	S	10		2M						
2N2363	G	P			RFA	75M	A	100	30	20	0	10	200	2M			10	E	250M	T
2N2364	S	N			HSS	400M	A	200	120	80	0	40	120	150M	.35	150M			50M	T
2N2364A	S	N			HSS	400M	A	200	120	80	0	40	120	150M	.25	150M			50M	T
2N2368	S	N	2N3227	8-92	HSS	360M	A	200	40	40	S	20	60	10M	.25	10M			400M	T
2N2369	S	N	2N3227	8-92	HSS	360M	A	200	40	40	S	40	120	10M	.25	10M			500M	T
2N2369A	S	N	2N3227	8-92	HSS	360M	A	200	40	40	S		120	10M	.2	10M			500M	T
2N2370	S	P			LNA	.2W	A	200	15	15	0	15		25*			15	E		
2N2371	S	P			LNA	.2W	A	200	15	15	0	20		25*			20	E		
2N2372	S	P			LNA	.15W	A	200	15	15	0	15		25*			15	E		
2N2373	S	P			LNA	.15W	A	200	15	15	0	20		25*			20	E		
2N2374	G	P	2N3427	7-41	AFC	250M	A	100	35	35	S	100	300	100M			100	E		
2N2375	G	P	2N1193	7-30	AFC	250M	A	100	35	35	S	35	110	100M			35	E		
2N2376	G	P	2N1193	7-30	AFC	250M	A	100	35	35	S	35	110	100M			35	E		
2N2377	S	P			RFA	150M	A	140	25	25	0	10	100	5M			15	E	8M	T
2N2378	S	P			RFA	150M	A	140	10	10	0	15		15M					7.2M	T
2N2379	G	P			PMS	150W	C	95	100	80	S	25	37	5A	1	15A			4K	E
2N2380	S	N			HSS	600M	A	175	80	40	0	20	120	150M	1.3	150M			100M	T
2N2380A	S	N			HSS	600M	A	175	80	40	0	20	120	150M	1.3	150M	60	E	100M	T
2N2381	G	P		8-96	HSS	300M	A	100	30	15	0	40		200M	.40	200M			300M	T
2N2382	G	P		8-96	HSS	300M	A	100	45	20	0	40		200M	.40	200M			300M	T
2N2383	S	N			LPA	85W	C	180	80	60	0	20	60	1.5A	1	1.5A	15	E	30K	E
2N2384	S	N			LPA	85W	C	180	80	60	0	20	60	1.5A	1	1.5A	15	E	30K	E
2N2386	Field Effect Transistor, see Table on Page 1-171																			
2N2387	S	N			AFA	300M	A	175	45	45	0	40	120	10*	1	10M	60	E	30M	T
2N2388	S	N			AFA	300M	A	175	45	45	0	100	300	10*	1	10M	150	E	30M	T
2N2389	S	N			AFA	450M	A	200	75	50	R	40	120	150M	1.5	150M	30	E	60M	T
2N2390	S	N			AFA	450M	A	200	75	50	R	100	300	150M	1.5	150M	50	E	70M	T
2N2391	S	P			AFA	300M	A	175	25	20	0	15	45	10M	.6	10M	15	E	140M	T
2N2392	S	P			AFA	300M	A	175	25	20	0	30	90	10M	.6	10M	30	E	140M	T
2N2393	S	P			AFA	450M	A	175	50	35	0	20	45	150M	1.5	150M	15	E	50M	T
2N2394	S	P			AFA	450M	A	175	50	35	0	30	90	150M	1.5	150M	25	E	60M	T
2N2395	S	N			AFA	450M	A	200	60	40	0	20	60	150M	1	150M			40M	T
2N2396	S	N			AFA	450M	A	200	60	40	0	40	120	150M	1	150M			50M	T
2N2397	S	N			HSS	300M	A	200	35	15	0	25	120	10M	.30	10M			200M	T
2N2398	G	P	2N3284	9-44	RFC	60M	A	100	20	20	S	10		2M						
2N2399	G	P	2N3284	9-44	RFC	60M	A	100	20	20	S	10		2M						
2N2400	G	P	2N964	8-48	HSS	150M	A	100	12	7	0	30		10M	.22	10M			150M	T

2N2401 — 2N2480

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_f—	Subscript	I_{--}	Units	Subscript
2N2401	G	P	2N964	8-48	HSS	150M	A	100	15	10	O	50		10M	.2	10M			200M	T
2N2402	G	P	2N2956	8-119	HSS	150M	A	100	18	12	O	60		10M	.2	10M			250M	T
2N2403	S	N			MSA	1W	A	200	60	60	O	20	60	.6A	1.5	.6A			147M	T
2N2404	S	N			MSA	1W	A	200	60	60	O	40	120	.6A	1.5	.6A			147M	T
2N2405	S	N	2N3498	8-70	AFA	5W	C		120	90	O	60	200	150M	.5	150M	50	E			
2N2410	S	N	2N2537	8-107	HSS	800M	A	200	60	30	O	30	120	10M					200M	T
2N2411	S	P	2N3250	8-141	HSS	300M	A	200	25	20	O	20	60	10M	.2	10M			140M	T
2N2412	S	P	2N3250	8-141	HSS	300M	A	200	25	20	O	40	120	10M	.2	10M			140M	T
2N2413	S	N			RFA	300M	A	175	40	18	O	30	120	10M	.4	10M			300M	T
2N2414	S	N			SPP	500M	A	200	60	40	R	50	250	10M	1.2	50M	50	E	50M	T
2N2415	G	P			RFA	75M	A	100	15	10	O	10	200	2M			15	E	500M	T
2N2416	G	P			RFA	75M	A	100	15	10	O	8	20	2M			10	E	400M	T
2N2417 thru 2N2422	Unijunction Transistors, see Table on Page 1-177																			
2N2423	G	P	2N3616	6-113	PMS	90W	C	100	100	80	V	20	100	2A	1.5	5A			3K	E
2N2424	S	P			MSS	375M	A	160	40	5	O	30	200	5M	.3	15M			15M	B
2N2425	S	P			MSS	375M	A	160	50	10	O	25	110	5M	.3	15M			10M	B
2N2426	G	N			AFA	150M	A	100	40	25	R				0.5	100M	35	E	25K	E
2N2427	S	N			RFA	.5W	A	200	40	40	O	20	60	10*			40	E	50M	T
2N2428	G	P	2N652	7-20	AFC	.5W	A	75	32	32	S	50	150	2M			60	E	10K	E
2N2429	G	P	2N652	7-20	AFC	.5W	A	75	32	32	S	65	300	2M			130	E	10K	E
2N2430	G	N			AFC	.28W	A	75	32	32	R	60	210	.1A					10K	E
2N2431		P			AFC	.55W	A	90	32	32	R	60	175	.3A					10K	E
2N2432	S	N			CHP	300M	A	175	30	30	O	50		1M	.15	10M			20M	T
2N2433	S	N			HSS	500M	A	200	75	45	O	40	120	150M	1.5	150M	30	E	80M	T
2N2434	S	N			HSS	500M	A	200	75	45	O	100	300	150M	1.5	150M	50	E	90M	T
2N2435	S	N			HSS	500M	A	200	120	80	O	40	120	150M	3	150M	30	E	80M	T
2N2436	S	N			HSS	500M	A	200	120	80	O	100	300	150M	3	150M	50	E	90M	T
2N2437	S	N			VID	500M	A	200	100	75	O	15		10M	.2	10M	18	E	70M	T
2N2438	S	N			VID	500M	A	200	100	75	O	35		10M	.4	50M	36	E	80M	T
2N2439	S	N			VID	500M	A	200	100	75	O	75		10M	.4	50M	76	E	90M	T
2N2440	S	N			HSS	300M	A	200	120	80	O	100	300	150M	.4	50M	50	E	90M	T
2N2443	S	N			RFA	800M	A	200	120	100	O	50	150	50M	1.2	50M	45	E	50M	T
2N2444	G	P			LPA	85W	C	110	80	80	O	90	120	3A	1	5A	50	E	4.5M	T
2N2445	G	P			LPA	90W	C	100	100	50	O	30	60	10A	1	10A	30	E	.1M	T
2N2446	G	P			PMS	90W	C	100	60	50	S	15	45	5A	1.5	7A			3K	E
2N2447	G	P	2N1187	7-25	AFA	75M	A	85	45	24	O						25	E		
2N2448	G	P	2N1187	7-25	AFA	75M	A	85	45	24	O						25	E		
2N2449	G	P	2N652	7-20	AFA	75M	A	85	35	20	O						50	E		
2N2450	G	P	2N652	7-20	AFA	75M	A	85	35	20	O						50	E		
2N2451	G	P			HSS	25M	A	85	6	5	O	25		10M	.1	10M	40	E	80M	T
2N2452	S	N			SPP	500M	A	200	100	80	R									
2N2453	S	N			DFA	0.5W	A	200	60	30	O	150	600	1M	1	5M	150	E	60M	T
2N2453A	S	N			DFA	0.5W	A	200	80	50	O	150	600	1M	1	5M	150	E	60M	T
2N2454	Thyristor, see Table on Page 1-161																			
2N2455	G	P			HSA	150M	A	100	15	15	S	20	100	2M	.19	10M	30	E	600M	T
2N2456	G	P			HSA	150M	A	100	15	15	S	20	100	2M	.19	10M	30	E	1G	T
2N2459	S	N			AFA	.4W	A	200	100	60	O	10		.1M	.3	10M	40	E	100M	T
2N2460	S	N			AFA	.4W	A	200	100	60	O	20		.1M	.3	10M	70	E	120M	T
2N2461	S	N			AFA	.4W	A	200	100	60	O	40		.1M	.3	10M	115	E	140M	T
2N2462	S	N			AFA	.4W	A	200	100	60	O	60		.1M	.3	10M	160	E	160M	T
2N2463	S	N			AFA	.5W	A	200	100	60	O	10		.1M	.3	10M	40	E	100M	T
2N2464	S	N			AFA	.5W	A	200	100	60	O	20		.1M	.3	10M	70	E	120M	T
2N2465	S	N			AFA	.5W	A	200	100	60	O	40		.1M	.3	10M	115	E	140M	T
2N2466	S	N			AFA	.5W	A	200	100	60	O	60		.1M	.3	10M	160	E	160M	T
2N2467	G	P			LPA	5W	C	110	60	30	O	30	90	.5A	.4	1A	40	E	20M	T
2N2468	G	P			LPA	5W	C	110	100	60	O	30	90	.5A	.4	1A	40	E	20M	T
2N2469	G	P			LPA	5W	C	110	200	100	O	30	90	.5A	.4	1A	40	E	20M	T
2N2472	S	N			LPA	1W	A	175	120	100	O	30	90	.2A	1.7	.2A	30	E	10M	T
2N2473	S	N			LPA	1W	A	175	120	100	O	30	90	.2A	1.7	.2A	30	E	10M	T
2N2474	S	P			AFA	250M	A	160	30	15	O	8		100*	.126	10M	8	E		
2N2475	S	N			HSS	300M	A	200	15	6	O	20	20	50M			6	E		
2N2476	S	N	2N3252	8-147	HSS	2W	C	200	60	20	O	20		150M	.4	150M			250M	T
2N2477	S	N	2N3252	8-147	HSS	2W	C	200	60	20	O	40		150M	.4	150M			250M	T
2N2478	S	N	2N2218	8-74	HSS	600M	A	175	120	40	O	30		150M	.7	150M			200M	T
2N2479	S	N	2N2218	8-74	HSS	600M	A	175	80	40	O	30	120	150M	.85	150M	60	E	150M	T
2N2480	S	N		11-4	DFA	.3W	A	200	75	40	O	30	350	1M	1.3	50M			50M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N2480A	S	N		11-4	DFA	.3W	A	200	80	40	0	50	200	1M	1.2	50M	50	E	50M	T
2N2481	S	N		8-100	HSS	1.2W	C	200	40	15	0	40	120	10M	.25	10M			300M	T
2N2482	G	N			RFA	150M	A		20	15	S	25	200	2M			15	E		
2N2483	S	N	MM2483	8-266	AFA	360M	A	200	60	60	0	40	120	10*	.35	1M	80	E	12M	T
2N2484	S	N	MM2484	8-266	AFA	360M	A	200	60	60	0	100	500	10*	.35	1M	150	E	15M	T
2N2485	S	N			HPA	8.8W	C	200	120	120	0	10		.5A					100M	T
2N2486	S	N			HPA	8.8W	C	200	140	140	0	10		.5A					100M	T
2N2487	G	P			HSS	60M	A	100	15	10	0	20		10M	.175	40M			360M	T
2N2488	G	P			HSS	60M	A	100	15	10	0	20		50M	.175	15M			360M	T
2N2489	G	P			HSS	60M	A	100	20	15	0	20		10M	.18	10M			300M	T
2N2490	G	P		6-82	PMS	170W	C	110	70	60	S	20	40	5A	.7	12A			5K	E
2N2491	G	P		6-82	PMS	170W	C	110	60	50	S	35	70	5A	.7	12A			5K	E
2N2492	G	P		6-82	PMS	170W	C	110	80	70	S	25	50	5A	.5	12A			5K	E
2N2493	G	P		6-82	PMS	170W	C	110	100	85	S	25	50	5A	.5	12A			5K	E
2N2494		P			RFC	83M	A	75	20	20	V	25		1M						
2N2495		P			RFC	125M	A	100	40	40	S	25		1M						
2N2496		P			RFC	100M	A	100	40	20	V	25		1M						
2N2497 thru 2N2500	Field Effect Transistors, see Table on Page 1-171																			
2N2501	S	N		8-104	HSS	.36W	A	200	40	20	0	50	150	10M	.2	10M			350M	T
2N2502 thru 2N2508	Thyristors, see Table on Page 1-161																			
2N2509	S	N			VID	1.2W	C	200	125	80	0	25		10*	1	5M			45M	T
2N2510	S	N			VID	1.2W	C	200	100	65	0	150	500	10M	1	5M			45M	T
2N2511	S	N	2N3444	8-147	VID	1.2W	C	200	80	50	0	240	750	10M	1	5M			45M	T
2N2512	G	P			VID	.15W	A	75	70	70	R	20		1M			40	E	140M	T
2N2514	S	N			AFA	.4W	A	200	80	60	0	15	50	5M	.5	10M	20	E	30M	T
2N2515	S	N			AFA	.4W	A	200	80	60	0	30	100	5M	.5	10M	40	E	60M	T
2N2516	S	N			AFA	.4W	A	200	80	60	0	60	200	5M	.5	10M	80	E	100M	T
2N2517	S	N			AFA	.4W	A	200	125	80	0	15	50	5M	.5	10M	20	E	30M	T
2N2518	S	N			AFA	.4W	A	200	125	80	0	30	100	5M	.5	10M	40	E	60M	T
2N2519	S	N			AFA	.4W	A	200	125	80	0	60	200	5M	.5	10M	80	E	100M	T
2N2520	S	N			AFA	.4W	A	200	60	60	0	12		1M	.5	10M	18	E	50M	B
2N2521	S	N			AFA	.4W	A	200	60	60	0	25		1M	.5	10M	36	E	50M	B
2N2522	S	N			AFA	.4W	A	200	60	60	0	50		1M	.5	10M	76	E	50M	B
2N2523	S	N			AFA	.4W	A	200	60	45	0	40	120	10*	.5	10M	60	E	45M	T
2N2524	S	N			AFA	.4W	A	200	60	45	0	100	300	10*	.5	10M	150	E	45M	T
2N2525	S	N			HPA	25W	C	200	100	80	0	10		.35A	.8	1A			154M	T
2N2526	G	P		6-83	PHS	85W	C	110	80	80	0	20	50	3A	.8	10A			30K	T
2N2527	G	P		6-83	PHS	85W	C	110	120	120	0	20	50	3A	.8	10A			30K	T
2N2528	G	P		6-83	PHS	85W	C	110	160	160	0	20	50	3A	.8	10A			30K	T
2N2529	S	N			AFA	150M	A	175	45	40	0	10	20	1M	2	10M	12	E	6M	B
2N2530	S	N			AFA	150M	A	175	45	40	0	12	35	1M	2	10M	18	E	10M	B
2N2531	S	N			AFA	150M	A	175	45	40	0	20	80	1M	2	10M	36	E	12M	B
2N2532	S	N			AFA	150M	A	175	45	40	0	45	185	1M	2	10M	76	E	16M	B
2N2533	S	N			AFA	150M	A	175	45	40	0	20	55	10M	1.5	10M	19	E	10M	B
2N2534	S	N			AFA	150M	A	175	45	40	0	45	150	10M	1.5	10M	39	E	20M	B
2N2535	G	P			AFA	10W	C	100	60	30	0	40	120	.4A	.5	1.0A	15	E	8K	E
2N2536	G	P			AFA	10W	C	100	80	40	0	40	120	.4A	.5	1.0A	15	E	8K	E
2N2537	S	N		8-107	HSS	.8W	A	200	60	30	0	50	150	150M	.45	150M			250M	T
2N2538	S	N		8-107	HSS	.8W	A	200	60	30	0	100	300	150M	.45	150M			250M	T
2N2539	S	N		8-107	HSS	.5W	A	200	60	30	0	50	150	150M	.45	150M			250M	T
2N2540	S	N		8-107	HSS	.5W	A	200	60	30	0	100	300	150M	.45	150M			250M	T
2N2541	G	P			MSS	215M	A	100	30	14	0	60	250	50M	.25	50M			10M	B
2N2542 thru 2N2550	Thyristors, see Table on Page 1-161																			
2N2551	S	P			AFA	.4W	A	200	150	150	0	15	45	.1A	1.2	.1A				
2N2552	G	P			LPA	20W	C	100	40	40	V	20	60	1A	.25	1A	18	E	225K	T
2N2553	G	P			LPA	20W	C	100	60	60	V	20	60	1A	.25	1A	18	E	225K	T
2N2554	G	P			LPA	20W	C	100	80	80	V	20	60	1A	.25	1A	18	E	225K	T
2N2555	G	P			LPA	20W	C	100	100	100	V	20	60	1A	.25	1A	18	E	225K	T
2N2556	G	P			LPA	20W	C	100	40	40	V	20	60	1A	.25	1A	18	E	225K	T
2N2557	G	P			LPA	20W	C	100	60	60	V	20	60	1A	.25	1A	18	E	225K	T
2N2558	G	P			LPA	20W	C	100	80	80	V	20	60	1A	.25	1A	18	E	225K	T
2N2559	G	P			LPA	20W	C	100	100	100	V	20	60	1A	.25	1A	18	E	225K	T
2N2560	G	P			LPA	20W	C	100	40	40	V	20	60	3A	.75	3A	25	E	250K	T
2N2561	G	P			LPA	20W	C	100	60	60	V	20	60	3A	.75	3A	25	E	250K	T

2N2562—2N2634

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	h_{f-}	Subscript	f_- Units	Subscript
2N2562	G	P			LPA	20W	C	100	80	80	V	20	60	3A	.75	3A	25	E	250K	T
2N2563	G	P			LPA	20W	C	100	100	100	V	20	60	3A	.75	3A	25	E	250K	T
2N2564	G	P			LPA	20W	C	100	40	40	V	20	60	3A	.75	3A	25	E	250K	T
2N2565	G	P			LPA	20W	C	100	60	60	V	20	60	3A	.75	3A	25	E	250K	T
2N2566	G	P			LPA	20W	C	100	80	80	V	20	60	3A	.75	3A	25	E	250K	T
2N2567	G	P			LPA	20W	C	100	100	100	V	20	60	3A	.75	3A	25	E	250K	T
2N2568	G	N			HPA	1W	C	100	32	32	S	10	60	40M	.75	100M			600M	T
2N2569	S	N			CHP	300M	A	200	20	5	O	50		100*					100M	T
2N2570	S	N			CHP	300M	A	200	20	5	O	50		100*					100M	T
2N2571	S	N			CHP	300M	A	200	20	15	O	50		100M					100M	T
2N2572 2N2573 thru 2N2579	S	N			CHP	300M	A	200	20	15	O	50		100M						
	Thyristors, see Table on Page 1-161																			
2N2580	S	N			PMS	150W	C	150	400	400	O	10	40	5A	.7	5A			30K	E
2N2581	S	N			PMS	150W	C	150	400	400	O	25	65	5A	1	10A			30K	E
2N2582	S	N			PMS	150W	C	150	500	500	O	10	40	5A	.7	5A			30K	E
2N2583	S	N			PMS	150W	C	150	500	500	O	25	65	5A	1	10A			30K	E
2N2584	S	N			PMS	150W	C	150	600	600	O	10	40	5A	.7	5A			30K	E
2N2585	S	N			PMS	150W	C	150	600	600	O	25	65	5A	1	10A			30K	E
2N2586	S	N			AFA	300M	A	175	60	45	O	120	360	10*	.5	10M	150	E	1.5K	T
2N2587	G	P			RFA	150M	A	100	30	30	S	15	100	8M	0.5	50M	.95	B	320M	T
2N2588	G	P			RFA	150M	A	100	40	20	O	50	150	1.5M			50	E	75M	T
2N2589	S	N			PMS	150W	C	200	150	150	O	17	51	7A	1.05	7A	5	E	.25M	T
2N2590	S	P			VID	.4W	A	200	100	60	O	10		.1M	.4	10M	40	E	50M	T
2N2591	S	P			VID	.4W	A	200	100	60	O	20		.1M	.4	10M	70	E	70M	T
2N2592	S	P			VID	.4W	A	200	100	60	O	40		.1M	.4	10M	115	E	90M	T
2N2593	S	P			VID	.4W	A	200	100	60	O	60		.1M	.4	10M	160	E	110M	T
2N2594	S	N			AFA	5W	C	200	80	90	R	50	150	100M	1	200M	15	E	40M	T
2N2595	S	P			VIO	.4W	A	200	80	60	D	15	60	5M	.5	10M	20	E	30M	T
2N2596	S	P			VID	.4W	A	200	80	60	O	30	120	5M	.5	10M	40	E	40M	T
2N2597	S	P			VID	.4W	A	200	80	60	O	60	240	5M	.5	10M	80	E	60M	T
2N2598	S	P			VID	.4W	A	200	125	80	O	15	60	5M	.5	10M	20	E	30M	T
2N2599	S	P			VID	.4W	A	200	125	80	O	30	120	5M	.5	10M	40	E	40M	T
2N2599A	S	P			VID	.4W	A	200	125	100	O	30	120	5M	.5	10M	40	E	40M	T
2N2600	S	P			VID	.4W	A	200	125	80	O	60	240	5M	.5	10M	80	E	60M	T
2N2600A	S	P			VID	.4W	A	200	125	100	O	60	240	5M	.5	10M	80	E	60M	T
2N2601	S	P			VID	.4W	A	200	60	60	O	12		1M	.5	10M	18	E	20M	T
2N2602	S	P			VID	.4W	A	200	60	60	O	25		1M	.5	10M	36	E	40M	T
2N2603	S	P			VID	.4W	A	200	60	60	O	50		1M	.5	10M	76	E	60M	T
2N2604	S	P			VID	.4W	A	200	60	45	O	40		10*	.5	10M	60	E	30M	T
2N2605	S	P	2N3798	8-208	VID	.4W	A	200	60	45	D	100		10*	.5	10M	150	E	30M	T
2N2605A	S	P			VID	.4W	A	200	60	45	O	50	200	1*	.25	10M	200	E	45M	T
2N2606 thru 2N2609	Field Effect Transistors, see Table on Page 1-171																			
2N2610	S	N			AFA	.15W	A	150	45	40	O				1	5M	4.5	E		
2N2611	S	N			LPA	2W	A	175	120	100	O	7	36	.2A	1.7	.2A	12	E	4M	T
2N2612	G	P	2N1559	6-63	LPA	75W	C	100	65	65	V	85	250	10A	1	10A				
2N2613	G	P	2N1193	7-30	AFA	120M	A	100	30	25	R						120	E	4M	B
2N2614	G	P	2N1193	7-30	AFA	120M	A	100	40	35	R						100	E	4M	B
2N2615	S	N			SPP	300M	A	200	30	15	O	20	200	3M	.5	3M			500M	T
2N2616	S	N			SPP	300M	A	200	30	15	O	20	200	3M	.4	10M			600M	T
2N2617	S	P			AFC	.25W	A	150	25			15	80	20M			25	E		
2N2618	S	N			VID	.6W	A	200	60	40	O	25		10M			30	E	200M	T
2N2619	Thyristor, see Table on Page 1-161																			
2N2621	G	P			RFC	150M	J	100	15	15	S	15		1M						
2N2622	G	P			RFC	150M	J	100	24	24	S	15		1M						
2N2623	G	P			RFC	150M	J	100	32	32	S	20		1M						
2N2624	G	P			RFC	150M	J	100	15	15	S	20		1M						
2N2625	G	P			RFC	150M	J	100	24	24	S	15		1M						
2N2626	G	P			RFC	150M	J	100	32	32	S	20		1M						
2N2627	G	P			RFC	150M	J	100	15	15	S	15		1M						
2N2628	G	P			RFC	150M	J	100	24	24	S	15		1M						
2N2629	G	P			RFC	150M	J	100	32	32	S	10		1M						
2N2630	G	P			HSS	300M	A	100	18	10	O	25		100M	.45	100M	3	E		
2N2631	S	N			AFA	8.75W	C	200	80	80	V	8		200M						
2N2632	S	N	2N3487	6-107	LPA	40W	C	175	90	60	O	40	120	1A	.25	1A	40	E	20M	T
2N2633	S	N	2N3488	6-107	LPA	40W	C	175	120	80	O	40	120	1A	.25	1A	40	E	20M	T
2N2634	S	N	2N3489	6-107	LPA	40W	C	175	150	100	O	40	120	1A	.25	1A	40	E	20M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N2635	G	P		8-109	HSS	150M	A	100	30	12	0	45	300	50M	.2	10M			150M	T
2N2636	G	P			PMS	100W	C	110	100	60	0	20	80	25A	.65	25A			.6M	T
2N2637	G	P			PMS	100W	C	110	100	60	0	20	80	25A	.65	25A			.6M	T
2N2638	G	P			PMS	100W	C	110	100	60	0	20	80	25A	.65	25A			.6M	T
2N2639	S	N			AFA	300M	A	175	45	45	0	50	300	10*	1	10M	65	E	33M	T
2N2640	S	N			AFA	300M	A	175	45	45	0	50	300	10*	1	10M	65	E	33M	T
2N2641	S	N			AFA	300M	A	175	45	45	0	50	300	10*	1	10M	65	E	33M	T
2N2642	S	N			AFA	300M	A	175	45	45	0	100	300	10*	1	10M	130	E	33M	T
2N2643	S	N			AFA	300M	A	175	45	45	0	100	300	10*	1	10M	130	E	33M	T
2N2644	S	N			AFA	300M	A	175	45	45	0	100	300	10*	1	10M	130	E	33M	T
2N2645	S	N			AFA	500M	A	200	75	50	R	100	300	150M	.4	10M	75	E	50M	T
2N2646 2N2647	Unijunction Transistors, see Table on Page 1-177																			
2N2648	G	P			MSA	5W	C	100	35	10	0	80	500	1A	.4	1A			10M	T
2N2649	S	N			HPA	8.7W	C	200	65	65	0	10		.5A					100M	T
2N2650	S	N			HPA	8.7W	C	200	140	140	0	10		.5A					100M	T
2N2651	S	N	2N2501	8-104	HSS	360M	A	200	40	20	0	25		10M	.25	10M			350M	T
2N2652	S	N	2N2060	11-4	OFA	.3W	A	200	100	60	0	50	200	1M	1.2	50M	50	E	60M	T
2N2652A	S	N	2N2060	11-4	OFA	.3W	A	200	100	60	0	50	200	1M	1.2	50M	50	E	60M	T
2N2653	Thyristor, see Table on Page 1-161																			
2N2654		P			RFC	.1W	A	75	25			25		1M						
2N2655	S	N			LPA	15W	C	200	100	100	0	30	90	.2A	2	.2A	30	E	.25M	E
2N2656	S	N			RFA	.36W	A	200	25	15	0	40	160	.1M	.5	10M			250M	T
2N2657	S	N			PMS	1.25W	A	200	80	60	0	40	120	1A	.5	1A			20M	T
2N2658	S	N			PMS	1.25W	A	200	100	80	0	40	120	1A	.5	1A			20M	T
2N2659	G	P			LPA	15W	C	100	50	50	V	30	90	500M	.2	500M	30	E	280K	T
2N2660	G	P			LPA	15W	C	100	70	70	V	30	90	500M	.2	500M	30	E	280K	T
2N2661	G	P			LPA	15W	C	100	90	90	V	30	90	500M	.2	500M	30	E	280K	T
2N2662	G	P			LPA	15W	C	100	50	50	V	30	90	500M	.2	500M	30	E	280K	T
2N2663	G	P			LPA	15W	C	100	70	70	V	30	90	500M	.2	500M	30	E	280K	T
2N2664	G	P			LPA	15W	C	100	90	90	V	30	90	500M	.2	500M	30	E	280K	T
2N2665	G	P			LPA	15W	C	100	50	50	V	50	150	500M	.2	500M	50	E	300K	T
2N2666	G	P			LPA	15W	C	100	70	70	V	50	150	500M	.2	500M	50	E	300K	T
2N2667	G	P			LPA	15W	C	100	90	90	V	50	150	500M	.2	500M	50	E	300K	T
2N2668	G	P			LPA	15W	C	100	50	50	V	50	150	500M	.2	500M	50	E	300K	T
2N2669	G	P			LPA	15W	C	100	70	70	V	50	150	500M	.2	500M	50	E	300K	T
2N2670	G	P			LPA	15W	C	100	70	70	V	50	150	500M	.2	500M	50	E	300K	T
2N2671		P			RFC	.1W	A	75	25			40		1M						
2N2672		P			RFC	.1W	A	90	25			40		1M						
2N2672A		P			RFC	.1W	A	90	32	32	S	40		1M						
2N2673	S	N			AFA	250M	A	200	60	45	0	8	22	1M	1.5	5M	9	E	2.5M	B
2N2674	S	N			AFA	250M	A	200	60	45	0	12	40	1M	1.5	5M	18	E	5M	B
2N2675	S	N			AFA	250M	A	200	60	45	0	22	76	1M	1.5	5M	37	E	10M	B
2N2676	S	N			AFA	250M	A	200	60	45	0	45	290	1M	1.5	5M	76	E	10M	B
2N2677	S	N			AFA	250M	A	200	45	35	0	20	55	1M	1.5	5M	19	E	10M	B
2N2678	S	N			AFA	250M	A	200	45	35	0	45	150	1M	1.5	5M	39	E	20M	B
2N2679 thru 2N2690	Thyristors, see Table on Page 1-161																			
2N2691	G	P			PMS	100W	C	110	100	80	0	30	100	20A	.65	20A			6M	T
2N2692	S	N			HSS	300M	A	175	45	30	0	90	360	100*	.12	100*			42M	T
2N2693	S	N			HSS	300M	A	175	45	30	0	40		10*	.12	100*			42M	T
2N2694	S	N			HSS	300M	A	175	45	20	0	20		10*	.12	100*			42M	T
2N2695	S	P			MNS	360M	A	200	25	25	0	30	130	50M	.25	50M	25	E	100M	T
2N2696	S	P	2N2837	8-111	MNS	360M	A	200	25	25	0	30	130	50M	.25	50M	25	E	100M	T
2N2697	S	N			PMS	18W	C	200	80	60	0	40	120	1A	.5	1A			20M	T
2N2698	S	N			PMS	18W	C	200	100	80	0	40	120	1A	.5	1A			20M	T
2N2699	G	P	2N964	8-48	HSS	150M	A	100	15	8	0	40	200	10M	.18	10M			300M	T
2N2706	G	P			AFC	.5W	A	75	32	32	S	65	120	20M			80	E	1.3M	B
2N2707	G																			
2N2708	S	N			RFC	200M	A	200	35	20	0	30	200	2M			30	E		
2N2709	S	P	2N2800	8-111	AFA	240M	A	160	50	35	0	10	22	.2M	.4	8M			200K	B
2N2710	S	N			HSS	360M	A	200	40	20	0	40		10M	.25	10M			500M	T
2N2711	S	N	MPS2711	8-281	AFC	.2W	A	125	18	18	0	30	90	2M			30	E		
2N2712	S	N	MPS2712	8-281	AFC	.2W	A	125	18	18	0	75	225	2M			80	E		
2N2713	S	N	MPS2713	8-283	AFC	.2W	A	125	18	18	0	30	90	2M	.3	50M	30	E		
2N2714	S	N	MPS2714	8-283	AFC	.2W	A	125	18	18	0	75	225	2M	.3	50M	80	E		
2N2715	S	N	MPS2715	8-281	AFC	.2W	A	125	18	18	0	30	90	2M			30	E		
2N2716	S	N	MPS2716	8-281	AFC	.2W	A	125	18	18	0	75	225	2M			80	E		
2N2717	G	P			HSS	.1W	A	75	20	15	0	50		30M	.35	10M			300M	T

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N2718	G	P			HSS	240M	A	100	20	12	0	25		170M	.27	170M			150M	T
2N2719	S	N			HSS	300M	A	175	25	8	0	30		60M	.40	60M			200M	T
2N2720	S	N	2N2060	11-4	DFA	.3W	A	200	80	60	0	30	120	.1M	1	10M	30	E	80M	T
2N2721	S	N	2N2060	11-4	DFA	.3W	A	200	80	60	0	30	120	.1M	1	10M	30	E	80M	T
2N2722	S	N	2N2916	11-7	DFA	.3W	A	200	45	45	0	50	250	1*	1	10M	100	E	100M	T
2N2723	S	N			SPP	.5W	A	200	80	60	0	2K	10K	10M	1	10M	1500	E	100M	T
2N2724	S	N			SPP	.5W	A	200	80	60	0	7K	50K	10M	1	10M	5000	E	100M	T
2N2725	S	N			SPP	.5W	A	200	45	45	0	2K	10K	.1M	1	10M	1500	E	100M	T
2N2726	S	N			HPA	1W	A	200	200	200	R	30	90	.2A	2	.2A	30	E	15M	T
2N2727	S	N			HPA	1W	A	200	200	200	R	75	150	.2A	2	.2A	75	E	15M	T
2N2728	G	P		6-85	PHS	170W	C	110	15	5	0	40	130	20A	.1	50A			3K	E
2N2729	S	N			RFA	300M	A	200	30	15	0	20	200	3M	.4	10M			600M	T
2N2730	G	P	MP506	6-168	PMS	170W	C	110	80	60	0	30	120	25A	.25	25A			200K	T
2N2731	G	P	MP505	6-168	PMS	170W	C	110	60	45	0	30	120	25A	.25	25A			200K	T
2N2732	G	P	MP504	6-168	PMS	170W	C	110	40	30		30	120	25A	.25	25A			200K	T
2N2733	G	P	MP506	6-168	PMS	140W	C	110	80	60	0	30	120	25A	.25	25A			200K	T
2N2734	G	P	MP505	6-168	PMS	140W	C	110	60	45	0	30	120	25A	.25	25A			200K	T
2N2735	G	P	MP504	6-168	PMS	140W	C	110	40	30	0	30	120	25A	.25	25A			200K	T
2N2736	G	P	MP506	6-168	PMS	140W	C	110	80	60	0	30	120	25A	.25	25A			200K	T
2N2737	G	P	MP505	6-168	PMS	140W	C	110	60	45	0	30	120	25A	.25	25A			200K	T
2N2738	G	P	MP504	6-168	PMS	140W	C	110	40	30	0	30	120	25A	.25	25A			200K	T
2N2739	S	N			PMS	200W	C	175	50	50	V	10		10A	1.5	10A				
2N2740	S	N			PMS	200W	C	175	100	100	V	10		10A	1.5	10A				
2N2741	S	N			PMS	200W	C	175	150	150	V	10		10A	1.5	10A				
2N2742	S	N			PMS	200W	C	175	200	200	V	10		10A	1.5	10A				
2N2743	S	N			PMS	200W	C	175	250	250	V	10		10A	1.5	10A				
2N2744	S	N			PMS	200W	C	175	300	300	V	10		10A	1.5	10A				
2N2745	S	N			PMS	200W	C	175	50	50	V	10		15A	1.5	15A				
2N2746	S	N			PMS	200W	C	175	100	100	V	10		15A	1.5	15A				
2N2747	S	N			PMS	200W	C	175	150	150	V	10		15A	1.5	15A				
2N2748	S	N			PMS	200W	C	175	200	200	V	10		15A	1.5	15A				
2N2749	S	N			PMS	200W	C	175	250	250	V	10		15A	1.5	15A				
2N2750	S	N			PMS	200W	C	175	300	300	V	10		15A	1.5	15A				
2N2751	S	N			PMS	200W	C	175	50	50	V	10		20A	1.5	20A				
2N2752	S	N			PMS	200W	C	175	100	100	V	10		20A	1.5	20A				
2N2753	S	N			PMS	200W	C	175	150	150	V	10		20A	1.5	20A				
2N2754	S	N			PMS	200W	C	175	200	200	V	10		20A	1.5	20A				
2N2755	S	N			PMS	200W	C	175	250	250	V	10		20A	1.5	20A				
2N2756	S	N			PMS	200W	C	175	300	300	V	10		20A	1.5	20A				
2N2757	S	N			PMS	200W	C	175	50	50	V	10		10A	1.5	10A				
2N2758	S	N			PMS	200W	C	175	100	100	V	10		10A	1.5	10A				
2N2759	S	N			PMS	200W	C	175	150	150	V	10		10A	1.5	10A				
2N2760	S	N			PMS	200W	C	175	200	200	V	10		10A	1.5	10A				
2N2761	S	N			PMS	200W	C	175	250	250	V	10		10A	1.5	70A				
2N2762	S	N			PMS	200W	C	175	300	300	V	10		10A	1.5	10A				
2N2763	S	N			PMS	200W	C	175	50	50	V	10		15A	1.5	15A				
2N2764	S	N			PMS	200W	C	175	100	100	V	10		15A	1.5	15A				
2N2765	S	N			PMS	200W	C	175	150	150	V	10		15A	1.5	15A				
2N2766	S	N			PMS	200W	C	175	200	200	V	10		15A	1.5	15A				
2N2767	S	N			PMS	200W	C	175	250	250	V	10		15A	1.5	15A				
2N2768	S	N			PMS	200W	C	175	300	300	V	10		15A	1.5	15A				
2N2769	S	N			PMS	200W	C	175	50	50	V	10		20A	1.5	20A				
2N2770	S	N			PMS	200W	C	175	100	100	V	10		20A	1.5	20A				
2N2771	S	N			PMS	200W	C	175	150	150	V	10		20A	1.5	20A				
2N2772	S	N			PMS	200W	C	175	200	200	V	10		20A	1.5	20A				
2N2773	S	N			PMS	200W	C	175	250	250	V	10		20A	1.5	20A				
2N2774	S	N			PMS	200W	C	175	300	300	V	10		20A	1.5	20A				
2N2775	S	N			PMS	200W	C	175	50	50	V	10		25A	1.5	25A				
2N2776	S	N			PMS	200W	C	175	100	100	V	10		25A	1.5	25A				
2N2777	S	N			PMS	200W	C	175	150	150	V	10		25A	1.5	25A				
2N2778	S	N			PMS	200W	C	175	200	200	V	10		25A	1.5	25A				
2N2779	S	N			PMS	200W	C	175	250	250	V	10		25A	1.5	25A				
2N2780	S	N			PMS	200W	C	175	300	300	V	10		25A	1.5	25A				
2N2781	S	N			HPA	200W	C	175	75	30	0	7.5	75	.35A	5	1A			75M	T
2N2782	S	N			HPA	200W	C	175	100	40	0	7.5	75	.35A	5	1A			75M	T
2N2783	S	N			HPA	200W	C	175	100	40	0	7.5	75	.35A	5	1A			75M	T
2N2784	S	N			HNS	200W	C	200	15	6	0	40		30M	.26	3M			1G	T
2N2785	S	N			AFA	200W	C	175	60	40	0	2K	20K	.1A	1	15M	600	E	10M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N2786	G	P			RFA	1.5W	C	90	35	20	0	33	200	.1A							
2N2786A	G	P			RFA	1.5W	C	90	35	20	0	33	200	.1A							
2N2787	S	N	2N2218	8-74	HSA	800M	A	175	75	35	0	20	60	150M	.4	150M	15	E	250M	T
2N2788	S	N	2N2218A	8-74	HSA	800M	A	175	75	35	0	40	120	150M	.4	150M	30	E	250M	T
2N2789	S	N	2N2219A	8-74	HSA	800M	A	175	75	35	0	100	300	150M	.4	150M	80	E	250M	T
2N2790	S	N	2N2218	8-74	HSA	500M	A	175	75	35	0	20	60	150M	.4	150M	15	E	250M	T
2N2791	S	N	2N2221A	8-74	HSA	500M	A	175	75	35	0	40	120	150M	.4	150M	30	E	250E	T
2N2792	S	N	2N2222A	8-74	HSA	500M	A	175	75	35	0	100	300	150M	.4	150M	80	E	250E	T
2N2793	G	P			HPA	170W	C	110	75	60	0	50	100	15A	.45	50A	20	E	2K	E
2N2795	G	P			HSS	75M	A	100	25	15	0	50		50M	.125	50M			300M	T
2N2796	G	P			HSS	75M	A	100	20	12	0	30		50M	.25	50M			300M	T
2N2797	G	P			HSS	75M	A	100	40	20	0	40		50M	.2	50M			150M	T
2N2798	G	P			HSS	75M	A	100	60	25	0	20		50M	.25	50M			120M	T
2N2799	G	P			HSS	75M	A	100	30	15	0	20		50M	.25	50M			120M	T
2N2800	S	P		8-111	HSS	.8W	A	200	50	35	0	30	90	150M	.4	150M			120M	T
2N2801	S	P		8-111	HSS	.8W	A	200	50	35	0	75	225	150M	.4	150M			120M	T
2N2802	S	P			LPA	250M	A	175	25	20	0	20	120	100*	.5	10M	20	E	60M	T
2N2803	S	P			LPA	250M	A	175	25	20	0	20	120	10*	.5	10M	20	E	60M	T
2N2804	S	P			LPA	250M	A	175	25	20	0	20	120	100*	.5	10M	20	E	60M	T
2N2805	S	P			LPA	250M	A	175	25	20	0	40	120	10*	.5	10M	40	E	60M	T
2N2806	S	P			LPA	250M	A	175	25	20	0	40	120	10*	.5	10M	40	E	60M	T
2N2807	S	P			LPA	250M	A	175	25	20	0	40	120	100*	.5	10M	40	E	60M	T
2N2808	S	N			RFA	300M	A	200	30	10		20	120	2M	.25	4M	20	E	1G	T
2N2808A	S	N			RFA	200M	A	200	30	10	0	20	120	2M	.25	4M	7	E	1.5G	T
2N2809	S	N			RFA	200M	A	200	30	15	0	20	120	2M	.25	4M	20	E	600M	T
2N2809A	S	N			RFA	200M	A	200	30	15	0	20	120	2M	.25	4M	20	E	1G	T
2N2810	S	N			RFA	200M	A	200	24	10	0	20	120	2M	.25	4M	20	E	600M	T
2N2810A	S	N			RFA	200M	A	200	24	10	0	20	120	2M	.25	4M	20	E	1G	T
2N2811	S	N	2N3487	6-107	LPA	70W	J	200	80	60	0	20	60	5A	.5	5A	20	E	15M	T
2N2812	S	N	2N3488	6-107	LPA	70W	J	200	80	60	0	40	120	5A	.5	5A	40	E	15M	T
2N2813	S	N	2N3489	6-107	LPA	70W	J	200	120	80	0	20	60	5A	.5	5A	20	E	15M	T
2N2814	S	N	2N3490	6-107	LPA	70W	J	200	120	80	0	40	120	5A	.5	5A	40	E	15M	T
2N2815	S	N			PMS	200W	C	200	80	80	0	10	50	10A	1.5	10A			.6M	T
2N2816	S	N			PMS	200W	C	200	100	100	0	10	50	10A	1.5	10A			.6M	T
2N2817	S	N			PMS	200W	C	200	150	150	0	10	50	10A	1.5	10A			.6M	T
2N2818	S	N			PMS	200W	C	200	200	200	0	10	50	10A	1.5	10A			.6M	T
2N2819	S	N			PMS	200W	C	200	80	80	0	10	50	15A	1.5	15A			.6M	T
2N2820	S	N			PMS	200W	C	200	100	100	0	10	50	15A	1.5	15A			.6M	T
2N2821	S	N			PMS	200W	C	200	150	150	0	10	50	15A	1.5	15A			.6M	T
2N2822	S	N			PMS	200W	C	200	200	200	0	10	50	15A	1.5	15A			.6M	T
2N2823	S	N			PMS	200W	C	200	80	80	0	10	40	20A	1.1	20A			.6M	T
2N2824	S	N			PMS	200W	C	200	100	100	0	10	40	20A	1.1	20A			.6M	T
2N2825	S	N			PMS	200W	C	200	150	150	0	10	40	20A	1.1	20A			.6M	T
2N2826	G	P			LPA	4.5W	C	95		15	0	75	200	100M	1	500M				
2N2827	G	P			LPA	4.5W	C	95		30	0	75	200	100M	1	500M				
2N2828	S	N			PMS	40W	C	200	80	60	0	20	60	.5A	.4	.5A			1M	T
2N2829	S	N			PMS	40W	C	200	80	60	0	20	60	1A	.3	1A			1M	T
2N2831	S	N			VID	360M	A	200	40	12	0	25		10M	0.25	10M	40	E	250M	T
2N2832	G	P		8-113	PMS	85W	C	110	80	50	0	25	100	10A	.5	20A			10M	T
2N2833	G	P		6-87	PMS	85W	C	110	120	75	0	25	100	10A	.5	20A			10M	T
2N2834	G	P		8-113	PMS	85W	C	110	140	100	0	25	100	10A	.5	20A				
2N2835	G	P			AFC	16W	C	90	32	32	R	30	100	1A	.4	1A			.3M	B
2N2836	G	P	2N3612	6-110	LPA	37.5W	C	100	55	55	R	30	100						250K	B
2N2837	S	P		8-111	HSS	.5W	A	200	50	35	0	30	90	150M	.4	150M			120M	T
2N2838	S	P		8-111	HSS	.5W	A	200	50	35	0	75	225	150M	.4	150M			120M	T
2N2840	Unijunction Transistor, see Table on Page 1-177																			
2N2841 thru 2N2844	Field Effect Transistors, see Table on Page 1-171																			
2N2845	S	N	2N2539	8-107	MSS	360M	A	200	60	30	0	30	120	150M	.4	150M			250M	T
2N2846	S	N	2N2537	8-107	MSS	800M	A	200	60	30	0	30	120	150M	.4	150M			250M	T
2N2847	S	N	2N2539	8-107	MSS	360M	A	200	60	20	0	40	140	150M	.4	150M			250M	T
2N2848	S	N	2N2538	8-107	MSS	800M	A	200	60	20	0	40	140	150M	.4	150M			250M	T
2N2849	S	N			HSS	850M	A	200	100	80	0	100	300	1A	.4	1A			30M	T
2N2850	S	N			HSS	850M	A	200	100	80	0	40	120	1A	.25	1A			30M	T
2N2851	S	N			HSS	850M	A	200	100	80	0	40	120	1A	.4	1A			30M	T
2N2852	S	N			HSS	850M	A	200	100	80	0	20	60	1A	.4	1A			30M	T
2N2853	S	N			HSS	850M	A	200	60	40	0	40		1A	1.5	5A			30M	T

2N2854—2N2914

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units	Subscript
2N2854	S	N			HSS	850M	A	200	60	40	0	100	300	1A	.4	1A			30M	T
2N2855	S	N			HSS	850M	A	200	60	40	0	40	120	1A	.4	1A			30M	T
2N2856	S	N			HSS	850M	A	200	60	40	0	20	60	1A	.4	1A			30M	T
2N2857	S	N			RFA	200M	A	200	30	15	0	30	150	2M			50	E	1G	T
2N2858	S	N			PMS	.6W	C	200	100	80	0	20	60	1A	.3	1A			1M	T
2N2859	S	N			PMS	.6W	C	200	120	100	0	20	60	1A	.3	1A			1M	T
2N2860	G	P			HSS	150M	A	100	18	7	0	40		40M	0.4	36M			250M	T
2N2861	S	P			AFA	300M	A	200	25	20	0	30	120	10*	.2	10M	50	E	60M	T
2N2862	S	P			AFA	300M	A	200	25	20	0	12	120	10*	.2	10M	25	E	45M	T
2N2863	S	N			RFA	800M	A	200	60	25	0	30	200	200M	1	500M			150M	T
2N2864	S	N			RFA	800M	A	200	60	25	0	20	200	200M	1	500M			150M	T
2N2865	S	N			RFA	200M	A	200	25	13	0	20	200	4M	.4	10M	20	E	600M	T
2N2866	S	N			HPA	40W	C	175	120	80	0	20	60	.5A	.75	1A			10M	T
2N2867	S	N			HPA	40W	C	175	120	80	0	40	120	.5A	.75	1A			10M	T
2N2868	S	N	2N3252	8-147	HSA	.8W	A	200	60	40	0	40	120	.15A	.25	.15A			50M	T
2N2869	G	P	2N3614	6-110	LPA	30W	C	100	60	50	0	50	165	1A	.75	10A			200K	T
2N2870	G	P	2N3617	6-113	LPA	30W	C	100	80	50	0	50	165	1A	.5	10A			200K	T
2N2871	S	P			CHP	.4W	A	200	60	60	0	15		1M					.2M	T
2N2872	S	P			CHP	.4W	A	200	110	110	0	15		1M					.2M	T
2N2873	G	P			RFC	115M	A	100	35	35	V	40		1M			40	E	300M	T
2N2874	S	N			HPA	2W	A	175	75	40	0	7.5	75	.35A	5	1A			140M	T
2N2875	S	P			HPA	20W	C	200	60	50	0	15	60	50M	1.5	.5A	20	E	25M	E
2N2876	S	N			RFA	17.5W	C	200	80	60	0	5		2.5A	1	2.5A			150M	T
2N2877	S	N			HPA	53W	C	200	80	60	0	20	60	1A	.25	1A	20	E	30M	T
2N2878	S	N			HPA	53W	C	200	80	60	0	40	120	1A	.25	1A	40	E	50M	T
2N2879	S	N			HPA	53W	C	200	100	80	0	20	60	1A	.25	1A	20	E	30M	T
2N2880	S	N			HPA	53W	C	200	100	80	0	40	120	1A	.25	1A	40	E	50M	T
2N2881	S	P	2N3740	6-129	LPA	8.5W	C	200	60	60	0	20	60	.5A	.4	.5A	10	E	25K	E
2N2882	S	P	2N3741	6-129	LPA	8.5W	C	200	100	100	0	20	60	.5A	.4	.5A	10	E	25K	E
2N2883	S	N	2N3309	9-64	HPA	800M	A	200	40	20	0	20		100M	.5	100M			400M	T
2N2884	S	N	2N3309	9-64	HPA	800M	A	200	40	20	0	20		100M	.5	100M			400M	T
2N2885	S	N			HSS	.15W	A	175	40	15	0	30	120	10M	.4	10M			300M	T
2N2886	S	N			AFA	800M	A	200	50	40	0	22	45	5M	1.2	8M				
2N2887	S	N			HPA	25W	C	200	100	80	0	15	80	.35A	1.2	1A			140M	T
2N2888 2N2889	Thyristors, see Table on Page 1-161																			
2N2890	S	N	2N3507	8-167	PMS	800M	A	200	100	80	0	30	90	1A	.5	1A	30	E	30M	T
2N2891	S	N	2N3507	8-167	PMS	800M	A	200	100	80	0	50	150	1A	.5	1A	50	E	30M	T
2N2892	S	N			PMS	30W	C	200	100	80	0	30	90	1A	.5	1A	30	E	30M	T
2N2893	S	N			PMS	30W	C	200	100	80	0	50	150	1A	.5	1A	50	E	30M	T
2N2894	S	P	2N3248	8-137	MSS	360M	A	200	12	12	0	40	150	30M	.15	10M			400M	T
2N2895	S	N			MSA	500M	A	200	120	65	0	40	120	150M	.6	150M	50	E	120M	T
2N2896	S	N			MSA	500M	A	200	140	90	0	60	200	150M	.6	150M	50	E	120M	T
2N2897	S	N			MSA	500M	A	200	60	45	0	50	200	150M	1	150M	50	E	120M	T
2N2898	S	N			MSA	500M	A	200	120	65	0	40	120	150M	.6	150M	50	E	120M	T
2N2899	S	N			MSA	500M	A	200	140	90	0	60	200	150M	.6	150M	50	E	120M	T
2N2900	S	N			MSA	500M	A	200	60	45	0	50	200	150M	1	150M	50	E	120M	T
2N2901	S	N			CHP	.36W	A	200	20	10	0	30		10M	.15	10M			300M	T
2N2902	S	N			LPA	40W	C	200	120	120	0	30	90	500M	7.5	500M	30	E	2M	T
2N2903	S	N	2N2917	11-7	DFA	600M	C	200	60	30	0	125	625	1M	1	5M	150	E	60M	T
2N2903A	S	N	2N2915	11-7	DFA	600M	C	200	60	30	0	125	625	1M	1	5M	150	E	60M	T
2N2904	S	P		8-115	HSS	3W	C	200	60	40	0	40	120	150M	.4	150M			200M	T
2N2904A	S	P		8-115	HSS	3W	C	200	60	60	0	40	120	150M	.4	150M			200M	T
2N2905	S	P		8-115	HSS	3W	C	200	60	40	0	100	300	150M	.4	150M			200M	T
2N2905A	S	P		8-115	HSS	3W	C	200	60	60	0	100	300	150M	.4	150M			200M	T
2N2906	S	P		8-115	HSS	1.8W	C	200	60	40	0	40	120	150M	.4	150M			200M	T
2N2906A	S	P		8-115	HSS	1.8W	C	200	60	60	0	40	120	150M	.4	150M			200M	T
2N2907	S	P		8-115	HSS	1.8W	C	200	60	40	0	100	300	150M	.4	150M			200M	T
2N2907A	S	P		8-115	HSS	1.8W	C	200	60	60	0	100	300	150M	.4	150M			200M	T
2N2908	S	N			LPA	75W	C	200	80	80	R	12	60	1A	10	1A	10	E	1M	E
2N2909	S	N			HSA	.4W	A	200	60	40	0	40	120	.15A	.25	.15A			50M	T
2N2910	S	N	2N3409	11-9	DFA	.3W	A	200	45	25	0	70		.1M	1	10M	50	E	11M	T
2N2911	S	N	2N3766	6-134	PMS	5W	C	200	150	125	0	20	60	1A	.3	1A			1M	T
2N2912	G	P		6-89	PMS	75W	C	110	15	6	0	75		10A	.5	25A			20M	T
2N2913	S	N		11-7	DFA	300M	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2914	S	N		11-7	DFA	300M	A	200	45	45	0	150	600	10*	.35	1M			60M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE-} (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_- Units	Subscript
2N2915	S	N		11-7	DFA	300M	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2916	S	N		11-7	DFA	300M	A	200	45	45	0	150	600	10*	.35	1M			60M	T
2N2917	S	N		11-7	DFA	.3W	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2918	S	N		11-7	DFA	.3W	A	200	45	45	0	150	600	10*	.35	1M			60M	T
2N2919	S	N		11-7	DFA	.3W	A	200	60	60	0	60	240	10*	.35	1M			60M	T
2N2920	S	N		11-7	DFA	.3W	A	200	60	60	0	150	600	10*	.35	1M			60M	T
2N2921	S	N			AFA	.2W	A	125	25	25	0						35	E		
2N2922	S	N	MPS6512	8-300	AFA	.2W	A	125	25	25	0						55	E		
2N2923	S	N	MPS2923	8-287	AFA	.2W	A	125	25	25	0						90	E		
2N2924	S	N	MPS2924	8-287	AFA	.2W	A	125	25	25	0						150	E		
2N2925	S	N	MPS2925	8-287	AFA	.2W	A	125	25	25	0						235	E		
2N2926	S	N	MPS2926	8-288	AFA	.2W	A	125	18	18	0						35	E		
2N2927	S	P			MNS	800M	A	200	25	25	0	30	130	50M	.25	50M	25	E	100M	T
2N2928	G	P			RFA	150M	A	100	15	13	0	.8	200	2M			.10	E	400M	T
2N2929	G	P		9-28	RFA	750M	C	100	25	10	0	10	100	10M	.5	50M	10	E	800M	T
2N2930	G	P	2N3427	7-41	MSS	250M	A	100	30	12	0	60	420	10M	.25	100M			4M	B
2N2931	S	N			AFC	50M	A	125	5	5	0	50		50M	.45	50M	30	E	20M	T
2N2932	S	N			AFC	50M	A	125	5	5	0	70		50M	.45	50M	70	E	20M	T
2N2933	S	N			AFC	50M	A	125	5	5	0	50		50M	.45	50M	45	E	20M	T
2N2934	S	N			AFC	50M	A	125	45	30	0	50		50M	.45	50M	30	E	20M	T
2N2935	S	N			AFC	50M	A	125	45	30	0	70		50M	.45	50M	70	E	20M	T
2N2936	S	N			LPA	300M	A	175	60	55	0	100	300	10*	.3	2M	150	E	30M	T
2N2937	S	N			LPA	300M	A	175	60	55	0	100	300	10*	.3	2M	150	E	30M	T
2N2938	S	N			HSS	300M	A	200	25	13	0	30		50M	.4	50M			500M	T
2N2939	S	N			HFA	.8W	A	300	75	60	0	60	240	.15A	.75	.15A			150M	T
2N2940	S	N			HFA	.8W	A	300	120	80	0	60	240	.15A	.75	.15A			150M	T
2N2941	S	N			HFA	.8W	A	200	150	100	0	60	240	.15A					150M	T
2N2942	G	P			HSS	150M	A	100	50	25	0	50		10M	.15	10M			150M	T
2N2943	G	P			HSS	150M	A	100	30	15	0	30		10M	.2	10M			120M	T
2N2944	S	P			CHP	400M	A	175	15	10	0	80		1M					10M	T
2N2945	S	P			CHP	400M	A	175	25	20	0	40		1M					5M	T
2N2946	S	P			CHP	400M	A	175	40	35	0	30		1M					3M	T
2N2947	S	N		9-30	MPA	25W	C	175	60	60	S	2.5	55	.4A	.5	1A			100M	T
2N2948	S	N		9-30	MPA	25W	C	175	40	40	S	2.5	100	.4A	.5	1A			100M	T
2N2949	S	N		9-33	MPA	6W	C	175	60	60	S	5	100	40M	.5	.4A			100M	T
2N2950	S	N		9-33	MPA	6W	C	175	60	60	S	5	100	40M	.5	.4A			100M	T
2N2951	S	N		9-35	MPA	3W	C	175	60	60	S	20	150	10M	.5	.15A			200M	T
2N2952	S	N		9-35	MPA	1.8W	C	175	60	60	S	20	150	10M	.5	.15A			200M	T
2N2953	G	P	2N1194	7-30	AFC	120M	A	100	30	25	R	100		50M			200	E		
2N2954	S	N			RFA	200M	A	200	30	20	0	25	300	2M			25	E	300M	T
2N2955	G	P		8-119	HSS	.15W	A	100	40			20	60	50M	.2	10M			200M	T
2N2956	G	P		8-119	HSS	.15W	A	100	40			40	120	50M	.18	10M			250M	T
2N2957	G	P		8-119	HSS	.15W	A	100	40			60		10M	.15	10M			300M	T
2N2958	S	N		8-125	HNS	3W	C	200	60	20	0	40	120	150M	.5	150M			250M	T
2N2959	S	N		8-125	HNS	3W	C	200	60	20	0	100	300	150M	.5	150M			250M	T
2N2960	S	N			HNS	3W	C	200	60	30	0	100	300	150M	0.5	150M			250M	T
2N2961	S	N			HNS	3W	C	200	60	30	0	100	300	150M	.5	150M			250M	T
2N2962	G	P			HPA	350M	A	100	40	18	0								660M	T
2N2963	G	P			HPA	350M	A	100	40	18	0								660M	T
2N2964	G	P			HPA	350M	A	100	30	15	0								660M	T
2N2965	G	P			HPA	350M	A	100	30	15	0								660M	T
2N2966	G	P	2N3283	9-44	RFA	60M	A	100	20	20	0	8	100	3M					500M	T
2N2967	S	N			HSS	300M	A	200	12	6	0	20	120	10M	.3	3M			400M	T
2N2968	S	P			BMS	150M	A	140	30	10	0	15			.6	10M			8M	T
2N2969	S	P			BMS	150M	A	140	30	10	0	15			.6	10M			8M	T
2N297D	S	P			BMS	150M	A	140	30	20	0	10			.8	10M			4M	T
2N2971	S	P			BMS	150M	A	140	30	20	0	10			.8	10M			4M	T
2N2972	S	N		11-7	DFA	.25W	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2973	S	N		11-7	DFA	.25W	A	200	45	45	0	150	600	10*	.35	1M			60M	T
2N2974	S	N		11-7	DFA	.25W	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2975	S	N		11-7	DFA	.25W	A	200	45	45	0	150	600	10*	.35	1M			60M	T
2N2976	S	N		11-7	DFA	250M	A	200	45	45	0	60	240	10*	.35	1M			60M	T
2N2977	S	N		11-7	DFA	250M	A	200	45	45	0	150	600	10*	.35	1M			60M	T
2N2978	S	N		11-7	DFA	250M	A	200	60	60	0	60	240	10*	.35	1M			60M	T

2N2979—2N3057A

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{fe}	Subscript	f— Units	Subscript
2N2979	S	N		11-7	DFA	.25W	A	200	60	60	0	150	600	10*	.35	1M		E	60M	T
2N2980	S	N	2N2060A	11-4	DFA	.25W	A	200	100	60	0	25	75	10*	1.2	50M	50	E	60M	T
2N2981	S	N	2N2223	11-4	DFA	.25W	A	200	100	60	0	50	200	10M	1.2	50M	40	E	50M	T
2N2982	S	N	2N2223A	11-4	DFA	.25W	A	200	100	60	0	50	200	10M	1.2	50M	40	E	50M	T
2N2983	S	N			LPA	1W	A	175	155	80	0	20	60	500M	.6	1A	20	E	60M	T
2N2984	S	N			LPA	1W	A	175	185	120	0	20	60	500M	.8	200M	20	E	60M	T
2N2985	S	N			LPA	1W	A	175	155	80	0	40	120	500M	.8	200M	40	E	60M	T
2N2986	S	N			LPA	1W	A	175	185	120	0	40	120	500M	.8	200M	40	E	60M	T
2N2987	S	N			LPA	1W	A	200	95	80	0	25	75	200M	.8	200M	25	E	30M	T
2N2988	S	N			LPA	1W	A	200	155	100	0	25	75	200M	.8	200M	25	E	30M	T
2N2989	S	N			LPA	1W	A	200	95	80	0	60	120	200M	.8	200M	50	E	30M	T
2N2990	S	N			LPA	1W	A	200	155	100	0	60	120	200M	.8	200M	50	E	30M	T
2N2991	S	N			LPA	2W	A	200	95	80	0	25	75	200M	.8	200M	25	E	30M	T
2N2992	S	N			LPA	2W	A	200	155	100	0	20		1M	.8	200M	25	E	30M	T
2N2993	S	N			LPA	2W	A	200	95	80	0	60	120	200M	.8	200M	50	E	30M	T
2N2994	S	N			LPA	2W	A	200	155	100	0	60	120	200M	.8	200M	50	E	30M	T
2N2995	S	N			HPA	1.5W	A	175	120	100	0	25	90	.2A	1.7	.2A	30	E	10M	T
2N2996	G	P	2N3283	9-44	RFA	75M	A	100	15	10	0	25	500	4M			35	E	400M	T
2N2997	G	P	2N3279	9-42	RFA	75M	A	100	30	15	0	40	500	4M			50	E	400M	T
2N2998	G	P	2N3284	9-44	RFA	75M	A	100	15	12	0	15	300	3M			20	E	600M	T
2N2999	G	P	2N3283	9-44	RFA	75M	A	100	15	10	0	10		3M			15	E	1.4G	T
2N3001 thru 2N3008	Thyristors, see Table on Page 1-161																			
2N3009	S	N	2N3511	8-172	HSS	360M	A	200	40	15	0	30	120	30M	.18	30M			350M	T
2N3010	S	N			HSS	300M	A	200	15	6	0	25	125	10M	.25	10M			600M	T
2N3011	S	N			HSS	360M	A	200	30	12	0	30	120	10M	.2	10M			400M	T
2N3012	S	P	MM2894	8-274	MSS	360M	A	200	12	12	0	30	120	30M	.15	10M			400M	T
2N3013	S	N	2N3511	8-172	HSS	360M	A	200	40	15	0	30	120	30M	.18	30M			350M	T
2N3014	S	N	2N3511	8-172	HSS	360M	A	200	40	20	0	30	120	30M	.18	10M			350M	T
2N3015	S	N	2N3537	8-107	HSS	800M	A	200	60	30	0	30	120	150M	.4	150M			250M	T
2N3016	S	N			HFA	3.33W	C	150	100	50	0	60	150	1A	.75	1A			200M	T
2N3017	S	N			HFA	3.33W	C	150	100	50	0	60	150	1A	.75	5A			200M	T
2N3018	S	N			HFA	25W	C	150	100	50	0	60	150	1A	.75	5A			200M	T
2N3019	S	N		8-127	RFA	.8W	A	200	140	80	0	100	300	.15A	.2	.15A	80	E	100M	T
2N3020	S	N		8-127	RFA	.8W	A	200	140	80	0	40	120	.15A	.2	.15A	30	E	80M	T
2N3021	S	P		6-91	PHS	25W	C	175	30	30	0	20	60	1A	1.5	3A			60M	T
2N3022	S	P		6-91	PHS	25W	C	175	45	45	0	20	60	1A	1.5	3A			60M	T
2N3023	S	P		6-91	PHS	25W	C	175	60	60	0	20	60	1A	1.5	3A			60M	T
2N3024	S	P		6-91	PHS	25W	C	175	30	30	0	50	180	1A	1	3A			60M	T
2N3025	S	P		6-91	PHS	25W	C	175	45	45	0	50	180	1A	1	3A			60M	T
2N3026	S	P		6-91	PHS	25W	C	175	60	60	0	50	180	1A	1	3A			60M	T
2N3027 thru 2N3032	Thyristors, see Table on Page 1-161																			
2N3033	S	N			SPP	300M	A	175	100	100	R				1	100M				
2N3034	S	N			SPP	300M	A	175	70	70	R				1	100M				
2N3035	S	N			SPP	300M	A	175	50	50	R				1	100M				
2N3036	S	N			AFA	800M	A	200	120	80	0	50	150	150M	.25	150M	40	E	50M	T
2N3037	S	N			AFA	360M	A	175	120	70	0	40	120	150M	.2	10M	30	E	50M	T
2N3038	S	N			AFA	360M	A	175	100	60	0	80	240	150M	.2	10M	60	E	50M	T
2N3039	S	P			AFA	360M	A	175	50	35	0	20	80	150M			20	E	50M	T
2N3040	S	P			AFA	360M	A	175	40	30	0	40	160	150M	.2	10M	40	E	50M	T
2N3043	S	N	2N2916	11-7	DFA	250M	A	175	45	45	0	100	300	10*	1	10M	130	E	30M	T
2N3044	S	N	2N2918	11-7	DFA	250M	A	175	45	45	0	100	300	10*	1	10M	130	E	30M	T
2N3045	S	N	2N2914	11-7	AFA	250M	A	175	45	45	0	100	300	10*	1	10M	130	E	30M	T
2N3046	S	N	2N2915	11-7	DFA	250M	A	175	45	45	0	50	200	10*	1	10M	65	E	30M	T
2N3047	S	N	2N2917	11-7	DFA	250M	A	175	45	45	0	50	200	10*	1	10M	65	E	30M	T
2N3048	S	N	2N2913	11-7	AFA	250M	A	175	45	45	0	50	200	10*	1	10M	65	E	30M	T
2N3049	S	P			DFA	250M	A	175	25	20	0	20	120	10*	.2	10M	30	E	60M	T
2N3050	S	P			DFA	250M	A	175	25	20	0	20	120	10*	.2	10M	30	E	60M	T
2N3051	S	P			AFA	250M	A	175	25	20	0	20	120	10*	.2	10M	30	E	60M	T
2N3052	S	N			HSS	250M	A	175	35	15	0	25	130	10M	.25	10M			200M	T
2N3053	S	N	2N3498	8-161	HSS	5W	C	200	60	40	0	50	250	.15A	1.4	.15A			100M	T
2N3054	S	N			LPA	25W	C	200	90	60	R	25	100	.5A	1	.5A	25	E	30K	E
2N3055	S	N		6-96	LPA	115W	C	200	100	70	R	20	70	4A	1.1	4A	15	E	20K	E
2N3056	S	N			RFA	.4W	A	200	100	60	0	40	120	.15A	.25	.15A	30	E	80M	T
2N3056A	S	N			RFA	.4W	A	200	140	80	0	40	120	.15A	.2	.15A	30	E	80M	T
2N3057	S	N			RFA	.4W	A	200	100	60	0	100	300	.15A	.25	.15A	80	E	100M	T
2N3057A	S	N			RFA	.4W	A	200	140	80	0	100	300	.15A	.2	.15A	80	E	100M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N3058	S	P			AFA	400M	A	200	6	6	0	40	120	100N			40	E		
2N3059	S	P			AFA	400M	A	200	10	10	0	100	300	10*			100	E		
2N3060	S	P			AFA	400M	A	200	70	60	0	30	90	1M			30	E		
2N3061	S	P			AFA	400M	A	200	70	60	0	60	180	1M			60	E		
2N3062	S	P			AFA	400M	A	200	90	80	0	20	80	1M			20	E		
2N3063	S	P			AFA	400M	A	200	90	80	0	50	150	1M			50	E		
2N3064	S	P			AFA	400M	A	200	110	100	0	15	45	1M			15	E		
2N3065	S	P			AFA	400M	A	200	110	100	0	30	90	1M			30	E		
2N3066 thru 2N3071	Field Effect Transistors, see Table on Page 1-171																			
2N3072	S	P			MNS	800M	A	200	60	60	0	30	130	50M	.25	50M	25	E	130M	T
2N3073	S	P			MNS	360M	A	200	60	60	0	30	130	50M	.25	50M	25	E	130M	T
2N3074	G	P			RFA	.14W	A	85	30	25	S	25	300	3.5M						
2N3075	G	P			RFA	.14W	A	85	35	25	S	20	250	3M						
2N3076	S	N			PHS	125W	C	175	140	50	0	30	90	7A	1	10A	60	E	50M	T
2N3077	S	N			AFC	.36W	A	200	80	60	0	100	400	10*	.35	1M	120	E	15M	T
2N3078	S	N			AFC	.36W	A	200	80	60	0	40	120	10*	.35	1M	50	E	15M	T
2N3079	S	N			PMS	178W	C	150	200	200	0	7	40	5A	.7	5A			30K	E
2N3080	S	N			PMS	178W	C	150	300	300	0	7	40	5A	.7	5A			30K	E
2N3081	S	P			HSS	600M	A	200	70	50	0	20		500M	0.3	150M			150M	T
2N3082	S	N			CHP	.5W	A	200	25	7	0	100		.25M					100M	T
2N3083	S	N			CHP	.5W	A	200	25	7	0	100		.25M					100M	T
2N3084 thru 2N3089	Field Effect Transistors, see Table on Page 1-171																			
2N3091 thru 2N3106	Thyristors, see Table on Page 1-161																			
2N3107	S	N			MSS	.8W	A	200	100	60	0	100	300	.15A	1	1A	60	E	70M	T
2N3108	S	N			MSS	800M	A	200	100	60	0	40	120	150M	.25	150M			60M	T
2N3109	S	N			MSS	.8W	A	200	80	40	0	100	300	.15A	1	1A	60	E	70M	T
2N3110	S	N	2N2218A	8-74	MSS	800M	A	200	80	40	0	40	120	150M	.25	150M			60M	T
2N3112 2N3113	Field Effect Trnsistors, see Table on Page 1-171																			
2N3114	S	N	2N3500	8-129	VID	800M	A	200	150	150	0	30	120	30M	1	50M	25	E	40M	T
2N3115	S	N		8-125	HNS	.4W	A	200	60	20	0	40	120	.15A	.5	.15A			250M	T
2N3116	S	N		8-125	HNS	.4W	A	200	60	20	0	100	300	.15A	.5	.15A			250M	T
2N3117	S	N			AFC	360M	A	200	60	60	0	250	500	10*	.35	1M	400	E	60M	T
2N3118	S	N			RFA	1W	A	200	85	60	0	50	275	25M					250M	T
2N3119	S	N			HSA	1W	A	200	100	80	0	50	200	100M	.5	100M			250M	T
2N3120	S	P	2N2800	8-111	MNS	800M	A	200	45	45	0	30	130	50M	.25	50M	25	E	130M	T
2N3121	S	P	2N2837	8-111	MNS	360M	A	200	45	45	0	30	130	50M	.25	50M	25	E	130M	T
2N3122	S	N			AFA	800M	A	200	50	30	0	25	100	300M	1.5	300M			60M	T
2N3123	S	N			HSS	.8W	A	175	60	30	0	100	300	.15A	.4	.15A			400M	T
2N3124	G	P			LPA	90W	C	100	40	30	S	50	100	10A	.5	10A	20	E	2.5K	E
2N3125	G	P			LPA	90W	C	100	80	80	S	30	75	3A	1.5	3A	10	E	5K	E
2N3126	G	P			LPA	90W	C	100	100	75	S	10	30	10A	1	10A	10	E	6K	E
2N3127	G	P		9-38	RFA	.1W	A	100	30	20	0	20	75	3M	.3	5M	20	E	400M	T
2N3128	S	N			AFA	.15W	A	150	20	20	0	50	150	.1M	.25	1M	75	E	60M	T
2N3129	S	N			AFA	.15W	A	150	45	45	0	100	300	10N	.25	1M	160	E	60M	T
2N3130	S	N			AFA	.15W	A	150	60	60	0	60	180	10N	.25	1M	110	E	60M	T
2N3131	S	N			HSS	.15W	A	150	40	15	0	30	120	10M	.25	10M			250M	T
2N3132	G	P			PMS	90W	C	100	100	70	S	40	200	2A	1.5	5A			3K	E
2N3133	S	P		8-131	HSS	.6W	A	200	50	35	0	40	120	.15A	.6	.15A			200M	T
2N3134	S	P		8-131	HSS	.6W	A	200	50	35	0	100	300	.15A	.6	.15A			200M	T
2N3135	S	P		8-131	HSS	.4W	A	200	50	35	0	40	120	.15A	.6	.15A			200M	T
2N3136	S	P		8-131	HSS	.4W	A	200	50	35	0	100	300	.15A	.6	.15A			200M	T
2N3137	S	N		9-40	RFA	600M	A	200	40	20	0				.3	50M			500M	T
2N3138	S	N			HPA	20W	C	200	65	65	0	10		1A					100M	T
2N3139	S	N			HPA	20W	C	200	140	140	0	10		1A					100M	T
2N3140	S	N			HPA	20W	C	200	65	65	0	10		1A					100M	T
2N3141	S	N			HPA	20W	C	200	140	140	0	10		1A					100M	T
2N3142	S	N			HPA	25W	C	200	65	65	0	10		1A					100M	T
2N3143	S	N			HPA	25W	C	200	140	140	0	10		1A					100M	T
2N3144	S	N			HPA	25W	C	200	65	65	0	10		1A					100M	T
2N3145	S	N			HPA	25W	C	200	140	140	0	10		1A					100M	T
2N3146	G	P	2N3616	6-113	LPA	150W	C	100	150	140	V	30	90	5A	.4	5A	20	E	200K	T
2N3147	G	P	2N3616	6-113	LPA	150W	C	100	180	160	V	30	90	5A	.4	5A	20	E	200K	T
2N3148	G	P			MSS	.45M	A	100	11	6	0	70		20M	.2	50M	80	E	25M	T

2N3149—2N3217

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE}— (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_f—	Subscript	f_T— Units	Subscript
2N3149	S	N			PMS	300W	C	200	80	80	0	10		50A	1.5	50A			.1M	T
2N3150	S	N			PMS	300W	C	200	100	100	0	10		50A	1.5	50A			.1M	T
2N3151	S	N			PMS	300W	C	200	150	150	0	10		50A	1.5	50A			.1M	T
2N3152	S	N			VID	25M	C	200	120	120	0	40		30M			20	E	200M	T
2N3153	S	N			CHP	.3W	A	200	15	15	0								30M	T
2N3154	G	P			PMS	37.5W	C	100	40	25	0	60	180	.5A	1.1	3A			15K	E
2N3155	G	P			PMS	37.5W	C	100	60	40	0	60	180	.5A	1.1	3A			15K	E
2N3156	G	P			PMS	37.5W	C	100	80	55	0	60	180	.5A	1.1	3A			15K	E
2N3157	G	P			PMS	37.5W	C	100	100	65	0	60	180	.5A	1.1	3A			15K	E
2N3158	G	P			PMS	37.5W	C	100	40	25	0	30	75	.5A	1.4	3A			10K	E
2N3159	G	P			PMS	37.5W	C	100	60	40	0	30	75	.5A	1.4	3A			10K	E
2N3160	G	P			PMS	37.5W	C	100	80	55	0	30	75	.5A	1.4	3A			10K	E
2N3161	G	P			PMS	37.5W	C	100	100	65	0	30	75	.5A	1.4	3A			10K	E
2N3162	S	N	2N3411	11-9	DFA	300M	A	200	45	25	0	50	200	10M	.5	10M			300M	T
2N3163	S	P			HPA	85W	C	200	40	40	0	12	36	1A	.75	1A	10	E	1M	T
2N3164	S	P			HPA	85W	C	200	60	60	0	12	36	1A	75	1A	10	E	1M	T
2N3165	S	P			HPA	85W	C	200	80	80	0	12	36	1A	.75	1A	10	E	1M	T
2N3166	S	P			HPA	85W	C	200	100	100	0	12	36	1A	.75	1A	10	E	1M	T
2N3167	S	P	MJ2267	6-160	HPA	85W	C	200	40	40	0	12	36	1A	.75	1A	10	E	1M	T
2N3168	S	P	2N3789	6-139	HPA	85W	C	200	60	60	0	12	36	1A	.75	1A	10	E	1M	T
2N3169	S	P	2N3790	6-139	HPA	85W	C	200	80	80	0	12	36	1A	.75	1A	10	E	1M	T
2N3170	S	P	2N3790	6-139	HPA	85W	C	200	100	100	0	12	36	1A	.75	1A	10	E	1M	T
2N3171	S	P	MJ2267	6-160	HPA	75W	C	200	40	40	0	12	36	1A	.75	1A	10	E	1M	T
2N3172	S	P	2N3789	6-139	HPA	75W	C	200	60	60	0	12	36	1A	.75	1A	10	E	1M	T
2N3173	S	P	2N3790	6-139	HPA	75W	C	200	80	80	0	12	36	1A	.75	1A	10	E	1M	T
2N3174	S	P	2N3790	6-139	HPA	75W	C	200	100	100	0	12	36	1A	.75	1A	10	E	1M	T
2N3175	S	P	MJ2267	6-160	HPA	85W	C	200	40	40	0	10	30	2A	1	2A	10	E	1M	T
2N3176	S	P	2N3789	6-139	HPA	85W	C	200	60	60	0	10	30	2A	1	2A	10	E	1M	T
2N3177	S	P	2N3790	6-139	HPA	85W	C	200	80	80	0	10	30	2A	1	2A	10	E	1M	T
2N3178	S	P	2N3790	6-139	HPA	85W	C	200	100	100	0	10	30	2A	1	2A	10	E	1M	T
2N3179	S	P	MJ2267	6-160	HPA	85W	C	200	40	40	0	10	30	2A	1	2A	10	E	1M	T
2N3180	S	P	2N3789	6-139	HPA	85W	C	200	60	60	0	10	30	2A	1	2A	10	E	1M	T
2N3181	S	P	2N3790	6-139	HPA	85W	C	200	80	80	0	10	30	2A	1	2A	10	E	1M	T
2N3182	S	P	2N3790	6-139	HPA	85W	C	200	100	100	0	10	30	2A	1	2A	10	E	1M	T
2N3183	S	P	2N3789	6-139	HPA	75W	C	200	40	40	0	10	30	2A	1	2A	10	E	1M	T
2N3184	S	P	2N3789	6-139	HPA	75W	C	200	60	60	0	10	30	2A	1	2A	10	E	1M	T
2N3185	S	P	2N3790	6-139	HPA	75W	C	200	80	80	0	10	30	2A	1	2A	10	E	1M	T
2N3186	S	P	2N3790	6-139	HPA	75W	C	200	100	100	0	10	30	2A	1	2A	10	E	1M	T
2N3187	S	P	MJ2267	6-160	HPA	85W	C	200	40	40	0	10	30	3A	.9	3A	10	E	1M	T
2N3188	S	P	2N3789	6-139	HPA	85W	C	200	60	60	0	10	30	3A	.9	3A	10	E	1M	T
2N3189	S	P	2N3790	6-139	HPA	85W	C	200	80	80	0	10	30	3A	.9	3A	10	E	1M	T
2N3190	S	P	2N3790	6-139	HPA	85W	C	200	100	100	0	10	30	3A	.9	3A	10	E	1M	T
2N3191	S	P			HPA	85W	C	200	40	40	0	10	30	3A	.9	3A	10	E	1M	T
2N3192	S	P	2N3789	6-139	HPA	85W	C	200	60	60	0	10	30	3A	.9	3A	10	E	1M	T
2N3193	S	P	2N3790	6-139	HPA	85W	C	200	80	80	0	10	30	3A	.9	3A	10	E	1M	T
2N3194	S	P	2N3790	6-139	HPA	85W	C	200	100	100	0	10	30	3A	.9	3A	10	E	1M	T
2N3195	S	P			HPA	75W	C	200	40	40	0	10	30	3A	.9	3A	10	E	1M	T
2N3196	S	P	2N3789	6-139	HPA	75W	C	200	60	60	0	10	30	3A	.9	3A	10	E	1M	T
2N3197	S	P	2N3790	6-139	HPA	75W	C	200	80	80	0	10	30	3A	.9	3A	10	E	1M	T
2N3198	S	P	2N3790	6-139	HPA	75W	C	200	100	100	0	10	30	3A	.9	3A	10	E	1M	T
2N3199	S	P			HPA	40W	C	200	40	40	0	20	60	1A	.3	1A	10	E	1M	T
2N3200	S	P	2N3740	6-129	HPA	40W	C	200	60	60	0	20	60	1A	.3	1A	10	E	1M	T
2N3201	S	P	2N3741	6-129	HPA	40W	C	200	80	80	0	20	60	1A	.3	1A	10	E	1M	T
2N3202	S	P			HPA	8.8W	C	200	40	40	0	20	60	1A	.3	1A	10	E	1M	T
2N3203	S	P	2N3740	6-129	HPA	8.8W	C	200	60	60	0	20	60	1A	.3	1A	10	E	1M	T
2N3204	S	P	2N3741	6-129	HPA	8.8W	C	200	80	80	0	20	60	1A	.3	1A	10	E	1M	T
2N3205	S	P			HPA	40W	C	200	40	40	0	20	60	.5A	.4	.5A	10	E	1M	T
2N3206	S	P	2N3740	6-129	HPA	40W	C	200	60	60	0	20	60	.5A	.4	.5A	10	E	1M	T
2N3207	S	P	2N3741	6-129	HPA	40W	C	200	100	100	0	20	60	.5A	.4	.5A	10	E	1M	T
2N3208	S	P	2N3740	6-129	HPA	8.8W	C	200	40	40	0	20	60	.5A	.4	.5A	10	E	1M	T
2N3209	S	P	MM2894	8-274	MSS	.36W	A	200	20	20	0	30	120	30M	.2	30M			400M	T
2N3210	S	N			HSS	.36W	A	200	40	15	0	30	120	10M	.75	.2A			300M	T
2N3211	S	N			HSS	.36W	A	200	40	15	0	50	150	10M	.2	10M			350M	T
2N3212	G	P			LPA	14W	C	110	100	80	0	30	90	3A	.5	5A	3	E		
2N3213	G	P			LPA	14W	C	110	80	60		30	90	3A	.5	5A	3	E		
2N3214	G	P			LPA	14W	C	110	60	40		30	90	3A	.5	5A	3	E		
2N3215	G	P			LPA	14W	C	110	40	30		25	100	3A	.5	5A	3	E		
2N3216	G	P			MSS	150M	A	100	20	10	0	60		200M	.22	200M			10M	T
2N3217	S	P			CHP	400M	A	200	15	10	0								1M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS									
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units	Subscript
2N3218	S	P			CHP	400M	A	200	25	20	0								1M	T	
2N3219	S	P			CHP	400M	A	200	40	35	0								1M	T	
2N3220	S	N			HFA	6W	C	175	100	80	0	20	60	1A	1.25	1A	20	E	10M	T	
2N3221	S	N			HPA	6W	C	175	100	80	0	40	120	1A	1.25	1A	40	E	10M	T	
2N3222	S	N			HPA	6W	C	175	80	60	0	20	60	1A	1.25	1A	20	E	10M	T	
2N3223	S	N			HPA	6W	C	175	80	60	0	40	120	1A	1.25	1A	40	E	10M	T	
2N3224	S	P	2N3498	8-161	VID	.7W	A	200	100	100	0	20	60	50M			20	E	60M	T	
2N3225	S	P	2N3498	8-161	VID	.7W	A	200	100	100	0	40	120	50M			40	E	80M	T	
2N3226	S	N			LPA	75W	C	200	35	35	0	20	50	2A	1.2	2.7A	20	E	30K	E	
2N3227	S	N		8-92	HSS	.36W	A	200	40	20	0	100	300	10M	.25	10M			500M	T	
2N3228	Thyristor, see Table on Page 1-161																				
2N3229	S	N			HPA	17.5W	C	200	105	60	0	5		2.5A	1	2.5A			150M	T	
2N3230	S	N			PHS	25W	C	200	80	60	0	2K	20K	2A	1.4	2A			40M	T	
2N3231	S	N			PHS	225W	C	200	100	80	0	2K	20K	2A	1.4	2A			40M	T	
2N3232	S	N		6-98	HPA	117W	C	200	80	60	0	18	55	3A	2.5	3A	10	E	1M	E	
2N3233	S	N			HPA	117W	C	200	110	100	0	18	55	3A	2.5	3A	10	E	1M	E	
2N3234	S	N			HPA	117W	C	200	160	160	0	18	55	3A	2.5	3A	10	E	1M	E	
2N3235	S	N		6-98	HPA	117W	C	200	65	55	0	20	70	4A	1.1	4A	10	E	1M	E	
2N3236	S	N			HPA	150W	C	200	90	90	0	17	60	5A	1.1	5A	10	E	1M	E	
2N3237	S	N			HPA	200W	C	200	90	75	0	12	36	10A	2	10A	10	E	1M	E	
2N3238	S	N			HPA	150W	C	200	80	80	0	8.5	25	10A	3	10A	10	E	1M	E	
2N3239	S	N			HPA	150W	C	200	80	80	0	8.5	25	10A	1	10A	10	E	1M	E	
2N3240	S	N			HPA	150W	C	200	160	160	0	8.5	25	10A	1	10A	10	E	1M	E	
2N3241	S	N			LNA	.5W	A	175	30	25	0	50	300	10M			70	E	50M	T	
2N3242	S	N			LNA	.5W	A	175	30	25	0	75		10M			100	E	50M	T	
2N3244	S	P		8-131	HSS	1W	A	200	40	40	0	50	150	.5A	.3	.15A			175M	T	
2N3245	S	P		8-131	HSS	1W	A	200	50	50	0	30	90	.5A	.35	.15A			150M	T	
2N3246	S	N			LNA	.35W	A	200	60	45	0	200	600	10*	.5	5M	200	E	60M	T	
2N3247	S	N			LNA	.15W	A	150	60	45	0	200	600	10*	.5	5M	200	E	60M	T	
2N3248	S	P		8-137	HSS	.36W	A	200	15	12	0	50	150	.1M	.125	10M			250M	T	
2N3249	S	P		8-137	HSS	.36W	A	200	15	12	0	100	300	.1M	.125	10M			300M	T	
2N3250	S	P		8-141	HSS	.36W	A	200	50	40	0	50	150	10M	.25	10M	50	E	250M	T	
2N3250A	S	P		8-141	HSS	.36W	A	200	60	60	0	50	150	10M	.25	10M	50	E	250M	T	
2N3251	S	P		8-141	HSS	.36W	A	200	50	40	0	100	300	10M	.25	10M	100	E	300M	T	
2N3251A	S	P		8-141	HSS	.36W	A	200	60	60	0	100	300	10M	.25	10M	100	E	300M	T	
2N3252	S	N		8-147	HSS	1W	A	200	60	30	0	30	90	.5A	.3	.15A			200M	T	
2N3253	S	N		8-147	HSS	1W	A	200	75	40	0	25	75	375M	.35	.15A			175M	T	
2N3254 thru 2N3259	Thyristors, see Table on Page 1-161																				
2N3260	S	N			PMS	200W	C	200	200	200	0	10	40	20A	1.5	20A			.6M	T	
2N3261	S	N			HSS	.3W	A	175	40	15	0	40	150	10M	.35	.1A			600M	T	
2N3262	S	N			HSS	8.75W	C	200	100	80	0	40		.5A	.6	1A			150M	T	
2N3263	S	N			PMS	75W	C	200	150	90	0	20	55	15A	1	20A			20M	T	
2N3264	S	N			PMS	75W	C	200	120	60	0	20	80	15A	1.6	20A			20M	T	
2N3265	S	N			PMS	125W	C	200	150	90	0	20	55	15A	1	20A			20M	T	
2N3266	S	N			PMS	125W	C	200	120	60	0	20	80	15A	1.6	20A			20M	T	
2N3267	G	P			RFA	75M	A	100	15	8	0	10	500	3M			15	E	900M	T	
2N3268	S	N			AFA	.15W	A	200	45	45	0	12	80	10M	1	5M	40	E	2.5M	B	
2N3269 thru 2N3276	Thyristors, see Table on Page 1-161																				
2N3277 2N3278	Field Effect Transistors, see Table on Page 1-171																				
2N3279	G	P		9-42	RFA	.1W	A	100	30	20	0	10	70	3M	.3	5M	10	E	400M	T	
2N3280	G	P		9-42	RFA	.1W	A	100	30	20	0	10	70	3M	.3	5M	10	E	400M	T	
2N3281	G	P		9-42	RFA	.1W	A	100	30	15	0	10	100	3M	.5	5M	10	E	300M	T	
2N3282	G	P		9-42	RFA	.1W	A	100	30	15	0	10	100	3M	.5	5M	10	E	300M	T	
2N3283	G	P		9-44	RFC	.1W	A	100	25	25	S	10		3M			10	E	250M	T	
2N3284	G	P		9-44	RFC	.1W	A	100	25	25	S	10		3M			10	E	250M	T	
2N3285	G	P		9-44	RFC	.1W	A	100	20	20	S	5		3M			5	E	250M	T	
2N3286	G	P		9-44	RFC	.1W	A	100	20	20	S	5		3M			5	E	250M	T	
2N3287	S	N		9-47	RFA	.2W	A	200	40	20	0	15	100	2M	.3	5M	15	E	350M	T	
2N3288	S	N		9-47	RFA	.2W	A	200	40	20	0	15	100	2M	.3	5M	15	E	350M	T	
2N3289	S	N		9-47	RFA	.2W	A	200	30	15	0	10	150	2M	.4	5M	10	E	300M	T	
2N3290	S	N		9-47	RFA	.2W	A	200	30	15	0	10	150	2M	.4	5M	10	E	300M	T	
2N3291	S	N		9-49	RFC	.2W	A	200	25	25	S	10		2M			10	E	250M	T	
2N3292	S	N		9-49	RFC	.2W	A	200	25	25	S	10		2M			10	E	250M	T	
2N3293	S	N		9-49	RFC	.2W	A	200	20	20	S	10		2M			10	E	250M	T	
2N3294	S	N		9-49	RFC	.2W	A	200	20	20	S	10		2M			10	E	250M	T	

2N3295 — 2N3391A

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	V_{CE} (volts)	Subscript	ELECTRICAL CHARACTERISTICS h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	h_{f-}	Subscript	f_-	Units	Subscript
2N3295	S	N		9-51	MPA	800M	A	175	60	60	S	20	60	10M	.5	.15A			200M	T
2N3296	S	N		9-54	MPA	700M	A	175	60	60	S	5	50	40M	.5	.4A			100M	T
2N3297	S	N		9-57	MPA	25W	C	175	60	60	S	2.5	35	.4A	.5	1A			100M	T
2N3298	S	N		9-60	HPA	1W	C	175	25	15	0	80	240	10M					200M	T
2N3299	S	N	2N2218A	8-74	HSS	.8W	A	200	60	30	0	40	120	.15A	.22	.15A			250M	T
2N3300	S	N	2N2219A	8-74	HSS	.8W	A	200	60	30	0	100	300	.15A	.22	.15A			250M	T
2N3301	S	N	2N2221A	8-74	HSS	.36W	A	200	60	30	0	40	120	.15A	.22	.15A			250M	T
2N3302	S	N	2N2222A	8-74	HSS	.36W	A	200	60	30	0	100	300	.15A	.22	.15A			250M	T
2N3303	S	N		8-152	HSS	.6W	A	200	25	12	0	30	120	.3A	.33	.3A			450M	T
2N3304	S	P	2N3546	8-175	MSS	.3W	A	200	6	6	0	30	120	10M	.16	10M			500M	T
2N3305	S	P			AFA	.6W	A	200	50	40	0	40	120	.1M	.2	10M	40	E	20M	T
2N3306	S	P			AFA	.6W	A	200	50	40	0	100	300	.1M	.2	10M	70	E	20M	T
2N 3307				9-62	RFA	.2W	A	200	40	35	0	40	250	2M	.4	3M	40	E	300M	T
2N3308	S	P		9-62	RFA	.2W	A	200	30	25	0	25	250	2M	.4	3M	25	E	300M	T
2N3309	S	N	2N3309A	9-64	MPA	3.5W	C	175	50	50	S	5	100	30M	.5	.25A			300M	T
2N3309A	S	N		9-64	HPA	5W	C	200	60	60	S	8	80	50M	.5	.25A			300M	T
2N3310	S	N			HPA	.3W	A	200	35	15	0	10		20M	.5	20M			300M	T
2N3311	G	P		6-100	LPA	170W	C	110	30	30	S	60	120	3A	.1	3A	30	E	1K	E
2N 3312	G	P		6-100	LPA	170W		110	45	45	S	60	120	3A	.1	3A	30	E	1K	E
2N3313	G	P		6-100	LPA	170W	C	110	60	60	S	60	120	3A	.1	3A	30	E	1K	E
2N3314	G	P		60100	LPA	170W	C	110	30	30	S	100	200	3A	.1	3A	40	E	1K	E
2N3315	G	P		6-100	LPA	170W	C	110	45	45	S	100	200	3A	.1	3A	40	E	1K	E
2N3316	G	P		6-100	LPA	170W	C	110	60	60	S	100	200	3A	.1	3A	40	E	1K	E
2N3317	S	P			CHP	.15W	A	140	30	30	0								6.4M	T
2N3318	S	P			CHP	.15W	A	140	15	15	0								7.6M	T
2N3319	S	P			CHP	.15W	A	140	10	6	0								12M	T
2N3320	G	P			HSS	60M	A	100	15	10	0	50		20M	.19	40M			600M	T
2N3321	G	P			HSS	60M	A	100	12	7	0	100		10M	.12	10M			600M	T
2N3322	G	P			HSS	60M	A	100	12	7	0	30		40M	.25	20M			600M	T
2N3323	G	P		9-66	RFC	.15W	A	100	35	35	S	30	200	3M			30	E	200M	T
2N3324	G	P		9-66	RFC	.15W	A	100	35	35	S	30	200	3M			30	E	200M	T
2N3325	G	P		9-66	RFC	.15W	A	100	35	35	S	30	200	3M			30	E	200M	T
2N3326	S	N	2N2218A	8-74	HSA	.8W	A	175	60	45	0	40	120	.15A	.4	.15A			250M	T
2N3327	S	N			HPA	20W	C	200	65	65	0	10		.5A					100M	T
2N3328 thru 2N3336	Field Effect Transistors, see Table on Page 1-171																			
2N3337	S	N	2N3287	9-47	RFA	.3W	A	200	40	40	0	30	300	4M			30	E	400M	T
2N3338	S	N	2N3289	9-47	RFA	.3W	A	200	40	40	0	30	300	4M			30	E	400M	T
2N3339	S	N	2N3288	9-47	RFA	.3W	A	200	40	40	0	30	300	4M			30	E	400M	T
2N3340	S	N			MSS	.4W	A	175	30	20	0	40		10*	.2	10*			70M	T
2N3341	S	P			MSS	.4W	A	175	30	20	0	40		10*	.25	10*			50M	T
2N3342	S	P			MSS	.25W	A	175	20	8	0	30		5M	.1	5M				
2N3343	S	P			CHP	.25W	A	175	25	8	0	20		.25M					2M	T
2N3344	S	P			CHP	.25W	A	175	30	30	0	25		1M					2M	T
2N3345	S	P			CHP	.25W	A	175	50	50	0	15		1M					2M	T
2N3346	S	P			CHP	.25W	A	175	50	50	0	25		1M					2M	T
2N3347	S	P			DFA	300M	A	175	60	45	0	40	300	10*	.5	10M	60	E	60M	T
2N3348	S	P			DFA	300M	A	175	60	45	0	40	300	10*	.5	10M	60	E	60M	T
2N3349	S	P			DFA	300M	A	175	60	45	0	40	300	10*	.5	10M	60	E	60M	T
2N3350	S	P			DFA	300M	A	175	60	45	0	100	300	10*	.5	10M	150	E	60M	T
2N3351	S	P			DFA	300M	A	175	60	45	0	100	300	10*	.5	10M	150	E	60M	T
2N3352	S	P			DFA	300M	A	175	60	45	0	100	300	10*	.5	10M	150	E	60M	T
2N3353 thru 2N3364	Thyristors, see Table on Page 1-161																			
2N3365 thru 2N3370	Field Effect Transistors, see Table on Page 1-171																			
2N3371	G	P			RFA	150M	A	100	25	10	0	20	300	12M			25	E	320M	T
2N3374	S	N			HPA	5W	C	200	80	80	0	10		.17A	.3	.15A			230M	T
2N3375	S	N		9-69	HPA	11.6W	C	200	65	40	0	10	100	.25A	1	.25A			400M	T
2N3376 thru 2N3387	Field Effect Transistors, see Table on Page 1-171																			
2N3388	S	N			MSS	.6W	A	175	125	100	0	60		2.5M	1	2.5M			36M	T
2N3389	S	N			MSS	.6W	A	175	195	160	0	60		7M	1	7M			36M	T
2N3390	S	N	MPS6521	8-300	AFC	.2W	A	125	25	25	0	400	800	2M			400	E		
2N3391	S	N	MPS6515	8-300	AFC	.2W	A	125	25	25	0	250	500	2M			250	E		
2N3391A	S	N	MPS6520	8-300	AFC	.2W	A	125	25	25	0	250	500	2M			250	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N3392	S	N	MPS3392	8-289	AFC	.2W	A	125	25	25	0	150	300	2M			150	E		
2N3393	S	N	MPS3393	8-289	AFC	.2W	A	125	25	25	0	90	180	2M			90	E		
2N3394	S	N	MPS3394	8-289	AFC	.2W	A	125	25	25	0	55	110	2M			55	E		
2N3395	S	N	MPS3395	8-289	AFC	.2W	A	125	25	25	0	150	500	2M			150	E		
2N3396	S	N	MPS3396	8-289	AFC	.2W	A	125	25	25	0	90	500	2M			90	E		
2N3397	S	N	MPS3397	8-289	AFC	.2W	A	125	25	25	0	55	500	2M			55	E		
2N3398	S	N	MPS3398	8-289	AFC	.2W	A	125	25	25	0	55	800	2M			55	E		
2N3399		P			RFC	80M	A	100	20			10		1.5M					400M	T
2N3400	G	P			HSS	.15W	A	100	20	20	0	50	300	10M	.15	10M			150M	T
2N3401	S	P			CHP	.25W	A	150	25	25	0				.25	5M	4	E	.1M	B
2N3402		N	MPS6513	8-300	AFC	.56W	A	150	25	25	0	75	225	2M	.3	50M	75	E		
2N3403		N	MPS6515	8-300	AFC	.56W	A	150	25	25	0	180	540	2M	.3	50M	180	E		
2N3404		N			AFC	.56W	A	150	50	50	0	75	225	2M	.3	50M	75	E		
2N3405		N			AFC	.56W	A	150	50	50	0	180	540	2M	.3	50M	100	E		
2N3406	Unijunction Transistor, see Table on Page 1-177																			
2N3407	S	N			RFA	.2W	A	200	35	18	0	10	100	10M			10	E	300M	T
2N3408	S	P			RFA	4W	A	200	40	25	0	10	100	40M			10	E	200M	T
2N3409	S	N		11-9	DFA	.5W	A	200	60	30	0	30	120	.1M	.15	10M			250M	T
2N3410	S	N		11-9	DFA	.5W	A	200	60	30	0	20	100	10*	.15	10M			250M	T
2N3411	S	N		11-9	DFA	.5W	A	200	60	30	0	20	100	10*	.15	10M			250M	T
2N3412	G	P			AFA	60M	A	100	20	20	S	30	200	10M	.2	10M	25	E	100M	T
2N3413	S	P			AFA	.4W	A	200	150	150	0	10	45	50M	1.2	.1A			.25M	T
2N3414		N	MPS6513	8-300	AFC	.36W	A	160	25	25	0	75	225	2M	.3	50M	75	E		
2N3415		N	MPS6515	8-300	AFC	.36W	A	160	25	25	0	180	540	2M	.3	50M	180	E		
2N3416		N	MPS6515	8-300	AFC	.36W	A	160	50	50	0	75	225	2M	.3	50M	75	E		
2N3417		N	MPS6515	8-300	AFC	.36W	A	160	50	50	0	180	540	2M	.3	50M	100	E		
2N3418	S	N			PMS	.8W	A	175	85	60	0	20	60	1A	.25	1A			40M	T
2N3419	S	N			PMS	.8W	A	175	125	80	0	20	60	1A	.25	1A			40M	T
2N3420	S	N			PMS	.8W	A	175	85	60	0	40	120	1A	.25	1A			40M	T
2N3421	S	N			PMS	.8W	A	175	125	80	0	40	120	1A	.25	1A			40M	T
2N3422	Thyristor, see Table on Page 1-161																			
2N3423	S	N			DFA	.3W	A	200	30	15	0	20	200	3M	.4	10M			600M	T
2N3424	S	N			DFA	.3W	A	200	30	15	0	20	200	3M	.4	10M			600M	T
2N3425	S	N			HPA	.3W	A	200	40	15	0	30	120	10M	.4	10M	20	E	300M	T
2N3426	S	N			HSS	.6W	A	200	25	12	0	30	120	.3A	.33	.3A			450M	T
2N3427	G	P		7-41	AFA	.2W	A	100	45	30	R	100	350	.1A	.2	.1A	200	E	4M	T
2N3428	G	P		7-41	AFA	.2W	A	100	45	30	R	150	400	.1A	.19	.1A	350	E	5M	T
2N3429	S	N	2N3713	6-117	PMS	150W	C	175	50	50	0	10	35	5A	1	5A			20K	E
2N3430	S	N	2N3714	6-117	PMS	150W	C	175	100	100	0	10	35	5A	1	5A			20K	E
2N3431	S	N			PMS	150W	C	175	150	150	0	10	35	5A	1	5A			20K	E
2N3432	S	N			PMS	150W	C	175	200	200	0	10	35	5A	1	5A			20K	E
2N3433	S	N			PMS	150W	C	175	250	250	0	10	35	5A	1	5A			20K	E
2N3434	S	N			PMS	150W	C	175	300	300	0	10	35	5A	1	5A				
2N3435	S	N			HPA	1W	A	200	80	60	0	50	200	10M					140M	T
2N3436 thru 2N3438	Field Effect Transistors, see Table on Page 1-171																			
2N3439	S	N	MJ3201	6-166	VID	1W	A	200	450	350	0	40	160	20M			25	E	15M	T
2N3440	S	N	MJ3202	6-166	VID	1W	A	200	300	250	0	40	160	20M			25	E	15M	T
2N3441	S	N	2N3738	6-125	LPA	25W	C	200	160	140	0	20	80	.5A	6	2.7A	15	E	.2M	T
2N3442	S	N	MJ3010	6-164	LPA	100W	C	200	160	140	0	20	70	3A	5	10A	12	E	80K	T
2N3443	G	P			RFA	.3W	A	100	20	15	0	20	150	10M			20	E	750M	T
2N3444	S	N		B-147	HSS	1W	A	200	80	50	0	20	60	.5A	.35	.15A			150M	T
2N3445	S	N		6-103	LPA	115W	C	200	80	60	0	20	60	3A	1.5	3A	20	E	10M	T
2N3446	S	N		6-103	LPA	115W	C	200	100	80	0	20	60	3A	1.5	3A	20	E	10M	T
2N3447	S	N		6-103	LPA	115W	C	200	80	60	0	40	120	5A	1.5	5A	40	E	10M	T
2N3448	S	N		6-103	LPA	115W	C	200	100	80	0	40	120	5A	1.5	5A	40	E	10M	T
2N3449	G	P			HSS	150M	A	100	15	6	0	20		10M	.2	2M			300M	T
2N3450	S	N			HSS	.6W	A	200	120	60	0	40	120	.15A	.5	.15A			100M	T
2N3451	S	P			HSS	.3W	A	200	6	6	0	30	120	10M	.16	10M			500M	T
2N3452 thru 2N3460	Field Effect Transistors, see Table on Page 1-171																			
2N3461	G	P			LPA	5W	C	110	60	30	0	90	150	.5A	.4	1A	40	E	10K	E
2N3462	S	N			LNA	.3W	A	200	50	35	0	100	300	10*	.35	5M	150	E	10M	T
2N3463	S	N			LNA	.3W	A	200	60	45	0	120	360	10*	.35	1M	150	E	45M	T
2N3464	S	N			HPA	5W	C	200	60	40	0	35	100	.2A	1	.2A	30	E	50M	T
2N3465 2N3466	Field Effect Transistors, see Table on Page 1-171																			

2N3467—2N3549

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N3467	S	P		8-154	HSS	1W	A	200	40	40	0	40	120	.5A	.3	.15A			175M	T
2N3468	S	P		8-154	HSS	1W	A	200	50	50	0	25	75	.5A	.35	.15A			150M	T
2N3469	S	N			HPA	1.25W	A	200	35	25	0	100	350	.5A	.5	1A	100	E	20M	T
2N3470	S	N			LPA	150W	C	150	50	50	0	100	500	9A	3.5	9A	50	E	7K	E
2N3471	S	N			LPA	150W	C	150	100	100	0	100	500	9A	3.5	9A	50	E	7K	E
2N3472	S	N			LPA	150W	C	150	150	150	0	100	500	9A	3.5	9A	50	E	7K	E
2N3473	S	N			LPA	150W	C	150	200	200	0	100	500	9A	3.5	9A	50	E	7K	E
2N3474	S	N			LPA	150W	C	150	50	50	0	700	10K	4A	3.5	9A	100	E	4K	E
2N3475	S	N			LPA	150W	C	150	100	100	0	700	10K	4A	3.5	9A	100	E	4K	E
2N3476	S	N			LPA	150W	C	150	150	150	0	700	10K	4A	3.5	9A	100	E	4K	E
2N3477	S	N			LPA	150W	C	150	200	200	0	700	10K	4A	3.5	9A	100	E	4K	E
2N3478	S	N			RFA	.2W	A	200	30	15	0	25	150	2M			25	E	750M	T
2N3479 thru 2N3484	Unijunction Transistors, see Table on Page 1-177																			
2N3485	S	P		8-115	HSS	2W	C	200	60	40	0	40	120	.15A	.4	.15A			200M	T
2N3485A	S	P		8-115	HSS	2W	C	200	60	60	0	40	120	.15A	.4	.15A			200M	T
2N3486	S	P		8-115	HSS	2W	C	200	60	40	0	100	300	.15A	.4	.15A			200M	T
2N3486A	S	P		8-115	HSS	2W	C	200	60	60	0	100	300	.15A	.4	.15A			200M	T
2N3487	S	N		6-107	LPA	115W	C	200	80	60	0	20	60	3A	.3	1A	20	E	10M	T
2N3488	S	N		6-107	LPA	115W	C	200	100	80	0	20	60	3A	.3	1A	20	E	10M	T
2N3489	S	N		6-107	LPA	115W	C	200	120	100	0	15	45	3A	.3	1A	20	E	10M	T
2N3490	S	N		6-107	LPA	115W	C	200	80	60	0	40	120	5A	.3	1A	40	E	10M	T
2N3491	S	N		6-107	LPA	115W	C	200	100	80	0	40	120	5A	.3	1A	40	E	10M	T
2N3492	S	N		6-107	LPA	115W	C	200	120	100	0	30	90	5A	.3	1A	40	E	10M	T
2N3493	S	N		8-157	HSS	.15W	A	200	12	8	0	40	120	.5M	.15	10*			400M	T
2N3494	S	P		8-159	VID	.6W	A	200	80	80	0	35		.1A	.3	10M	40	E	200M	T
2N3495	S	P		8-159	VID	.6W	A	200	120	120	0	35		.1M	.35	10M	40	E	150M	T
2N3496	S	P		8-159	VID	.4W	A	200	80	80	0	35		.1A	.3	10M	40	E	200M	T
2N3497	S	P		8-159	VID	.4W	A	200	120	120	0	35		.1M	.35	10M	40	E	150M	T
2N3498	S	N		8-161	VID	1W	A	200	100	100	0	40	120	.15A	.2	10M	50	E	150M	T
2N3499	S	N		8-161	VID	1W	A	200	100	100	0	100	300	.15A	.2	10M	75	E	150M	T
2N3500	S	N		8-161	VID	1W	A	200	150	150	0	40	120	.15A	.2	10M	50	E	150M	T
2N3501	S	N		8-161	VID	1W	A	200	150	150	0	100	300	.15A	.2	10M	75	E	150M	T
2N3502	S	P	2N2905	8-115	HSS	.7W	A	200	45	45	0	115	300	50M	.25	50M	135	E	200M	T
2N3503	S	P	2N2905A	8-115	HSS	.7W	A	200	60	60	0	115	300	50M	.25	50M	135	E	200M	T
2N3504	S	P	2N2907	8-115	HSS	.4W	A	200	45	45	0	115	300	50M	.25	50M	135	E	200M	T
2N3505	S	P	2N2907A	8-115	HSS	.4W	A	200	60	60	0	115	300	50M	.25	50M	135	E	200M	T
2N3506	S	N		8-167	HSS	1W	A	200	60	40	0	40	200	1.5A	1	1.5A			60M	T
2N3507	S	N		8-167	HSS	1W	A	200	80	50	0	30	150	1.5A	1	1.5A			60M	T
2N3508	S	N		8-169	HSS	.4W	A	200	40	20	0	40	120	10M	.25	10M			500M	T
2N3509	S	N		8-169	HSS	.4W	A	200	40	20	0	100	300	10M	.25	10M			500M	T
2N3510	S	N		8-172	HSS	.36W	A	200	40	10	0	25	150	.15A	.25	10M	20	E	350M	T
2N3511	S	N		8-172	HSS	.36W	A	200	40	15	0	30	120	.15A	.25	10M	20	E	450M	T
2N3512	S	N		8-107	HSS	.8W	A	200	60	35	0	10		.5A	1	.5A			250M	T
2N3513	S	N	2N2480A	11-4	DFA	.25W	A	200	80	40	0	50	200	1M	1.2	50M	50	E	50M	T
2N3514	S	N			OFA	.25W	A	175	80	40	0	50	200	1M	1.2	50M	50	E	50M	T
2N3515	S	N			DFA	.25W	A	175	80	40	0	50	200	1M	1.2	50M	50	E	50M	T
2N3516	S	N			OFA	.25W	A	200	100	60	0	50	200	1M	1.2	50M	50	E	60M	T
2N3517	S	N			DFA	.25W	A	175	100	60	0	50	200	1M	1.2	50M	50	E	60M	T
2N3518	S	N			DFA	.25W	A	175	100	60	0	50	200	1M	1.2	50M	50	E	60M	T
2N3519	S	N			DFA	.25W	A	175	60	30	0	150	600	1M	1	5M	150	E	60M	T
2N3520	S	N			OFA	.25W	A	175	60	30	0	150	600	1M	1	5M	150	E	60M	T
2N3521	S	N			DFA	.3W	A	200	70	55	0	100	300	10*	1	10M			30M	T
2N3522	S	N			DFA	.25W	A	200	70	55	0	100	300	10*	1	10M			30M	T
2N3523	S	N			DFA	.25W	A	175	70	55	0	100	300	10*	1	10M			30M	T
2N3524	S	N			OFA	.25W	A	175	70	55	0	100	300	10*	1	10M			30M	T
2N3525	Thyristor, see Table on Page 1-161																			
2N3526	S	N			VID	.8W	A	200	130	120	0	30	120	30M	1	50M	25	E	40M	T
2N3527	S	P			AFA	.4W	A	200	30	30	0	25	75	.1N		.1N	100	E	5M	T
2N3528 thru 2N3541	Thyristors, see Table on Page 1-161																			
2N3543	S	N			HPA	60W	C	200	65	60	0	10	80	4.5A	1	4.5A			150M	T
2N3544	S	N		9-73	RFC	.3W	A	175	25	25	S	25		10M					600M	T
2N3545	S	P			HSS	.36W	A	200	20	20	0	40	120	10M	.2	10M			250M	T
2N3546	S	P		8-175	HSS	.36W	A	200	15	12	0	30	120	10M	.15	10M			700M	T
2N3547	S	P			LNA	.4W	A	200	60	60	0	100	500	1M	1	10M	120	E	45M	T
2N3548	S	P			LNA	.4W	A	200	60	45	0	100	300	10*	1	10M	150	E	60M	T
2N3549	S	P			LNA	.4W	A	200	60	60	0	100	500	10*	1	10M	150	E	60M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	f_- Units	Subscript
2N3550	S	P			LNA	.4W	A	200	60	45	0	200	600	10*	.9	5M	300	E	60M	T
2N3551	S	N			PHS	40W	C	175	115	60	0	20	90	10A	1	10A			40M	T
2N3552	S	N			PHS	40W	C	175	140	80	0	20	90	10A	1	10A			40M	T
2N3553	S	N		9-69	HPA	7W	C	200	65	40	0	10	100	.25A	1	.25A			400M	T
2N3554	S	N			HSS	.8W	A	200	60	30	0	25	100	.75A	.7	.75A			450M	T
2N3556 thru 2N3562	Thyristors, see Table on Page 1-161																			
2N3563	S	N			RFA	.2W	A	125	30	12	0	20	200	8M			20	E	600M	T
2N3564	S	N			RFA	.2W	A	125	30	15	0	20	500	15M	.3	20M	20	E	400M	T
2N3565	S	N	MPS6514	8-302	AFA	.2W	A	125	30	25	0	150	600	1M			120	E	40M	T
2N3566	S	N	MPS6514	8-302	AFA	.3W	A	125	40	30	0	150	600	10M	1	.1A			40M	T
2N3567	S	N	MPS6530	8-310	AFA	.3W	A	125	80	40	0	40	120	.15A	.25	.15A			60M	T
2N3568	S	N			AFA	.3W	A	125	80	60	0	40	120	.15A	.25	.15A			60M	T
2N3569	S	N	MPS6531	8-310	AFA	.3W	A	125	80	40	0	100	300	.15A	.25	.15A			60M	T
2N3570	S	N			RFA	.2W	A	200	30	15	0	20	150	5M			20	E	1.5G	T
2N3571	S	N			RFA	.2W	A	200	25	15	0	20	200	5M			20	E	1.2G	T
2N3572	S	N			RFA	.2W	A	200	25	13	0	20	300	5M			20	E	1G	T
2N3573 thru 2N3575	Field Effect Transistors, see Table on Page 1-171																			
2N3576	S	P			HSS	.36W	A	200	20	15	0	40	120	10M	.15	10M			400M	T
2N3577	S	N			HPA	85W	C	175	100	80	0	12	60	1A	5.25	1A	12	E	10M	T
2N3578	Field Effect Transistor, see Table on Page 1-171																			
2N3579	S	P			VID	.4W	A	200	60	60	0	30	120	1M	.5	5M	30	E	80M	T
2N3580	S	P			VID	.4W	A	200	60	60	0	60	240	1M	.5	5M	60	E	80M	T
2N3581	S	P			VID	.4W	A	200	50	40	0	50	150	.1M	.5	5M	50	E	30M	T
2N3582	S	P			VID	.4W	A	200	50	40	0	100	300	.1M	.5	5M	100	E	30M	T
2N3583	S	N	MJ2251	6-154	HPA	35W	C	200	250	175	0	40	200	.5A	5	1A	25	E	10M	T
2N3584	S	N			PMS	35W	C	200	330	250	0	8	140	1A	.75	1A			10M	T
2N3585	S	N	2N3767	6-134	PMS	35W	C	200	440	300	0	8	140	1A	.75	1A			10M	T
2N3586	S	P			CHP	125M	A	200	45	45	0								.1M	T
2N3587	S	N			DFA	.3W	A	200	60	45	0	80	500	1M	1	10M			80M	T
2N3588	G	P			RFC	.1W	A	85	25			20		1M					200M	T
2N3589	S	N			HPA	2W	A	175	200	200	R	30	90	.2A	2	.2A	30	E	15M	T
2N3590	S	N			HPA	2W	A	175	200	200	R	75	150	.2A	2	.2A	75	E	15M	T
2N3591	S	N			HPA	1W	A	175	200	200	R	30	90	.2A	2	.2A	30	E	15M	T
2N3592	S	N			HPA	1W	A	175	200	200	R	75	150	.2A	2	.2A	75	E	15M	T
2N3593	S	N			HPA	1W	A	175	200	200	R	30	90	.2A	2	.2A	30	E	15M	T
2N3594	S	N			HPA	1W	A	175	200	200	R	75	150	.2A	2	.2A	75	E	15M	T
2N3595	S	N			HPA	1.5W	A	175	200	200	R	30	90	.2A	2	.2A	30	E	15M	T
2N3596	S	N			HPA	1.5W	A	175	200	200	R	75	150	.2A	2	.2A	75	E	15M	T
2N3597	S	N	2N3767	6-134	PHS	100W	C	200	60	40	0	40	120	10A	.5	10A	75	E	30M	T
2N3598	S	N	2N3446	6-103	PHS	100W	C	200	80	60	0	40	120	10A	.5	10A	75	E	30M	T
2N3599	S	N	2N3447	6-103	PHS	100W	C	200	100	80	0	40	120	10A	.5	10A	75	E	30M	T
2N3600	S	N			RFA	.2W	A	200	30	15	0	20	150	3M			40	E	850M	T
2N3601	G	P			PMS	.286W	C	100	100	40	0	60	180	1A	.2	.1A	50	E	20M	T
2N3602	G	P			PMS	.286W	C	100	100	40	0	60	180	1A	.2	.1A	50	E	20M	T
2N3603	G	P			PMS	.286W	C	100	130	55	0	60	180	1A	.2	.1A	50	E	20M	T
2N3604	G	P			PMS	.286W	C	100	130	55	0	60	180	1A	.2	.1A	50	E	20M	T
2N3605	S	N	MPS3646	8-298	MSC	.2W	A	150	18	14	0	30		10M	.25	10M			300M	T
2N3606	S	N	MPS3646	8-298	MSC	.2W	A	150	18	14	0	30		10M	.25	10M			300M	T
2N3607	S	N	MPS3646	8-298	MSC	.2W	A	150	18	14	0	30		10M	.25	10M			300M	T
2N3611	G	P		6-110	LPA	85W	C	110	40	30	S	35	70	3A	.25	3A	40	E	.3M	T
2N3612	G	P		6-110	LPA	85W	C	110	60	45	S	35	70	3A	.25	3A	40	E	.3M	T
2N3613	G	P		6-110	LPA	85W	C	110	40	30	S	60	120	3A	.25	3A	60	E	.3M	T
2N3614	G	P		6-110	LPA	85W	C	110	60	45	S	60	120	3A	.25	3A	60	E	.3M	T
2N3615	G	P		6-113	LPA	85W	C	110	80	60	S	30	60	3A	.25	3A	40	E	.3M	T
2N3616	G	P		6-113	LPA	85W	C	110	100	75	S	30	60	3A	.25	3A	40	E	.3M	T
2N3617	G	P		6-113	LPA	85W	C	110	80	60	S	45	90	3A	.25	3A	60	E	.3M	T
2N3618	G	P		6-113	LPA	85W	C	110	100	75	S	45	90	3A	.25	3A	60	E	.3M	T
2N3619	S	N			HPA	7.5W	C	175	75	40	0	40		1A	.75	1A			200M	T
2N3620	S	N			HPA	7.5W	C	175	75	40	0	40		1A	1	3A			200M	T
2N3621	S	N			HPA	30W	C	175	75	40	0	40		1A	1.25	5A			200M	T
2N3622	S	N			HPA	30W	C	175	75	40	0	40		1A	1.25	5A			200M	T
2N3623	S	N			HPA	7.5W	C	175	75	40	0	40		1A	.75	1A			200M	T
2N3624	S	N			HPA	7.5W	C	175	75	40	0	40		1A	1	3A			200M	T
2N3625	S	N			HPA	30W	C	175	75	40	0	40		1A	1.25	5A			200M	T
2N3626	S	N			HPA	30W	C	175	75	40	0	40		1A	1.25	5A			200M	T
2N3627	S	N			HPA	7.5W	C	175	100	50	0	40		1A	.75	1A			200M	T

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N3628	S	N			HPA	7.5W	C	175	100	50	0	40		1A	1	3A			200M	T
2N3629	S	N			HPA	30W	C	175	100	50	0	40		1A	1.25	5A			200M	T
2N3630	S	N			HPA	30W	C	175	100	50	0	40		1A	1.25	5A			200M	T
2N3632	S	N		9-69	HPA	23W	C	200	65	40	0	10	150	.25A	1	1A			250M	T
2N3631	Field Effect Transistor, see Table on Page 1-171																			
2N3633	S	N			HNS	.3W	A	200	15	6	0	50	150	10M	.21	3M			1.3G	T
2N3634	S	P		8-178	VID	1W	A	200	140	140	0	50	150	50M			40	E	150M	T
2N3635	S	P		8-178	VID	1W	A	200	140	140	0	100	300	50M			80	E	200M	T
2N3636	S	P		8-178	VID	1W	A	200	175	175	0	50	150	50M			40	E	150M	T
2N3637	S	P		8-178	VID	1W	A	200	175	175	0	100	300	50M			80	E	200M	T
2N3638	S	P			HSS	.3W	A	125	25	25	0	30		50M	.25	50M	25	E	100M	T
2N3638A	S	P			HSS	.3W	A	125	25	25	0	100		50M	.25	50M	100	E	150M	T
2N3639	S	P	MPS3639	8-293	HSS	.2W	A	125	6	6	0	30	120	10M	.16	10M			500M	T
2N3640	S	P	MPS3640	8-296	HSS	.2W	A	125	12	12	0	30	120	10M	.2	10M			500M	T
2N3641	S	N	MPS6530	8-310	HPA	.35W	A	125	60	30	0	40	120	.15A	.22	.15A			250M	T
2N3642	S	N	MPS6530	8-310	HPA	.35W	A	125	60	45	0	40	120	.15A	.22	.15A			250M	T
2N3643	S	N	MPS6531	8-310	HPA	.35W	A	125	60	30	0	100	300	.15A	.22	.15A			250M	T
2N3644	S	P			HSS	.3W	A	125	45	45	0	115	300	50M	.25	50M			200M	T
2N3645	S	P			HSS	.3W	A	125	60	60	0	115	300	50M	.25	50M			200M	T
2N3646	S	N	MPS3646	8-298	HSS	.2W	A	125	40	15	0	30	120	30M	.2	30M			350M	T
2N3647	S	N		8-172	HSS	.4W	A	200	40	10	0	25	150	.15A	.25	10M	20	E	350M	T
2N3648	S	N		8-172	HSS	.4W	A	200	40	15	0	30	120	.15A	.25	10M	20	E	450M	T
2N3649 thru 2N3658	Thyristors, see Table on Page 1-161																			
2N3659	S	N			VID	4W	C	200	220	170	0	20		10M			20	E	50M	T
2N3660	S	P			HPA	5W	C	200	40	30	0	25	100	.5A	1.2	.5A			25M	T
2N3661	S	P			HPA	5W	C	200	60	50	0	25	100	.5A	1.2	.5A			25M	T
2N3662	S	N			RFC	.2W	A	125	18	12	0	20		8M					700M	T
2N3663	S	N			RFC	.2W	A	125	30	12	0	20		8M					700M	T
2N3664	S	N		9-75	HPA	5W	C	200	60	60	S	8	80	50M	.75	.25A			300M	T
2N3665	S	N			MNS	5W	C	200	120	80	0	40	120	.15A	.5	.15A			60M	T
2N3666	S	N			MNS	5W	C	200	120	80	0	100	300	.15A	.5	.15A			60M	T
2N3667	S	N			PMS	117W	C	200	50	50	0	15	60	8A	1.5	8A			.5M	T
2N3668 thru 2N3670	Thyristors, see Table on Page 1-161																			
2N3671	S	P			HSS	.6W	A	200	60	50	0	75	225	.15A	.4	.15A			200M	T
2N3672	S	P			HSS	.4W	A	200	60	50	0	75	225	.15A	.4	.15A			200M	T
2N3673	S	P			HSS	.35W	A	200	60	50	0	75	225	.15A	.4	.15A			200M	T
2N3675	S	N			PMS	8.8W	C	200	90	55	0	12	60	1A	.8	1A			1M	T
2N3676	S	N			PMS	8.8W	C	200	90	90	0	12	60	1A	.8	1A			1M	T
2N3677	S	P			CHP	.4W	A	200	30	20	D								5M	T
2N3678	S	N			HSS	.8W	A	200	75	55	0	40	120	.15A	.4	.15A			250M	T
2N3679	Unijunction Transistor, see Table on Page 1-177																			
2N3680	S	N			DFA	.3W	A	200	60	50	0	150	600	10*	.7	10M	300	E	60M	T
2N3681	S	N			RFA	.2W	A	200	10	7	0	20	220	2M	.37	4M	20	E	1G	T
2N3682	S	N			RFA	.36W	A	200	40	15	0	40	120	10M			45	E	600M	T
2N3683	S	N			RFA	.2W	A	200	30	12	0	20	150	8M			30	E	1G	T
2N3684 thru 2N3687	Field Effect Transistors, see Table on Page 1-171																			
2N3688	S	N			RFC	.2W	A	125	40	40	0	30		4M					400M	T
2N3689	S	N			RFC	.2W	A	125	40	40	0	30		4M					400M	T
2N3690	S	N			RFC	.2W	A	125	40	40	0	30		4M					400M	T
2N3691	S	N	MPS6512	8-302	AFC	.2W	A	125	35	20	0	40	160	10M	.7	10M	40	E	200M	T
2N3692	S	N	MPS6513	8-302	AFC	.2W	A	125	35	20	0	100	400	10M	.7	10M	100	E	200M	T
2N3693	S	N			RFC	.2W	A	125	45	45	0	40	160	10M					200M	T
2N3694	S	N			RFC	.2W	A	125	45	45	0	100	400	10M					200M	T
2N3695 thru 2N3698	Field Effect Transistors, see Table on Page 1-171																			
2N3700	S	N			RFA	.5W	A	200	140	80	0	100	300	.15A	.2	.15A	80	E	100M	T
2N3701	S	N			RFA	.5W	A	200	140	80	0	40	120	.15A	.2	.15A	30	E	80M	T
2N3702	S	P			AFC	.3W	A	150	40	25	0	60	300	50M	.25	50M			100M	T
2N3703	S	P			AFC	.3W	A	150	50	30	0	30	150	50M	.25	50M			100M	T
2N3704	S	N			AFC	.36W	A	150	50	30	0	100	300	50M	.6	.1A			100M	T
2N3705	S	N			AFC	.36W	A	150	50	30	0	50	150	50M	.8	.1A			100M	T
2N3706	S	N			AFC	.36W	A	150	40	20	0	30	600	50M	1	.1A			100M	T
2N3707	S	N			AFC	.25W	A	150	30	30	0	100	400	.1M	1	10M	100	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N3708	S	N			AFC	.25W	A	150	30	30	0	45	660	1M	1	10M	45	E		
2N3709	S	N			AFC	.25W	A	150	30	30	0	45	165	1M	1	10M	45	E		
2N3710	S	N			AFC	.25W	A	150	30	30	0	90	330	1M	1	10M	90	E		
2N3711	S	N			AFC	.25W	A	150	30	30	0	180	660	1M	1	10M	180	E		
2N3712	S	N			RFC	.8W	A	200	150	150	0	30	150	30M	2	50M	25	E	40M	T
2N3713	S	N		6-117	HPA	150W	C	200	80	60	0	25	75	1A	1	5A	25	E	30K	E
2N3714	S	N		6-117	HPA	150W	C	200	100	80	0	25	75	1A	1	5A	25	E	30K	E
2N3715	S	N		6-117	HPA	150W	C	200	80	60	0	50	150	1A	.8	5A	25	E	30K	E
2N3716	S	N		6-117	HPA	150W	C	200	100	80	0	50	150	1A	.8	5A	25	E	30K	E
2N3717	S	N			HPA	7.5W	C	200	60	60	S	2	100	.5A	1	.5A			250M	T
2N3718	S	N			HPA	10W	C	200	60	60	S	2	100	.5A	1	.5A			250M	T
2N3719	S	P		6-121	PHS	6W	C	200	40	40	0	25	180	1A	1.5	.3A			60M	T
2N3720	S	P		6-121	PHS	6W	C	200	60	60	0	25	180	1A	1.5	3A			60M	T
2N3721	S	N			AFC	.2W	A	125	18	18	0						60	E		
2N3722	S	N			MSS	.8W	A	200	80	60	0	40	150	.1A	.22	.1A			300M	T
2N3723	S	N			HSS	.8W	A	200	100	80	0	40	150	.1A	.25	10M			300M	T
2N3724	S	N			HSS	.8W	A	200	50	30	0	60	150	.1A	.2	.1A			300M	T
2N3725	S	N			HSS	.8W	A	200	80	50	0	60	150	.1A	.26	.1A			300M	T
2N3726	S	P			OFA	.4W	A	200	45	45	0	135	350	1M	.25	50M	135	E	200M	T
2N3727	S	P			OFA	.4W	A	200	45	45	0	135	350	1M	.25	50M	135	E	200M	T
2N3728	S	N			OFA	.45W	A	200	60	30	0	80	280	.15A	.22	.15A	50	E	250M	T
2N3729	S	N			DFA	.45W	A	200	60	30	0	80	280	.15A	.22	.15A	50	E	250M	T
2N3733	S	N		9-77	HPA	23W	C	200	65	40	0	10	150	.25A	1	1A			250M	T
2N3734	S	N		8-189	HSS	1W	A	200	50	30	0	30	120	1A	.2	10M			300M	T
2N3735	S	N		8-189	HSS	1W	A	200	75	50	0	20	80	1A	.2	10M			250M	T
2N3736	S	N		8-189	HSS	.5W	A	200	50	30	0	30	120	1A	.2	10M			300M	T
2N3737	S	N		8-189	HSS	.5W	A	200	75	50	0	20	80	1A	.2	10M			250M	T
2N3738	S	N		6-125	LPA	20W	C	175	250	225	0	40	200	.1A	2.5	.25A	35	E	15M	T
2N3739	S	N		6-125	LPA	20W	C	175	325	300	0	40	200	.1A	2.5	.25A	35	E	15M	T
2N3740	S	P		6-129	LPA	25W	C	200	60	60	0	30	100	.25A	.6	1A	25	E	4M	T
2N3741	S	P		6-129	LPA	25W	C	200	80	80	0	30	100	.25A	.6	1A	25	E	4M	T
2N3742	S	N		8-195	VID	1W	A	200	300	300	0	20	200	30M	1	10M	20	E	30M	T
2N3743	S	P		8-203	VID	1W	A	200	300	300	0	25	250	30M	5	10M	30	E	30M	T
2N3744	S	N			HPA	30W	C	200	60	40	0	20	60	1A	.25	1A	20	E	30M	T
2N3745	S	N			HPA	30W	C	200	80	60	0	20	60	1A	.25	1A	20	E	30M	T
2N3746	S	N			HPA	30W	C	200	100	80	0	20	60	1A	.25	1A	20	E	30M	T
2N3747	S	N			HPA	30W	C	200	60	40	0	40	120	1A	.25	1A	40	E	40M	T
2N3748	S	N			HPA	30W	C	200	80	60	0	40	120	1A	.25	1A	40	E	40M	T
2N3749	S	N			HPA	30W	C	200	100	80	0	40	120	1A	.25	1A	40	E	40M	T
2N3750	S	N			HPA	30W	C	200	60	40	0	100	300	1A	.25	1A	100	E	50M	T
2N3751	S	N			HPA	30W	C	200	80	60	0	100	300	1A	.25	1A	100	E	50M	T
2N3752	S	N			HPA	30W	C	200	100	80	0	100	300	1A	.25	1A	100	E	50M	T
2N3753 thru 2N3761	Thyristors, see Table on Page 1-161																			
2N3762	S	P		8-203	HSS	1W	A	200	40	40	0	30	120	1A	.1	10M			180M	T
2N3763	S	P		8-203	HSS	1W	A	200	60	60	0	20	80	1A	.1	10M			150M	T
2N3764	S	P		8-203	HSS	.5W	A	200	40	40	0	30	120	1A	.1	10M			180M	T
2N3765	S	P		8-203	HSS	.5W	A	200	60	60	0	20	80	1A	.1	10M			150M	T
2N3766	S	N		6-134	LPA	20W	C	175	80	60	0	40	160	.5A	2.5	1A	40	E	15M	T
2N3767	S	N		6-134	LPA	20W	C	175	100	80	0	40	160	.5A	2.5	1A	40	E	15M	T
2N3770	G	P			RFA	50M	A	100	10	6	0	10	200	1M			10	E	100M	T
2N3771	S	N			LPA	150W	C	200	50	40	0	15	60	15A	2	15A	40	E	.2M	T
2N3772	S	N	2N3715	6-117	LPA	150W	C	200	100	60	0	15	60	10A	1.4	10A	40	E	.2M	T
2N3773	S	N			LPA	150W	C	200	160	140	0	15	60	8A	1.4	8A	40	E	.2M	T
2N3774	S	P			PMS	5W	C	200	40	40	0	20	60	.2A	.2	.2A			1M	T
2N3775	S	P			PMS	5W	C	200	60	60	0	20	60	.2A	.2	.2A			1M	T
2N3776	S	P			PMS	5W	C	200	80	80	0	20	60	.2A	.2	.2A			1M	T
2N3777	S	P			PMS	5W	C	200	100	100	0	20	60	.2A	.2	.2A			1M	T
2N3778	S	P			PMS	5W	C	200	40	40	0	10	40	.2A	.2	.2A			1M	T
2N3779	S	P			PMS	5W	C	200	60	60	0	10	40	.2A	.2	.2A			1M	T
2N3780	S	P			PMS	5W	C	200	80	80	0	10	40	.2A	.2	.2A			1M	T
2N3781	S	P			PMS	5W	C	200	100	100	0	10	40	.2A	.2	.2A			1M	T
2N3782	S	P			PMS	5W	C	200	40	40	0	10	60	1A	.75	1A			1M	T
2N3783	G	P		9-79	RFA	.15W	A	100	30	20	0	20	200	3M	.25	5M	20	E	.8G	T
2N3784	G	P		9-79	RFA	.15W	A	100	30	20	0	20	200	3M	.25	5M	20	E	.7G	T
2N3785	G	P		9-79	RFA	.15W	A	100	15	12	0	15	200	3M	.35	5M	15	E	.7G	T
2N3789	S	P		6-139	LPA	150W	C	200	60	60	0	25	90	1A	1	5A	25	E	30K	E
2N3790	S	P		6-139	LPA	150W	C	200	80	80	0	25	90	1A	1	5A	25	E	30K	E
2N3791	S	P		6-139	LPA	150W	C	200	60	60	0	50	180	1A	1	5A	25	E	30K	E

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TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS						ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N3792	S	P		6-139	LPA	150W	C	200	80	80	0	50	180	1A	1	5A	25	E	30K	E
2N3793	S	N			AFA	.25W	A	125	40	20	0	20	120	10M	.4	10M			100M	T
2N3794	S	N			AFA	.25W	A	125	40	20	0	100	600	10M	.4	10M			100M	T
2N3795	S	P			PMS	5W	C	200	120	120	0	12	36	10M	.2	10M			.5M	T
2N3796 2N3797	Field Effect Transistors, see Table on Page 1-171																			
2N3798	S	P		8-208	AFA	.36W	A	200	60	60	0	150	450	.5M	.2	.1M	150	E	30M	T
2N3799	S	P		8-208	AFA	.36W	A	200	60	60	0	300	900	.5M	.2		300	E	30M	T
2N3800	S	P		L1011	AFA	.25W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N3801	S	P		11-11	AFA	.25W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3802	S	P		11-11	DFA	.25W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N3803	S	P		11-11	DFA	.25W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3804	S	P		11-11	DFA	.25W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N3805	S	P		11-11	DFA	.25W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3806	S	P		11-11	AFA	.5W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N38D7	S	P		11-11	AFA	.5W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3808	S	P		11-11	DFA	.5W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N3809	S	P		11-11	DFA	.5W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3810	S	P		11-11	DFA	.5W	A	200	60	60	0	150	450	.1M	.2	.1M	150	E	100M	T
2N3811	S	P		11-11	DFA	.5W	A	200	60	60	0	300	900	.1M	.2	.1M	300	E	100M	T
2N3818 2N3819 thru 2N3824	S	N		9-84	HPA	25W	C	175	60	60	S	5	50	400M	.5	1A	3	E		
	Field Effect Transistors, see Table on Page 1-171																			
2N3825	S	N			RFC	.25W	A	150	30	15	0	20		2M	.25	2M			200M	T
2N3826	S	N			RFC	.2W	A	150	60	45	0	40	160	10M					200M	T
2N3827	S	N			RFC	.2W	A	150	60	45	0	100	400	10M					200M	T
2N3828	S	N			RFC	.3W	A	150	40	40	0	30	200	12M					360M	T
2N3829	S	P			HSS	.36W	A	200	35	20	0	30	120	30M	.18	10M			350M	T
2N3830	S	N			HSS	1W	A	200	80	50	0	30		.15A	.3	.15A			200M	T
2N3831	S	N			HSS	1W	A	200	70	40	0	35		.15A	.3	.15A			200M	T
2N3832	S	N			HSS	.2W	A	200	15	6	0	25	125	2M	.4	10M			800M	T
2N3836	S	N			PHS	1W	A	200	80	60	0	2K	20K	2A	1.8	5A			40M	T
2N3837	S	N			PHS	1W	A	200	100	80	0	2K	20K	2A	1.8	5A			40M	T
2N3838	S				HSA	.25W	A	200	60	40	0	100	300	.15A	.4	.15A	60	E	200M	T
2N3840	S	P			CHP	.4W	A	200	50	50	0	30		.2M	.1	5M			6M	T
2N3841	S	P			CHP	.3W	A	200	100	100	0	15		.2M	.12	5M			1.5M	T
2N3842	S	P			CHP	.3W	A	200	120	120	0	10		1M		5M			1M	T
2N3843	S	N			RFC	.2W	A	125	30	30	0	20	40	2M					60M	T
2N3843A	S	N			RFC	.2W	A	125	30	30	0	20	40	2M					60M	T
2N3844	S	N	MPS6512	8-300	RFC	.2W	A	125	30	30	0	35	70	2M					90M	T
2N3844A	S	N	MPS6512	8-300	RFC	.2W	A	125	30	30	0	35	70	2M					90M	T
2N3845	S	N	MPS6512	8-300	RFC	.2W	A	125	30	40	0	60	120	2M					126M	T
2N3845A	S	N	MPS6513	8-300	RFC	.2W	A	125	30	30	0	60	120	2M					126M	T
2N3846	S	N			LPA	4W	A	175	300	200	0	10	60	10A	.75	10A	50	E	10M	T
2N3847	S	N			LPA	4W	A	175	400	300	0	10	60	10A	.75	10A	50	E	10M	T
2N3848	S	N			LPA	4W	A	175	300	300	0	10	60	15A	1	15A	50	E	10M	T
2N3849	S	N			LPA	4W	A	175	400	300	0	10	60	15A	1	15A	50	E	10M	T
2N3850	S	N			PHS	30W	C	200	100	80	0	50	150	1A	.25	1A			20M	T
2N3851	S	N			PHS	30W	C	200	100	80	0	30	90	1A	.25	1A			20M	T
2N3852	S	N			PHS	30W	C	200	60	40	0	50	150	1A	.25	1A			20M	T
2N3853	S	N			PHS	30W	C	200	60	40	0	30	90	1A	.25	1A			20M	T
2N3854	S	N	MPS6512	8-300	RFC	.2W	A	150	18	18	0	35	70	2M					100M	T
2N3854A	S	N	MPS6512	8-300	RFC	.2W	A	150	30	30	0	35	70	2M					100M	T
2N3855	S	N	MPS6512	8-300	RFC	.2W	A	150	18	18	0	60	120	2M					130M	T
2N3855A	S	N	MPS6512	8-300	RFC	.2W	A	150	30	30	0	60	120	2M					130M	T
2N3856	S	N	MPS6513	8-300	RFC	.2W	A	150	18	18	0	100	200	2M					140M	T
2N3856A	S	N	MPS6513	8-300	RFC	.2W	A	150	30	30	0	100	200	2M					140M	T
2N3857	S	P			AFA	.6W	A	200	45	45	0	50	200	1M	.1	10M	45	E	4M	T
2N3858	S	N	MPS6512	8-300	RFC	.2W	A	125	30	30	0	60	120	2M					90M	T
2N3859	S	N	MPS6513	8-300	RFC	.2W	A	125	30	30	D	100	200	2M					90M	T
2N3860	S	N	MPS6514	8-300	RFC	.2W	A	125	30	30	0	150	300	2M					90M	T
2N3861	S	N			LPA	2W	A	175	530	530	V	30	200	25M	1.5	25M	20	E	50M	T
2N3862	S	N			HSS	.36W	A	200	50	20	0	50	150	10M	.25	10M			600M	T
2N3863	S	N			PMS	117W	C	200	70	50	0	30	90	3A	1	3A			.5M	T
2N3864	S	N			PMS	117W	C	200	110	90	0	30	90	3A	1	3A			.5M	T
2N3865	S	N			PMS	117W	C	200	160	150	0	30	90	3A	1	3A			.5M	T
2N3866	S	N		9-86	HPA	5W	C	200	55	30	0	10	200	50M	1	.1A			250M	T
2N3867	S	P			HSS	1W	A	200	40	40	0	40	200	1.5A	.75	1.5A			60M	T
2N3868	S	P			HSS	1W	A	200	60	60	0	30	150	1.5A	.75	1.5A			60M	T

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_—$ Units	Subscript
2N3869	S	N			HPA	2.5W	C	175	40	20	0	20	150	30M	.7	.45A			.4G	T
2N3870 thru 2N3873	Thyristors, see Table on Page 1-161																			
2N3876	S	N			LPA	150W	C	175	140	50	0	25	150	10A	1	10A	80	E	50M	T
2N3877	S	N			AFC	.2W	A	150	70	70	0	20	250	2M						
2N3877A	S	N			AFC	.2W	A	150	85	85	0	20	250	2M						
2N3878	S	N			HPA	35W	C	200	120	50	0	40	200	.5A	2	4A	40	E	40M	T
2N3879	S	N			PMS	35W	C	200	120	75	0	12	100	4A	1.2	4A			40M	T
2N3880	S	N			RFA	.2W	A	200	30	15	0	30	200	3M			50	E	1.2G	T
2N3881	S	N			RFA	.6W	A	200	60	35	0				1.5	.15A	50	E	70M	T
2N3882	Field Effect Transistor, see Table on Page 1-171																			
2N3883	G	P		8-212	HSS	.3W	A	100	25	15	0	30		.2A	.5	.2A			100M	T
2N3884 thru 2N3899	Thyristors, see Table on Page 1-161																			
2N3900	S	N	MPS6515	8-300	AFC	.2W	A	125	18	18	0	250	500	2M			170	E		
2N3900A	S	N	MPS6520	8-300	AFC	.2W	A	125	18	18	0	250	500	2M			170	E		
2N3901	S	N	MPS6521	8-300	AFC	.2W	A	125	18	18	0	350	700	2M			350	E		
2N3902	S	N			PMS	100W	C	150	400	400	0	20	100	1A	2.5	2.5A			40K	E
2N3903	S	N		8-216	HSS	.31W	A	135	60	40	0	50	150	10M	.2	10M	50	E	250M	T
2N3904	S	N		8-216	HSS	.31W	A	135	60	40	0	100	300	10M	.2	10M	100	E	300M	T
2N3905	S	P		8-221	HSS	.31W	A	135	40	40	0	50	150	10M	.25	10M	50	E	200M	T
2N3906	S	P		8-221	HSS	.31W	A	135	40	40	0	100	300	10M	.25	10M	100	E	250M	T
2N3907	S	N	2N2915	11-7	DFA	.3W	A	200	60	45	0	60	300	10*	.35	1M			60M	T
2N3908	S	N	2N2916	11-7	DFA	.3W	A	200	60	60	0	100	500	10*	.35	1M			60M	T
2N3909	Field Effect Transistor, see Table on Page 1-171																			
2N3910	S	P			CHP	.5W	A	200	60	50	0	40	160	1M	.3	10M			4M	T
2N3911	S	P			CHP	.5W	A	200	60	40	0	60	240	1M	.3	10M			8M	T
2N3912	S	P			CHP	.5W	A	200	60	30	0	90		1M	.3	10M			10M	T
2N3913	S	P			CHP	.4W	A	200	60	50	0	40	160	1M	.3	10M			4M	T
2N3914	S	P			CHP	.4W	A	200	60	40	0	60	240	1M	.3	10M			8M	T
2N3915	S	P			CHP	.4W	A	200	60	30	0	90		1M	.3	10M			10M	T
2N3916	S	N			LPA	5W	C	150	150	150	0	40	200	.15A	5	.15A	30	E	50M	T
2N3917	S	N			LPA	20W	C	150	80	40	0	30	120	1A	1.2	1A	15	E	50M	T
2N3918	S	N			LPA	20W	C	150	80	40	0	100	300	1A	1.2	1A	30	E	50M	T
2N3919	S	N			PMS	15W	C	150	120	60	0	40	120	2A	1.2	10A			80M	T
2N3920	S	N			PMS	15W	C	150	120	60	0	100	300	2A	1.2	10A			80M	T
2N3921 2N3922	Field Effect Transistors, see Table on Page 1-171																			
2N3923	S	N			VID	.8W	A	200	150	150	0	30	120	25M	1	25M	20	E	40M	T
2N3924	S	N		9-91	HPA	7W	C	200	36	18	0								250M	T
2N3925	S	N		9-91	HPA	10W	C	200	36	18	0								250M	T
2N3926	S	N		9-91	HPA	11.6W	C	200	36	18	0								250M	T
2N3927	S	N		9-91	HPA	23.2W	C	200	36	18	0								200M	T
2N3928	S	N			PHS	7.5W	C	175	80	40	0	20	300	1.5A	5	1.5A			200M	T
2N3929	S	N			PHS	30W	C	175	80	40	0	20	300	1.5A	5	1.5A			200M	T
2N3930	S	P			AFA	.4W	A	200	180	180	0	80	300	10M	.25	10M	100	E	40M	T
2N3931	S	P			AFA	.7W	A	200	180	180	0	80	300	10M	.25	10M	100	E	40M	T
2N3932	S	N			RFA	.2W	A	200	30	20	0	40	150	2M			50	E	750M	T
2N3933	S	N			RFA	.2W	A	200	40	30	0	60	200	2M			60	E	750M	T
2N3934 2N3935 2N3936	Field Effect Transistors, see Table on Page 1-171																			
2N3940	Thyristors, see Table on Page 1-161																			
2N3941	S	N			OFA	.75W	C	200	60	45	0	400		10*			300	E	200M	T
2N3942	S	N			OFA	.75W	C	200	60	45	0	400		10*			300	E	200M	T
2N3943	S	N			DFA	.5W	C	200	60	45	0	400		10*			300	E	200M	T
2N3944	S	N			DFA	.5W	C	200	60	45	0	400		10*			300	E	200M	T
2N3945	S	N			MNS	5W	C	200	70	50	0	40	250	.15A	.5	.15A			60M	T
2N3946	S	N		8-226	HSA	360M	A	200	60	40	0	50	150	10M	.3	50M	50	E	250M	T
2N3947	S	N		8-226	HSA	360M	A	200	60	40	0	100	300	10 M	.3	50M	100	E	300M	T
2N3953	S	N			RFA	.2W	A	200	15	12	0	30	360	2M			40	E	1.3G	T
2N3954 thru 2N3958	Field Effect Transistors, see Table on Page 1-171																			
2N3959	S	N		8-232	HNS	400M	A	200	20	12	0	40	200	10M	.3	30 M	13	E	1.3 G	T
2N3960	S	N		8-232	HNS	400M	A	200	20	12	0	40	200	10 M	.3	30M	16	E	1.6 G	T

2N3961 — 2N4062

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS							
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} @ I_C (min)	(max)	Units	$V_{CE(SAT)}$ @ I_C (volts)	Units	$h_{f—}$	Subscript	$f_{—}$ Units	Subscript
2N3961	S	N		9-69	HPA	10W	C	200	65	40	0								400M	T
2N3962	S	P			AFA	.36W	A	200	60	60	0	100	300	10*	.25	10M	100	E	40M	T
2N3963	S	P			AFA	.36W	A	200	80	80	0	100	300	10*	.25	10M	100	E	40M	T
2N3964	S	P			AFA	.36W	A	200	45	45	0	250	500	10*	.25	10M	250	E	50M	T
2N3965	S	P			AFA	.36W	A	200	60	60	0	250	500	1D*	.25	10M	250	E	50M	T
2N3966 thru 2N3972	Field Effect Transistors, see Table on Page 1-171																			
2N3973	S	N			MSC	.36W	A	150	60	30	0	35	100	10M	.3	.15A			200M	T
2N3974	S	N			MSC	.36W	A	150	60	30	0	55	200	10M	.3	.15A			200M	T
2N3975	S	N			MSC	.36W	A	150	60	30	0	35	100	10M	.3	.15A			200M	T
2N3976	S	N			MSC	.36W	A	150	60	30	0	55	200	10M	.3	.15A			200M	T
2N3977	S	P			CHP	.4W	A	200	15	10	0	40		5M	.1	5M			1M	T
2N3978	S	P			CHP	.4W	A	200	25	20	0	30		5M	.15	5M			1M	T
2N3979	S	P			CHP	.4W	A	200	40	35	0	20		5M	.15	5M			1M	T
2N3980	Unijunction Transistor, see Table on Page 1-177																			
2N3981	S	N			HSS	.8W	A	200	60	30	0	30	120	.15A	.4	.15A			250M	T
2N3982	S	N			HSS	.8W	A	200	50	20	0	40	140	.15A	.4	.15A			250M	T
2N3983	S	N			RFC	.2W	A	150	30	12	0	30		4M					500M	T
2N3984	S	N			RFC	.2W	A	150	30	12	0	20		4M					400M	T
2N3985	S	N			RFC	.2W	A	150	30	12	0	20		4M					300M	T
2N3986 thru 2N3992	Thyristors, see Table on Page 1-161																			
2N3993 2N3994	Field Effect Transistors, see Table on Page 1-171																			
2N3995	G	P	2N2929	9-28	RFA	.3W	A	100	20	12	0	40	200	2M			150	E	.6G	T
2N3996	S	N			PHS	2W	A	200	100	80	0	40	120	1A	.25	1A			40M	T
2N3997	S	N			PHS	2W	A	200	100	80	0	80	240	1A	.25	1A			40M	T
2N3998	S	N			PHS	2W	A	200	100	80	0	40	120	1A	.25	1A			40M	T
2N3999	S	N			PHS	2W	A	200	100	80	0	80	240	1A	.25	1A			40M	T
2N4000	S	N			PHS	1W	A	200	100	80	0	30	120	.5A	.3	.5A			40M	T
2N4001	S	N			PHS	1W	A	200	120	100	0	40	120	.5A	.3	.5A			40M	T
2N4012	S	N		9-95	LPA	11.6W	C	200	65	40	0	4	40	1A	1	.25A			400M	T
2N4015	S	P			DFA	.4W	A	200	60	60	0	135	350	1M	.25	50M	135	E	200M	T
2N4016	S	P			DFA	.4W	A	200	60	60	0	135	350	1M	.25	50M	135	E	200M	T
2N4020	S	P			DFA	.4W	A	200	45	45	0	250	500	10*	.25	10M	250	E	50M	T
2N4021	S	P			DFA	.4W	A	200	60	60	0	100	350	10*	.25	10M	100	E	40M	T
2N4022	S	P			DFA	.4W	A	200	60	60	0	250	500	10*	.25	10M	250	E	50M	T
2N4023	S	P			DFA	.4W	A	200	45	45	0	250	500	1D*	.25	10M	250	E	50M	T
2N4024	S	P			DFA	.4W	A	200	60	60	0	100	350	10*	.25	10M	100	E	40M	T
2N4025	S	P			DFA	.4W	A	200	60	60	0	250	500	1D*	.25	10M	250	E	50M	T
2N4026	S	P			AFA	.5W	A	200	60	60	0	40	120	.1A	1	1A			100M	T
2N4027	S	P			AFA	.5W	A	200	80	80	0	40	120	.1A	.5	.5A			100M	T
2N4028	S	P			AFA	.5W	A	200	60	60	0	100	300	.1A	1	1A			150M	T
2N4029	S	P			AFA	.5W	A	200	80	80	0	100	300	.1A	.5	.5A			150M	T
2N4030	S	P			AFA	.8W	A	200	60	60	0	40	120	.1A	1	1A			100M	T
2N4031	S	P			AFA	.8W	A	200	80	80	0	40	120	.1A	.5	.5A			100M	T
2N4032	S	P			AFA	.8W	A	200	60	60	0	100	300	.1A	1	1A			150M	T
2N4033	S	P			AFA	.8W	A	200	80	80	0	100	300	.1A	.5	.5A			150M	T
2N4034	S	P			HSS	.36W	A	200	40	40	0	70	200	10M	.13	1M	50	E	400M	T
2N4035	S	P			HSS	.36W	A	200	40	40	0	150	300	10M	.13	1M	150	E	450M	T
2N4040	S	N			HPA	17.5W	C	200	60	40	0	10	80	.1A	2	1A			400M	T
2N4041	S	N			HPA	10W	C	200	60	40	0	10	80	75M	2	.5A			400M	T
2N4042	S	N			DFA	.3W	C	200	60	60	0	200	600	10*	.35	1M			200M	T
2N4043	S	N			DFA	.3W	C	200	45	45	0	80	800	10*	.35	1M			150M	T
2N4044	S	N			DFA	.4W	C	200	60	60	0	200	600	10*	.35	1M			200M	T
2N4045	S	N			DFA	.4W	C	200	45	45	0	80	800	10*	.35	1M			150M	T
2N4048	G	P		6-144	LPA	170W	C	110	45	30	0	60	120	15 A	.30	60 A			2 K	E
2N4049	G	P		6-144	LPA	170W	C	110	60	45	0	60	120	15 A	.30	60 A			2 K	E
2N4050	G	P		6-144	LPA	170W	C	110	75	60	0	60	120	15 A	.30	60 A			2 K	E
2N4051	G	P		6-144	LPA	170W	C	110	45	30	0	60	180	15 A	.30	60 A			2 K	E
2N4052	G	P		6-144	LPA	170W	C	110	60	45	0	60	180	15 A	.30	60 A			2 K	E
2N4053	G	P		6-144	LPA	170W	C	110	75	60	0	60	180	15 A	.30	60 A			2 K	E
2N4058	S	P			AFC	.25W	A	150	30	30	0	100	400	.1M	.7	1DM	100	E		
2N4059	S	P			AFC	.25W	A	150	30	30	D	45	660	1M	.7	10M	45	E		
2N4060	S	P			AFC	.25W	A	150	30	30	D	45	165	1M	.7	10M	45	E		
2N4061	S	P			AFC	.25W	A	150	30	30	0	90	330	1M	.7	1DM	90	E		
2N4062	S	P			AFC	.25W	A	150	30	30	D	180	660	1M	.7	10M	180	E		

TYPE	MATERIAL	POLARITY	REPLACEMENT	PAGE NUMBER	USE	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS								
						P_D @ 25°C	Ref Point	T_J °C	V_{CBO} (volts)	$V_{CE—}$ (volts)	Subscript	h_{FE} (min)	h_{FE} (max)	@ I_C Units	$V_{CE(SAT)}$ @ I_C (volts)	@ I_C Units	$h_{f—}$	Subscript	$f_—$	Units Subscript
2N4072	S	N		9-97	HPA	1.5W	C	200	40	20	0	10	-	25 A					550M	T
2N4073	S	N		9-97	HPA	1.5W	C	200	40	20	0	10	-	25 A					550M	T
2N4082 thru 2N4085	Field Effect Transistors, see Table on Page 1-171																			
2N4091 thru 2N4093	Field Effect Transistors, see Table on Page 1-171																			
2N4101 thru 2N4103	Thyristors, see Table on Page 1-161																			
2N4117 thru 2N4119	Field Effect Transistors, see Table on Page 1-171																			
2N4123	S	N		8-236	HSA	310M	A	135	40	30	0	50	150	2mA	0.3	50 mA	50	E	250M	T
2N4124	S	N		8-236	HSA	310M	A	135	30	25	0	120	360	2mA	0.3	50 mA	120	E	300M	T
2N4125	S	N		8-240	HSA	310M	A	135	30	30	0	50	150	2mA	0.3	50 mA	2.0	E	200M	T
2N4126	S	N		8-240	HSA	310M	A	135	25	25	0	360	120	2mA	0.3	50 mA	2.5	E	250M	T
2N4144 thru 2N4149	Thyristors, see Table on Page 1-161																			
2N4151 thru 2N4204	Thyristors, see Table on Page 1-161																			
2N4220 thru 2N4224	Field Effect Transistors, see Table on Page 1-171																			
2N4234	S	P		6-146	LPA	6W	C	200	40	40	0	30	150	250mA	0.6	1.0 A	25	E	3.0M	T
2N4235	S	P		6-146	LPA	6W	C	200	60	60	0	30	150	250mA	0.6	1.0 A	25	E	3.0M	T
2N4236	S	P		6-146	LPA	6W	C	200	80	80	0	30	150	250mA	0.6	1.0 A	25	E	3.0M	T
2N4237	S	P		6-148	LPA	5W	C	175	50	40	0	40	160	500mA	2.5	1.0 A	40	E	10M	T
2N4238	S	P		6-148	LPA	5W	C	175	80	60	0	40	160	500mA	2.5	1.0 A	40	E	10M	T
2N4239	S	P		6-148	LPA	5W	C	175	100	60	0	40	160	500mA	2.5	1.0 A	40	E	10M	T
2N4260	S	P		8-244	HNS	200M	A	200	15	15	0	30	150	10mA	15	10 mA	16	E	1500M	T
2N4261	S	P		8-244	HNS	200M	A	200	5	15	0	30	150	15 A	15	10 mA	20	E	2000M	T
2N4264	S	P		8-248	HSS	310M	A	135	30	15	0	40	160	15 A	0.22	10 mA			300M	T
2N4265	S	P		8-248	HSS	310M	A	135	30	12	0	100	400	15 A	0.22	10 mA			300M	T
2N4276	G	P		6-150	LPA	170W	C	110	30	20	0	60	120	15 A	0.30	50 A			0.4M	T
2N4277	G	P		6-150	LPA	170W	C	110	30	20	0	80	180	15 A	0.30	50 A			0.4M	T
2N4278	G	P		6-150	LPA	170W	C	110	45	30	0	60	120	15 A	0.30	50 A			0.4M	T
2N4279	G	P		6-150	LPA	170W	C	110	45	30	0	80	180	15 A	0.30	50 A			0.4M	T
2N4280	G	P		6-150	LPA	170W	C	110	60	45	0	60	120	15 A	0.30	50 A			0.4M	T
2N4281	G	P		6-150	LPA	170W	C	110	60	45	0	80	180	15 A	0.30	50 A			0.4M	T
2N4282	G	P		6-150	LPA	170W	C	110	75	60	0	60	120	15 A	0.30	50 A			0.4M	T
2N4283	G	P		6-150	LPA	170W	C	110	75	60	0	80	180	15 A	0.30	50 A			0.4M	T
2N4351 thru 2N4352	Field Effect Transistors, see Table on Page 1-171																			
3N39 thru 3N44	Reference Amplifiers, see Table on Page 1-175																			
3N45	G	P			PMS	75W	C	100	60	35		30	120	5 A	.4	5 A	30	E	600K	T
3N46	G	P			PMS	75W	C	100	80	50		20	80	5 A	.4	5 A			300K	T
3N47	G	P			PMS	75W	C	100	40	25		30	120	5 A	.4	5 A	30	E	500K	T
3N48	G	P			PMS	75W	C	100	60	40		20	80	5 A	.4	5 A			300K	T
3N49	G	P			PMS	94W	C	100	60	35		30	120	5 A	.4	5 A	30	E	600K	T
3N50	G	P			PMS	94W	C	100	80	50		20	80	5 A	.4	5 A			300K	T
3N51	G	P			PMS	94W	C	100	40	25		30	120	5 A	.4	5 A	30	E	500K	T
3N52	G	P			PMS	94W	C	100	60	40		20	80	5 A	.4	5 A			300K	T
3N58 thru 3N60	Thyristors, see Table on Page 1-161																			
3N80 thru 3N86	Thyristors, see Table on Page 1-161																			
3N89	Field Effect Transistor, see Table on Page 1-171																			
3N96 thru 3N99	Field Effect Transistors, see Table on Page 1-171																			
3N124 thru 3N126	Field Effect Transistors, see Table on Page 1-171																			

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

THYRISTORS

Index and Short Form Specifications

This table contains a numerical listing and short-form specifications for thyristors with EIA-registered 2N and 3N numbers. Specific types of thyristors listed include silicon controlled rectifiers, gate-controlled switches, and silicon controlled switches.

KEY

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
Numerical Listing of Registered Type Numbers *Device with gate turn-off characteristics							
	Type number of recommended replacement or of nearest electrical equivalent fully characterized in this book						
		Page in this book on which the device is fully characterized					
			Average Forward Current (180° conduction angle) *Pulse current rating				
				Maximum Forward Voltage Maximum Reverse Voltage For most thyristors, $V_{FOM} = V_{ROM}$ and only one voltage value is tabulated			
					Maximum Junction Temperature		
						Maximum DC Gate Current required to cause switching from the "OFF" state to the "ON" state (at 25°C)	
							The DC Voltage between gate and cathode required to produce the DC Gate Trigger Current (I_{GT})

THYRISTOR INDEX 2N681—2N1597A

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N681		5-9	16	25	125	40	2.0
2N681A			18	25	125	40	2.0
2N682		5-9	16	50	125	40	2.0
2N682A			18	50	125	40	2.0
2N683		5-9	16	100	125	40	2.0
2N683A			18	100	125	40	2.0
2N684		5-9	16	150	125	40	2.0
2N684A			18	150	125	40	2.0
2N685		5-9	16	200	125	40	2.0
2N685A			18	200	125	40	2.0
2N686		5-9	16	250	125	40	2.0
2N686A			18	250	125	40	2.0
2N687		5-9	16	300	125	40	2.0
2N687A			18	300	125	40	2.0
2N688		5-9	16	400	125	40	2.0
2N688A			18	400	125	40	2.0
2N689		5-9	16	500	125	40	2.0
2N689A			18	500	125	40	2.0
2N690			16	600	125	40	2.0
2N690A			18	600	125	40	2.0
2N691			16	700	125	40	2.0
2N692			16	800	125	40	2.0
2N764*			.20	30	125	1.0	1.0
2N765*			.20	60	125	1.0	1.0
2N766*			.20	100	125	1.0	1.0
2N767*			.20	200	125	1.0	1.0
2N876			.20	15	150	.2	.8
2N877			.20	30	150	.2	.8
2N878			.20	60	150	.2	.8
2N879			.20	100	150	.2	.8
2N880			.20	150	150	.2	.8
2N881			.20	200	150	.2	.8
2N882			.20	300	150	.2	.8
2N883			.20	400	150	.2	.8
2N884			.20	15	150	.02	.6
2N885			.20	30	150	.02	.6
2N886			.20	60	150	.02	.6
2N887			.20	100	150	.02	.6
2N888			.20	150	150	.02	.6
2N889			.20	200	150	.02	.6
2N890			.20	300	150	.02	.6
2N891			.20	400	150	.02	.6
2N892*			.250	15	125	.05	.70
2N893*			.250	15	125	.05	.70
2N894*			.250	30/15	125	0.05	0.70
2N895*			.250	30/15	125	0.05	0.70
2N896*			.250	60/15	125	0.05	0.70
2N897*			.250	60/15	125	0.05	0.70
2N898*			.250	100/15	125	0.05	0.70
2N899*			.250	100/15	125	0.05	0.70
2N900*			.250	200/15	125	0.05	0.70
2N901*			.250	200/15	125	0.05	0.70
2N948			.200	30	150	0.02	1.0
2N949			.200	60	150	0.02	1.0
2N950			.200	100	150	0.02	1.0
2N951			.200	200	150	0.02	1.0
2N1595		5-12	1.0	50	125	10	3.0
2N1595A			1.0	50	150	2.0	2.0
2N1596		5-12	1.0	100	125	10	3.0
2N1596A			1.0	100	150	2.0	2.0
2N1597		5-12	1.0	200	125	10	3.0
2N1597A			1.0	200	150	2.0	2.0

2N1598—2N1845B THYRISTOR INDEX (continued)

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N1598		5-12	1.0	300	125	10	3.0
2N1598A			1.0	300	150	2.0	2.0
2N1599		5-12	1.0	400	125	10	3.0
2N1599A			1.0	400	150	2.0	2.0
2N1600	2N4168	5-23	3	50	125	10	3.0
2N1600A			3	50	125	4.5	3.0
2N1601	2N4169	5-23	3	100	125	10	3.0
2N1602	2N4170	5-23	3	200	125	10	3.0
2N1603	2N4171	5-23	3	300	125	10	3.0
2N1604	2N4172	5-23	3	400	125	10	3.0
2N1686*			.5	30	125	1	1
2N1687*			.5	60	125	1	1
2N1688*			.5	100	125	1	1
2N1689*			.5	200	125	1	1
2N1765			50	400/-	85	10	1.5
2N1770	2N4167	5-23	4.7	25	125	15	2
2N1770A			5.7	25	150	15	2.0
2N1771	2N4168	5-23	4.7	50	125	15	2
2N1771A			4.7	50	150	15	2.0
2N1772	2N4169	5-23	4.7	100	125	15	2
2N1772A			4.7	100	150	15	2.0
2N1773	2N4170	5-23	4.7	150	125	15	2
2N1773A			4.7	150	150	15	2.0
2N1774	2N4170	5-23	4.7	200	125	15	2
2N1774A			4.7	200	150	15	2.0
2N1775	2N4171	5-23	4.7	250	125	15	2
2N1775A			4.7	250	150	15	2.0
2N1776	2N4171	5-23	4.7	300	125	15	2
2N1776A			4.7	300	150	15	2.0
2N1776B			4.7	300	150	15	2.0
2N1777	2N4172	5-23	4.7	400	125	15	2
2N1777A			4.7	400	150	15	2.0
2N1778	2N4173	5-23	4.7	500	125	15	2
2N1778A			4.7	500	150	15	2.0
2N1792			70	60	125	75	3.0
2N1793			70	120	125	75	3.0
2N1794			70	180	125	75	3.0
2N1795			70	240	125	75	3.0
2N1796			70	300	125	75	3.0
2N1797			70	360	125	75	3.0
2N1798			70	480	125	75	3.0
2N1799			70	600	125	75	3.0
2N1800			70	720	125	75	3.0
2N1801			70	840	125	75	3.0
2N1802			70	960	125	75	3.0
2N1803			70	1080	125	90	3.0
2N1804			70	1200	125	90	3.0
2N1805			70	500	125	75	3.0
2N1806			70	600	125	75	3.0
2N1807			70	700	125	75	3.0
2N1842		5-14	10	25	100	80	2.0
2N1842A		5-17	10	25	125	80	2.0
2N1842B			13	25	125	75	3.0
2N1843		5-14	10	50	100	80	2.0
2N1843A		5-17	10	50	125	80	2.0
2N1843B			13	50	125	75	3.0
2N1844		5-14	10	100	100	80	2.0
2N1844A		5-17	10	100	125	80	2.0
2N1844B			13	100	125	75	3.0
2N1845		5-14	10	150	100	80	2.0
2N1845A		5-17	10	150	125	80	2.0
2N1845B			13	150	125	75	3.0

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N1846		5-14	10	200	100	80	2.0
2N1846A		5-17	10	200	125	80	2.0
2N1846B			13	200	125	75	3.0
2N1847		5-14	10	250	100	80	2.0
2N1847A		5-17	10	250	125	80	2.0
2N1847B			13	250	125	75	3.0
2N1848		5-14	10	300	100	80	2.0
2N1848A		5-17	10	300	125	80	2.0
2N1848B			13	300	125	75	3.0
2N1849		5-14	10	400	100	80	2.0
2N1849A		5-17	10	400	125	80	2.0
2N1849B			13	400	125	75	3.0
2N1850		5-14	10	500	100	80	2.0
2N1850A		5-17	10	500	125	80	2.0
2N1850B			13	500	125	75	3.0
2N1869			.80	15	150	.2	.8
2N1869A			.80	15	150	.2	.8
2N1870			.80	30	150	.2	.8
2N1870A			.80	30	150	.2	.8
2N1871			.80	60	150	.2	.8
2N1871A			.80	60	150	.2	.8
2N1872			.80	100	150	.2	.8
2N1872A			.80	100	150	.2	.8
2N1873			.80	150	150	.2	.8
2N1873A			.80	150		.2	.8
2N1874			.80	200	150	.2	.8
2N1874A			.80	200	150	.2	.8
2N1875			.80	15	150	.020	.6
2N1875A			.80	15	150	.020	.6
2N1876			.80	30	150	.020	.6
2N1876A			.80	30	150	.020	.6
2N1877			.80	60	150	.020	.6
2N1877A			.80	60	150	.020	.6
2N1878			.80	100	150	.020	.6
2N1878A			.80	100	150	.020	.6
2N1879			.80	150	150	.020	.6
2N1879A			.80	150	150	.020	.6
2N1880			.80	200	150	.020	.6
2N1880A			.80	200	150	.020	.6
2N1881			1.00	30	150	2	2
2N1882			1.00	60	150	2	2
2N1883			1.00	100	150	2	2
2N1884			1.00	150	150	2	2
2N1885			1.00	200	150	2	2
2N1909			70	25	125	75	3.0
2N1910			70	50	125	75	3.0
2N1911			70	100	125	75	3.0
2N1912			70	150	125	75	3.0
2N1913			70	200	125	75	3.0
2N1914			70	250	125	75	3.0
2N1914A			70	250	125	75	3.0
2N1914B			70	250	125	75	3.0
2N1915			70	300	125	75	3.0
2N1916			70	400	125	75	3.0
2N1929	2N4191	5-23	.550	25	125	15	2.0
2N1930	2N4192	5-23	.550	50	125	15	2.0
2N1931	2N4193	5-23	.550	100	125	15	2.0
2N1932	2N4194	5-23	.550	150	125	15	2.0
2N1933	2N4194	5-23	.550	200	125	15	2.0
2N1934	2N4195	5-23	.550	250	125	15	2.0
2N1935	2N4195	5-23	.550	300	125	15	2.0
2N2009			1.0	25	150	0.2	1.0

2N2010—2N2547 THYRISTOR INDEX (continued)

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N2010			1.0	50	150	0.2	1.0
2N2011			1.0	100	150	0.2	1.0
2N2012			1.0	200	150	0.2	1.0
2N2013			1.0	300	150	0.2	1.0
2N2014			1.0	400	150	0.2	1.0
2N2023			70	25	150	75	3
2N2024			70	50	150	75	3
2N2025			70	100	150	75	3
2N2026			70	150	150	75	3
2N2027			70	200	150	75	3
2N2028			70	250	150	75	3
2N2029			70	300	150	75	3
2N2030			70	400	150	75	3
2N2031			70	50	125	75	3
2N2044			150	200	125	80	3
2N2045			150	300	125	80	3
2N2046			150	400	125	80	3
2N2047			150	500	125	80	3
2N2074			1	50	150	0.2	.65
2N2260*			200	30	100	.25	-
2N2261*			200	30	100	.5	-
2N2262*			200	30	100	5	-
2N2322			1.0	25	125	.2	.8
2N2322A			1.0	25	125	.02	.6
2N2323			1.0	50	125	.2	.8
2N2323A			1.0	50	125	.02	.6
2N2324			1.0	100	125	.2	.8
2N2324A			1.0	100	125	.02	.6
2N2325			1.0	150	125	.2	.8
2N2325A			1.0	150	125	.02	.6
2N2326			1.0	200	125	.2	.8
2N2326A			1.0	200	125	.02	.6
2N2327			1.0	250	125	.2	.8
2N2327A			1.0	250	125	.02	.6
2N2328			1.0	300	125	.2	.8
2N2328A			1.0	300	125	.02	.6
2N2329			1.0	400	125	.2	.8
2N2329A			1.0	400	125	.02	.6
2N2344			1.0	25	100	.02	.8
2N2345			1.0	50	100	.02	.8
2N2346			1.0	100	100	.02	.8
2N2347			1.0	150	100	.02	.8
2N2348			1.0	200	100	.02	.8
2N2454			2.5	400	105	15	3.0
2N2502	2N1850A	5-17	7	500	125	75	3.0
2N2503			150	50	125	100	2.5
2N2504			150	100	125	100	2.5
2N2505			150	200	125	100	2.5
2N2506			150	300	125	100	2.5
2N2507			150	400	125	100	2.5
2N2508			150	500	125	100	2.5
2N2542			230	50	125	125	3
2N2543			230	100	125	125	3
2N2544			230	200	125	125	3
2N2545			230	300	125	125	3
2N2546			230	400	125	125	3
2N2547			230	500	125	125	3

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N2548			230	600	125	125	3
2N2549			150	800	125	125	3
2N2550			150	1000	125	125	3
2N2573		5-20	16	25	125	40	3.5
2N2574		5-20	16	50	125	40	3.5
2N2575		5-20	16	100	125	40	3.5
2N2576		5-20	16	200	125	40	3.5
2N2577		5-20	16	300	125	40	3.5
2N2578		5-20	16	400	125	40	3.5
2N2579		5-20	16	500	125	40	3.5
2N2619	2N4174	5-23	4.7	600	125	45	2.0
2N2653	2N4172	5-23	2.5	400	105	35	3.0
2N2679			0.25	30	150	.02	.7
2N2679A			0.25	30	150	0.02	0.7
2N2680			0.25	60	150	.02	.7
2N2680A			0.25	60	150	0.02	0.7
2N2681			0.25	100	150	.02	.7
2N2681A			0.25	100	150	0.02	0.70
2N2682			0.25	200	150	.02	.7
2N2682A			0.25	200	150	0.02	0.70
2N2683			0.20	30	125	0.02	.8
2N2683A			0.20	30	125	0.02	0.80
2N2684			0.20	60	125	0.02	.8
2N2684A			0.20	60	125	0.02	0.80
2N2685			0.20	100	125	0.02	.8
2N2685A			0.20	100	125	0.02	0.80
2N2686			0.20	200	125	0.02	.8
2N2686A			0.20	200	125	0.02	0.80
2N2687			0.20	30	125	.2	1.0
2N2688			0.20	60	125	.2	1.0
2N2689			.20	100	125	.2	1.0
2N2690			.20	200	125	.2	1.0
2N2888			16	200	125	40	1.5
2N2889			16	250	125	40	1.5
2N3001			.25	30	150	.02	0.7
2N3002			0.25	60	150	.02	0.7
2N3003			0.25	100	150	.02	0.7
2N3004			0.25	200	150	.02	0.7
2N3005			0.25	30	150	.2	.8
2N3006			0.25	60	150	.2	.8
2N3007			0.25	100	150	.2	.8
2N3008			0.25	200	150	.2	.8
2N3027			.25	30	150	.2	.8
2N3028			.25	60	150	.2	.8
2N3029			.25	100	150	.2	.8
2N3030			.25	30	150	.02	.6
2N3031			.25	60	150	.02	.6
2N3032			.25	100	150	.02	.6
2N3091			70	600	125	70	2.0
2N3092			70	700	125	70	2.0
2N3093			70	800	125	70	2.0
2N3094			70	900	125	70	2.0
2N3095			70	1000	125	70	2.0
2N3096			70	1100	125	70	2.0
2N3097			70	1200	125	70	2.0
2N3098			70	1300	125	70	2.0
2N3099			70	600	125	70	2.0
2N3100			70	700	125	70	2.0

2N3101 — 2N3649 THYRISTOR INDEX (continued)

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N3101			70	800	125	70	2.0
2N3102			70	900	125	70	2.0
2N3103			70	1000	125	70	2.0
2N3104			70	1100	125	70	2.0
2N3105			70	1200	125	70	2.0
2N3106			70	1300	125	70	2.0
2N3228	2N4154	5-23	3.2	200	100	15	2.0
2N3254			0.25	15	150	0.02	0.75
2N3255			0.25	30	150	0.02	0.75
2N3256			0.25	60	150	0.02	0.75
2N3257			0.25	15	150	0.2	0.75
2N3258			0.25	30	150	0.2	0.75
2N3259			0.25	60	150	0.2	0.75
2N3269			6	100	150	0.2	0.8
2N3270			6	200	150	0.2	0.8
2N3271			6	300	150	0.2	0.8
2N3272			6	400	150	0.2	0.8
2N3273			1.7	100	150	0.2	.8
2N3274			1.7	200	150	0.2	0.8
2N3275			1.7	300	150	0.2	0.8
2N3276			1.7	400	150	0.2	0.8
2N3353			250	50	125	200	4.0
2N3354			250	100	125	200	4.0
2N3355			250	200	125	200	4.0
2N3356			250	300	125	200	4.0
2N3357			250	400	125	200	4.0
2N3358			250	500	125	200	4.0
2N3359			250	600	125	200	4.0
2N3360			250	700	125	200	4.0
2N3361			250	800	125	200	4.0
2N3362			250	900	125	200	4.0
2N3363			250	1000	125	200	4.0
2N3364			250	1200	126	200	4.0
2N3422			125	600	125	150	3.0
2N3525	2N4156	5-23	3.2	400	100	15	2
2N3528	2N4186	5-23	1.3	200	100	15	2
2N3529	2N4188	5-23	1.3	400	100	15	2
2N3530			250	50	125	300	4.0
2N3531			250	100	125	300	4.0
2N3532			250	200	125	300	4.0
2N3533			250	300	125	300	4.0
2N3534			250	400	125	300	4.0
2N3535			250	500	125	300	4.0
2N3536			250	600	125	300	4.0
2N3537			250	700	125	300	4.0
2N3538			250	800	125	300	4.0
2N3539			250	900	125	300	4.0
2N3540			250	1000	125	300	4.0
2N3541			250	1200	125	300	4.0
2N3555			1.0	30	150	.020	0.7
2N3556			1.0	60	150	.020	0.7
2N3557			1.0	100	150	.020	0.7
2N3558			1.0	200	150	.020	0.7
2N3559			1.0	30	150	0.20	0.8
2N3560			1.0	60	150	0.20	0.8
2N3561			1.0	100	150	0.20	0.8
2N3562			1.0	200	150	0.20	0.8
2N3649			16	50	120	180	3

THYRISTOR INDEX (continued) 2N3650—2N4144

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N3650			16	100	120	180	3
2N3651			16	200	120	180	3
2N3652			16	300	120	180	3
2N3653			16	400	120	180	3
2N3654			16	50	120	180	3
2N3655			16	100	120	180	3
2N3656			16	200	120	180	3
2N3657			16	300	120	180	3
2N3658			16	400	120	180	3
2N3668	MCR649P-3	5-28	8	100	100	40	2
2N3669	MCR649P-4	5-28	8	200	100	40	2
2N3670	MCR649P-6	5-28	8	400	100	40	2
2N3753			22	50	120	100	3
2N3754			22	100	120	100	3
2N3755			22	200	120	100	3
2N3756			22	300	120	100	3
2N3757			22	400	120	100	3
2N3758			22	500	120	100	3
2N3759			22	600	120	100	3
2N3760			22	700	120	100	3
2N3761			22	800	120	100	3
2N3870	MCR808-3	5-33	22	100	100	40	2
2N3871	MCR808-4	5-33	22	200	100	40	2
2N3872	MCR808-6	5-33	22	400	100	40	2
2N3873	MCR808-8	5-33	22	600	100	40	2
2N3884			175	50	125	300	4
2N3885			175	100	125	300	4
2N3886			175	200	125	300	4
2N3887			175	300	125	300	4
2N3888			175	400	125	300	4
2N3889			175	500	125	300	4
2N3890			175	600	125	300	4
2N3891			175	700	125	300	4
2N3892			175	800	125	300	4
2N3893			175	900	125	300	4
2N3894			175	1000	125	300	4
2N3895			175	1200	125	300	4
2N3896	MCR1308-3	5-33	22	100	100	40	2
2N3897	MCR1308-4	5-33	22	200	100	40	2
2N3898	MCR1308-6	5-33	22	400	100	40	2
2N3899	MCR1308-8	5-33	22	600	100	40	2
2N3936			5.25	100	125	60	3.2
2N3937			5.25	200	125	60	3.2
2N3938			5.25	300	125	60	3.2
2N3939			5.25	400	125	60	3.2
2N3940			5.25	500	125	60	3.2
2N3986			70	500	125	150	3
2N3987			70	600	125	150	3
2N3988			70	700	125	150	3
2N3989			70	800	125	150	3
2N3990			70	900	125	150	3
2N3991			70	1000	125	150	3
2N3992			70	1100	125	150	3
2N4101	2N4158	5-23	3.2	600	100	15	2
2N4102	2N4166	5-23	1.3	600	100	15	2
2N4103	MCR649P-8	5-28	8	600	100	40	2
2N4144			.250	15	150	1.0	.8

2N4145—2N4202 THYRISTOR INDEX (continued)

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N4145			.250	30	150	1.0	.8
2N4146			.250	60	150	1.0	.8
2N4147			.250	100	150	1.0	.8
2N4148			.250	150	150	1.0	.8
2N4149			.250	200	150	1.0	.8
2N4151		5-23	5	25	100	20	1.5
2N4152		5-23	5	50	100	20	1.5
2N4153		5-23	5	100	100	20	1.5
2N4154		5-23	5	200	100	20	1.5
2N4155		5-23	5	300	100	20	1.5
2N4156		5-23	5	400	100	20	1.5
2N4157		5-23	5	500	100	20	1.5
2N4158		5-23	5	600	100	20	1.5
2N4159		5-23	5	25	100	20	1.5
2N4160		5-23	5	50	100	20	1.5
2N4161		5-23	5	100	100	20	1.5
2N4162		5-23	5	200	100	20	1.5
2N4163		5-23	5	300	100	20	1.5
2N4164		5-23	5	400	100	20	1.5
2N4165		5-23	5	500	100	20	1.5
2N4166		5-23	5	600	100	20	1.5
2N4167		5-23	5	25	100	20	1.5
2N4168		5-23	5	50	100	20	1.5
2N4169		5-23	5	100	100	20	1.5
2N4170		5-23	5	200	100	20	1.5
2N4171		5-23	5	300	100	20	1.5
2N4172		5-23	5	400	100	20	1.5
2N4173		5-23	5	500	100	20	1.5
2N4174		5-23	5	600	100	20	1.5
2N4175		5-23	5	25	100	20	1.5
2N4176		5-23	5	50	100	20	1.5
2N4177		5-23	5	100	100	20	1.5
2N4178		5-23	5	200	100	20	1.5
2N4179		5-23	5	300	100	20	1.5
2N4180		5-23	5	400	100	20	1.5
2N4181		5-23	5	500	100	20	1.5
2N4182		5-23	5	600	100	20	1.5
2N4183		5-23	5	25	100	20	1.5
2N4184		5-23	5	50	100	20	1.5
2N4185		5-23	5	100	100	20	1.5
2N4186		5-23	5	200	100	20	1.5
2N4187		5-23	5	300	100	20	1.5
2N4188		5-23	5	400	100	20	1.5
2N4189		5-23	5	500	100	20	1.5
2N4190		5-23	5	600	100	20	1.5
2N4191		5-23	5	25	100	20	1.5
2N4192		5-23	5	50	100	20	1.5
2N4193		5-23	5	100	100	20	1.5
2N4194		5-23	5	200	100	20	1.5
2N4195		5-23	5	300	100	20	1.5
2N4196		5-23	5	400	100	20	1.5
2N4197		5-23	5	500	100	20	1.5
2N4198		5-23	5	600	100	20	1.5
2N4199		5-26	100*	300	105	50	1.5
2N4200		5-26	100*	400	105	50	1.5
2N4201		5-26	100*	500	105	50	1.5
2N4202		5-26	100*	600	105	50	1.5

TYPE	REPLACEMENT	PAGE NUMBER	I_O A	V_{FOM}/V_{ROM} V	T_J °C	I_{GT} mA	V_{GT} V
2N4203		5-26	100*	700	105	50	1.5
2N4204		5-26	100*	800	105	50	1.5
3N58			.064	40	150	.001	.65
3N59			.064	40	150	.001	.65
3N60			.064	40	150	.001	.65
3N80			.127	40	150	.001	.65
3N81			.127	65	150	.001	.65
3N82			.127	100	150	.001	.65
3N83			.032	70	125	.15	.80
3N84			.111	40	125	.01	.65
3N85			.111	100	125	.01	.65
3N86			.127	65	150	.001	.65

FIELD-EFFECT TRANSISTORS

This table contains a numerical listing and short-form specifications for field-effect transistors with EIA-registered 2N and 3N numbers.

KEY

TYPE	POLARITY	PAGE NUMBER	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Sub-script	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{is} pF	NF @ f dB / μV* / √Hz Units	NOTE
Numerical Listing of Registered Type Numbers	N = n-channel P = p-channel	Page in this book on which the device is fully characterized	Minimum and Maximum Drain Current with gate connected to source	Maximum Gate Current (leakage) with drain connected to source *Maximum leakage from drain to gate with source open		Minimum Breakdown Voltage (Subscript defines conditions)		Minimum and Maximum Forward Transadmittance		Maximum Input Capacitance	Noise Figure in dB or * μV / √Hz at a specified frequency; frequency units: H = Hz, K = kHz, M = MHz	

GS = Gate to source, drain connection not specified
GSS = Gate to source, drain connected to source
GD = Gate to drain, source connection not specified
GDS = Gate to drain, source connected to drain
DGO = Drain to gate, source open
DGS = Drain to gate, source connected to drain
DS = Drain to source, gate connection not specified
DSX = Drain to source, gate biased to cutoff or beyond

FIELD-EFFECT TRANSISTORS INDEX

TYPE	POLARITY	PAGE NUMBER	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Subscript	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{is} pF	NF @ f dB	NF @ f μV*/√Hz	NF @ f Units	NOTE
2N2386	P				10	20	GS	1000		50				
2N2497	P		1.0	5.0	10	20	GD	1000	2000	32	3.0		1K	
2N2498	P		2.0	6.0	10	20	GD	1500	3000	32	3.0		1K	
2N2499	P		5.0	15	10	20	GD	2000	4000	32	4.0		1K	
2N2500	P		1.0	6.0	10	20	GS	1000	2000	32	1.0		1K	
2N2606	P		.1	.5	1	30	GDS	110		6	3		1K	
2N2607	P		.3	1.5	3	30	GDS	330		10	3		1K	
2N2608	P		.9	4.5	10	30	GDS	1000		17	3		1K	
2N2609	P		2.0	10	30	30	GDS	2500		30	3		1K	
2N2841	P		.025	.125	1.0			60		6	3		1K	
2N2842	P		.065	.325	3			180		10	3		1K	
2N2843	P		.2	1.0	10			540		17	3		1K	
2N2844	P		1.0	2.2	30			1400		30	3		1K	
2N3066	N		.8	4.0	1.0	50	DGO	400	1000	10	3		1K	
2N3066A	N		.8	4.0	1.0	50	DGO	400	1000	10	.25		1K	
2N3067	N		.2	1.0	1.0	50	DGO	400		18	3		1K	
2N3067A	N		.2	1.0	1.0	50	DGO	300	1000	10	.25		1K	
2N3068	N		.05	0.25	1.0	50	DGO	200		18	3		1K	
2N3068A	N		.05	0.25	1.0	50	DGO	200	1000	10	.25		1K	
2N3069	N		2.0	10	1.0	50	DGO	1000		15	3		1K	
2N3069A	N		2.0	10	1.0	50	DGO	1000	2500	15	.25		1K	
2N3070	N		.5	2.5	1.0	50	DGO	750		15	3		1K	
2N3070A	N		0.5	2.5	1.0	50	DGO	750	2500	15	.25		1K	
2N3071	N		0.1	.6	1.0	50	DGO	500	2500	15	3		1K	
2N3084	N		.8	3	.1	15	DGO	400	2000	14				
2N3085	N		0.8	3.0	0.1	15	DGO	400	2000	14				
2N3086	N		0.8	3.0	1.0	30	DGS	400	2000	14				
2N3087	N		0.8	3.0	1.0	30	DGS	400	2000	14				
2N3088	N		0.5	2.0	1.0	10	DGS	300	2000	14	3			
2N3088A	N		0.5	2.0	1.0	10	DGS	300	2000	14	.5		10H	
2N3089	N		0.5	2.0	1.0	10	DGS	300	2000	14	3			
2N3089A	N		0.5	2.0	1.0	10	DGS	300	2000	14	.5		10H	
2N3112	P		.035	0.175	.05	20	GDS	50	115	3.5				
2N3113	P		.035	0.175	.05	20	GDS	50	115	2				
2N3277	P		.15	0.5	0.4	25	DGO	100		3				
2N3278	P		0.4	0.9	0.4	25	DGO	150		3				
2N3328	P		1.0		1.0	20	GSS	100		3	3			
2N3329	P		1.0	3.0	10	20	GSS	1000	2000	20	3			
2N3330	P		2.0	6.0	10	20	GSS	1500	3000	20	3			
2N3331	P		5.0	15	10	20	GSS	2000	4000	20	4			
2N3332	P		1.0	6.0	10	20	GSS	1000	2200	20	1			
2N3333	P		0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3334	P		0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3335	P		0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3336	P		0.3	1.0	10	20	GSS	600	1800	30				Dual
2N3365	N		0.8	4.0	5	40	DGO	250	1000	15				
2N3366	N		0.2	1.0	5	40	DGO	250	1000	15				
2N3377	N		.005	.25	5	40	DGO	100	1000	15				
2N3368	N		2.0	12	5	40	DGO	1000	4000	20				
2N3369	N		0.5	2.5	5	40	DGO	600	2500	20				
2N3370	N		0.1	0.6	5	40	DGO	300	2500	20				
2N3376	P		0.6	6.0	3	30	DGS	800		5				
2N3377	P		0.6	6.0	3	30	DGS	800	2300	4				
2N3378	P		3.0	6.0	3	30	DGS	1500	2300	5				
2N3379	P		3.0	6.0	3	30	DGS	1500	2300	4				
2N3380	P		3.0	20	3	30	DGS	1500	3000	4				
2N3381	P		3.0	20	3	30	DGS	1500	3000	4				
2N3382	P		3.0	30	15	30	DGS	4500	12500					
2N3383	P		3.0	30	15	30	DGS	4500	12500					
2N3384	P		15	30	15	30	DGS	7500	12500					
2N3385	P		15	30	15	30	DGS	7500	12500					

FIELD-EFFECT TRANSISTORS INDEX (continued)

2N3386 — 2N4085

TYPE	POLARITY	PAGE NUMBER	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} / I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Subscript	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{iss} pF	NF @ f dB	NF @ f μV* / √Hz	NF @ f Units	NOTE
2N3386	P		13	50	15	30	DGS	7500	12500					
2N3387	P		13	50	15	30	DGS	5000	10000					
2N3436	N		3	15	0.5	50	DGO	2500	10000	18	2			
2N3437	N		0.8	4.0	0.5	50	DGO	1500	6000	18	2			
2N3438	N		0.2	1.0	0.5	50	DGO	800	4500	18	2			
2N3452	N		0.8	4.0	0.1	50	DGO	200	1200	6	2			
2N3453	N		0.2	1.0	0.1	50	DGO	150	900	6	2			
2N3454	N		.05	0.25	0.1	50	DGO	100	600	6	2			
2N3455	N		0.8	4.0	.04	50	DGO	400	1200	5	4			
2N3456	N		0.2	1.0	.04	50	DGO	300	900	5	4			
2N3457	N		.05	0.25	.04	50	DGO	150	600	5	4			
2N3458	N		3.0	15	.25	50	DGO	2500	10000	18	6			
2N3459	N		0.8	4.0	.25	50	DGO	1500	6000	18	4			
2N3460	N		0.2	1.0	.25	50	DGO	800	4500	18	4			
2N3465	N		1.0	5.0	1	40	DGO	400	1200	15	5			
2N3466	N		1.0	5.0	1	40	DGO	400	1200	15	5			
2N3573	P		.02	0.1	0.6	25	GSS	100	300	6	3			
2N3574	P		.075	.375	0.6	25	GSS	200	600	6	3			
2N3575	P		0.2	1.0	0.6	25	GSS	300	900	6	3			
2N3578	P		0.9	4.5	15	20	GSS	1200	3500	65				
2N3631	N		2.0	10		20	DSX	1400	2800	7.5				
2N3684	N		2.5	7.5	0.1	50	GS	2000	3000	4	0.5			
2N3685	N		1.0	3.0	0.1	50	GS	1500	2500	4	0.5			
2N3686	N		0.4	1.2	0.1	50	GS	1000	2000	4	0.5			
2N3687	N		0.1	0.5	0.1	50	GS	500	1500	4	.15*			
2N3695	P		1.25	3.75	0.1	30	GS	1000	1750	5	.2*			
2N3696	P		0.5	1.5	0.1	30	GS	750	1250	5	.2*			
2N3697	P		0.2	0.6	0.1	30	GS	500	1000	5	.2*			
2N3698	P		.05	0.25	0.1	30	GS	250	750	5	.2*			
2N3796	N	10-4	0.5	3.0	.001	25	DSX	900	1800	6	4			
2N3797	N	10-4	2.0	6.0	.001	20	DSX	1500	3000	8	4			
2N3819	N		2	20	2	25	GSS	2000	6500	8				
2N3820	P		0.3	15	20	20	GSS	800	5000	32				
2N3821	N	10-8	0.5	2.5	0.1	50	GSS	1500	4500	6	5	10	H	
2N3822	N	10-8	2.0	10	0.1	50	GSS	3000	6500	6	5	10	H	
2N3823	N		4.0	20	0.5	30	DGS	3500	6500	6	2.5	100	M	
2N3824	N	10-8			0.1	50	GSS			6				
2N3882	P		.25		0.1	30	DS	1000	2400	4	3			
2N3909	P		0.3	15	10	20	DGS	1000	5000	32				
2N3921	N		1.0	10	0.25	50	GSS	1500	7500	18	2	1	K	Dual
2N3922	N		1.0	10	0.25	50	GSS	1500	7500	18	2	1	K	Dual
2N3934	N		.25	1.3	0.1	50	GSS	300	900	7	2	100	H	Dual
2N3935	N		.25	1.3	0.1	50	GSS	300	900	7	2	100	H	Dual
2N3954	N		0.5	5.0	0.1	50	GSS	1000		4	0.5	100	H	Dual
2N3955	N		0.5	5.0	0.1	50	GSS	1000		4	0.5	100	H	Dual
2N3956	N		0.5	5.0	0.1	50	GSS	1000		4	0.5	100	H	Dual
2N3957	N		0.5	5.0	0.1	50	GSS	1000		4	0.5	100	H	Dual
2N3958	N		0.5	5.0	0.1	50	GSS	1000		4	0.5	100	H	Dual
2N3966	N		2		0.1	30	DGS			6				
2N3967	N		2.5	10	0.1	30	DGS	1600	2400	5				
2N3968	N		1.0	5.0	0.1	30	DGS	1400	2000	5				
2N3969	N		0.4	2.0	0.1	30	DGS	950	1450	5				
2N3970	N		50	150	.25*	40	DGS			25				
2N3971	N		25	75	.25*	40	DGS			25				
2N3972	N		5	30	.25*	40	DGS			25				
2N3993	P		10		1.2*	25	GSS	6000	12000	16				
2N3994	P		2.0		1.2*	25	GSS	4000	10000	16				
2N4082	N		.25	1.3	0.1	50		300		7				Dual
2N4083	N		.25	1.3	0.1	50		300		7				Dual
2N4084	N		1.0	10	.25	50		1500		18				Dual
2N4085	N		1.0	10	.25	50		1500		18				Dual

FIELD-EFFECT TRANSISTORS INDEX (continued)

TYPE	POLARITY	PAGE NUMBER	I_{DSS} Min mA	I_{DSS} Max mA	I_{GSS} / I_{DGO}* nA	Breakdown Voltage $V_{(BR)}$ Volts	Breakdown Voltage Subscript	y_{fs} Min μmhos	y_{fs} Max μmhos	C_{ls} pF	NF @ f dB	NF @ f μV*/√Hz	NF @ f Units	NOTE
2N4091	N		30		.2*	40	DGO			16				
2N4092	N		15		.2*	40	DGO			16				
2N4093	N		8		.2*	40	DGO			16				
2N4117	N		.03	.09	.01	40	GSS	70	210	3				
2N4118	N		.08	.24	.01	40	GSS	80	250	3				
2N4119	N		0.2	0.6	.01	40	GSS	100	330	3				
2N4220	N	10-9	0.5	3.0	0.1	30	GSS	1000	4000	6				
2N4221	N	10-9	2.0	6.0	0.1	30	GSS	2000	5000	6				
2N4222	N	10-9	5.0	15	0.1	30	GSS	2500	6000	6				
2N4223	N	10-12	3	18	.25	30	GSS	3000	7000	6	5		200 M	
2N4224	N	10-12	2	20	0.5	30	GSS	2000	7500	6				
2N4351	N	10-15		.01	.01	25	DSS	1000		5.5				
2N4352	P	10-19		.005	.01	25	DSS	1000		6.5				
3N89	P		0.5	2.5	5.0	30		450	1300	3				
3N96	P		0.5	2.5	5.0	30		450	1300	4				Dual
3N97	P		0.5	2.5	5.0	30		450	1300	4				Dual
3N98	N		3.5	7.7	.05	32		1000	3000	7				
3N99	N		5.0	10.5	.05	32		1000	4500	7				
3N124	N	10-23	0.2	2.0	.25	50	GSS	500	2000	14	4		1 K	
3N125	N	10-23	1.5	4.5	.25	50	GSS	800	2400	14	4		1 K	
3N126	N	10-23	3.0	9.0	.25	50	GSS	1200	3600	14	4		1 K	

REFERENCE AMPLIFIERS

This table contains a numerical listing and short-form specifications for reference amplifiers with EIA-registered 3N numbers. In addition, short form specifications are also provided for special house numbered reference amplifiers.

KEY

TYPE	PAGE NUMBER	V_{REF} (volts)	Tol ±%	$\frac{\Delta V_{REF} \text{ (volts)}}{^{*}TC \text{ (\%/°C)}}$	I_{ZT} (mA)	Z_{ZT} (ohms)	T_1 °C	T_2 °C
Numerical Listing of Registered Type Numbers		Nominal Reference Voltage	Tolerance of Nominal Reference Voltage				Temperature Range over which ΔV_{REF} is specified *Maximum Operating Temperature	
Page in this book on which the device is fully characterized								
Maximum Voltage Variation over the Temperature Range from T_1 to T_2 *Temperature Coefficient $\left(\frac{\Delta V_1 \ 100}{V\,(T_2 - T_1)}\right)$						Maximum Zener Impedance		
					Zener Test Current			

REFERENCE AMPLIFIER INDEX

TYPE	PAGE NUMBER	V_{REF} (volts)	Tol ±%	ΔV_{REF} (volts) / °TC (%/°C)	I_{ZT} (mA)	Z_{ZT} (ohms)	T_1 °C	T_2 °C
3N39		9.0	9	.005*	5			71*
3N40		9.0	9	.003*	5			71*
3N41		9.0	9	.002*	5			71*
3N42		9.0	9	.005*	5			100*
3N43		9.0	9	.003*	5			100*
3N44		9.0	9	.002*	5			100*
3N44A		9.0	10	.001*	5			150*
MCA1911	2-39	6.8	10	.051	5	40	0	75
MCA1912	2-39	6.8	10	.025	5	40	0	75
MCA1913	2-39	6.8	10	.010	5	40	0	75
MCA1914	2-39	6.8	10	.005	5	40	0	75
MCA1921	2-39	6.8	5	.105	5	40	-55	100
MCA1922	2-39	6.8	5	.052	5	40	-55	100
MCA1923	2-39	6.8	5	.020	5	40	-55	100
MCA1924	2-39	6.8	5	.010	5	40	-55	100
MCA1931	2-39	6.8	5	.139	5	40	-55	150
MCA1932	2-39	6.8	5	.069	5	40	-55	150
MCA1933	2-39	6.8	5	.026	5	40	-55	150
MCA1934	2-39	6.8	5	.013	5	40	-55	150
MCA2011	2-39	8.6	10	.060	5	40	0	75
MCA2012	2-39	8.6	10	.030	5	40	0	75
MCA2013	2-39	8.6	10	.012	5	40	0	75
MCA2014	2-39	8.6	10	.006	5	40	0	75
MCA2021	2-39	8.6	5	.124	5	40	-55	100
MCA2022	2-39	8.6	5	.062	5	40	-55	100
MCA2023	2-39	8.6	5	.024	5	40	-55	100
MCA2024	2-39	8.6	5	.012	5	40	-55	100
MCA2031	2-39	8.6	5	.164	5	40	-55	150
MCA2032	2-39	8.6	5	.082	5	40	-55	150
MCA2033	2-39	8.6	5	.032	5	40	-55	150
MCA2034	2-39	8.6	5	.016	5	40	-55	150
MCA2111	2-39	9.5	10	.071	5	40	0	75
MCA2112	2-39	9.5	10	.035	5	40	0	75
MCA2113	2-39	9.5	10	.014	5	40	0	75
MCA2114	2-39	9.5	10	.007	5	40	0	75
MCA2121	2-39	9.5	5	.147	5	40	-55	100
MCA2122	2-39	9.5	5	.073	5	40	-55	100
MCA2123	2-39	9.5	5	.028	5	40	-55	100
MCA2124	2-39	9.5	5	.014	5	40	-55	100
MCA2131	2-39	9.5	5	.194	5	40	-55	150
MCA2132	2-39	9.5	5	.097	5	40	-55	150
MCA2133	2-39	9.5	5	.038	5	40	-55	150
MCA2134	2-39	9.5	5	.019	5	40	-55	150
MCA2211	2-39	11.0	10	.082	5	40	0	75
MCA2212	2-39	11.0	10	.041	5	40	0	75
MCA2213	2-39	11.0	10	.016	5	40	0	75
MCA2214	2-39	11.0	10	.008	5	40	0	75
MCA2221	2-39	11.0	5	.170	5	40	-55	100
MCA2222	2-39	11.0	5	.085	5	40	-55	100
MCA2223	2-39	11.0	5	.034	5	40	-55	100
MCA2224	2-39	11.0	5	.017	5	40	-55	100
MCA2231	2-39	11.0	5	.225	5	40	-55	150
MCA2232	2-39	11.0	5	.112	5	40	-55	150
MCA2233	2-39	11.0	5	.044	5	40	-55	150
MCA2234	2-39	11.0	5	.022	5	40	-55	150

UNIJUNCTION TRANSISTORS

This table contains a numerical listing and short-form specifications for unijunction transistors with EIA-registered 2N numbers.

KEY

P_D = Power Dissipation @ 25°C
R_{BB} = Interbase Resistance
η = Intrinsic Standoff Ratio
$I_{V(min)}$ = Minimum Valley Current
$I_{P(max)}$ = Maximum Peak Point Current
I_{EO} = Maximum Emitter Reverse Current at Indicated V_{EB2}
$V_{E(SAT)}$ = Emitter Saturation Voltage @ $I_E = 50$ mA, $V_{BB} = 10$ V

UNIJUNCTION TRANSISTORS INDEX

TYPE	REPLACEMENT	PAGE NUMBER	P_D (mW)	R_{BB} (kΩ)	η	I_V(min) (mA)	I_P(max) (μA)	I_{EO} @ V_{EB2} (μA @ V max)	$V_{E(SAT)}$ (V @ 50 mA)
2N489			450	6.8	0.62	8.0	20	12 @ 60	5.0
2N489A			450	6.8	0.62	8.0	15	12 @ 60	4.0
2N489B			450	6.8	0.62	8.0	6.0	0.2 @ 60	4.0
2N490			450	9.1	0.62	8.0	20	12 @ 60	5.0
2N490A			450	9.1	0.62	8.0	15	12 @ 60	4.0
2N490B			450	9.1	0.62	8.0	6.0	0.2 @60	4.0
2N490C			450	9.1	0.51				
2N491			450	6.8	0.68	8.0	20	12 @ 60	5.0
2N491A			450	6.8	0.68	8.0	15	12 @ 60	4.3
2N491B			450	6.8	0.68	8.0	6.0	0.2 @ 60	4.3
2N492			450	9.1	0.68	8.0	20	12 @ 60	5.0
2N492A			450	9.1	0.68	8.0	15	12 @ 60	4.3
2N492B			450	9.1	0.68	8.0	6.0	0.2 @ 60	4.3
2N492C			450	9.1	0.56				
2N493			450	6.8	0.75	8.0	20	12 @ 60	5.0
2N493A			450	6.8	0.75	8.0	15		
2N493B			450	6.8	0.75	8.0	6.0	0.2 @ 60	5.0
2N494			450	9.1	0.75	8.0	20	12 @ 60	5.0
2N494A			450	9.1	0.75	8.0	15	12 @ 60	4.6
2N494B			450	9.1	0.75	8.0	6.0	0.2 @ 60	4.6
2N494C			450	9.1	0.62	8.0	2.0	0.02 @ 60	4.6
2N1671			450	9.1	0.62	8.0	25	12 @ 30	5.0
2N1671A			450	9.1	0.62	8.0	25	12 @ 30	5.0
2N1671B			450	9.1	0.62	8.0	6.0	0.2 @ 30	5.0
2N1671C			450	4.1 -9.1					
2N2160			450	4.0 -12	0.47 -0.80	8.0	25	12 @ 30	
2N2417			390	0.68	0.62	8.0	20	12 @ 60	5.0
2N2417A			390	0.68	0.62	8.0	20	12 @ 60	4.0
2N2417B			300	6.8	0.51 -0.62	8.0	6.0	0.2 @ 30	4.0
2N2418			390	0.68	0.62	8.0	20	12 @ 60	5.0
2N2418A			390	9.1	0.62	8.0	20	12 @ 60	4.0
2N2418B			300	9.1	0.51 -0.62	8.0	6.0	0.2 @ 60	4.0
2N2419			390	4.7 -6.8	0.68	8.0	20	12 @ 60	5.0
2N2419A			390	6.8	0.68	8.0	20	12 @ 60	4.3
2N2419B			300	6.8	0.56 -0.68	8.0	6.0	0.2 @ 30	4.3
2N2420			390	9.1	0.68	8.0	20	12 @ 60	5.0
2N2420A			390	9.1	0.68	8.0	20	12 @ 60	4.3
2N2420B			300	9.1	0.56 -0.68	8.0	6.0	0.2 @ 30	4.3
2N2421			390	6.8	0.75	8.0	20	12 @ 60	5.0
2N2421A			390	6.8	0.75	8.0	20	12 @ 60	4.6
2N2421B			300	6.8	4.7 -6.8	8.0	6.0	0.2 @ 30	4.6

2N2422 — 2N3980 UNIJUNCTION TRANSISTORS INDEX (continued)

TYPE	REPLACEMENT	PAGE NUMBER	P_D (mW)	R_{BB} (kΩ)	η	I_V(min) (mA)	I_P(max) (μA)	I_{EO} @ V_{EB2} (μA @ V max)	$VE_{(BAT)}$ (V @ 50 mA)
2N2422			390	9.1	0.75	8.0	20	12 @ 60	5.0
2N2422A			390	9.1	0.75	8.0	20	12 @ 60	4.6
2N2422B			300	9.1	0.62 -0.75	8.0	6.0	0.2 @ 30	
2N2646			300	4.7	0.56	4.0	25	12 @ 30	2.0
2N2647			300	4.7	0.68	8.0	2.0	0.2 @ 30	2.0
2N2840			300	4.7 -9.1	1.3 -1.5	0.70	10	1 @ 30	
2N3406			450			8.0			
2N3479			400	4.7 -9.1	0.47 -0.62	6.0	20	12 @ 30	5.0
2N3480			400	9.1	0.75	4.0	15	12 @ 30	5.0
2N3481			400	9.1	0.85	6.0	15	12 @ 30	5.0
2N3482			400	4.7 -6.8	0.51 -0.62	8.0	2.0	0.02 @ 30	5.0
2N3483			400	9.1	0.72	8.0	2.0	1 @ 30	5.0
2N3484			400	9.1	0.85	8.0	2.0	0.2 @ 30	5.0
2N3679			250	9.1	0.80	4.2			
2N3980			360	8.0					

ADDITIONS AND MODIFICATIONS

ALPHABETICAL INDEX OF NON-REGISTERED TYPE NUMBERS

This table lists non-registered device types characterized in this manual in alphabetical sequence.

Type No.	Page	Type No.	Page	Type No.	Page
1/4M2.4AZ	2-8	1/4M47Z	2-8	MA882	7-50
1/4M2.7AZ	2-8	1/4M50Z	2-8	MA883	7-50
1/4M3.0AZ	2-8	1/4M52Z	2-8	MA884	7-50
1/4M3.3AZ	2-8	1/4M56Z	2-8	MA885	7-50
1/4M3.6AZ	2-8	1/4M62Z	2-8	MA886	7-50
1/4M3.9AZ	2-8	1/4M68Z	2-8	MA887	7-50
1/4M4.3AZ	2-8	1/4M75Z	2-8	MA888	7-50
1/4M4.7AZ	2-8	1/4M82Z	2-8	MA889	7-50
1/4M5.1AZ	2-8	1/4M91Z	2-8	MA909	7-52
1/4M5.6AZ	2-8	1/4M100Z	2-8	MA910	7-52
1/4M6.2AZ	2-8	1/4M105Z	2-8	MA1702	7-53
1/4M6.8Z	2-8	1/4M110Z	2-8	MA1703	7-53
1/4M7.5Z	2-8	1/4M120Z	2-8	MA1704	7-53
1/4M8.2Z	2-8	1/4M130Z	2-8	MA1705	7-53
1/4M9.1Z	2-8	1/4M140Z	2-8	MA1706	7-53
1/4M10Z	2-8	1/4M150Z	2-8	MA1707	7-53
1/4M11Z	2-8	1/4M175Z	2-8	MA1708	7-53
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1/4M13Z	2-8	MA100	7-44	MC201	13-5
1/4M14Z	2-8	MA112	7-46	MC202	13-5
1/4M15Z	2-8	MA113	7-46	MC203	13-7
1/4M16Z	2-8	MA114	7-46	MC204	13-9
1/4M17Z	2-8	MA115	7-46	MC205	13-11
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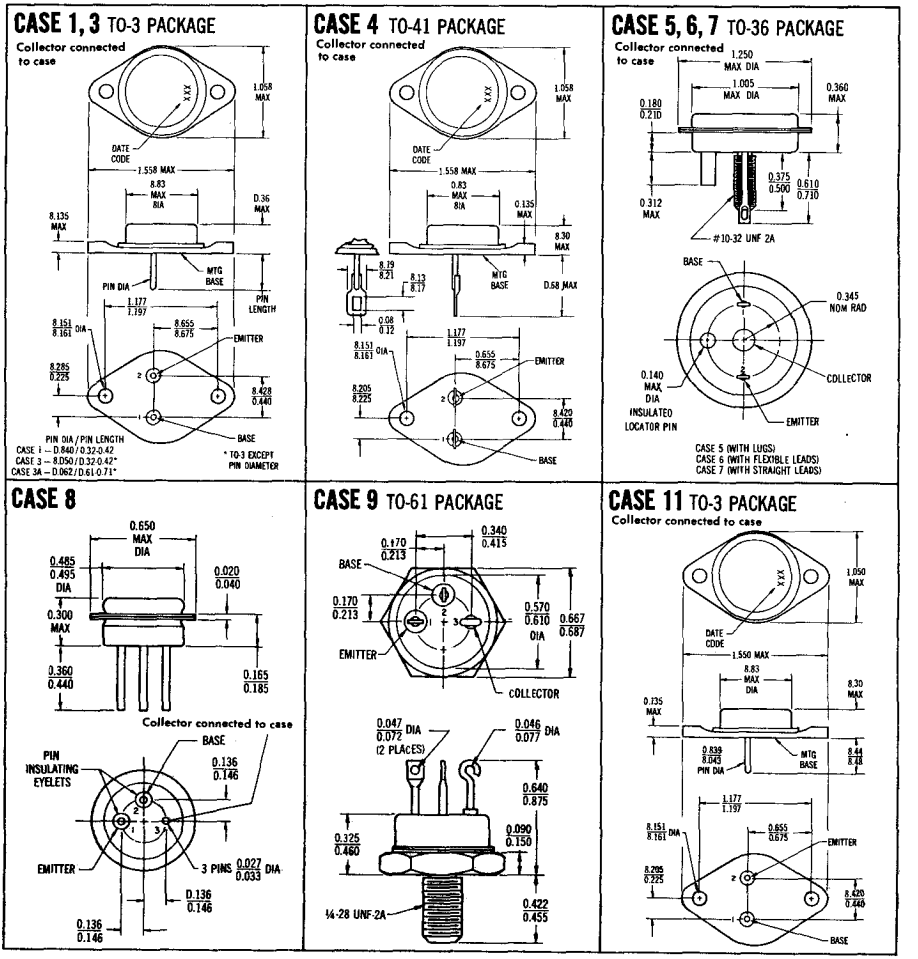
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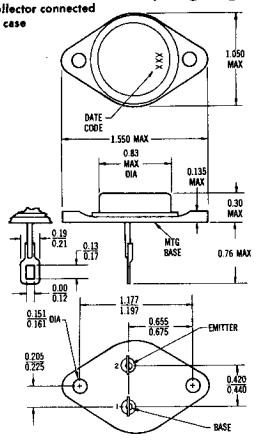
DEVICE OUTLINE DIMENSIONS

All dimensions are in inches.

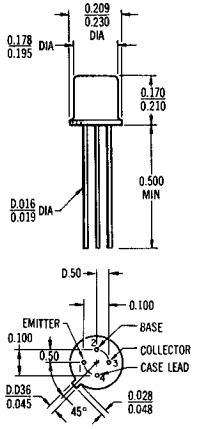


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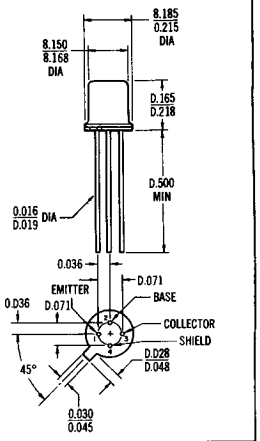
Collector connected to case



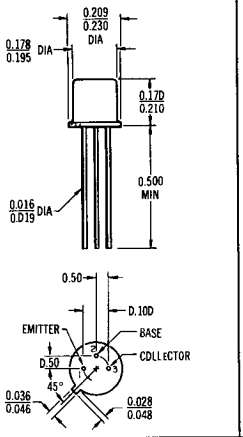
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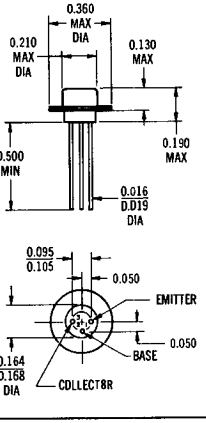
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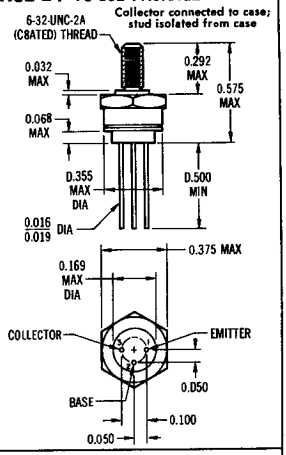
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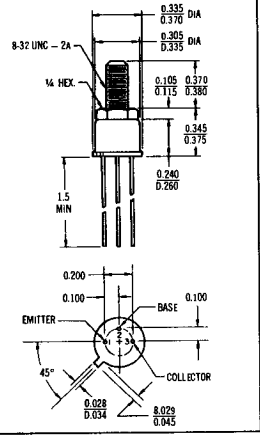
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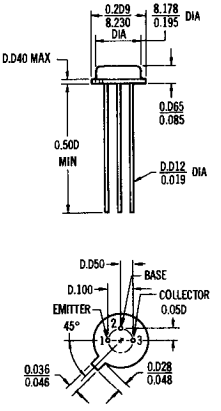
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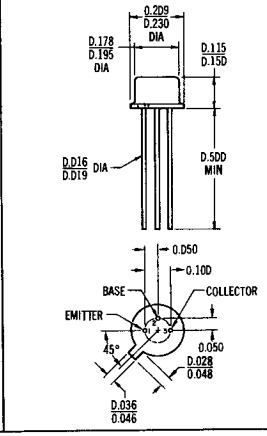
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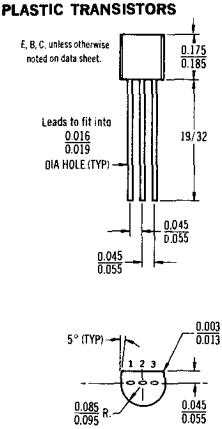


CASE 27 TO-52 PACKAGE

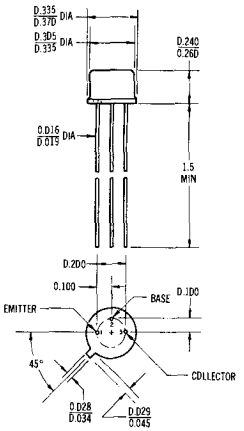


All dimensions are in inches.

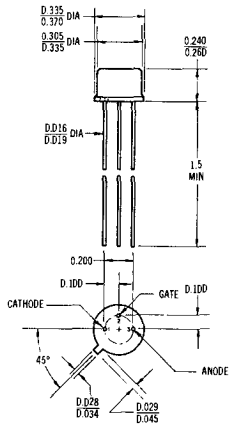
CASE 29 TO-92 PACKAGE
PLASTIC TRANSISTORS



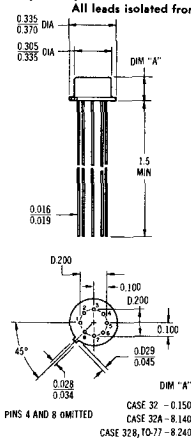
CASE 31 TO-5 PACKAGE



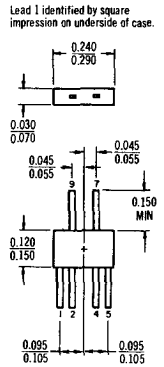
CASE 31A TO-5 PACKAGE



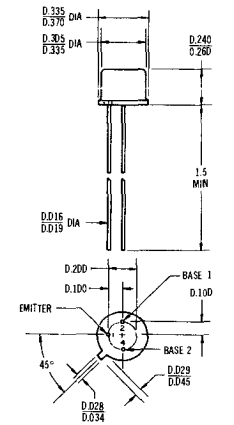
CASE 32, 32A, 32B
All leads isolated from case



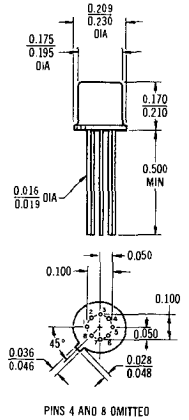
CASE 33 TO-89 PACKAGE
All leads isolated from case



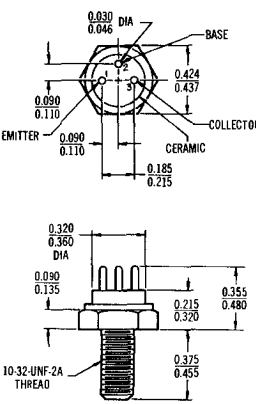
CASE 34



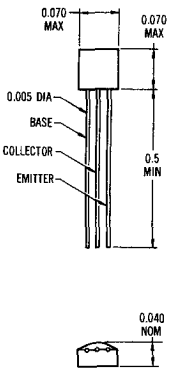
CASE 35 TO-71 PACKAGE
All leads isolated from case



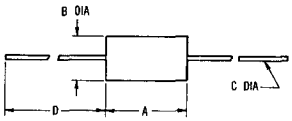
CASE 36 TO-60 PACKAGE



CASE 37 CERAMIC PACKAGE

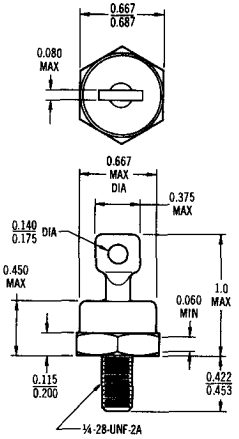


CASE 41

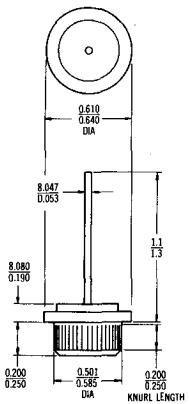


PKG.	OUTLINE DIMENSIONS (INCHES) A MAX	B MAX	C ±0.002	D MIN
41-1	1.00	0.500	0.032	1.25
41-2	0.500	0.375	0.032	1.25
41-3	1.030	0.378	0.032	1.25
41-4	1.220	0.641	0.032	1.75
41-5	0.655	0.641	0.032	1.25
41-6	0.520	0.275	0.022	1.25
41-7	1.000	0.375	0.032	1.25

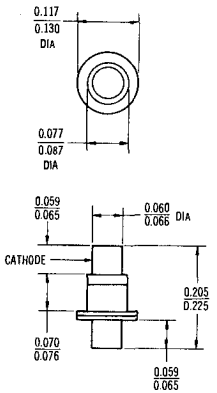
CASE 42 DO-5 PACKAGE



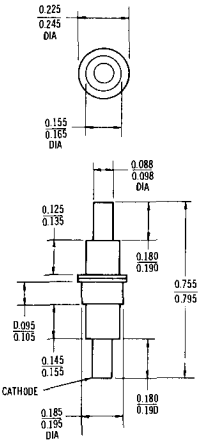
CASE 43 DO-21 PACKAGE



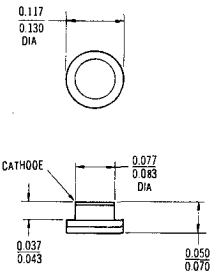
CASE 46



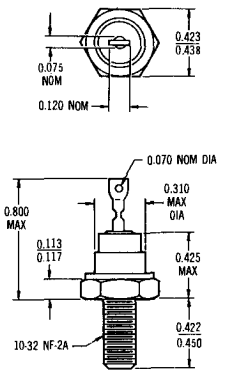
CASE 47



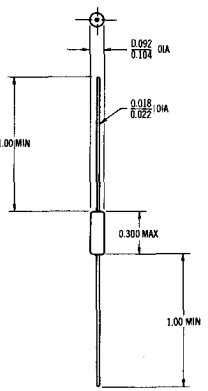
CASE 48



CASE 49

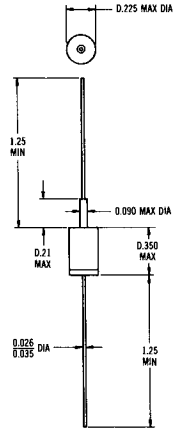


CASE 51 DO-7 GLASS PACKAGE

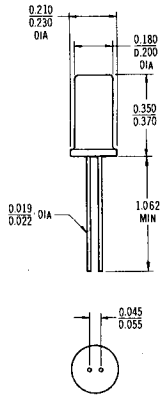


All dimensions are in inches.

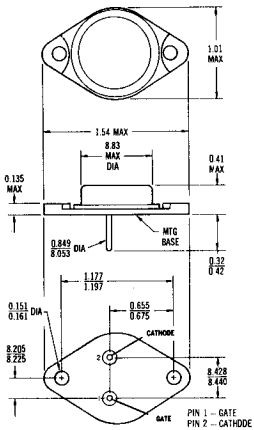
CASE 52 DO-13 PACKAGE



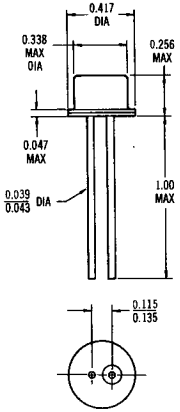
CASE 53



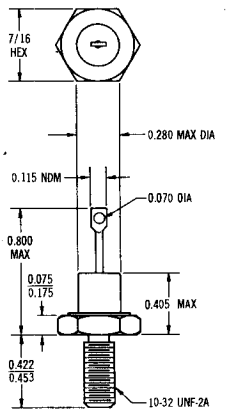
CASE 54 (TO-3 Except Pin Diameter)



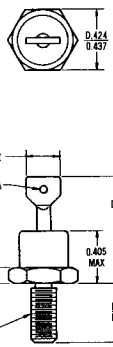
CASE 55



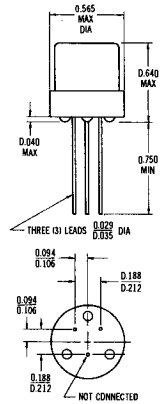
CASE 56 DO-4 PACKAGE



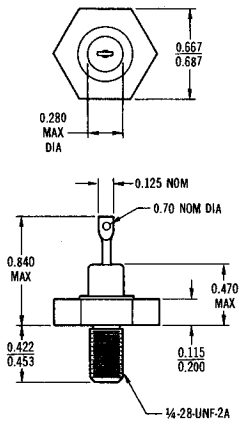
CASE 56A DO-4 PACKAGE



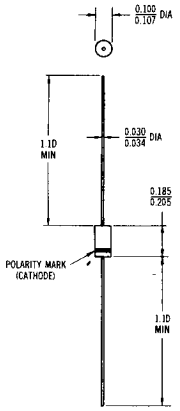
CASE 57



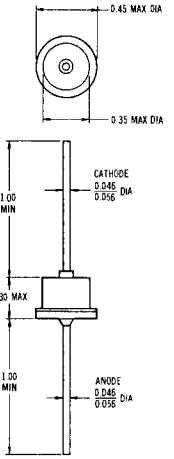
CASE 58



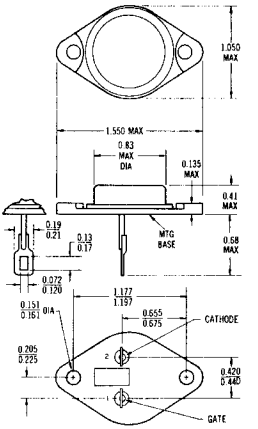
CASE 59



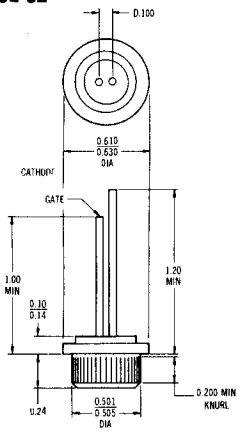
CASE 60



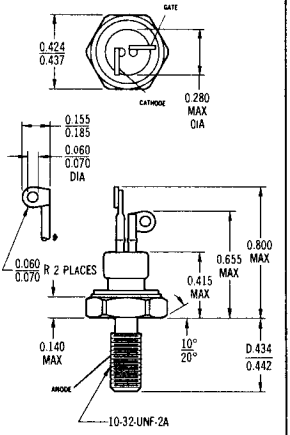
CASE 61 TO-41 PACKAGE



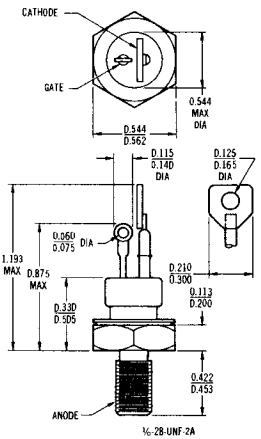
CASE 62



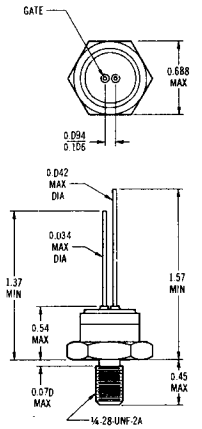
CASE 63



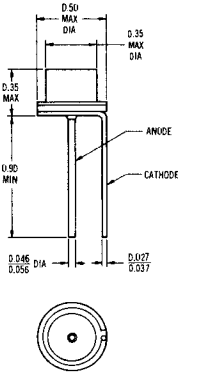
CASE 64 TO-48 PACKAGE



CASE 68



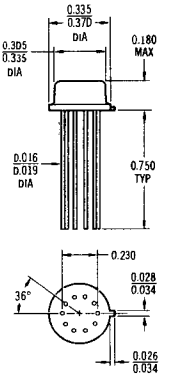
CASE 70



CASE 71, 71A

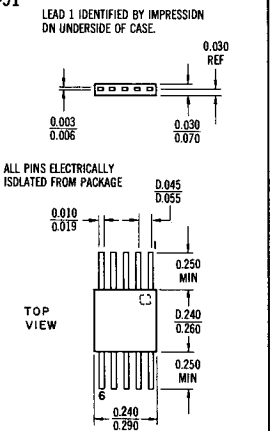
CASE 71A –
PIN 10 UNDER
TAB



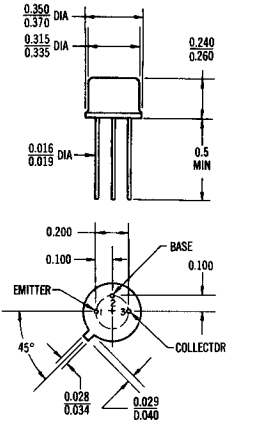


All dimensions are in inches.

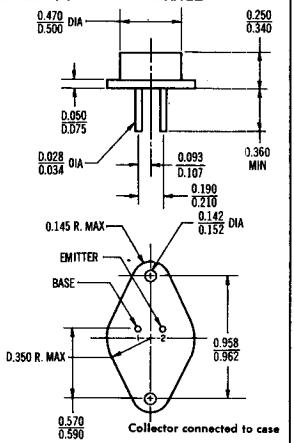
CASE 72 10-LEAD FLAT PACKAGE TO-91



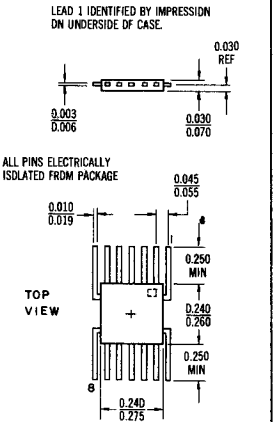
CASE 79 TO-39 PACKAGE



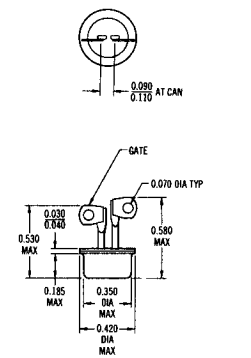
CASE 80 TO-66 PACKAGE



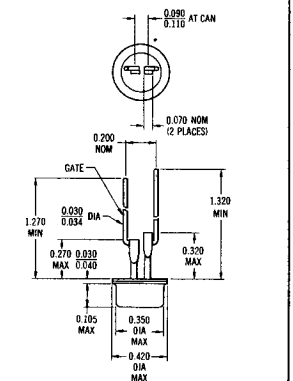
CASE 83 14-LEAD FLAT PACKAGE TO-86



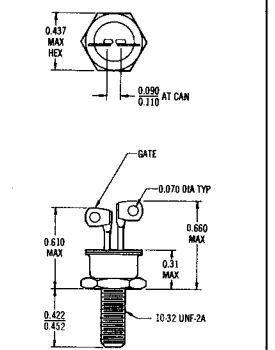
CASE 85



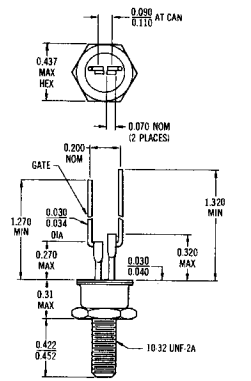
CASE 85L



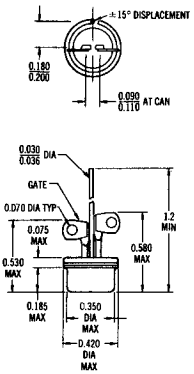
CASE 86



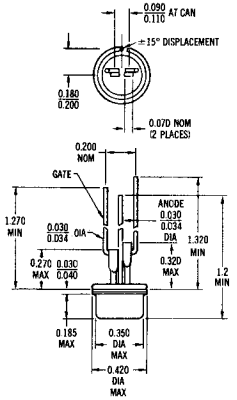
CASE 86L



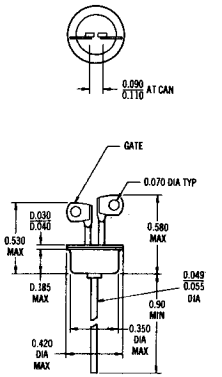
CASE 87



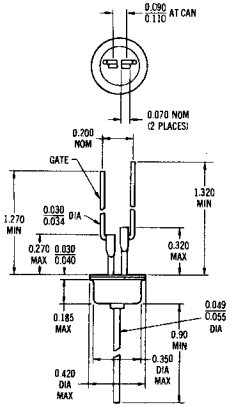
CASE 87L



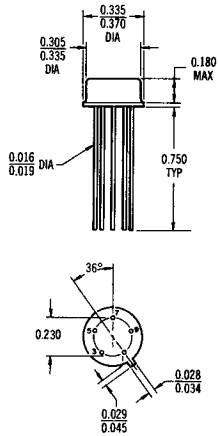
CASE 88



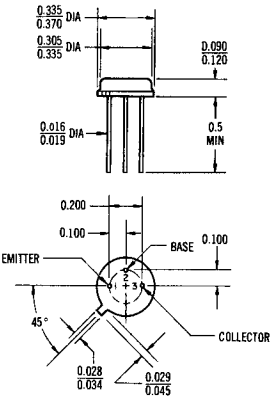
CASE 88L



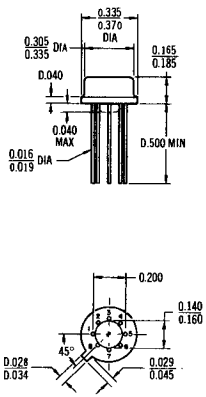
CASE 89



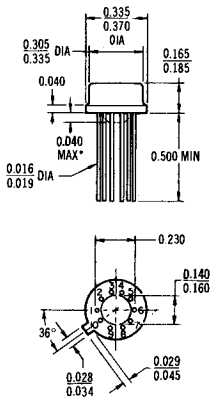
CASE 94



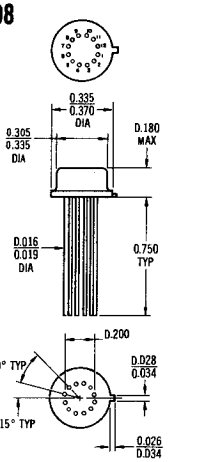
CASE 96 TO-99 PACKAGE



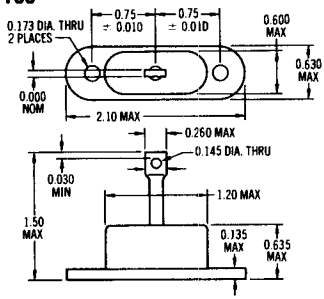
CASE 96A TO-100 PACKAGE



CASE 98



CASE 100



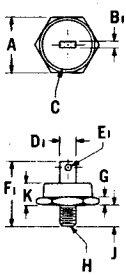
Io Output Current	Dimensions — Inches						
	A HEX	B1 MAX	B2 MAX	C MAX DIA	D1 MAX	D2 MAX	E DIA
80	1.250	0.135	0.113	1.20	0.525	0.590	0.250
160	1.75	0.260	0.155	1.72	0.760	0.64	0.375
240	2.00	0.260	0.200	1.94	1.10	1.00	0.562
400	2.250	0.320	0.260	2.20	1.10	1.155	0.562

	E2 DIA	F1 MAX	F2 MAX	G	H THREAD	J MAX	K MAX
80	0.281	2.25	6.25	0.125	10-32	0.500	0.570
160	0.343	3.0	8.10	0.375	3/8-16 UNF	1.00	1.10
240	0.531	3.50	8.10	0.375	3/8-16 UNF	1.00	1.10
400	0.562	3.72	8.10	0.375	3/8-16 UNF	1.00	1.10

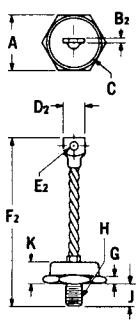
Io Output Current	Dimensions — Inches						
	A	B DIA	C MAX	D MAX DIA	E1 MAX	E2 MAX	F1 MAX
160	2.25	0.203	0.880	1.720	0.260	0.155	0.760
240	3.00	0.281	1.255	2.100	0.260	0.200	1.100
400	3.00	0.281	1.255	2.200	0.320	0.260	1.100
650	3.25	0.281	1.380	2.885	0.500	—	1.30

	F2 MAX	G1 MAX	G2 MAX	H1 DIA	H2 DIA	J MAX	K MAX
160	0.64	1.9	7.10	0.375	0.343	0.260	1.00
240	1.00	2.50	6.90	0.562	0.531	0.260	1.00
400	1.155	2.70	6.90	0.562	0.562	0.260	1.00
650	—	2.50	—	0.562	—	0.260	1.00

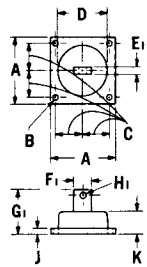
CASE 101



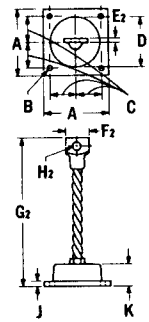
CASE 102



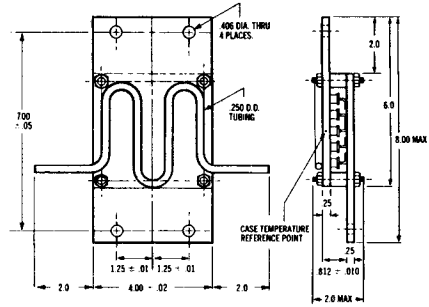
CASE 103



CASE 104



CASE 105



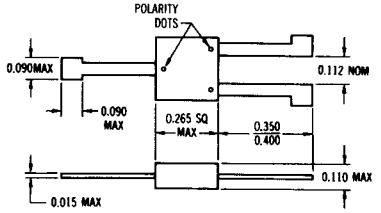
COLOR-CODED POLARITY DOTS:

Y = AC INPUT

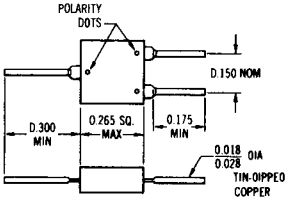
R = +DC OUTPUT

(NO MARK) = −DC OUTPUT

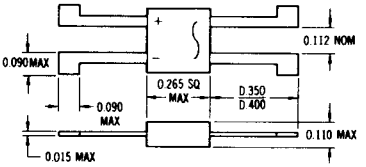
CASE 106



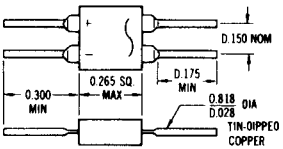
CASE 107



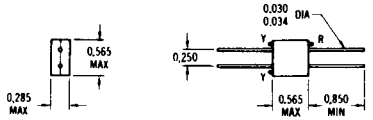
CASE 108



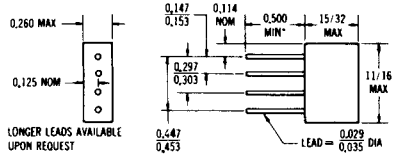
CASE 109



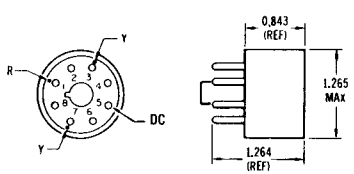
CASE 110



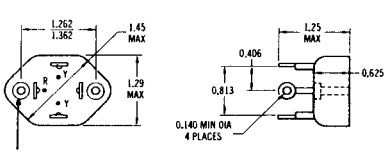
CASE 111



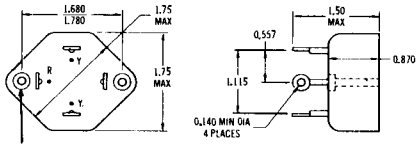
CASE 112



CASE 113

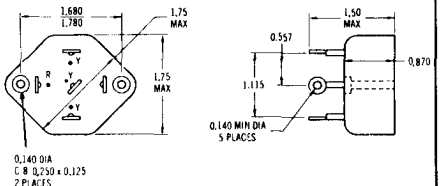


CASE 114

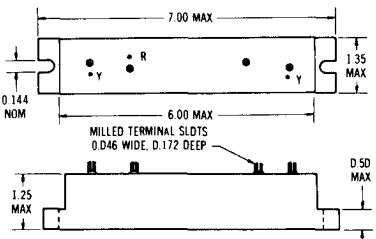


Device Outline Dimensions

CASE 115



CASE 116



ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

SILICON ZENER DIODES

Including

TEMPERATURE COMPENSATED DIODES

REFERENCE AMPLIFIERS

The following table lists a number of semiconductor devices that comply with the terms of military specifications, the applicable military specifications and the appropriate page in the data sections of this manual. For additional information, military-type data sheets are available.

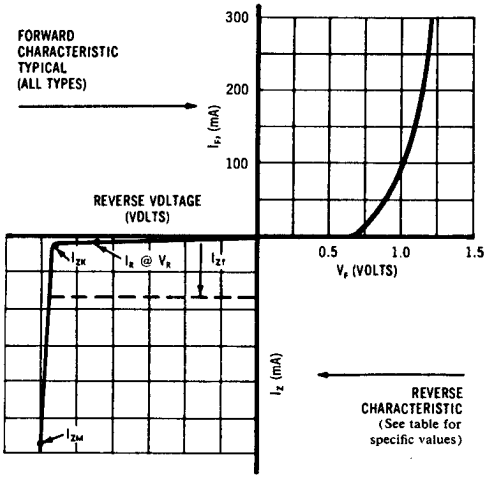
SILICON REGULATOR DIODES

		page
JAN 1N746A thru JAN 1N759A	MIL-S-19500/127	2-10
JAN 1N962B thru JAN 1N984B	MIL-S-19500/117	2-11
JAN 1N2804B thru JAN 1N2811B	MIL-S-19500/114	2-15
JAN 1N2813B	MIL-S-19500/114	2-15
JAN 1N2814B	MIL-S-19500/114	2-15
JAN 1N2816B	MIL-S-19500/114	2-15
JAN 1N2818B thru JAN 1N2820B	MIL-S-19500/114	2-15
JAN 1N2822B thru JAN 1N2827B	MIL-S-19500/114	2-15
JAN 1N2829B	MIL-S-19500/114	2-15
JAN 1N2831B thru JAN 1N2838B	MIL-S-19500/114	2-15
JAN 1N2804B thru JAN 1N2846B	MIL-S-19500/114	2-15
JAN 1N2970B thru JAN 1N2977B	MIL-S-19500/124	2-18
JAN 1N2979B	MIL-S-19500/124	2-18
JAN 1N2980B	MIL-S-19500/124	2-18
JAN 1N2982B	MIL-S-19500/124	2-18
JAN 1N2984B	MIL-S-19500/124	2-18
JAN 1N2988B thru JAN 1N2993B	MIL-S-19500/124	2-18
JAN 1N2995B	MIL-S-19500/124	2-18
JAN 1N2997B	MIL-S-19500/124	2-18
JAN 1N2999B thru JAN 1N3005B	MIL-S-19500/124	2-18
JAN 1N3007B thru JAN 1N3009B	MIL-S-19500/124	2-18
JAN 1N3011B	MIL-S-19500/124	2-18
JAN 1N3012B	MIL-S-19500/124	2-18
JAN 1N3014B	MIL-S-19500/124	2-18
JAN 1N3015B	MIL-S-19500/124	2-18
JAN 1N3016B thru JAN 1N3051B	MIL-S-19500/115	2-19
JAN 1N3821A thru JAN 1N3828A	MIL-S-19500/115	2-23
JAN 1N3993A thru JAN 1N4000A	MIL-S-19500/272	2-24
JAN 1N4370A thru JAN 1N4372A	MIL-S-19500/127	2-10

SILICON REFERENCE DIODES

		page
JAN 1N429	MIL-S-19500/299	2-32
USN 1N821	MIL-S-19500/159	2-32
USN 1N823	MIL-S-19500/159	2-32
USN 1N825	MIL-S-19500/159	2-32
USN 1N827	MIL-S-19500/159	2-32
USN 1N829	MIL-S-19500/159	2-32
USN 1N935B	MIL-S-19500/156	2-32
USN 1N937B	MIL-S-19500/156	2-32
USN 1N938B	MIL-S-19500/156	2-32
USN 1N939B	MIL-S-19500/156	2-32
USN 1N941B	MIL-S-19500/157	2-32
USN 1N943B	MIL-S-19500/157	2-32
USN 1N944B	MIL-S-19500/157	2-32
JAN 1N3154 thru JAN 1N3157	MIL-S-19500/158	2-32

SILICON ZENER DIODES



- I_F - Forward Current
- I_Z - Zener Current
- I_{ZK} - Zener Current Near Breakdown Knee
- I_{ZM} - Maximum DC Zener Current (limited by power dissipation)
- I_{ZT} - Zener Test Current
- V_F - Forward Voltage
- V_Z - Nominal Zener Voltage
- Z_Z - Zener Impedance
- Z_{ZK} - Zener Impedance Near Breakdown Knee (I_{ZK})
- Z_{ZT} - Zener Impedance At Test Current (I_{ZT})
- I_R - Reverse Current
- V_R - Reverse Test Voltage

The zener diode is unique within the semiconductor family of devices in that its important electrical properties are associated with a p - n junction operated under reverse-bias avalanche (breakdown) conditions. The major electrical characteristics associated with such devices, from an applications viewpoint, are defined as follows:

Zener Voltage -- (V_Z) -- Nominal zener voltage, measured at a specified test current (I_{ZT}) in the constant-voltage region, with the device junction in thermal equilibrium with a 25°C ambient temperature.

Zener Impedance -- (Z_Z) -- The impedance of a zener diode is normally specified at two points of the zener characteristics curve: at the knee of the zener plateau, and near the midrange of the zener excursion. The values of Z_Z are derived by superimposing a 60-cycle current on the zener test current (I_{ZT}) or on the zener knee current (I_{ZK}) and measuring the resulting AC voltage across the device. The RMS value of the applied 60-cycle current is 10% of the zener current (I_{ZT} or I_{ZK}).

A 100% CRT curve trace is used to insure that each zener diode breakdown region begins at a current lower than I_{ZK} and continues at nearly constant voltage to a current level in excess of I_{ZM}.

Maximum Zener Current Rating -- (I_{ZM}) -- This current rating denotes the maximum current that can be supplied by a device without exceeding the rated power level. This depends, of course, on the nominal zener voltage (V_Z).

Reverse Current -- (I_R) -- Reverse current is the leakage current of the zener diode in the non-conducting region of the device, i.e., in the area of an applied voltage between 0 and avalanche breakdown. It is normally specified at a reverse voltage (V_R) of approximately 0.8 (V_Z -- tolerance).

For case outline dimensions, see page 1-186.

HOW TO OBTAIN NON-STANDARD ZENER DIODES

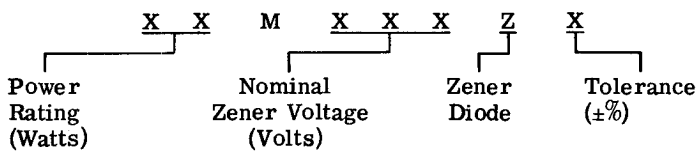
Zener Diodes With Special Voltage Ratings and Tolerances

Each of JEDEC "1N" type numbers for zener diodes stands for a device with a specific zener voltage, power rating and voltage tolerance. A variation of voltage tolerances, however, is provided for in the EIA registration by a series of suffixes. For example, the JEDEC type number 1N4728 stands for a 1-watt diode with a zener voltage rating of 3.3 volts ±10%. The same type number, with a suffix A, i.e., 1N4728A, indicates a ±5% voltage tolerance.

The suffix usage varies with individual registrations. Consult data sheets or Selection Guide for particulars.

There are many instances, however, when a circuit design calls for a device with a special zener voltage rating and/or a special tolerance not provided for in the standard registration format. Nevertheless, such special devices are normally available on special order, giving the designer a tremendous choice of voltages and tolerances for his design.

To facilitate the purchase of a device with a non-standard voltage or tolerance, a special code number has been devised, as follows:



For example, a special 10 watt zener diode with a zener voltage of 41 volts ±1% would be ordered as follows:

10M41Z1

The above nomenclature applies for all packages and all power categories indicated in the selector guide on pages 2-6 and 2-7, except for the 1-watt plastic package and the 50-watt stud package. These two exceptions are made necessary by the fact that each of these power categories is served by two different package types.

Special 1-watt plastic packaged devices are specified as follows:

1MXXXZSX

Special 10-watt or 50-watt stud packaged devices are specified as follows:

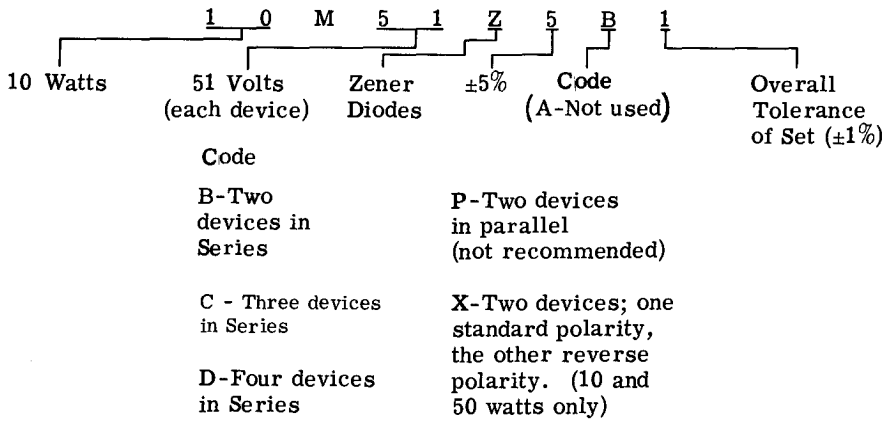
50MXXXSZXX

Matched Sets of Zener Diodes

Zener diodes can also be obtained in sets consisting of two or more matched devices. The method for specifying such matched sets is similar to that used in specifying special units except that two extra suffixes are added to the specification described above.

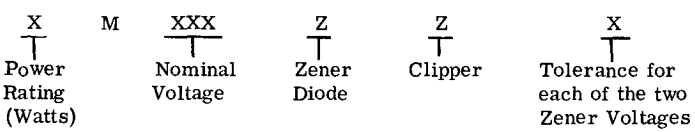
These units are marked with code letters to identify the matched sets.

For example:



ZENER CLIPPERS

Special clipper diodes with opposing zener junctions built into the device are available by using the following nomenclature



This nomenclature is applicable to all packages and power ratings as restricted on page 2-4 and above.

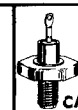
ZENER DIODE SELECTION GUIDE

IMPORTANT . . . The devices listed represent a basic profile of the largest inventoried zener diode line in the industry. Many additional types not listed, including in-between voltages, matched pairs, double-anode clippers and combination molded assemblies are also available.

Nominal Zener Voltage Vz	¼ WATT Cathode = Polarity Mark		400 MILLIWATT Cathode = Polarity Mark		1 WATT Cathode = Polarity Mark	1 WATT Cathode to Case	
	 CASE 51		 CASE 51		 CASE 59	 CASE 52	
	INDUSTRIAL (NOTE 1)	INDUSTRIAL ±5% TOLERANCE	INDUSTRIAL (NOTE 2, 3)	MEETS SPECS OF MIL-S-19500/127 (1N746A-759A 1N4370A-4372A) MIL-S-19500/117 (1N962B-992B)	INDUSTRIAL (NOTE 2)	INDUSTRIAL (NOTE 2, 3)	MEETS SPECS OF MIL-S-19500/115
2.4	¼M2.4AZ		1N4370	1N4370A			
2.7	¼M2.7AZ		1N4371	1N4371A			
3.0	¼M3.0AZ		1N4372	1N4372A			
3.3	¼M3.3AZ		1N746	1N746A	1N472B	1N3821	1N3821A
3.6	¼M3.6AZ		1N747	1N747A	1N4729	1N3822	1N3822A
3.9	¼M3.9AZ		1N748	1N748A	1N4730	1N3823	1N3823A
4.3	¼M4.3AZ		1N749	1N749A	1N4731	1N3824	1N3824A
4.7	¼M4.7AZ		1N750	1N750A	1N4732	1N3825	1N3825A
5.1	¼M5.1AZ		1N751	1N751A	1N4733	1N3826	1N3826A
5.6	¼M5.6AZ		1N752	1N752A	1N4734	1N3827	1N3827A
6.2	¼M6.2AZ		1N753	1N753A	1N4735	1N3828	1N3828A
6.8	¼M6.8Z	1N4099	1N754 1N957	1N754A	1N4736	1N3829 1N3016	1N3016B
7.5	¼M7.5Z	1N4100	1N755 1N95B	1N755A	1N4737	1N3830 1N3017	1N3017B
8.2	¼M8.2Z	1N4101	1N756 1N959	1N756A	1N4738	1N301B	1N3018B
9.1	¼M9.1Z	1N41D3	1N757 1N960	1N757A	1N4739	1N3019	1N3019B
1D	¼M10Z	1N4104	1N75B 1N961	1N758A	1N4740	1N3020	1N3020B
11	¼M11Z	1N4105	1N962	1N962B	1N4741	1N3021	1N3021B
12	¼M12Z	1N4106	1N759 1N963	1N759A 1N963B	1N4742	1N3022	1N3022B
13	¼M13Z	1N4107	1N964	1N964B	1N4743	1N3023	1N3023B
15	¼M15Z	1N4109	1N965	1N965B	1N4744	1N3024	1N3024B
16	¼M16Z	1N4110	1N966	1N966B	1N4745	1N3025	1N3025B
18	¼M18Z	1N4112	1N967	1N967B	1N4746	1N3026	1N3026B
20	¼M20Z	1N4114	1N968	1N968B	1N4747	1N3027	1N3027B
22	¼M22Z	1N4115	1N969	1N969B	1N4748	1N3028	1N3028B
24	¼M24Z	1N4116	1N970	1N970B	1N4749	1N3029	1N3029B
27	¼M27Z	1N4118	1N971	1N971B	1N4750	1N3030	1N3030B
30	¼M30Z	1N4120	1N972	1N972B	1N4751	1N3031	1N3031B
33	¼M33Z	1N4121	1N973	1N973B	1N4752	1N3032	1N3032B
36	¼M36Z	1N4122	1N974	1N974B	1N4753	1N3033	1N3033B
39	¼M39Z	1N4123	1N975	1N975B	1N4754	1N3034	1N3034B
43	¼M43Z	1N4124	1N976	1N976B	1N4755	1N3035	1N3035B
47	¼M47Z	1N4125	1N977	1N977B	1N4756	1N3036	1N3036B
51	¼M51Z	1N4126	1N978	1N978B	1N4757	1N3037	1N3037B
56	¼M56Z	1N4127	1N979	1N979B	1N4758	1N303B	1N3038B
62	¼M62Z	1N4129	1N980	1N980B	1N4759	1N3039	1N3039B
68	¼M68Z	1N4130	1N981	1N981B	1N4760	1N3040	1N3040B
75	¼M75Z	1N4131	1N982	1N982B	1N4761	1N3041	1N3041B
B2	¼M82Z	1N4132	1N983	1N983B	1N4762	1N3042	1N3042B
91	¼M91Z	1N4134	1N984	1N984B	1N4763	1N3043	1N3043B
100	¼M100Z	1N4135	1N985	1N985B	1N4764	1N3044	1N3044B
110	¼M110Z		1N986	1N986B		1N3045	1N3045B
120	¼M120Z		1N987	1N987B		1N3046	1N3046B
130	¼M130Z		1N988	1N988B		1N3047	1N3047B
150	¼M150Z		1N989	1N989B		1N3048	1N3048B
160	¼M160Z		1N990	1N990B		1N3049	1N3049B
180	¼M180Z		1N991	1N991B		1N3050	1N3050B
200	¼M200Z		1N992	1N992B		1N3051	1N3051B

NOTES:

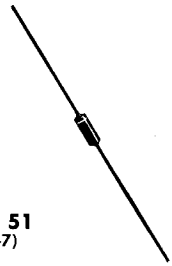
1. *Standard tolerances of 5, 10, and 20% are available — no suffix is ±20% tolerance; "10" suffix is ±10% tolerance and "5" suffix is ±5% tolerance.*
2. *No suffix denotes ±10% tolerance. "A" suffix is ±5% tolerance. (1N4370-4372, 1N746-759; 1N3821-30, 1N3993-4000)*
3. *Standard tolerances of 5, 10, and 20% are available — no suffix is ±20% tolerance; "A" suffix is ±10% tolerance, and "B" suffix is ±5% tolerance. (1N957-992; 1N3016-3051; 1N3785-3820; 1N2970&R-3015&R; 1N4549-4556; 1N4557-4564; 1N2804&R-2846&R; 1N3305&R-3350&R)*
4. *R & RB = Reverse Polarity Types Available.*

1½ WATT Cathode to Case	10 WATT Cathode to Case = 1N3993 series Anode to Case = 1N2970 series		50 WATT Anode to Case			
 CASE 55	 CASE 56		 CASE 54		 CASE 58	Nominal Zener Voltage
INDUSTRIAL (NDTE 3)	INDUSTRIAL (NOTE 2, 3, 4)	MEETS SPECS OF MIL-S-19500/272 (1N3993A-4000A) MIL-S-19500/124 (1N2970B-3015B)	INDUSTRIAL (NOTE 3, 4)	MEETS SPECS OF MIL-S-19500/114 (NOTE 4)	INDUSTRIAL (NOTE 3, 4)	Vz
	1N3993	1N3993A&RA	1N4557&R		1N4549&R	2.4 2.7 3.0 3.3 3.6 3.9
	1N3994 1N3995 1N3996 1N3997 1N3998	1N3994A 1N3995A 1N3996A 1N3997A 1N3998A&RA	1N4558&R 1N4559&R 1N4560&R 1N4561&R 1N4562&R		1N4550&R 1N4551&R 1N4552&R 1N4553&R 1N4554&R	4.3 4.7 5.1 5.6 6.2
1N3785	1N3999 1N297D&R	1N3999A 1N2970B&RB	1N4563&R 1N2804&R	1N2804B&RB	1N4555&R 1N3305&R	6.8
1N3786	1N4D00 1N2971&R	1N4000A 1N2971B&RB	1N4564&R 1N28D5&R	1N2805B&RB	1N4556&R 1N3306&R	7.5
1N3787	1N2972&R	1N2972B&RB	1N2806&R	1N2806B&RB	1N3307&R	8.2
1N3788	1N2973&R	1N2973B&RB	1N2807&R	1N28078&RB	1N3308&R	9.1
1N3789	1N2974&R	1N2974B&RB	1N2808&R	1N2808B&RB	1N3309&R	10
1N3790	1N2975&R	1N2975B&RB	1N2809&R	1N2809B&RB	1N3310&R	11
1N3791	1N2976&R	1N2976B&RB	1N2810&R	1N2810B&RB	1N3311&R	12
1N3792 1N3793 1N3794 1N3795 1N3796 1N3797	1N2977&R 1N2978&R 1N298D&R 1N2982&R 1N2984&R 1N2985&R	1N2977B&RB 1N2978B&RB 1N2980B&RB 1N2982B&RB 1N2984B&RB 1N2985B&RB	1N2811&R 1N2813&R 1N2814&R 1N2816&R 1N2818&R 1N2819&R	1N2811B&RB 1N2813B&RB 1N2814B&RB 1N2816B&RB 1N2818B&RB 1N2819B&RB	1N3312&R 1N3314&R 1N3315&R 1N3317&R 1N3319&R 1N3320&R	13 15 16 18 20 22
1N3798 1N3799 1N3800 1N3801 1N38D2 1N3803	1N2986&R 1N2988&R 1N2989&R 1N299D&R 1N2991&R 1N2992&R	1N2986B&RB 1N2988B&RB 1N2989B&RB 1N2990B&RB 1N2991B&RB 1N2992B&RB	1N282D&R 1N2822&R 1N2823&R 1N2824&R 1N2825&R 1N2826&R	1N2820B&RB 1N2822B&RB 1N2823B&RB 1N2824B&RB 1N2825B&RB 1N2826B&RB	1N3321&R 1N3323&R 1N3324&R 1N3325&R 1N3326&R 1N3327&R	24 27 30 33 36 39
1N3804 1N3805 1N3806 1N3807 1N3808 1N3809	1N2993&R 1N2995&R 1N2997&R 1N2999&R 1N3D00&R 1N3001&R	1N2993B&RB 1N2995B&RB 1N2997B&RB 1N2999B&RB 1N3000B&RB 1N3001B&RB	1N2827&R 1N2829&R 1N2831&R 1N2832&R 1N2833&R 1N2834&R	1N2827B&RB 1N2829B&RB 1N2831B&RB 1N2832B&RB 1N2833B&RB 1N2834B&RB	1N3328&R 1N3330&R 1N3332&R 1N3334&R 1N3335&R 1N3336&R	43 47 51 56 62 68
1N3810 1N3811 1N3812 1N3813 1N3814 1N3815	1N3002&R 1N3003&R 1N3004&R 1N3005&R 1N3007&R 1N3008&R	1N3002B&RB 1N3003B&RB 1N3004B&RB 1N3005B&RB 1N3007B&RB 1N3008B&RB	1N2835&R 1N2836&R 1N2837&R 1N2838&R 1N2840&R 1N2841&R	1N2835B&RB 1N2836B&RB 1N2837B&RB 1N2838B&RB 1N2840B&RB 1N2841B&RB	1N3337&R 1N3338&R 1N3339&R 1N3340&R 1N3342&R 1N3343&R	75 82 91 100 110 120
1N3816 1N3817 1N3818 1N3819 1N3820	1N3009&R 1N3011&R 1N3012&R 1N3014&R 1N3015&R	1N3009B&RB 1N3011B&RB 1N3012B&RB 1N3014B&RB 1N3015B&RB	1N2842&R 1N2843&R 1N2844&R 1N2845&R 1N2846&R	1N2842B&RB 1N2843B&RB 1N2844B&RB 1N2845B&RB 1N2846B&RB	1N3344&R 1N3346&R 1N3347&R 1N3349&R 1N3350&R	130 150 160 180 200

Military Types

¼M2.4AZ thru ¼M200Z

¼ W
2.4 — 200 V



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D-C Power Dissipation: 1/4 Watt (Derate 1.67 mW/°C Above 25°C)

The type numbers specified have a standard voltage (V_Z) tolerance of ±20%. For closer tolerances, add suffix "10" for ±10% or "5" for ±5%. (3%, 2%, 1% tolerances also available. See page 2-4.)

ELECTRICAL CHARACTERISTICS (At 25°C Ambient $V_F = 1.5$ V max @ 100 mA)

TYPE NO.	NOMINAL* ZENER VOLTAGE (V_Z) VOLTS @ I_{ZT}	TEST CURRENT (I_{ZT}) mA	MAXIMUM ZENER IMPEDANCE (Z_{ZT}) ohms @ I_{ZT}	MAXIMUM DC ZENER CURRENT (I_{ZM}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc * V_{R_1}	V_{R_2}
1/4M2.4AZ	2.4	10	60	70	75	1	1
1/4M2.7AZ	2.7	10	60	65	75	1	1
1/4M3.0AZ	3.0	10	55	60	50	1	1
1/4M3.3AZ	3.3	10	55	55	50	1	1
1/4M3.6AZ	3.6	10	50	52	50	1	1
1/4M3.9AZ	3.9	10	50	49	25	1	1
1/4M4.3AZ	4.3	10	45	46	25	1.5	1.5
1/4M4.7AZ	4.7	10	35	42	10	1.5	1.5
1/4M5.1AZ	5.1	10	25	39	5	1.5	1.5
1/4M5.6AZ	5.6	10	20	36	5	1.5	1.5
1/4M6.2AZ	6.2	10	15	33	5	3.5	3.5
1/4M6.8Z	6.8	9.2	7.0	33	150	5.2	4.9
1/4M7.5Z	7.5	8.3	8.0	30	75	5.7	5.4
1/4M8.2Z	8.2	7.6	9.0	26	50	6.2	5.9
1/4M9.1Z	9.1	6.9	10	24	25	6.9	6.6
1/4M10Z	10	6.3	11	21	10	7.6	7.2
1/4M11Z	11	5.7	13	19	5	8.4	8.0
1/4M12Z	12	5.2	15	18	5	9.1	8.6
1/4M13Z	13	4.8	18	16	5	9.9	9.4
1/4M14Z	14	4.5	20	15	5	10.6	10.1
1/4M15Z	15	4.2	22	14	5	11.4	10.8
1/4M16Z	16	3.9	24	13	5	12.2	11.5
1/4M17Z	17	3.7	26	12.5	5	13.0	12.2
1/4M18Z	18	3.5	28	11.5	5	13.7	13.0
1/4M19Z	19	3.3	30	11.0	5	14.4	13.7
1/4M20Z	20	3.1	33	10.5	5	15.2	14.4

¼M2.4AZ thru ¼M 200 Z (continued)

ELECTRICAL CHARACTERISTICS (At 25°C Ambient $V_F = 1.5$ V max @ 100 mA)

TYPE NO.	NOMINAL ZENER VOLTAGE (V_z) VOLTS @ I_{zt}	TEST CURRENT (I_{zt}) mA	MAXIMUM ZENER IMPEDANCE (Z_{zt}) ohms @ I_{zt})	MAXIMUM DC ZENER CURRENT (I_{zm}) mA	REVERSE LEAKAGE CURRENT		
					I_R MAX (μA)	TEST VOLTAGE Vdc *	
						V_{R1_1}	V_{R1_2}
1/4M22Z	22	2.8	40	9.5	5	16.7	15.8
1/4M24Z	24	2.6	46	9.0	5	18.2	17.3
1/4M25Z	25	2.5	50	8.0	5	19.0	18.0
1/4M27Z	27	2.3	58	7.5	5	20.6	19.4
1/4M30Z	30	2.1	70	7.0	5	22.8	21.6
1/4M33Z	33	1.9	85	6.5	5	25.1	23.8
1/4M36Z	36	1.7	100	6.0	5	27.4	25.9
1/4M39Z	39	1.6	120	5.0	5	29.7	28.1
1/4M43Z	43	1.5	140	4.8	5	32.7	31.0
1/4M45Z	45	1.4	150	4.5	5	34.2	32.4
1/4M47Z	47	1.3	160	4.3	5	35.8	33.8
1/4M50Z	50	1.2	180	4.1	5	38.0	36.0
1/4M52Z	52	1.2	200	4.0	5	39.5	37.4
1/4M56Z	56	1.1	230	3.8	5	42.6	40.3
1/4M62Z	62	1.0	290	3.3	5	47.1	44.6
1/4M68Z	68	0.92	350	3.0	5	51.7	49.0
1/4M75Z	75	0.83	450	2.8	5	56.0	54.0
1/4M82Z	82	0.76	550	2.5	5	62.2	59.0
1/4M91Z	91	0.69	700	2.3	5	69.2	65.5
1/4M100Z	100	0.63	900	2.0	5	76.0	72.0
1/4M105Z	105	0.60	1000	1.9	5	79.8	75.6
1/4M110Z	110	0.57	1200	1.8	5	83.6	79.2
1/4M120Z	120	0.52	1500	1.7	5	91.2	86.4
1/4M130Z	130	0.48	1900	1.5	5	98.8	93.6
1/4M140Z	140	0.45	2200	1.4	5	106.4	100.8
1/4M150Z	150	0.42	2500	1.3	5	114.0	108.0
1/4M175Z	175	0.36	3300	1.1	5	133.0	126.0
1/4M200Z	200	0.31	4300	1.0	5	152.0	144.0

SPECIAL SELECTIONS 1 — Nominal zener voltages between those shown.
2 — Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance
} *Standard Tolerances are ±5%, ±2%, and ±1%*

*V_{R1} — Test Voltage for 5% Tolerance Device
V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

1N702 thru 1N745

¼ W
2 — 200 V



CASE 51
(DO-7)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N746--, 1N957-- and 1N4370-- series. Absolute maximum rating-junction and storage temperature range -65 to +175°C, derated 1.67 mW/°C.

1N746 thru 1N759

400 mW
2.4 —12 V

1N764A thru 1N 759A USN and HI-REL

1N4370 thru 1N4372
1N4370A thru 1N4372A USN and HI-REL



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C
D-C Power Dissipation: 400 Milliwatts at 50°C Ambient (Derate 3.2 mW/°C Above 50° Ambient)

TOLERANCE DESIGNATION

The type numbers shown have tolerance designations as follows:
1N4370 series: ± 10%, suffix A for ± 5% units.
1N746 series: ± 10%, suffix A for ± 5% units.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

TYPE NUMBER	NOMINAL ZENER VOLTAGE V_z @ I_{zt} Volts	TEST CURRENT I_{zt} mA	MAXIMUM ZENER IMPEDANCE Z_{zt} @ I_{zt} Ohms	MAXIMUM DC ZENER CURRENT I_{zm} mA	REVERSE LEAKAGE CURRENT T_A = 25°C I_R @ V_R = 1 V µA	REVERSE LEAKAGE CURRENT T_A = 150°C I_R @ V_R = 1 V µA
1N4370	2.4	20	30	150	100	200
1N4371	2.7	20	30	135	75	150
1N4372	3.0	20	29	120	50	100
1N746	3.3	20	28	110	10	30
1N747	3.6	20	24	100	10	30
1N748	3.9	20	23	95	10	30
1N749	4.3	20	22	85	2	30
1N750	4.7	20	19	75	2	30
1N751	5.1	20	17	70	1	20
1N752	5.6	20	11	65	1	20
1N753	6.2	20	7	60	0.1	20
1N754	6.8	20	5	55	0.1	20
1N755	7.5	20	6	50	0.1	20
1N756	8.2	20	8	45	0.1	20
1N757	9.1	20	10	40	0.1	20
1N758	10.0	20	17	35	0.1	20
1N759	12.0	20	30	30	0.1	20

1N761 thru 1N769

Recommended for applications requiring an exact replacement only. For new designs see 1N746 -- and 1N4370 -- series.

1N957 thru 1N992

400 mW
6.8 — 200 V

1N962B thru 1N992B USN

1N962B thru 1N984B HI-REL



CASE 51
(DO-7)

Hermetically sealed, all-glass case with all external surfaces corrosion resistant. Cathode end, indicated by color band, will be positive with respect to anode end when operated in the zener region.

MAXIMUM RATINGS

Junction and Storage Temperature: -65 to +175°C
DC Power Dissipation: 400 mW at 50°C Ambient (Derate 3.2 mw/°C above 50°C Ambient.)

TOLERANCE DESIGNATIONS

With no suffix, tolerance is ± 20%, for ± 10% units, add suffix A, for ± 5% units, add suffix B.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

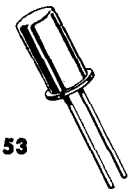
TYPE NUMBER	NOMINAL ZENER VOLTAGE V_Z VOLTS	TEST CURRENT I_{ZT} mA	MAXIMUM ZENER IMPEDANCE Z_{ZT}@I_{ZT} Ohms	MAXIMUM ZENER IMPEDANCE Z_{ZK}@I_{ZK} Ohms	MAXIMUM ZENER IMPEDANCE I_{ZK} mA	MAXIMUM DC ZENER CURRENT I_{ZM} mA	REVERSE LEAKAGE CURRENT I_R MAXIMUM (μA)	REVERSE LEAKAGE CURRENT TEST VOLTAGE V_{R_1}	REVERSE LEAKAGE CURRENT TEST VOLTAGE V_R	REVERSE LEAKAGE CURRENT TEST VOLTAGE *V_{R_2}
1N957	6.8	18.5	4.5	700	1.0	47	150	5.2		4.9
1N958	7.5	16.5	5.5	700	0.5	42	75	5.7		5.4
1N959	8.2	15	8.5	700	0.5	38	50	6.2		5.9
1N960	9.1	14	7.5	700	0.5	35	25	8.9		6.6
1N961	10	12.5	8.5	700	0.25	32	10	7.6		7.2
1N962	11	11.5	9.5	700	0.25	28	5	8.4		8.0
1N963	12	10.5	11.5	700	0.25	26	5	9.1		8.6
1N964	13	9.5	13	700	0.25	24	5	9.9		9.4
1N965	15	8.5	16	700	0.25	21	5	11.4		10.8
1N966	16	7.8	17	700	0.25	19	5	12.2		11.5
1N967	18	7.0	21	750	0.25	17	5	13.7		13.0
1N968	20	6.2	25	750	0.25	15	5	15.2		14.4
1N969	22	5.6	29	750	0.25	14	5	16.7		15.8
1N970	24	5.2	33	750	0.25	13	5	18.2		17.3
1N971	27	4.6	41	750	0.25	11	5	20.6		19.4
1N972	30	4.2	49	1000	0.25	10	5	22.8		21.6
1N973	33	3.8	58	1000	0.25	9.2	5	25.1		23.8
1N974	36	3.4	70	1000	0.25	8.5	5	27.4		25.9
1N975	39	3.2	80	1000	0.25	7.8	5	29.7		28.1
1N976	43	3.0	93	1500	0.25	7.0	5	32.7		31.0
1N977	47	2.7	105	1500	0.25	8.4	5	35.8		33.8
1N976	51	2.5	125	1500	0.25	5.9	5	38.8		36.7
1N979	56	2.2	150	2000	0.25	5.4	5	42.6		40.3
1N980	62	2.0	185	2000	0.25	4.9	5	47.1		44.6
1N981	68	1.8	230	2000	0.25	4.5	5	51.7		49.0
1N982	75	1.7	270	2000	0.25	4.0	5	56.0		54.0
1N983	82	1.5	330	3000	0.25	3.7	5	62.2		59.0
1N984	91	1.4	400	3000	0.25	3.3	5	69.2		65.5
1N985	100	1.3	500	3000	0.25	3.0	5	76.0		72.0
1N986	110	1.1	750	4000	0.25	2.7	5	83.6		79.2
1N987	120	1.0	900	4500	0.25	2.5	5	91.2		86.4
1N988	130	0.95	1100	5000	0.25	2.3	5	98.8		93.6
1N989	150	0.85	1500	6000	0.25	2.0	5	114.0		108.0
1N990	160	0.80	1700	6500	0.25	1.9	5	121.6		115.2
1N991	180	0.68	2200	7100	0.25	1.7	5	136.8		129.8
1N992	200	0.65	2500	8000	0.25	1.5	5	152.0		144.0

SPECIAL SELECTIONS 1 — Nominal zener voltages between those shown.
2 — Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance
} Standard Tolerances are ±5%, ±2%, and ±1%

*V_{R1} — Test Voltage for 5% Tolerance Device
V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

1N1313 thru 1N1327

150 mW
8.75 — 127.5 V



CASE 53

Very low power zener diodes with standard ±10% tolerances. Available with ±5% tolerance by adding suffix "A" to type number.

Standard cathode-to-case polarity.

MAXIMUM RATINGS

Junction and Storage Temperature Range: -65 to +175°C (Derate 1 mW/°C above 25°C).

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1313	8.75	0.5	5	6.8
1N1314	10.50	0.5	5	8.2
1N1315	12.75	0.5	5	10
1N1316	15.75	0.5	5	12
1N1317	19.00	0.5	5	15

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1318	23.50	0.1	10	18
1N1319	28.50	0.1	10	22
1N1320	34.50	0.1	10	27
1N1321	41.00	0.1	10	33
1N1322	48.50	0.1	10	39

Type	Nominal Voltage $V_Z @ I_{ZT} = 200\ \mu A$ volts	Max Reverse Current $T_A = 25°C$ $I_R @ V_R$ μA	Max Reverse Current $T_A = 100°C$ $I_A @ V_R$ μA	Test Voltage V_R volts
1N1323	58.00	0.1	10	47
1N1324	71.00	1.0	50	56
1N1325	87.50	1.0	50	68
1N1326	105.0	1.0	50	82
1N1327	127.5	1.0	50	100

Standard types are ±10% tolerance; suffix "A" denotes ±5% tolerance.

1N1351 thru 1N1375

10 W
10 — 100 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N1507 thru 1N1517

¾ W
3.9 — 27 V



CASE 52

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1-watt, 1N3016 and 1N3821 series.

1N1518 thru 1N1528

1 W
3.9 — 27 V



CASE 52

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3016 and 1N3821 series.

1N1588 thru 1N1598

3.5 W
3.9 — 27 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 and 1N3993 series.

1N1599 thru 1N1609

10 W
3.9 — 27 V

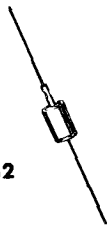


CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 and 1N3993 series.

1N1765 thru 1N1802

1 W
5.6 — 200 V



CASE 52

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3016 series.

1N1803 thru 1N1836

10 W
5.6 — 200 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 and 1N3993 series.

1N2008 thru 1N2012

10 W
100 — 150 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

1N2032 thru 1N2040

¾ W
4.3 — 12 V



CASE 52

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3821 and 1N3016 series.

1N2041 thru 1N2049

10 W
4.3 — 27 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N3993 and 1N2970 series.

1N2498 thru 1N2500

10 W
10 — 12 V



CASE 56
(DO-4)

Recommended for applications requiring an exact replacement only. For new designs and for industry preferred replacement devices, see 1N2970 series.

TO-3 Package

50 W
3.9 — 200 V

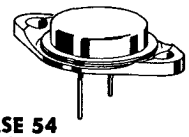
1N2804 thru 1N2846 (6.8 V thru 200 V)

1N2804B and RB thru 1N2846B and RBJAN

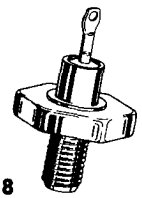
1N2804B thru 1N2846B HI-REL

1N4557 thru 1N4564 (3.9 V thru 7.5 V)
Stud Package

1N3305 thru 1N3350 (6.8 V thru 200 V)
1N4549 thru 1N4556 (3.9 V thru 7.5 V)



CASE 54
(TO-3)



CASE 58
(stud package)

Units are available with anode-to-case and cathode-to-case connections (standard and reverse polarity). For reverse polarity, add suffix "R" to type number.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 50 Watts. (Derate 0.5 W/°C above 75°C).

TOLERANCE DESIGNATION

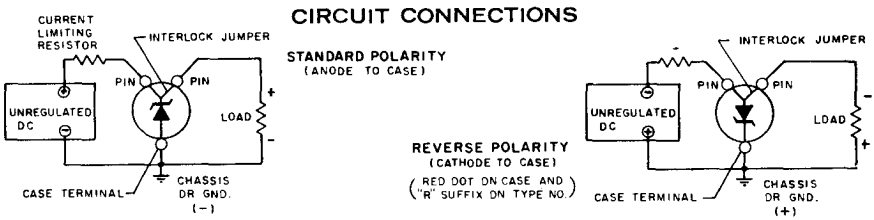
The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available. See page 2-4.)

TO-3 APPLICATIONS INFORMATION

If these units are used with a socket, the unregulated line should be connected to one pin through a suitable current limiting resistor and the load should be connected to the other pin. The load will now be disconnected from the line if the unit is removed from the socket.

Typical circuit connections for anode-to-case and cathode-to-case polarities (standard and reverse polarities, respectively) are shown below:

CIRCUIT CONNECTIONS



1N2804 thru 1N2846 (continued)

ELECTRICAL CHARACTERISTICS

(T_C = 30°C unless otherwise specified) V_F = 1.5 V max @ 10 A on all types.

50 Watt (TO-3)	50 Watt (Stud)	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current (I_{ZT}) mA	Max Zener Impedance		Max DC Zener Current 75°C Case Temp (I_{ZM}) mA	REVERSE * LEAKAGE CURRENT			Typical Zener Voltage Temp. Coeff. %/°C
				Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ I_{ZK} = 5mA ohms		I_R MAX (μA)	V_{R1}	V_{R2}	
1N4557	1N4549	3.9	3200	0.16	400	11900	150	0.5	0.5	-.025
1N4558	1N4550	4.3	2900	0.16	500	10650	150	0.5	0.5	-.025
1N4559	1N4551	4.7	2650	0.12	600	9700	100	1.0	1.0	.010
1N4560	1N4552	5.1	2450	0.12	650	8900	20	1.0	1.0	.015
1N4561	1N4553	5.6	2250	0.12	900	8100	20	1.0	1.0	.030
1N4562	1N4554	6.2	2000	0.14	1000	7300	20	2.0	2.0	.040
1N2804	1N3305	6.8	1850	0.2	70	6600	150	4.5	4.3	.040
1N4563	1N4555	6.8	1850	0.16	200	6650	10	2.0	2.0	.045
1N2805	1N3306	7.5	1700	0.3	70	5800	75	5.0	4.7	.045
1N4564	1N4556	7.5	1650	0.24	100	6050	10	3.0	3.0	.053
1N2806	1N3307	8.2	1500	0.4	70	5200	50	5.4	5.2	.048
1N2807	1N3308	9.1	1370	0.5	70	4800	25	6.1	5.7	.051
1N2808	1N3309	10	1200	0.8	80	4300	10	6.7	6.3	.055
1N2808	1N3310	11	1100	0.8	80	3900	5	8.4	8.0	.080
1N2810	1N3311	12	1000	1.0	80	3600	5	9.1	8.6	.065
1N2611	1N3312	13	960	1.1	80	3300	5	8.9	9.4	.065
1N2812	1N3313	14	890	1.2	80	3000	5	10.6	10.1	.070
1N2813	1N3314	15	830	1.4	80	2800	5	11.4	10.8	.070
1N2814	1N3315	16	780	1.8	80	2650	5	12.2	11.5	.070
1N2815	1N3316	17	740	1.8	80	2500	5	13.0	12.2	.075
1N2816	1N3317	18	700	2.0	80	2300	5	13.7	13.0	.075
1N2817	1N3318	19	680	2.2	80	2200	5	14.4	13.7	.075
1N2818	1N3319	20	630	2.4	60	2100	5	15.2	14.4	.075
1N2818	1N3320	22	570	2.5	80	1900	5	16.7	15.8	.080
1N2820	1N3321	24	520	2.6	80	1750	5	18.2	17.3	.080
1N2821	1N3322	25	500	2.7	90	1550	5	19.0	18.0	.060
1N2822	1N3323	27	480	2.8	90	1500	5	20.6	19.4	.085
1N2823	1N3324	30	420	3.0	90	1400	5	22.8	21.6	.085
1N2824	1N3325	33	380	3.2	90	1300	5	25.1	23.8	.085
1N2825	1N3326	36	350	3.5	90	1150	5	27.4	25.9	.065
1N2828	1N3327	39	320	4.0	90	1050	5	29.7	28.1	.090
1N2827	1N3328	43	290	4.5	90	975	5	32.7	31.0	.090
1N2828	1N3329	45	280	4.5	100	930	5	34.2	32.4	.090
1N2829	1N3330	47	270	5.0	100	880	5	35.8	33.8	.090
1N2830	1N3331	50	250	5.0	100	830	5	38.0	36.0	.090
1N2831	1N3332	51	245	5.2	100	810	5	38.8	36.7	.090
-	1N3333	52	240	5.5	100	790	5	39.5	37.4	.080
1N2832	1N3334	56	220	6	110	740	5	42.6	40.3	.090
1N2833	1N3335	82	200	7	120	680	5	47.1	44.6	.090
1N2834	1N3338	68	180	8	140	600	5	51.7	49.0	.090
1N2835	1N3337	75	170	9	150	540	5	58.0	54.0	.090
1N2836	1N3338	82	150	11	160	480	5	62.2	59.0	.090
1N2837	1N3339	91	140	15	180	420	5	69.2	65.5	.090
1N2838	1N3340	100	120	20	200	400	5	76.0	72.0	.090
1N2839	1N3341	105	120	25	210	380	5	79.8	75.6	.095
1N2840	1N3342	110	110	30	220	365	5	83.6	79.2	.095
1N2841	1N3343	120	100	40	240	335	5	91.2	86.4	.095
1N2842	1N3344	130	95	50	275	310	5	98.8	93.6	.095
-	1N3345	140	90	60	325	290	5	106.4	100.8	.095
1N2843	1N3348	150	85	75	400	270	5	114.0	108.0	.095
1N2844	1N3347	160	80	80	450	250	5	121.6	115.2	.095
-	1N3348	175	70	85	500	230	5	133.0	126.0	.095
1N2845	1N3349	180	68	90	525	220	5	136.6	129.6	.095
1N2846	1N3350	200	85	100	600	200	5	152.0	144.0	.100

SPECIAL SELECTIONS

1—Nominal zener voltages between those shown.

2—Matched sets: a. Two or more units for series connections with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance

} Standard Tolerances are ± 5%, ± 2%, and ± 1%.

*V_{R1} — Test Voltage for 5% Tolerance Device

V_{R2} — Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

1N2804 thru 1N2846 (continued)

FIGURE 1 — TEMPERATURE CHARACTERISTICS

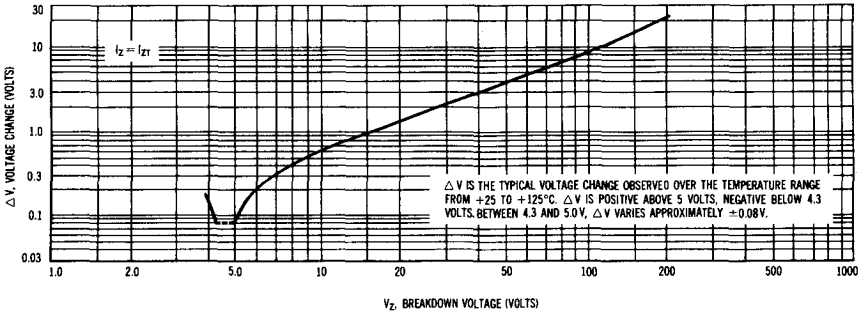


FIGURE 2 — POWER-TEMPERATURE DERATING CURVE

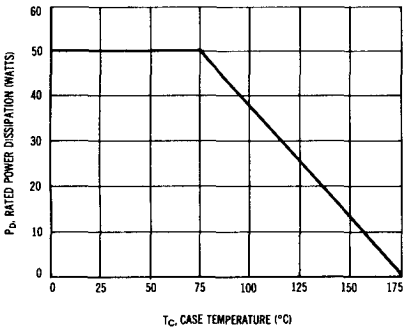


FIGURE 3 — LEAKAGE CURRENT

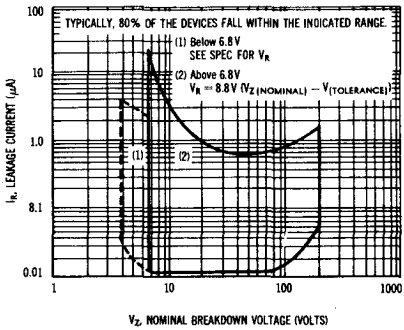
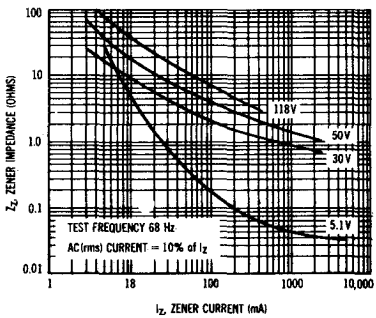


FIGURE 4 — ZENER IMPEDANCE versus ZENER CURRENT



1N2970 thru 1N3015

10W
6.8 — 200 V

1N2970B, RB thru 1N3015B, RBJAN

1N2970B, RB thru 1N3015B, RB HI-REL



CASE 56
(DO-4)

Diffused-junction zener diodes for both military and high-reliability industrial applications. Available with anode-to-case and cathode-to-case connections (standard and reverse polarity), i. e., 1N2970 and 1N2970R. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available. See page 2-4.)

ELECTRICAL CHARACTERISTICS

(At 30°C case temperature unless otherwise specified)
$V_F = 1.5$ V max @ $I_F = 2$ amp on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} Ohms	Max Zener Impedance I_{ZK} mA	Max DC Zener Current I_{ZM} mA	REVERSE LEAKAGE CURRENT * I_R Max (μA)	REVERSE LEAKAGE CURRENT * V_{R1}	REVERSE LEAKAGE CURRENT * V_{R2}
1N2970	6.8	370	1.2	500	1.0	1,320	150	5.2	4.9
1N2971	7.5	335	1.3	250	1.0	1,180	75	5.7	5.4
1N2972	8.2	305	1.5	250	1.0	1,040	50	6.2	5.9
1N2973	9.1	275	2.0	250	1.0	960	25	6.9	6.6
1N2974	10	250	3	250	1.0	860	10	7.6	7.2
1N2975	11	230	3	250	1.0	780	5	8.4	8.0
1N2976	12	210	3	250	1.0	720	5	9.1	8.6
1N2977	13	190	3	250	1.0	660	5	9.9	9.4
1N2978	14	180	3	250	1.0	600	5	10.6	10.1
1N2979	15	170	3	250	1.0	560	5	11.4	10.8
1N2980	16	155	4	250	1.0	530	5	12.2	11.5
1N2982	18	140	4	250	1.0	460	5	13.7	13.0
1N2983	19	130	4	250	1.0	440	5	14.4	13.7
1N2984	20	125	4	250	1.0	420	5	15.2	14.4
1N2985	22	115	5	250	1.0	380	5	16.7	15.8
1N2986	24	105	5	250	1.0	350	5	18.2	17.3
1N2988	27	95	7	250	1.0	300	5	20.6	19.4
1N2989	30	85	8	300	1.0	280	5	22.8	21.6
1N2990	33	75	9	300	1.0	260	5	25.1	23.8
1N2991	36	70	10	300	1.0	230	5	27.4	25.9

1N2970 thru 1N3015 (continued)

ELECTRICAL CHARACTERISTICS (At 30°C case temperature unless otherwise specified)
$V_F = 1.5$ V max @ $I_F = 2$ amp on all types.

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} Ohms	Max Zener Impedance I_{ZK} mA	Max DC Zener Current I_{ZM} mA	REVERSE LEAKAGE CURRENT * I_R Max (μA)	REVERSE LEAKAGE CURRENT * V_{R1}	REVERSE LEAKAGE CURRENT * V_{R2}
1N2992	39	65	11	300	1.0	210	5	29.7	28.1
1N2993	43	60	12	400	1.0	195	5	32.7	31.0
1N2995	47	55	14	400	1.0	175	5	35.8	33.8
1N2996	50	50	15	500	1.0	165	5	38.0	36.0
1N2997	51	50	15	500	1.0	163	5	38.8	36.7
1N2998	52	50	15	500	1.0	160	5	39.5	37.4
1N2999	56	45	16	500	1.0	150	5	42.6	40.3
1N3000	62	40	17	600	1.0	130	5	47.1	44.6
1N3001	68	37	18	600	1.0	120	5	51.7	49.0
1N3002	75	33	22	600	1.0	110	5	56.0	54.0
1N3003	82	30	25	700	1.0	100	5	62.2	59.0
1N3004	91	28	35	800	1.0	85	5	69.2	65.5
1N3005	100	25	40	900	1.0	80	5	76.0	72.0
1N3006	105	25	45	1,000	1.0	75	5	79.8	75.6
1N3007	110	23	55	1,100	1.0	72	5	83.6	79.2
1N3008	120	20	75	1,200	1.0	67	5	91.2	86.4
1N3009	130	19	100	1,300	1.0	62	5	98.8	93.6
1N3010	140	18	125	1,400	1.0	58	5	106.4	100.8
1N3011	150	17	175	1,500	1.0	54	5	114.0	108.0
1N3012	160	16	200	1,600	1.0	50	5	121.6	115.2
1N3014	180	14	260	1,850	1.0	45	5	136.8	129.6
1N3015	200	12	300	2,000	1.0	40	5	152.0	144.0

SPECIAL SELECTIONS 1 – Nominal zener voltages between those shown.
2 – Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance
} *Standard Tolerances are ±5%, ±2%, and ±1%*

*V_{R1} – Test Voltage for 5% Tolerance Device

V_{R2} – Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

1N3016 thru 1N3051

1 W
6.8 — 200 V

1N3016B thru 1N3051B USN/JAN

1N3016B thru 1N3051B HI-REL

CASE 52



Hermetically sealed package, with 36 standard voltage ratings and 5%, 10% and 20% standard tolerances. Cathode connected to case.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 1 Watt. (Derate 6.67 mW/°C above 25°C).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units. (2% and 1% tolerance also available. See page 2-4.)

1N3016 thru 1N3051 (continued)

ELECTRICAL CHARACTERISTICS

(At 25°C case temperature unless otherwise specified)

$V_F = 1.5$ Vmax @ 200 mA on all types

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} Ohms	Max Zener Impedance I_{ZK} mA	REVERSE LEAKAGE CURRENT * I_R Max (μA)	REVERSE LEAKAGE CURRENT * V_{R1}	REVERSE LEAKAGE CURRENT * V_{R2}	Max DC Zener Current I_{ZM} mA	Typical Zener Voltage Temp. Coeff. %/°C
1N3016	6.8	37	3.5	700	1.0	150	5.2	4.9	130	.040
1N3017	7.5	34	4.0	700	0.5	75	5.7	5.4	120	.045
1N3018	8.2	31	4.5	700	0.5	50	6.2	5.9	105	.048
1N3019	9.1	28	5.0	700	0.5	25	6.9	6.6	95	.051
1N3020	10	25	7	700	0.25	10	7.6	7.2	85	.055
1N3021	11	23	8	700	0.25	5	8.4	8.0	75	.060
1N3022	12	21	9	700	0.25	5	9.1	8.6	70	.065
1N3023	13	19	10	700	0.25	5	9.9	9.4	65	.065
1N3024	15	17	14	700	0.25	5	11.4	10.8	56	.070
1N3025	16	15.5	16	700	0.25	5	12.2	11.5	53	.070
1N3026	18	14	20	750	0.25	5	13.7	13.0	46	.075
1N3027	20	12.5	22	750	0.25	5	15.2	14.4	42	.075
1N3028	22	11.5	23	750	0.25	5	16.7	15.8	38	.080
1N3029	24	10.5	25	750	0.25	5	18.2	17.3	35	.080
1N3030	27	9.5	35	750	0.25	5	20.6	19.4	30	.085
1N3031	30	8.5	40	1,000	0.25	5	22.8	21.6	28	.085
1N3032	33	7.5	45	1,000	0.25	5	25.1	23.8	26	.085
1N3033	36	7.0	50	1,000	0.25	5	27.4	25.9	24	.085
1N3034	39	6.5	60	1,000	0.25	5	29.7	28.1	20	.090
1N3035	43	6.0	70	1,500	0.25	5	32.7	31.0	19	.090
1N3036	47	5.5	80	1,500	0.25	5	35.8	33.8	17	.090
1N3037	51	5.0	95	1,500	0.25	5	38.8	36.7	16	.090
1N3038	56	4.5	110	2,000	0.25	5	42.6	40.3	15	.090
1N3039	62	4.0	125	2,000	0.25	5	47.1	44.6	13	.090
1N3040	68	3.7	150	2,000	0.25	5	51.7	49.0	12	.090
1N3041	75	3.3	175	2,000	0.25	5	56.0	54.0	11	.090
1N3042	82	3.0	200	3,000	0.25	5	62.2	59.0	10	.090
1N3043	91	2.8	250	3,000	0.25	5	69.2	65.5	9	.090
1N3044	100	2.5	350	3,000	0.25	5	76.0	72.0	8	.090
1N3045	110	2.3	450	4,000	0.25	5	83.6	79.2	7.2	.095
1N3046	120	2.0	550	4,500	0.25	5	91.2	86.4	7.0	.095
1N3047	130	1.9	700	5,000	0.25	5	98.8	93.6	6.0	.095
1N3048	150	1.7	1,000	6,000	0.25	5	114.0	108.0	5.5	.095
1N3049	160	1.6	1,100	6,500	0.25	5	121.6	115.2	5.2	.095
1N3050	180	1.4	1,200	7,000	0.25	5	136.8	129.6	4.6	.095
1N3051	200	1.2	1,500	8,000	0.25	5	152.0	144.0	4.0	.100

SPECIAL SELECTIONS 1 – Nominal zener voltages between those shown.
2 – Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance
} *Standard Tolerances are ±5%, ±2%, and ±1%*

*V_{R1} – Test Voltage for 5% Tolerance Device

V_{R2} – Test Voltage for 10% Tolerance Device

No Leakage Specified as 20% Tolerance Device

1N3305 thru 1N3350

For Specifications, see 1N2804 data sheet.

1N3675 thru 1N3703

¾ W
6.8 — 100 V



CASE 59

Oxide passivated silicon zener diodes in void-free silicone polymer case. Offer 3/4 Watt performance in a package no larger in volume than a conventional 400 mW glass package.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 750 Milliwatts at 50°C Ambient.
(Derate 6 mW/°C)
Lead Temperature, 1/16 ± 1/32 inch from case: +235°C for 12 seconds.
(Method 2031, MIL-STD-750).

The type numbers shown have a standard tolerance of ±20% on the nominal zener voltage. Add suffix "A" for ±10% units or "B" for ±5% units.

ELECTRICAL CHARACTERISTICS 25°C Ambient $V_F = 1.5V$ @ $I_F = 200$ mA for all units)

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} Ohms	Max DC Zener Current I_{ZM} mA	$I_R = 5\mu A$ Max @ Reverse Voltage	Typical Zener Voltage Temp. Coeff. %/°C
1N3675	6.8	18.5	4.5	700	100	5.2	4.9
1N3676	7.5	16.5	5.5	700	90	5.7	5.4
1N3677	8.2	15.0	6.5	700	80	6.2	5.9
1N3678	9.1	14.0	7.5	700	70	6.9	6.2
1N3679	10	12.5	8.5	700	65	7.6	7.2
1N3680	11	11.5	9.5	700	55	8.4	8.0
1N3681	12	10.5	11.5	700	53	9.1	8.6
1N3682	13	9.5	13.0	700	50	9.9	9.4
	14	9.0	14.5	700	45	10.6	10.1
1N3683	15	8.5	16.0	700	42	11.4	10.8
1N3684	16	7.8	17.0	700	40	12.2	11.5
	17	7.2	19.0	700	38	13.0	12.2
1N3685	18	7.0	21.0	750	35	13.7	13.0
	19	6.5	23.0	750	33	14.4	13.7
1N3686	20	6.2	25.0	750	32	15.2	14.4
1N3687	22	5.6	29.0	750	29	16.7	15.8
1N3688	24	5.2	33.0	750	26	18.2	17.3
	25	5.0	36.0	750	24	19.0	18.0
1N3689	27	4.6	41.0	750	23	20.6	19.4
1N3690	30	4.2	49.0	1000	21	22.8	21.6
1N3691	33	3.8	58.0	1000	20	25.1	23.8
1N3692	36	3.4	70.0	1000	18	27.4	25.9
1N3693	39	3.2	80.0	1000	15	29.7	28.1
1N3694	43	3.0	93.0	1500	14	32.7	31.0
	45	2.8	99.0	1500	13.5	34.2	32.4
1N3695	47	2.7	105.0	1500	13	35.8	33.8
1N3696	51	2.5	125.0	1500	12.2	38.8	36.7
1N3697	56	2.2	150.0	2000	11	42.6	40.3
1N3698	62	2.0	185.0	2000	10	47.1	44.6
1N3699	68	1.8	230.0	2000	9	51.7	49.0
1N3700	75	1.7	270.0	2000	8.5	56.0	54.0
1N3701	82	1.5	330.0	3000	7.5	62.2	59.0
1N3702	91	1.4	400.0	3000	7	69.2	65.5
1N3703	100	1.3	500.0	3000	6	76.0	72.0

1N3785 thru 1N3820

1.5 W
6.8 — 200 V



CASE 55

Low silhouette single-ended package for printed circuit or socket mounting. Cathode connected to case, but reverse polarity available on special order.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 1.5 Watts. (Derate 10 mW/°C)

The type numbers shown have a standard tolerance of ±20% on the zener voltage. Standard tolerances of ±10% and ±5% on individual units are also available and are indicated by suffixing "A" for ±10% and "B" for ±5% unit to the standard type number.

ELECTRICAL CHARACTERISTICS @ 25°C Ambient V_F = 1.5 Volts max @ 300 mA

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT}@I_{ZT} ohms	Max Zener Impedance Z_{ZK}@I_{ZK} ohms	Max Zener Impedance I_{ZK} mA	Max DC Zener Current I_{ZM} mA	REVERSE LEAKAGE CURRENT* I_R Max (μA)	REVERSE LEAKAGE CURRENT* V_{R1}	REVERSE LEAKAGE CURRENT* V_{R2}	Typical Zener Voltage Temp. Coeff. %/°C
1N3785	6.8	55	2.7	700	1.0	195	150	5.2	4.9	.040
1N3786	7.5	50	3.0	700	0.5	175	75	5.7	5.4	.045
1N3787	8.2	46	3.5	700	0.5	155	50	8.2	5.9	.048
1N3788	9.1	41	4.0	700	0.5	140	25	6.9	6.8	.051
1N3789	10	37	5	700	0.25	125	10	7.6	7.2	.055
1N3790	11	34	6	700	0.25	115	5	8.4	8.0	.080
1N3791	12	31	7	700	0.25	105	5	9.1	8.6	.085
1N3792	13	29	8	700	0.25	98	5	9.9	9.4	.065
1N3793	15	25	10	700	0.25	85	5	11.4	10.8	.070
1N3794	16	23	11	700	0.25	80	5	12.2	11.5	.070
1N3795	16	21	13	750	0.25	70	5	13.7	13.0	.075
1N3796	20	19	15	750	0.25	62	5	15.2	14.4	.075
1N3797	22	17	16	750	0.25	58	5	18.7	15.8	.080
1N3798	24	16	17	750	0.25	51	5	18.2	17.3	.080
1N3799	27	14	20	750	0.25	46	5	20.6	19.4	.085
1N3800	30	12	25	1,000	0.25	41	5	22.8	21.8	.085
1N3801	33	11	30	1,000	0.25	38	5	25.1	23.8	.085
1N3802	36	10	35	1,000	0.25	35	5	27.4	25.8	.065
1N3803	38	10	40	1,000	0.25	31	5	29.7	28.1	.090
1N3804	43	9.0	45	1,500	0.25	28	5	32.7	31.0	.090
1N3805	47	8.0	55	1,500	0.25	28	5	35.8	33.8	.090
1N3806	51	7.4	65	2,000	0.25	24	5	38.6	36.6	.090
1N3807	56	6.7	75	2,000	0.25	22	5	42.6	40.3	.090
1N3808	62	6.0	85	2,000	0.25	20	5	47.1	44.6	.090
1N3809	66	5.5	85	2,000	0.25	18	5	51.7	49.0	.090
1N3810	75	5.0	110	2,000	0.25	16	5	56.0	54.0	.090
1N3611	82	4.5	130	3,000	0.25	14	5	62.0	58.0	.090
1N3812	91	4.1	150	3,000	9.25	13	5	89.2	65.5	.090
1N3813	100	3.7	200	3,000	0.25	12.0	5	78.0	72.0	.090
1N3814	110	3.4	300	4,000	0.25	11.0	5	83.6	79.2	.095
1N3815	120	3.1	350	4,500	0.25	10.5	5	91.2	88.4	.095
1N3816	130	2.9	400	5,000	0.25	8.0	5	98.8	93.6	.095
1N3817	150	2.5	700	6,000	0.25	8.0	5	114.0	108.0	.095
1N3618	180	2.3	750	8,500	0.25	8.0	5	121.8	115.0	.095
1N3819	180	2.1	800	7,000	0.25	7.0	5	137.0	130.0	.095
1N3820	200	1.9	1,000	8,000	0.25	6.0	5	152.0	144.0	.100

SPECIAL SELECTIONS 1 — Nominal zener voltages between those shown.
2 — Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage
b. Two or more units matched to one another with any specified tolerance
} *Standard Tolerances are ±5%, ±2%, and ±1%*

*V_{R1} — Test Voltage for 5% Tolerance Device
V_{R2} — Test Voltage for 10% Tolerance Device
No Leakage Specified as 20% Tolerance Device

1N3821 thru 1N3830

1 W
3.3 — 7.5 V

1N3821A thru 1N3828A USN/JAN

1N3821A thru 1N3828A HI-REL



CASE 52

Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected-to-case. Available as standard industrial types as well as for military and high-reliability applications.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 1 Watt.(Derate 6.67 mW/°C above 25°C)

The type numbers shown have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS (25°C Ambient $V_F = 1.5$ V @ $I_F = 200$ mA for all units)

TYPE NO.	Nominal Zener Voltage @ I_{ZT} (V_Z) Volts	Test Current I_{ZT} mA	Max Zener Impedance		Max DC Zener Current I_{ZM} mA	$I_R = 10\mu A$ Max @ Reverse Voltage V_R	Typical Zener Voltage/temp. Coeff. %/°C
			Z_{ZT} @ I_{ZT} ohms	Z_{ZK} @ $I_{ZK} = 1.0$mA ohms			
1N3821	3.3	76	10	400	276	1	-.075
1N3821A	3.3	76	10	400	276	1	-.075
1N3822	3.6	69	10	400	252	1	-.065
1N3822A	3.6	69	10	400	252	1	-.065
1N3823	3.9	64	9	400	238	1	-.055
1N3823A	3.9	64	9	400	236	1	-.855
1N3824	4.3	58	9	400	213	1	-.040
1N3824A	4.3	58	9	400	213	1	-.040
1N3825	4.7	53	9	500	194	1	-.020
1N3825A	4.7	53	8	500	194	1	-.020
1N3826	5.1	49	7	550	178	1	+.005
1N3826A	5.1	49	7	550	178	1	+.005
1N3827	5.6	45	5	600	162	2	+.020
1N3827A	5.8	45	5	600	162	2	+.020
1N3828	6.2	41	2	700	146	3	+.835
1N3828A	8.2	41	2	700	146	3	+.035
1N3829	8.8	37	1.5	500	133	3	+.048
1N3829A	8.8	37	1.5	500	133	3	+.040
1N3830	7.5	34	1.5	250	121	3	+.045
1N3830A	7.5	34	1.5	250	121	3	+.045

1N3993 thru 1N4000

10 W
3.9 — 7.5 V

1N3993A thru 1N4000A USA/JAN

1N3993A thru 1N4000A HI-REL



CASE 56
(DO-4)

Low-voltage, alloy-junction zener diodes in hermetically sealed package with cathode connected to case. Supplied with mounting hardware.

MAXIMUM RATINGS

Junction and Storage Temperature: -65°C to +175°C.
D-C Power Dissipation: 10 Watts. (Derate 83.3 mW/°C above 55°C).

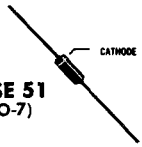
The type numbers shown in the table have a standard tolerance on the nominal zener voltage of ±10%. A standard tolerance of ±5% on individual units is also available and is indicated by suffixing "A" to the standard type number.

ELECTRICAL CHARACTERISTICS ($T_a = 30°C \pm 3$, $V_F = 1.5$ max @ $I_F = 2$ amp for all units)

Type No.	Nominal Zener Voltage V_Z @ I_{ZT} Volts	Test Current I_{ZT} mA	Max Zener Impedance Z_{ZT} @ I_{ZT} Ohms	Max Zener Impedance Z_{ZK} @ I_{ZK} = 1.0 mA Ohms	Max DC Zener Current I_{ZM} mA	REVERSE LEAKAGE CURRENT I_R (μA)	REVERSE LEAKAGE CURRENT V_R Volts
1N3993	3.9	640	2	400	2380	100	0.5
1N3994	4.3	580	1.5	400	2130	100	0.5
1N3995	4.7	530	1.2	500	1940	50	1
1N3996	5.1	490	1.1	550	1780	10	1
1N3997	5.6	445	1.0	600	1620	10	1
1N3998	6.2	405	1.1	750	1460	10	2
1N3999	6.8	370	1.2	500	1330	10	2
1N4000	7.5	335	1.3	250	1210	10	3

1N4099 thru 1N4135

¼ W
6.8 — 100 V



CASE 51
(DO-7)

Oxide passivated devices with extremely low, specified noise level. Designed for low-level operation over expanded temperature range from -75°C to +200°C.

MAXIMUM RATINGS

Characteristic	Rating	Unit
DC Power Dissipation, 25°C Ambient	250	mW
Derating Factor	1.43	mW/°C
Junction and Storage Temperature	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (At 25°C Ambient temperature unless otherwise specified.)

$V_F = 1.0$ max @ $I_F = 200$ mA on all types

Type Number	@ I_{ZT} = 250 μAmps: Nominal Zener Voltage V_Z (volts)	Min. Zener Voltage V_Z (volts)	Max. Zener Voltage V_Z (volts)	Max. Zener Impedance Z_{ZT} (ohms)	Reverse Leakage Current I_R (μA)	@ Test Voltage V_R (volts)	Max. Noise Density at I_{ZT} = 250μA N_D (Fig 1) (micro-volts per square root cycle)	Max. Zener Current I_{ZM} (mA)
1N4099	6.8	6.460	7.140	200	10	5.17	40	35.0
1N4100	7.5	7.125	7.875	200	10	5.70	40	31.8
1N4101	8.2	7.790	8.610	200	1.0	6.24	40	29.0
1N4102	8.7	8.265	9.135	200	1.0	6.61	40	27.4
1N4103	9.1	8.645	9.555	200	1.0	6.92	40	26.2
1N4104	10	9.500	10.50	200	1.0	7.60	40	24.8
1N4105	11	10.45	11.55	200	.05	8.44	40	21.6
1N4106	12	11.40	12.60	200	.05	9.12	40	20.4
1N4107	13	12.35	13.65	200	.05	9.87	40	19.0
1N4108	14	13.30	14.70	200	.05	10.65	40	17.5
1N4109	15	14.25	15.75	100	.05	11.40	40	16.3
1N4110	16	15.20	16.80	100	.05	12.15	40	15.4
1N4111	17	16.15	17.85	100	.05	12.92	40	14.5
1N4112	18	17.10	18.90	100	.05	13.67	40	13.2
1N4113	19	18.05	19.95	150	.05	14.44	40	12.5
1N4114	20	19.00	21.00	150	.01	15.20	40	11.9
1N4115	22	20.90	23.10	150	.01	16.72	40	10.8
1N4116	24	22.80	25.20	150	.01	18.25	40	9.9
1N4117	25	23.75	26.25	150	.01	19.00	40	9.5
1N4118	27	25.65	28.35	150	.01	20.46	40	8.8
1N4119	28	26.60	29.40	200	.01	21.28	40	8.5
1N4120	30	28.50	31.50	200	.01	22.80	40	7.9
1N4121	33	31.35	34.65	200	.01	25.08	40	7.2
1N4122	36	34.20	37.80	200	.01	27.38	40	6.6
1N4123	39	37.05	40.95	200	.01	29.65	40	6.1
1N4124	43	40.85	45.15	250	.01	32.65	40	5.5
1N4125	47	44.65	49.35	250	.01	35.75	40	5.1
1N4126	51	48.45	53.55	300	.01	38.76	40	4.6
1N4127	56	53.20	58.80	300	.01	42.60	40	4.2
1N4128	60	57.00	63.00	400	.01	45.60	40	4.0
1N4129	62	58.90	65.10	500	.01	47.10	40	3.8
1N4130	68	64.60	71.40	700	.01	51.68	40	3.5
1N4131	75	71.25	78.75	700	.01	57.00	40	3.1
1N4132	82	77.90	86.10	800	.01	62.32	40	2.9
1N4133	87	82.65	91.35	1000	.01	66.12	40	2.7
1N4134	91	86.45	95.55	1200	.01	69.16	40	2.6
1N4135	100	95.00	105.00	1500	.01	76.00	40	2.3

SPECIAL SELECTIONS 1 — Nominal zener voltages between those shown.
2 — Matched sets:
a. Two or more units for series connection with specified tolerance on total voltage } *Standard Tolerances are ±5%, ±2%, and ±1%.*
b. Two or more units matched to one another with any specified tolerance }

1N4099 thru 1N4135 (continued)

The type numbers shown have a standard tolerance of ±5% on the nominal zener voltage.

ZENER NOISE DENSITY

A zener diode generates noise when it is biased in the zener direction. A small part of this noise is due to the internal resistance associated with the device. A larger part of zener noise is a result of the zener breakdown phenomenon and is called microplasma noise. This microplasma noise is generally considered "white" noise with equal amplitude for all frequencies from about zero cycles to approximately 200,000 cycles. To eliminate the higher frequency components of noise a small shunting capacitor can be used. The lower frequency noise generally must be tolerated since a capacitor required to eliminate the lower frequencies would degrade the regulation properties of the zener in many applications.

This series is rated with a maximum noise density at 250 microvolts. The rating of microvolts RMS per square root cycle enables calculation of the maximum RMS noise for any bandwidth.

Noise density decreases as zener current increases. This can be seen by the graph in Figure 2 where a typical noise density is plotted as a function of zener current.

The junction temperature will also change the zener noise levels. As temperature is increased, the noise levels decrease. The change is approximately 20% from 25°C to 100°C. Thus the noise rating must indicate bandwidth, current level and temperature.

The block diagram given in Figure 1 shows the method used to measure noise density. The input voltage and load resistance is high so that the zener is driven from a constant current source. The amplifier must be low noise so that the amplifier noise is negligible compared to the test zener. The filter bandpass is known so that the noise density in volts RMS per square root cycle can be calculated.

1N4099 thru 1N4135 (continued)

FIGURE 1 — NOISE DENSITY MEASUREMENT METHOD

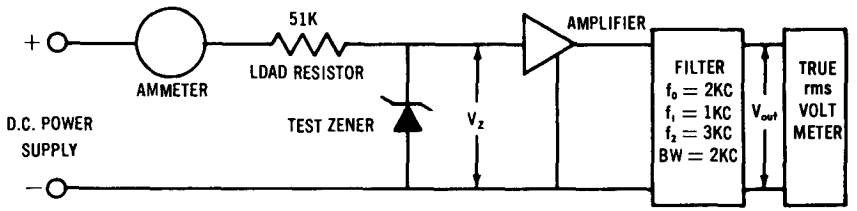
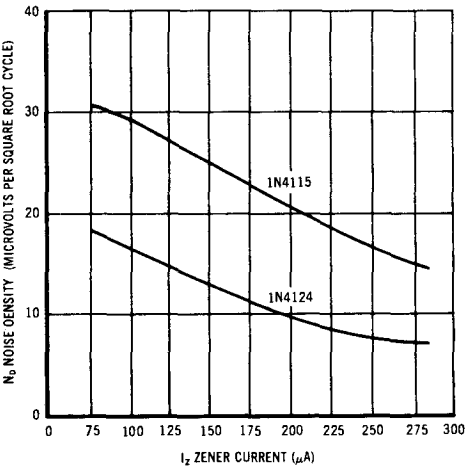


FIGURE 2 — NOISE DENSITY versus ZENER CURRENT



$$\text{NOISE DENSITY (VOLTS PER SQUARE ROOT CYCLE)} = \frac{V_{out}}{\text{DVERALL GAIN } \sqrt{BW}}$$

WHERE: BW = FILTER BANDWIDTH (CYCLES)

V_{out} = OUTPUT NOISE (VOLTS RMS)

1N4370 thru 1N4372

For Specifications, see 1N746 thru 1N759 data sheet.

1N4549 thru 1N4556
1N4557 thru 1N4564

For Specifications, See IN2804 Data Sheet

1N4728 thru 1N4764

1W
3.3-100 V

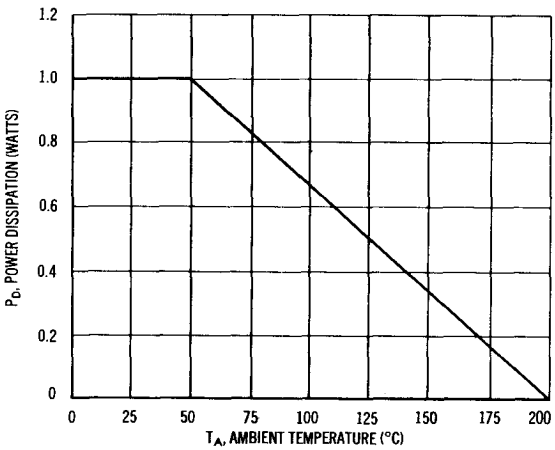
CASE 59



One-watt silicon zener diodes designed for constant voltage reference from 3.3 thru 100 volts, with 10% and 5% tolerances. These diodes are packaged in a void-free silicone polymer case which is no larger than the conventional 400 mW glass package.

MAXIMUM RATINGS

Characteristic	Rating	Unit
DC Power Dissipation	1	Watt
Derating Factor	6.67	mW/°C
Junction and storage Temperature	-65 to +200	°C



POWER RATING versus AMBIENT TEMPERATURE

1N4728 thru 1N4764 (continued)

ELECTRICAL CHARACTERISTICS

(At 25°C ambient temperature unless otherwise specified) $V_F = 1.5V$ max @ 200 mA on all types

Type No.	Nominal Zener Voltage $V_Z @ I_{ZT}$ Volts (Note 2)	Test Current I_{ZT} mA	Max Zener Impedance (Note 3) $Z_{ZT} @ I_{ZT}$ Ohms	$Z_{ZK} @ I_{ZK}$ Ohms	I_{ZK} mA	REVERSE LEAKAGE CURRENT I_R μA Max @	V_R Volts	Surge Current @ $T_A = 25°C$ I_R (Note 5)	Max DC Zener Current I_{ZM} mA (Note 4)
1N4726	3.3	76	10	400	1.0	100	1	1380	276
1N4729	3.6	69	10	400	1.0	100	1	1260	252
1N4730	3.9	64	9	400	1.0	50	1	1190	234
1N4731	4.3	58	9	400	1.0	10	1	1070	217
1N4732	4.7	53	8	500	1.0	10	1	970	193
1N4733	5.1	49	7	550	1.0	10	1	890	178
1N4734	5.6	45	5	600	1.0	10	2	810	162
1N4735	6.2	41	2	700	1.0	10	3	730	146
1N4736	6.8	37	3.5	700	1.0	10	4	660	133
1N4737	7.5	34	4.0	700	0.5	10	5	605	121
1N4738	8.2	31	4.5	700	0.5	10	6	550	110
1N4739	9.1	28	5.0	700	0.5	10	7	500	100
1N4740	10	25	7	700	0.25	10	7.6	454	91
1N4741	11	23	8	700	0.25	5	8.4	414	83
1N4742	12	21	9	700	0.25	5	9.1	380	76
1N4743	13	19	10	700	0.25	5	9.9	344	69
1N4744	15	17	14	700	0.25	5	11.4	304	61
1N4745	16	15.5	16	700	0.25	5	12.2	285	57
1N4746	18	14	20	750	0.25	5	13.7	250	50
1N4747	20	12.5	22	750	0.25	5	15.2	225	45
1N4748	22	11.5	23	750	0.25	5	16.7	205	41
1N4749	24	10.5	25	750	0.25	5	18.2	190	38
1N4750	27	9.5	35	750	0.25	5	20.6	170	34
1N4751	30	8.5	40	1,000	0.25	5	22.6	150	30
1N4752	33	7.5	45	1,000	0.25	5	25.1	135	27
1N4753	36	7.0	50	1,000	0.25	5	27.4	125	25
1N4754	39	6.5	60	1,000	0.25	5	29.7	115	23
1N4755	43	6.0	70	1,500	0.25	5	32.7	110	22
1N4756	47	5.5	80	1,500	0.25	5	35.6	95	19
1N4757	51	5.0	95	1,500	0.25	5	38.6	90	18
1N4758	56	4.5	110	2,000	0.25	5	42.6	80	16
1N4759	62	4.0	125	2,000	0.25	5	47.1	70	14
1N4760	68	3.7	150	2,000	0.25	5	51.7	65	13
1N4761	75	3.3	175	2,000	0.25	5	56.0	60	12
1N4762	82	3.0	200	3,000	0.25	5	62.2	55	11
1N4763	91	2.6	250	3,000	0.25	5	69.2	50	10
1N4764	100	2.5	350	3,000	0.25	5	76.0	45	9

The type numbers shown have a standard tolerance of ±10% on the nominal zener voltage. Suffix "A" for ±5% units.

MECHANICAL CHARACTERISTICS

CASE: Void free, transfer molded, thermosetting silicone polymer.

FINISH: All external surfaces are corrosion resistant. Leads are readily solderable.

POLARITY: Cathode, indicated by color band. When operated in zener mode cathode will be positive with respect to anode.

MOUNTING POSITION: Any

WEIGHT: 0.42 gram (approximately)

ADDITIONS AND MODIFICATIONS

TEMPERATURE COMPENSATED REFERENCE DIODES

Temperature compensated reference diodes are made possible by the differing thermal characteristics of forward and reverse biased silicon PN junctions. A forward biased junction has a negative temperature coefficient of approximately 2.0 millivolts/^{o}C. Reverse biased junctions above 5 volts have a positive temperature coefficient and therefore it is possible, by judicious selection of combinations of forward and reverse biased junctions, to obtain a device, due to cancellation, which shows a very low temperature coefficient. Because of the differing impedance-versus-temperature characteristics of the junctions involved, optimum temperature stability is obtained by operating in the zener current range at which the temperature coefficient is a minimum.

VOLTAGE VARIATION ($\triangle V_z$) AND TEMPERATURE COEFFICIENT

Reference diodes are most completely characterized by the "box" method. This method provides for a guaranteed maximum voltage variation (V_Z in mV) over a specified temperature range, verified by tests at several points within the range. (Maximum voltage variations over the specified temperature ranges are given in tables associated with each device type.) The design engineer now has a specific number - without any calculations - telling him the stability of the voltage over the temperature range of interest; thus giving him the maximum flexibility as well as economy in selecting the temperature stability required. Military specifications now being issued use this approach to characterize TC diodes.

Since reference diodes have a non-linear voltage-temperature relationship the temperature coefficients in the tables are provided primarily for reference purposes and guaranteed only at the end points of the temperature range.

VOLTAGE-CURRENT CHARACTERISTICS

The reference voltage will vary with changes in zener current. These variations can be minimized by driving the device from a constant current source.

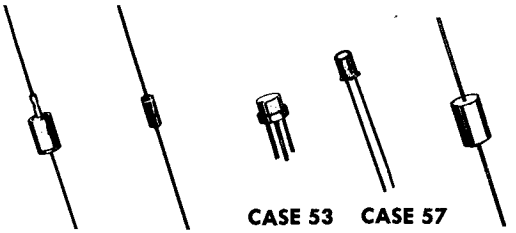
ZENER IMPEDANCE DERIVATION

The dynamic zener impedance, Z_{ZT}, is derived from the 60 cycle ac voltage which results when an ac current having an rms value equal to 10% of the dc zener current, I_{ZT}, is superimposed on I_{ZT}. A 100% cathode-ray tube curve trace test is used to ensure that each zener characteristic has a sharp and stable knee region.

TEMPERATURE COMPENSATED REFERENCE DIODES – INDEX

(Table numbers refer to tables on subsequent pages)

Type Number	Voltage	Table Number
1N429	6.2 V	1
1N821, 1N823, 1N825, 1N827, 1N829	6.2 V	1
1N821A, 1N823A, 1N825A, 1N827A, 1N829A	6.2 V	1
1N935 - 1N939	9.0 V	12
1N935A - 1N939A	9.0 V	13
1N935B - 1N939B	9.0 V	14
1N941 - 1N945	11.7 V	22
1N941A - 1N945A	11.7 V	23
1N941B - 1N945B	11.7 V	24
1N1530, 1N1530A	8.4 V	6
1N1735	6.2 V	1
1N1736, 1N1736A	12.4 V	25
1N1737, 1N1737A	18.6 V	26
1N1738, 1N1738A	24.8 V	28
1N1739, 1N1739A	31.0 V	30
1N1740, 1N1740A	37.2 V	32
1N1741, 1N1741A	43.4 V	34
1N1742, 1N1742A	49.6 V	35
1N2620 - 1N2624	9.3 V	19
1N2620A - 1N2624A	9.3 V	20
1N2620B - 1N2624B	9.3 V	21
1N2769, 1N2769A	34.0 V	31
1N2770, 1N2770A	40.8 V	33
1N3154 - 1N3157	8.4 V	6
1N3154A - 1N3157A	8.4 V	7
1N3580 - 1N3582	11.7 V	22
1N3580A - 1N3582A	11.7 V	23
1N3580B - 1N3582B	11.7 V	24
1N4565 - 1N4569	6.4 V	2
1N4565A - 1N4569A	6.4 V	3
1N4570 - 1N4574	6.4 V	4
1N4570A - 1N4574A	6.4 V	5
1N4765 - 1N4569	9.1 V	15
1N4765A - 1N4569A	9.1 V	16
1N4770 - 1N4774	9.1 V	17
1N4770A - 1N4774A	9.1 V	18
1N4775 - 1N4779	8.5 V	8
1N4775A - 1N4779A	8.5 V	9
1N4780 - 1N4784	8.5 V	10
1N4780A - 1N4784A	8.5 V	11



CASE 51 CASE 52 CASE 53 CASE 57 PACKAGE 4

Temperature compensated zener reference diodes designed for circuits requiring a high degree of voltage-temperature stability over a broad temperature range.

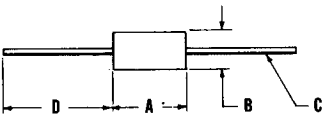
MAXIMUM RATINGS

Characteristics	Symbol	Rating	Units
Operating Temperature See notes on P_D in individual data tables 1- 2-	T_J	 -65 to +150 -65 to +175	°C
Storage Temperature All Types	T_{stg}	 -65 to +175	°C

MECHANICAL CHARACTERISTICS

	Glass	Metal	Molded
Case:	All glass, hermetically sealed	Welded, hermetically sealed, metal & glass	Void free, thermo-setting polymer
Polarity:	Cathode indicated by polarity band	Indicated by diode symbol	Indicated by diode symbol except 1N429, 1N1530, 1N1530A where cathode indicated by polarity dot of contrasting color
Weight:	0.2 grams (approx.)	1.5 grams (approx.)	Varies according to device min 0.5 grams max 12 grams
Finish:	All external surfaces corrosion resistant and leads readily solderable.		

PACKAGE 4



PKG	OUTLINE DIMENSIONS (INCHES)			
	A MAX	B MAX	C ±.002	D MAX
4-1	.100	.500	.032	1.25
4-2	.500	.375	.032	1.25
4-3	1.030	.378	.032	1.25
4-4	1.220	.641	.032	1.75
4-5	.655	.641	.032	1.25
4-6	.520	.275	.022	1.25
4-7	1.000	.375	0.32	1.25

TABLE 1

V_Z = 6.2 V ±5% at I_{ZT} = 7.5 mA

Test Temperatures: -55, +25, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N429	0.050	0.01	20	200①	53
1N821	0.096	0.01	15	†250②	51
1N821A	0.096	0.01	10	†250②	51
1N823	0.048	0.005	15	†250②	51
1N823A	0.048	0.005	10	†250②	51
1N825	0.019	0.002	15	†250②	51
1N825A	0.019	0.002	10	†250②	51
1N827	0.009	0.001	15	†250②	51
1N827A	0.009	0.001	10	†250②	51
1N829	0.004	0.0005	15	†250②	51
1N829A	0.004	0.0005	10	†250②	51
1N1735	0.050	0.01	20	200①	4-6

TABLE 2

V_Z = 6.4 V ±5% at I_{ZT} = 0.5 mA

Test Temperatures: 0, 25, 75°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4565	0.048	0.01	200	†250②	51
1N4566	0.024	0.005	200	†250②	51
1N4567	0.010	0.002	200	†250②	51
1N4568	0.005	0.001	200	†250②	51
1N4569	0.002	0.0005	200	†250②	51

TABLE 3

V_Z = 6.4 V ± 5% at I_{ZT} = 0.5 mA

Test Temperatures: -55, 0, +25, +75, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4565A	0.099	0.01	200	†250②	51
1N4566A	0.050	0.005	200	†250②	51
1N4567A	0.020	0.002	200	†250②	51
1N4568A	0.10	0.001	200	†250②	51
1N4569A	0.005	0.0005	200	†250②	51

TABLE 4

V_Z = 6.4 V ± 5% at I_{ZT} = 1.0 mA

Test Temperatures: 0, 25, 75°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4570	0.048	0.01	100	†250②	51
1N4571	0.024	0.005	100	†250②	51
1N4572	0.010	0.002	100	†250②	51
1N4573	0.005	0.001	100	†250②	51
1N4574	0.002	0.0005	100	†250②	51

TABLE 5

V_Z = 6.4 V ± 5% at I_{ZT} = 1.0 mA

Test Temperatures: -55, 0, +25, +75, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4570A	0.099	0.01	100	†250②	51
1N4571A	0.050	0.005	100	†250②	51
1N4572A	0.020	0.002	100	†250②	51
1N4573A	0.010	0.001	100	†250②	51
1N4574A	0.005	0.0005	100	†250②	51

*Temperature range noted. See Maximum Rating.

TABLE 6

V_Z = 8.4 V ± 5% at I_{ZT} = 10 mA

Test Temperatures: -55, +25, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N1530	0.014	0.002	15	250①	57
1N1530A	0.007	0.001	15	250①	57
1N3154	0.130	0.01	15	250②	51
1N3155	0.065	0.005	15	250②	51
1N3156	0.026	0.002	15	250②	51
1N3157	0.013	0.001	15	250②	51

TABLE 7

V_Z = 8.4 V ± 5% at I_{ZT} = 10 mA

Test Temperatures: -55, +25, +100, +150°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N3154A	0.172	0.01	15	†250②	51
1N3155A	0.086	0.005	15	†250②	51
1N3156A	0.034	0.002	15	†250②	51
1N3157A	0.017	0.001	15	†250②	51

TABLE 8

V_Z = 8.5 V ± 5% at I_{ZT} = 0.5 mA

Test Temperatures: 0, 25, 75°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4775	0.064	0.01	200	250②	51
1N4776	0.032	0.005	200	250②	51
1N4777	0.013	0.002	200	250②	51
1N4778	0.006	0.001	200	250②	51
1N4779	0.003	0.0005	200	250②	51

TABLE 9

V_Z = 8.5 V ± 5% at I_{ZT} = 0.5 mA

Test Temperatures: -55, 0, +25, +75, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4775A	0.132	0.01	200	250②	51
1N4776A	0.066	0.005	200	250②	51
1N4777A	0.026	0.002	200	250②	51
1N4778A	0.013	0.001	200	250②	51
1N4779A	0.007	0.0005	200	250②	51

TABLE 10

V_Z = 8.5 V ± 5% at I_{ZT} = 1.0 mA

Test Temperatures: 0, 25, 75°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
1N4780	0.064	0.01	100	250②	51
1N4781	0.032	0.005	100	250②	51
1N4782	0.013	0.002	100	250②	51
1N4783	0.006	0.001	100	250②	51
1N4784	0.003	0.0005	100	250②	51

① T_J = -65 to +150°C

② T_J = -65 to +175°C

† The indicated power rating is recommended for conservative design limits in critical high reliability applications. Registered power ratings vary from 250 mW to 500 mW. Alt devices indicated are supplied in the 400 mW glass package.

TABLE 11

V_Z = 8.5 V ±5% at I_{ZT} = 1.0 mA

Test Temperatures: -55, 0, +25, +75, +100°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{zt} Ohms	Power Dissipation P mW*	Case
1N4780A	0.132	0.01	100	250②	51
1N4781A	0.066	0.005	100	250②	51
1N4782A	0.026	0.002	100	250②	51
1N4783A	0.013	0.001	100	250②	51
1N4784A	0.007	0.0005	100	250②	51

TABLE 12

V_Z = 9.0 V ± 5% at I_{ZT} = 7.5 mA

Test Temperatures: 0, 25, 75°C

1N935	0.067	0.01	20	†250②	51
1N936	0.033	0.005	20	†250②	51
1N937	0.013	0.002	20	†250②	51
1N938	0.006	0.001	20	†250②	51
1N939	0.003	0.0005	20	†250②	51

TABLE 13

V_Z = 9.0 V ±5% at I_{ZT} = 7.5 mA

Test Temperatures: -55, 0, +25, +75, +100°C

1N935A	0.139	0.01	20	†250②	51
1N936A	0.069	0.005	20	†250②	51
1N937A	0.027	0.002	20	†250②	51
1N938A	0.013	0.001	20	†250②	51
1N939A	0.007	0.0005	20	†250②	51

TABLE 14

V_Z = 9.0 V ± 5% at I_{ZT} = 7.5 mA

Test Temperatures: -55, 0, +25, +75, +100, +150°C

1N935B	0.184	0.01	20	†250②	51
1N936B	0.092	0.005	20	†250②	51
1N937B	0.037	0.002	20	†250②	51
1N938B	0.018	0.001	20	†250②	51
1N939B	0.009	0.0005	20	†250②	51

TABLE 15

V_Z = 9.1 V ±5% at I_{ZT} = 0.5 mA

Test Temperatures: 0, 25, 75°C

1N4765	0.068	0.01	350	250②	51
1N4766	0.034	0.005	350	250②	51
1N4767	0.014	0.002	350	250②	51
1N4768	0.007	0.001	350	250②	51
1N4769	0.003	0.0005	350	250②	51

TABLE 16

V_Z = 9.1 V ±5% at I_{ZT} = 0.5 mA

Test Temperatures: -55, 0, +25, +75, +100°C

1N4765A	0.141	0.01	350	250②	51
1N4766A	0.070	0.005	350	250②	51
1N4767A	0.028	0.002	350	250②	51
1N4768A	0.014	0.001	350	250②	51
1N4769A	0.007	0.0005	350	250②	51

TABLE 17

V_Z = 9.1 V ± 5% at I_{ZT} = 1.0 mA

Test Temperatures: 0, 25, 75°C

Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{zt} Ohms	Power Dissipation P mW*	Case
1N4770	0.068	0.01	200	250②	51
1N4771	0.034	0.005	200	250②	51
1N4772	0.014	0.002	200	250②	51
1N4773	0.007	0.001	200	250②	51
1N4774	0.003	0.0005	200	250②	51

TABLE 18

V_Z = 9.1 V ± 5% at I_{ZT} = 1.0 mA

Test Temperatures: -55, 0, +25, +75, +100°C

1N4770A	0.141	0.01	200	250②	51
1N4771A	0.070	0.005	200	250②	51
1N4772A	0.028	0.002	200	250②	51
1N4773A	0.014	0.001	200	250②	51
1N4774A	0.007	0.0005	200	250②	51

TABLE 19

V_Z = 9.3 V ±5% at I_{ZT} = 10 mA

Test Temperatures: 0, 25, 75°C

1N2620	0.070	0.01	15	750②	52
1N2621	0.035	0.005	15	750②	52
1N2622	0.014	0.002	15	750②	52
1N2623	0.007	0.001	15	750②	52
1N2624	0.003	0.0005	15	750②	52

TABLE 20

V_Z = 9.3 V ±5% at I_{ZT} = 10 mA

Test Temperatures: -55, 0, +25, +75, +100°C

1N2620A	0.144	0.01	15	750②	52
1N2621A	0.072	0.005	15	750②	52
1N2622A	0.029	0.002	15	750②	52
1N2623A	0.014	0.001	15	750②	52
1N2624A	0.007	0.0005	15	750②	52

TABLE 21

V_Z = 9.3 V ±5% at I_{ZT} = 10 mA

Test Temperatures: -55, 0, +75, +100, +150°C

1N2620B	0.191	0.01	15	750②	52
1N2621B	0.095	0.005	15	750②	52
1N2622B	0.038	0.002	15	750②	52
1N2623B	0.019	0.001	15	750②	52
1N2624B	0.010	0.0005	15	750②	52

TABLE 22

V_Z = 11.7 V ± 5% at I_{ZT} = 7.5 mA

Test Temperatures: 0, 25, 75°C

1N941	0.088	0.01	30	†250②	51
1N942	0.044	0.005	30	†250②	51
1N943	0.018	0.002	30	†250②	51
1N944	0.009	0.001	30	†250②	51
1N945	0.004	0.0005	30	†250②	51

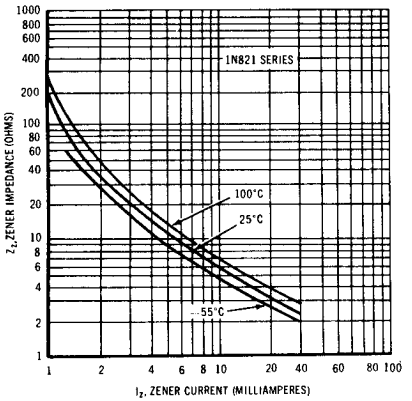
Type Number	Max Voltage Change ΔV Volts	Temperature Coefficient %/°C For Reference	Max Dynamic Impedance Z_{ZT} Ohms	Power Dissipation P mW*	Case
TABLE 22 (Cont'd)					
1N3580	0.088	0.01	25	750②	52
1N3581	0.044	0.005	25	750②	52
1N3582	0.018	0.002	25	750②	52
TABLE 23 V_Z = 11.7 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, 0, +25, +75, +100°C					
1N941A	0.181	0.01	30	†250②	51
1N942A	0.090	0.005	30	†250②	51
1N943A	0.036	0.002	30	†250②	51
1N944A	0.018	0.001	30	†250②	51
1N945A	0.009	0.0005	30	†250②	51
1N3580A	0.181	0.01	25	750②	52
1N3581A	0.090	0.005	25	750②	52
1N3582A	0.036	0.002	25	750②	52
TABLE 24 V_Z = 11.7 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, 0, +25, +75, +100, +150°C					
1N941B	0.239	0.01	30	†250②	51
1N942B	0.120	0.005	30	†250②	51
1N943B	0.047	0.002	30	†250②	51
1N944B	0.024	0.001	30	†250②	51
1N945B	0.012	0.0005	30	†250②	51
1N3580B	0.239	0.01	25	750②	52
1N3581B	0.120	0.005	25	750②	52
1N3582B	0.048	0.002	25	750②	52
TABLE 25 V_Z = 12.4 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1736	0.100	0.01	40	400①	4-3
1N1736A	0.050	0.005	40	400①	4-3
TABLE 26 V_Z = 18.6 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1737	0.150	0.01	60	600①	4-5
1N1737A	0.075	0.005	60	600①	4-5
TABLE 27 V_Z = 20.4 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N2767	0.158	0.005	60	600①	4-7
1N2767A	0.079	0.0025	60	600①	4-7
TABLE 28 V_Z = 24.8 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1738	0.200	0.01	80	800①	4-5
1N1738A	0.100	0.005	80	800①	4-5
TABLE 29 V_Z = 27.2 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N2768	0.210	0.005	80	800①	4-7
1N2768A	0.105	0.0025	80	800①	4-7
TABLE 30 V_Z = 31.0 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1739	0.250	0.01	100	1000①	4-4
1N1739A	0.125	0.005	100	1000①	4-4
TABLE 31 V_Z = 34.0 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, + 25, +100°C					
1N2769	0.265	0.005	100	1000①	4-1
1N2769A	0.132	0.0025	100	1000①	4-1
TABLE 32 V_Z = 37.2 V ± 5% at I_{ZT} = 7.5 mA					
1N1740	0.300	0.01	120	1200①	4-4
1N1740A	0.150	0.005	120	1200①	4-4
TABLE 33 V_Z = 40.8 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N2770	0.316	0.005	120	1200①	4-1
1N2770A	0.158	0.0025	120	1200①	4-1
TABLE 34 V_Z = 43.4 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1741	0.350	0.01	140	1400①	4-4
1N1741A	0.175	0.005	140	1400①	4-4
TABLE 35 V_Z = 49.6 V ± 5% at I_{ZT} = 7.5 mA Test Temperatures: -55, +25, +100°C					
1N1742	0.400	0.01	180	1600①	4-4
1N1742A	0.200	0.005	180	1600①	4-4

① T_J = -65 to +150°C

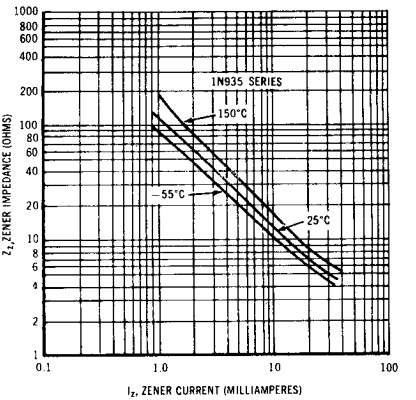
② T_J = -65 to +175°C

† The indicated power rating is recommended for conservative design limits in critical high reliability applications. Registered power ratings vary from 250 mW to 500 mW. All devices indicated are supplied in the 400 mW glass package.

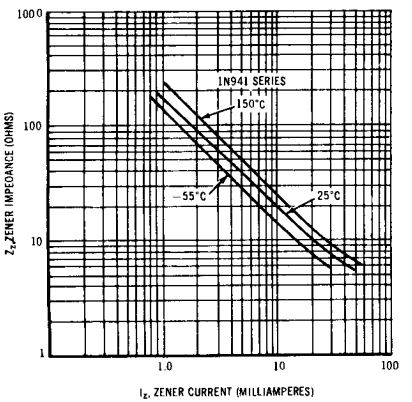
ZENER IMPEDANCE versus ZENER CURRENT



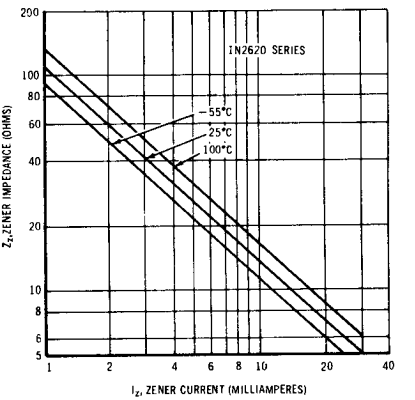
ZENER IMPEDANCE versus ZENER CURRENT



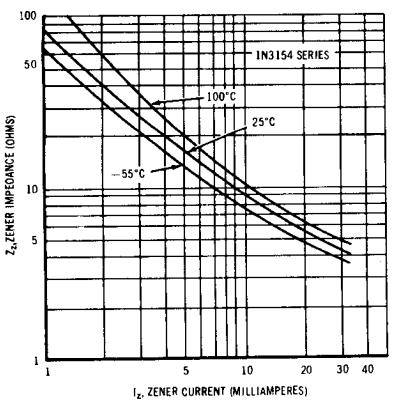
ZENER IMPEDANCE versus ZENER CURRENT



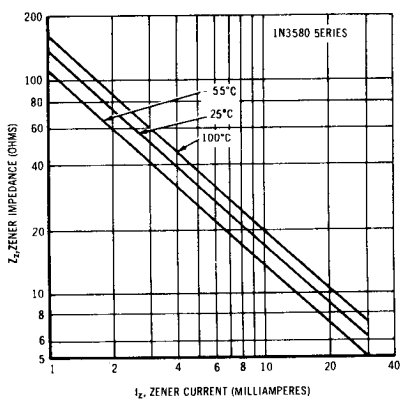
ZENER IMPEDANCE versus ZENER CURRENT



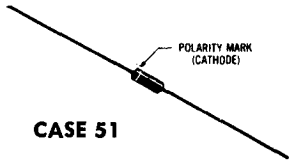
ZENER IMPEDANCE versus ZENER CURRENT



ZENER IMPEDANCE versus ZENER CURRENT



MZ600 SERIES — 6.2 Volt
MZ800 SERIES — 8.4 Volt



CASE 51

Precision reference diodes designed, manufactured, and tested for applications requiring a precision voltage reference with ultra-high stability of voltage with time and temperature.

Operating Temperature Range: 25 to 100°C

MZ600 Series

Voltage: V_Z = 6.2 V ±5% at I_{ZT} = 7.5 mA

Voltage-Temperature Stability: ΔV_Z = 2.5 mVdc (Maximum allowable change between voltages recorded at 25, 75, and 100°C.)

Dynamic Impedance: Z_{ZT} = 10 Ohms at I_{ZT} = 7.5 mAdc, I_{ac} = 0.75 mA

Type	Voltage-Time Stability (Maximum Change) μV/1000 hr	Parts Per Million Change ppm/1000 hr
MZ605	30	< 5
MZ610	60	<10
MZ620	120	<20
MZ640	240	<40

MZ800 Series

Voltage: V_Z = 8.4 V ±5% at I_{ZT} = 10 mA

Voltage-Temperature Stability: ΔV_Z = 3.5 mVdc (Maximum allowable change between voltages recorded at 25, 75, and 100°C.)

Dynamic Impedance: Z_{ZT} = 15 Ohms at I_{ZT} = 10 mAdc, I_{ac} = 1.0 mA

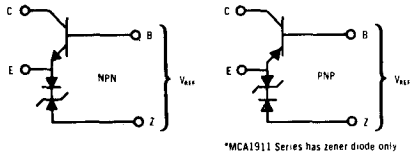
Type	Voltage-Time Stability (Maximum Change) μV/1000 hr	Parts Per Million Change ppm/1000 hr
MZ805	45	< 5
MZ810	90	<10
MZ820	180	<20
MZ840	360	<40

All diodes are serialized with a unique serial number and are also marked with a date code, polarity band, and device type number.

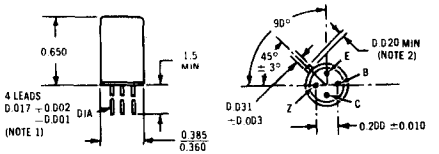
REFERENCE AMPLIFIERS

MCA1911 SERIES 6.8 V
MCA2011 SERIES 8.6 V
MCA2111 SERIES 9.5 V
MCA2211 SERIES 11.0 V

Reference amplifiers for use in regulated power supplies as a combination reference element and error voltage amplifier. Available with either PNP or NPN transistors.



*MCA1911 Series has zener diode only



NOTES:
1. The specified lead diameter applies in the zone between 0.050 and 0.250 from the base seat. Between 0.250 and 0.5 maximum of 0.021 diameter is held. Outside of these zones the lead diameter is not controlled.
2. Measured from max diameter of the actual device.

ABSOLUTE MAXIMUM RATINGS (at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Zener Current	I_Z	20	mA
Collector Current	I_C	20	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Junction and Storage Temperature Range	T_J T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Rating		Unit
Nominal Reference Voltage (I_Z = 5 mA, V_{CE} = 3 V, I_C = 250 μA)	V_{REF}	6.8-11.0 nom (See Table 1)		Volts
Maximum Reference Voltage Change with Temperature (I_Z = 5 mA, V_{CE} = 3 V, I_C = 250 μA)	ΔV_{REF}	(See Table 1)		Volts
		Min	Max	
Zener Impedance (I_{ZT} = 5 mA, I_{ac} = 10% I_Z)	Z_{ZT}	-	40	Ohms
Collector-Emitter Breakdown Voltage (I_C = 250 μA)	BV_{CEO}	30	-	Volts
Collector Cutoff Current (V_{CB} = 45 V) (V_{CB} = 45 V, T_A = 150°C)	I_{CBO}	- -	50 mA 10 μA	
DC Current Gain (I_C = 250 μA; V_{CE})	h_{FE}	50	100	-
Small-Signal Transconductance (V_{CE} = 3 V, I_C - 250 μA, f = 1 kc)	g_{fe}	6500	-	μmhos

TABLE 1 ELECTRICAL CHARACTERISTICS

(at I_{ZT} = 7.5 mA & T_A = 25°C unless otherwise specified)

Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	Test @ Temperature (°C)	Reference Voltage V_{REF} (Volts)
6.8 Volt Series (I_{ZT} = 5 mA)			
MCA1911N MCA1912N MCA1913N MCA1914N	.051 .025 .010 .005	0, +25, +75	6.8 ± 10%
MCA1921N MCA1922N MCA1923N MCA1924N	.105 .052 .020 .010	-55, 0, +25, +75, +100	6.8 ± 5%
MCA1931N MCA1932N MCA1933N MCA1934N	.139 .069 .026 .013	-55, 0, +25, +75, +100, +150	6.8 ± 5%
9.5 Volt Series (I_{ZT} = 5 mA)			
MCA2111N MCA2112N MCA2113N MCA2114N	.071 .035 .014 .007	0, +25, +75	9.5 ± 10%
MCA2121N MCA2122N MCA2123N MCA2124N	.147 .073 .028 .014	-55, 0, +25, +75, +100	9.5 ± 5%
MCA2131N MCA2132N MCA2133N MCA2134N	.194 .097 .038 .019	-55, 0, +25, +75, +100, +150	9.5 ± 5%

Type Number (Note 1)	Max Voltage Change (Note 2) ΔV_{REF} (Volts)	Test @ Temperature (C)	Reference Voltage V_{REF} (Volts)
8.6 Volt Series (I_{ZT} = 5 mA)			
MCA2011N MCA2012N MCA2013N MCA2014N	.060 .030 .012 .006	0, +25, +75	8.6 ± 10%
MCA2021N MCA2022N MCA2023N MCA2024N	.124 .062 .024 .012	-55, 0, +25, +75, +100	8.6 ± 5%
MCA2031N MCA2032N MCA2033N MCA2034N	.164 .082 .032 .016	-55, 0, +25, +75, +100, +150	8.6 ± 5%
11.0 Volt Series (I_{ZT} = 5 mA)			
MCA2211N MCA2212N MCA2213N MCA2214N	.082 .041 .016 .008	0, +25, +75	11.0 ± 10%
MCA2221N MCA2222N MCA2223N MCA2224N	.170 .085 .034 .017	-55, 0, +25, +75, +100	11.0 ± 5%
MCA2231N MCA2232N MCA2233N MCA2234N	.225 .112 .044 .022	-55, 0, +25, +75, +100, +150	11.0 ± 5%

NOTES:

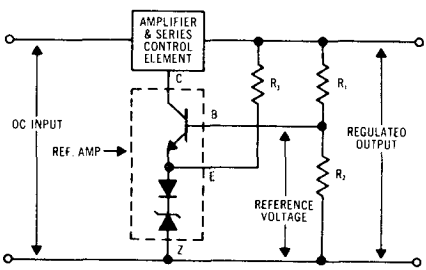
1. Type numbers shown are for devices containing NPN transistors; for devices with PNP transistors substitute a "P" suffix for the "N" suffix in the type number.
2. ΔV_{REF} is the maximum voltage variation over the specified temperature range, verified by tests at specified points within the range.

NOMENCLATURE

MCA 1911N

- Circuit Assembly
- Reference Voltage: 19 - 6.8 V; 20 - 8.6 V; 21 - 9.5 V; 22 - 11.0 V
- Temperature Range: 1. 0 to 75°C; 2. -55 to +100°C; 3. -55 to +150°C
- Potarity N-NPN P-PNP
- ΔV_{REF} as Specified on Table 1 (i.e., for 6.8 Volt Series, 1 designates ΔV_{REF} of .051 V)

TYPICAL APPLICATION IN REGULATED POWER SUPPLIES



ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

SILICON RECTIFIERS

For case outline dimensions, see page 1-186.

SILICON RECTIFIERS

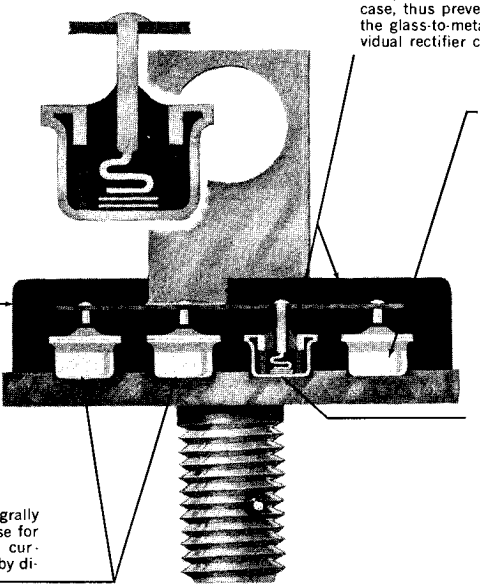
The trend in rectifiers, today, is toward silicon. Technically, there are many reasons why this is so. In comparison with thermionic tubes, silicon rectifiers offer a new era of reliability and performance, and no other solid-state rectifier has the inherant advantages of silicon. Silicon shrugs at operating temperatures that would quickly wilt other solid-state devices. The high forward conductance and low-reverse-leakage current of silicon out-classes selenium, and no other type of rectifier packs as much current-carrying capacity into as small a package. Moreover, these advantages of silicon rectifiers are now available at costs that are more than competitive with other types.

The following section contains data sheets for a complete line of silicon rectifiers for current requirements ranging from milliamperes to kiloamperes. These are housed in a variety of package types, making them suitable for every electrical and electronic application.

In addition, rectifier assemblies for higher voltage and current devices and for applications such as bridges and other circuit configurations are available as standard devices and can easily be made to order for custom applications, (see page 4-3).

MULTI-CELL RECTIFIERS

High-current rectifiers in this book employ the multi-cell concept. This approach not only permits the fabrication of higher-current rectifiers, but also eliminates many of the problems associated with large single-junction devices. The construction of a typical multi-cell rectifier is shown below.



Complete seal strength is afforded by the outer case, thus preventing any excessive stress on the glass-to-metal hermetic inner seal of individual rectifier cells.

Internal, hermetically sealed, welded metal case rectifier cells. All individual cells are specially processed, tested and matched for similarity of forward voltage characteristics to assure balanced current sharing and reliable parallel operation. Each cell is rated to operate at only 75 per cent of maximum current capability, providing a built-in safety margin.

Void-free, molded external case affords excellent mechanical strength, electrical isolation, and corrosion resistance. Color coding of the external case provides easy polarity identification:

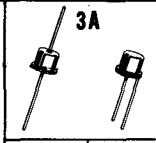
RED—Cathode to Case
BLACK—Anode to Case

Resistance to thermal fatigue of each cell is assured through the use of double back-up discs and high temperature solder construction to protect the silicon die against stresses. In addition, the small junction areas of the individual paralleled cells result in a total rectifier which can better resist thermal fatigue because of the smaller excursion of dissimilar bonded materials (as opposed to a large single-junction rectifier).

Plated copper base is integrally connected to the inner case for optimum heat transfer and current balance between cells by direct thermal coupling.

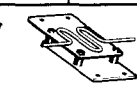
PREFERRED SILICON RECTIFIER SELECTION GUIDE

This list covers only the preferred rectifiers and by no means represents all the devices available from stock or currently under development. For information concerning rectifiers not listed here refer to the individual data sheets.

$V_{RM(REP)}$ MAX PEAK REPETITIVE REVERSE VOLTAGE	1A		1.5A	3A		6A	12A		15A
									
	CASE 59	FAST RECOVERY CASE 52	CASE 55	CASE 60	CASE 70	FAST RECOVERY CASE 56A	CASE 56A	FAST RECOVERY CASE 56A	CASE 42
50V	1N4001	MR1337-1		1N4719 (MR1030A)	1N4997 (MR1030B)	1N3879	MR1120	1N3889	1N3208
100V	1N4002	MR1337-2	1N1563	1N4720 (MR1031A)	1N4998 (MR1031B)	1N3880	MR1121	1N3890	1N3209
150V									
200V	1N4003 •1N3611	MR1337-3	1N1564	1N4721 (MR1032A)	1N4999 (MR1032B)	1N3881	MR1122	1N3891	1N3210
250V									
300V		MR1337-4	1N1565	MR1033A	MR1033B	1N3882	MR1123	1N3892	1N3211
350V									
400V	1N4004 •1N3612	MR1337-5	1N1566	1N4722 (MR1034A)	1N5000 (MR1034B)	1N3883	MR1124	1N3893	1N3212
500V		MR1337-6	1N1567	MR1035A	MR1035B		MR1125		1N3213
600V	1N4005 •1N3613	MR1337-7	1N1568	1N4723 (MR1036A)	1N5001 (MR1036B)		MR1126		1N3214
800V	1N4006			1N4724 (MR1038A)	1N5002 (MR1038B)		MR1128		
1000V	1N4007			1N4725 (MR1040A)	1N5003 (MR1040B)		MR1130		

*Available to USN Spec MIL-S-19500/228

REVERSE POLARITIES AVAILABLE IN ALL 3A TO 1000A TYPES

20A	25A	30A	35A	50A	80A	160A	240A	400A	650A	1000A
										
CASE 42	CASE 43	CASE 43	CASE 42	50A CASE 100	80A 160A 240A 400A CASE 101	80A 160A 240A 400A CASE 102	160A 240A 400A 650A CASE 103	160A 240A 400A CASE 104	1000A (WATER COOLED) CASE 105	
1N2488	1N3491 (MR322)	1N3659	1N1183	MR1200	MR1210	MR1220	MR1230	MR1240	MR1260	MR1290
1N2489	1N3492 (MR323)	1N3660	1N1184	MR1201	MR1211	MR1221	MR1231	MR1241	MR1261	MR1291
1N1193			1N1185	MR1202	MR1212	MR1222	MR1232	MR1242	MR1262	MR1292
1N2508	1N3493 (MR324)	1N3661	1N1186	MR1203	MR1213	MR1223	MR1233	MR1243	MR1263	MR1293
				MR1204	MR1214	MR1224	MR1234	MR1244	MR1264	MR1294
1N1195	1N3494 (MR325)	1N3662	1N1187	MR1205	MR1215	MR1225	MR1235	MR1245	MR1265	MR1295
				MR1206	MR1216	MR1226	MR1236	MR1246	MR1266	MR1296
1N1196	1N3495 (MR326)	1N3663	1N1188	MR1207	MR1217	MR1227	MR1237	MR1247	MR1267	MR1297
1N1197	MR327		1N1189	MR1208	MR1218	MR1228	MR1238	MR1248	MR1268	MR1298
1N1198	MR328		1N1190	MR1209	MR1219	MR1229	MR1239	MR1249	MR1269	MR1299
	MR330									
	MR331									

REVERSE POLARITIES AVAILABLE IN ALL 3A TO 1000A TYPES

LOW CURRENT RECTIFIERS – 0.1 to 12.0 Amperes

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (25°C)	Forward Current $I_{FM(surge)}$ amps (25°C)	$I_{R(AV)}$ mA (100°C)
Case 51				
1N3282	1000	0.1	2.5	0.01
1N3283	1500	0.1	2.5	0.01
1N3284	2000	0.1	2.5	0.01
1N3285	2500	0.1	2.5	0.01
1N3286	3000	0.1	2.5	0.01
Case 41 ①				
1N1738	1000	0.2	2.5	—
1N1731	1500	0.2	2.5	—
1N1732	2000	0.2	2.5	—
1N1733	3000	0.15	2.5	—
1N1734	5000	0.10	2.5	—
1N2382	4000	0.15	2.5	—
1N2383	6000	0.10	2.5	—
1N2384	8000	0.07	2.5	—
1N2385	10000	0.07	2.5	—
Case 59			(75°C)	(25°C)
MR998	1000	.250	15	0.01
MR991	1500	.250	15	0.01
MR992	2000	.250	15	0.01
MR993	2500	.250	15	0.01
MR994	3000	.250	15	0.01
Case 55		(55°C) (150°C)	(25°C)	(25°C)
1N1563	100	1.5 0.3	70	.005
1N1563A	100	1.5 0.3	70	.003
1N1564	200	1.5 0.3	70	.005
1N1564A	200	1.5 0.3	70	.003
1N1565	300	1.5 0.3	70	.005
1N1565A	300	1.5 0.3	70	.003
1N1566	400	1.5 0.3	70	.005
1N1566A	400	1.5 0.3	70	.003
1N1567	500	1.5 0.3	70	.005
1N1567A	500	1.5 0.3	70	.003
1N1568	600	1.5 0.3	70	.005
1N1568A	600	1.5 0.3	70	.003

① See data sheet for device dimensions

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (75°C)	Forward Current $I_{FM(surge)}$ amps (25°C)	$I_{R(AV)}$ mA (75°C)
Case 59				
1N4001	50	1.0	30	.03
1N4002	100	1.0	30	.03
1N4003	200	1.0	30	.03
1N4004	400	1.0	30	.03
1N4005	600	1.0	30	.03
1N4006	800	1.0	30	.03
1N4007	1000	1.0	30	.03
Case 60			(75°C)	
1N4719/MR1830A	50	3.0	300	1.5
1N4720/MR1831A	100	3.0	300	1.5
1N4721/MR1832A	200	3.0	300	1.5
—/MR1833R	300	3.0	300	1.5
1N4722/MR1834A	400	3.0	300	1.5
—/MR1835A	500	3.0	300	1.5
1N4723/MR1836A	600	3.0	300	1.5
1N4724/MR1838A	800	3.0	300	1.5
1N4725/MR1848A	1000	3.0	300	1.5
Case 70				
1N4997/MR1838B	50	3.0	300	1.5
1N4998/MR1831B	100	3.0	300	1.5
1N4999/MR1832B	200	3.0	300	1.5
—/MR1033B	300	3.0	300	1.5
1N5888/MR1034B	400	3.0	300	1.5
—/MR1035B	500	3.0	300	1.5
1N5001/MR1836B	600	3.0	300	1.5
1N5002/MR1838B	800	3.0	300	1.5
1N5083/MR1040B	1000	3.0	300	1.5
Case 56		(150°C)	(150°C)	(25°C)
MR1128	50	12.0	300	1.5
MR1121	100	12.0	300	1.5
MR1122	200	12.0	300	1.5
MR1123	300	12.0	300	1.5
MR1124	400	12.0	300	1.5
MR1125	500	12.0	300	1.5
MR1126	600	12.0	300	1.5
MR1128	800	12.0	300	1.5
MR1138	1000	12.0	300	1.5

FAST SWITCHING POWER RECTIFIERS – t_{rr} = 0.2 μsec maximum

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (75°C)	Forward Current $I_{FM(surge)}$ amps (75°C)	$I_{R(AV)}$ mA (75°C)
Case 52				
MR1337-1	50	0.75	30	0.75
MR1337-2	100	0.75	30	0.75
MR1337-3	200	0.75	30	0.75
MR1337-4	300	0.75	30	0.75
MR1337-5	400	0.75	30	0.75
Case 50		(100°C)	(100°C)	(100°C)
1N3879	50	6.0	75	3.0
1N3888	100	6.0	75	3.0

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (100°C)	Forward Current $I_{FM(surge)}$ amps (100°C)	$I_{R(AV)}$ mA (100°C)
Case 50				
1N3881	200	6.0	75	3.0
1N3882	300	6.0	75	3.0
1N3883	400	6.0	75	3.0
1N3889	50	12	150	5.0
1N3890	100	12	150	5.0
1N3891	200	12	150	5.0
1N3892	300	12	150	5.0
1N3893	400	12	150	5.0

MEDIUM CURRENT RECTIFIERS – 15 to 35 Amperes

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (150°C)	Forward Current $I_{FM(surge)}$ amps (25°C)	$I_{R(AV)}$ mA (150°C)
Case 42				
1N3288	50	15	250	10
1N3209	100	15	250	10
1N3210	200	15	250	10
1N3211	300	15	250	10
1N3212	400	15	250	10
Case 43				
1N3491-MR322	50	18	300	10
1N3492-MR323	100	18	300	10
1N3493-MR324	200	18	300	8
1N3494-MR325	300	18	300	6
1N3495-MR326	400	18	300	4
MR327	500	18	300	3
MR328	600	18	300	2.5
MR330	800	18	300	2
MR331	1000	18	300	1.5
Case 42			(150°C)	
1N248B	50	20	350	5.0
1N248C	55	20	350	3.8
1N249B	100	20	350	5.0
1N249C	110	20	350	3.6
1N258B	200	20	350	5.0
1N250C	220	20	350	3.4
Case 42				
1N1191	50	20	350	5.0
1N1192	100	20	350	5.0
1N1193	150	20	350	5.0
1N1194	200	20	350	5.0

Type	$V_{RRM(rep)}$ volts	Forward Current I_O amps (150°C)	Forward Current $I_{FM(surge)}$ amps (150°C)	$I_{R(AV)}$ mA (150°C)
Case 42				
1N1195	300	20	350	5.0
1N1195A	300	20	350	3.2
1N1196	400	20	350	5.0
1N1196A	300	20	350	2.5
1N1197	500	20	350	5.0
1N1197A	500	20	350	2.2
1N1198	600	20	350	5.0
1N1198A	600	20	350	1.5
1N3213	500	20	350	10.0
1N3214	600	20	350	10.0
Case 43				
1N3659	50	25	400	5.0
1N3660	100	25	400	4.5
1N3661	200	25	400	4.0
1N3662	300	25	400	3.5
1N3663	400	25	400	3.0
Case 42		(140°C)	(140°C)	(140°C)
1N1183	50	35	400	10
1N1184	100	35	400	10
1N1185	150	35	400	10
1N1186	200	35	400	10
1N1187	300	35	400	10
1N1188	400	35	400	10
1N1189	500	35	400	10
1N1190	600	35	400	10

HIGH CURRENT RECTIFIERS – 50 to 1000 Amperes

Type	$V_{RM(rep)}$ volts	Forward Current I_O amps (150°C)	Forward Current $I_{FM(surge)}$ amps (150°C)	$I_{R(AV)}$ mA (150°C)
Flat-mount with solid lug terminal (FL) ①				
MR1200	50	50	800	10
MR1201	100	50	800	10
MR1202	150	50	800	10
MR1203	200	50	800	10
MR1204	250	50	800	10
MR1205	300	50	800	10
MR1206	350	50	800	10
MR1207	400	50	800	10
Stud-mount with flexible braided lead (SB) Stud-mount with solid lug terminal (SL) ①				
MR1210	50	80	2000	15
MR1211	100	80	2000	15
MR1212	150	80	2000	15
MR1213	200	80	2000	15
MR1214	250	80	2000	15
MR1215	300	80	2000	15
MR1216	350	80	2000	15
MR1217	400	80	2000	15
Stud-mount with flexible braided lead (SB) or solid lug terminal (SL) Flat-mount with flexible braided lead (FB) or solid lug terminal (FL) ①				
MR1220	50	160	3600	20
MR1221	100	160	3600	20
MR1222	150	160	3600	20
MR1223	200	160	3600	20
MR1224	250	160	3600	20
MR1225	300	160	3600	20
MR1226	350	160	3600	20
MR1227	400	160	3600	20
MR1230	50	240	5000	35
MR1231	100	240	5000	35
MR1232	150	240	5000	35
MR1233	200	240	5000	35
MR1234	250	240	5000	35
MR1235	300	240	5000	35
MR1236	350	240	5000	35
MR1237	400	240	5000	35

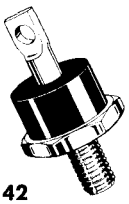
Type	$V_{RM(rep)}$ volts	Forward Current I_O amps (150°C)	Forward Current $I_{FM(surge)}$ amps (150°C)	$I_{R(AV)}$ mA (150°C)
Stud-mount with flexible braided lead (SB) or solid lug terminal (SL) Flat-mount with flexible braided lead (FB) or solid lug terminal (FL) ①				
MR1240	50	400	8000	50
MR1241	100	400	8000	50
MR1242	150	400	8000	50
MR1243	200	400	8000	50
MR1244	250	400	8000	50
MR1245	300	400	8000	50
MR1246	350	400	8000	50
MR1247	400	400	8000	50
Flat-mount with solid lug terminal (FL)①				
MR1260	50	650	12000	100
MR1261	100	650	12000	100
MR1262	150	650	12000	100
MR1263	200	650	12000	100
MR1264	250	650	12000	100
MR1265	300	650	12000	100
MR1266	350	650	12000	100
MR1267	400	650	12000	100
Bus-bar mount, water cooled				
MR1290	50	1000	18000	200
MR1291	100	1000	18000	200
MR1292	150	1000	18000	200
MR1293	200	1000	18000	200
MR1294	250	1000	18000	200
MR1295	300	1000	18000	200
MR1296	350	1000	18000	200
MR1297	400	1000	18000	200

①For desired package configuration (SB, SL, FB, FL) as well as reverse polarity (R), add the proper suffix to the part number, i.e. MR1237SBR. For complete outline dimensions and specifications see data sheets.

1N248B,C thru 1N250B,C

I_O = 20 A
V_R to 600 V

1N1191 thru 1N1198
1N1195A thru 1N1198A
1N3213 thru 1N3214



CASE 42
(DO-5)

Medium current silicon rectifiers. Unique double-case construction consists of hermetically sealed inner metallic case surrounded by molded external case; provides highest degree of ruggedness and reliability. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N248BR.

MAXIMUM RATINGS

Characteristics	Symbol	Rating	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	$V_{RM\ (rep)}$ V_R		Volts
1N248B, 1N1191		50	
1N248C		55	
1N249B, 1N1192		100	
1N249C		110	
1N1193		150	
1N250B, 1N1194		200	
1N250C		220	
1N1195, 1N1195A		300	
1N1196, 1N1196A		400	
1N1197, 1N1197A, 1N3213		500	
1N1198, 1N1198A, 1N3214		600	
RMS Reverse Voltage	V_r		Volts
1N248B, 1N1191		35	
1N248C		38.5	
1N249B, 1N1192		70	
1N249C		77	
1N1193		105	
1N250B, 1N1194		140	
1N250C		154	
1N1195, 1N1195A		210	
1N1196, 1N1196A		280	
1N1197, 1N1197A, 1N3213		350	
1N1198, 1N1198A, 1N3214		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 cps, T_C = 150°C)	I_O	20	Amps
Peak Repetitive Forward Current (T_C = 150°C)	$I_{FM\ (rep)}$	90	Amps
Peak Surge Current (T_C = 150°C, superimposed on Rated Current at Rated Voltage, 1/2-Cycle, 1/120 sec)	$I_{FM\ (surge)}$	350	Amps

1N248B,C thru 1N250B,C (continued)

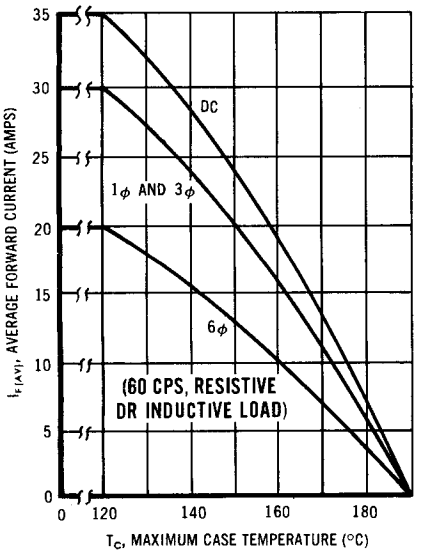
THERMAL CHARACTERISTICS

Maximum Operating and Storage Temperature: −65 to + 190°C
Maximum Thermal Impedance, Junction to Case: θ_{JC} = 1.50°C/W DC

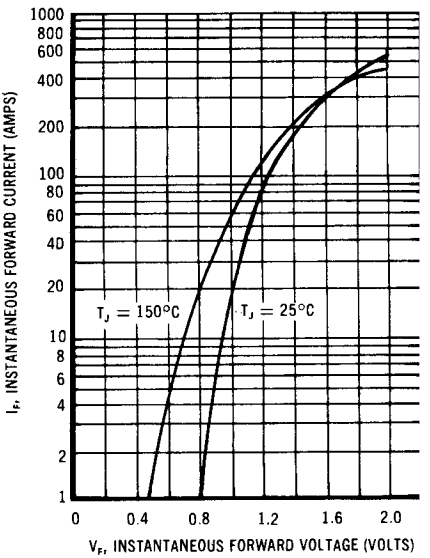
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.6	Volts
Instantaneous Forward Voltage Drop (i_F = 100 Amps, T_J = 25°C)	V_F	1.5	Volts
Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 150°C)	$I_{R(AV)}$		mA
1N248B thru 1N250B, 1N1191 thru 1N1198		5.0	
1N248C		3.8	
1N249C		3.6	
1N250C		3.4	
1N1195A		3.2	
1N1196A		2.5	
1N1197A		2.2	
1N1198A		1.5	
1N3213 and 1N3214		10.0	
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	1.0	mA

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE



TYPICAL FORWARD CHARACTERISTICS



1N1124, A thru 1N1128, A

Obsolete, discontinued types, replace with devices from the MR1030 series.

1N1183 thru 1N1190

I_O = 35 A
V_R — to 600 V



CASE 42
(DO-5)

Medium current silicon rectifiers. Unique double-case construction consists of hermetically sealed inner metallic case surrounded by molded external case; provides highest degree of ruggedness and reliability. Type numbers shown have cathode connected to case, but reverse-polarity units can be obtained by adding suffix "R" to standard type number, e.g. 1N1183R.

MAXIMUM RATINGS

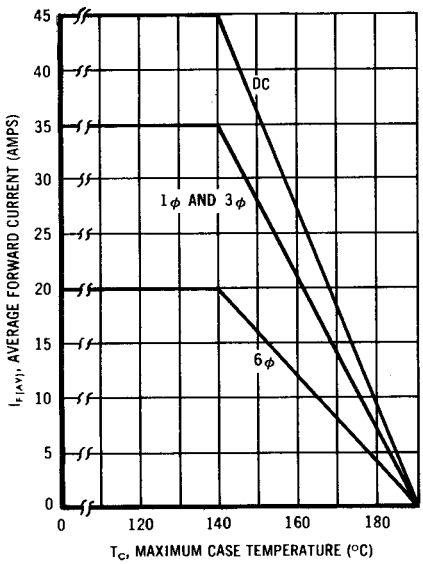
Characteristic	Symbol	Rating	Unit
Peak Repetitive Reverse Voltage and DC Blocking Voltage	$V_{RM\ (rep)}$ V_R		Volts
1N1183		50	
1N1184		100	
1N1185		150	
1N1186		200	
1N1187		300	
1N1188		400	
1N1189		500	
1N1190		600	
RMS Reverse Voltage	V_r		Volts
1N1183		35	
1N1184		70	
1N1185		105	
1N1186		140	
1N1187		210	
1N1188		280	
1N1189		350	
1N1190		420	
Average 1/2-Wave Rectified Forward Current (Resistive Load, 60 cps, T_C = 140°C)	I_O	35	Amperes
Peak Repetitive Forward Current (T_C = 140°C)	$I_{FM\ (rep)}$	150	Amperes
Peak Surge Current (T_C = 140°C, superimposed on Rated Current at Rated Voltage)	$I_{FM\ (surge)}$	400	Amperes
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190	°C
Thermal Impedance	θ_{JC}	1.0	°C/W, DC steady state

1N1183 thru 1N1190 (continued)

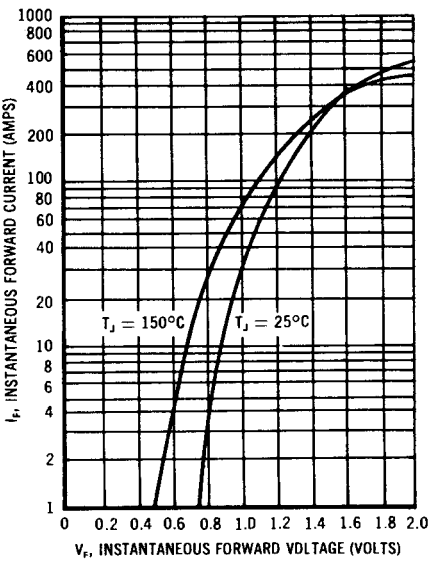
ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Rating	Unit
Max. Full Cycle Average Forward Voltage Drop ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 140°C)	$V_{F(AV)}$	0.6	Volts
Max Instantaneous Forward Voltage Drop (i_F = 100 Amps, T_J = 25°C)	V_F	1.3	Volts
Max Full Cycle Average Reverse Current ($I_{O\ (max)}$, rated V_r, 60 cps, T_C = 140°C)	$I_{R(AV)}$	10.0	mA
Max DC Reverse Current (Rated V_R, T_C = 25°)	I_R	1.0	mA

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM CASE TEMPERATURE (60 CPS, RESISTIVE OR INDUCTIVE LOAD)



TYPICAL FORWARD CHARACTERISTICS



1N1191 thru 1N1198

For Specifications, See 1N248B Data Sheet

1N1563, A thru 1N1568, A

I_O = 1.5 A
V_R — to 600 V



CASE 55

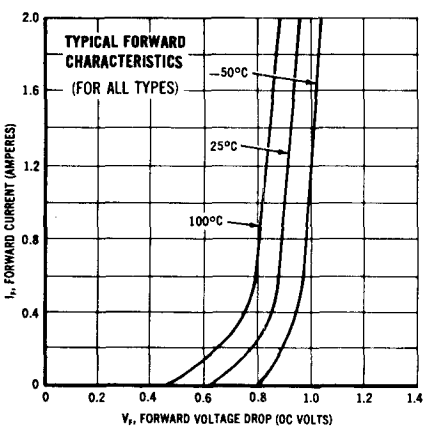
Low-current silicon rectifiers in hermetically sealed, low-silhouette single-ended package designed to operate under military environmental conditions. Cathode connected to case, but reverse polarity devices are available on special order.

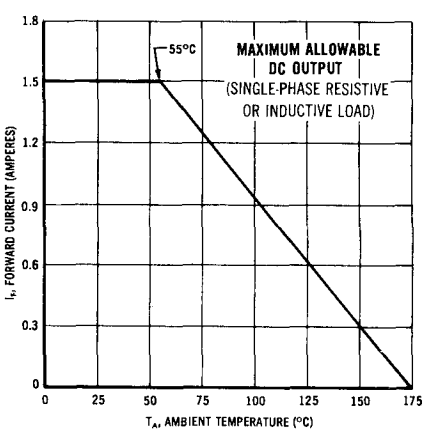
MAXIMUM RATINGS (At 60 cps Sinusoidal Input, Resistive or Inductive Load)

Rating	Symbol	1N1563A 1N1563	1N1564A 1N1564	1N1565A 1N1565	1N1566A 1N1566	1N1567A 1N1567	1N1568A 1N1568	Unit
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	100	200	300	400	500	600	Volts
RMS Reverse Voltage	V_r	70	140	210	280	350	420	Volts
Average Half-Wave Rectified Forward Current (55°C Ambient) (150°C Ambient)	I_O	1500 300	1500 300	1500 300	1500 300	1500 300	1500 300	mA mA
Peak Surge Current (I/2 Cycle Surge, 60 cps)	$I_{FM(surge)}$	70	70	70	70	70	70	Amps
Peak Repetitive Forward Current	$I_{FM(rep)}$	10	10	10	10	10	10	Amps
Operating and Storage Temperature Range	T_J T_{stg}	-65 to +175						°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N1563A 1N1568A Rating	1N1563– 1N1568 Rating	Unit
Maximum Forward Voltage Drop @ 500 mA, Continuous DC (25°C) (150°C)	V_F	1.2 0.9	1.2 1.0	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C)	I_R	1.5		μA
Maximum Full-Cycle Average Reverse Current (25°C) @ Max Rated PIV and Current (as Half-Wave (150°C) Rectifier, Resistive Load	$I_{R(AV)}$	3.0 150	5.0 500	μA





1N2609 thru 1N2617

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N3189 thru 1N3191

Obsolete, discontinued types, replace with devices from the 1N4001 series.

1N3208 thru 1N3212

I_O = 15 A
V_R — to 400 V



CASE 42
DO-5

Medium-current silicon rectifiers. Cathode connected to case, but reverse polarity (anode-to-case connection) also available by adding suffix "R" to type number, e.g. 1N3208R. Supplied with mounting hardware.

MAXIMUM RATINGS

Rating	Symbol	1N3208 1N3208R	1N3209 1N3209R	1N3210 1N3210R	1N3211 1N3211R	1N3212 1N3212R	Unit
D-C Blocking Voltage	V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current With Resistive Load	I_O*	15	15	15	15	15	Amps
Peak One Cycle Surge Current (60 cps & 25°C Case Temp)	$I_{FM(surge)}$	250	250	250	250	250	Amps
Operating Junction Temperature	T_J	-65 to + 175					°C
Storage Temperature	T_{stg}	-65 to + 175					°C

*T_C = 150°C

ELECTRICAL CHARACTERISTICS (All Types) at 25°C Case Temp.

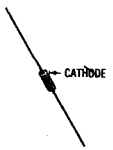
Characteristic	Symbol		
Maximum Forward Voltage at 40 Amp D-C Forward Current	V_F	1.5	Volts
Maximum Reverse Current at Rated D-C Reverse Voltage	I_R	1.0	mAdc
Typical Thermal Resistance, Junction To Case	θ_{JC}	1.7	C/W

1N3213, 1N3214

For Specifications, See **1N248B** Data Sheet

1N3282 thru 1N3286

I_O = 100 mA
V_R — to 3000 V



CASE 51
(DO-7)

Low-current silicon rectifiers for applications requiring extremely high reverse-voltage capability. Hermetically sealed, subminiature glass package, offering excellent stability and reliability under environmental extremes.

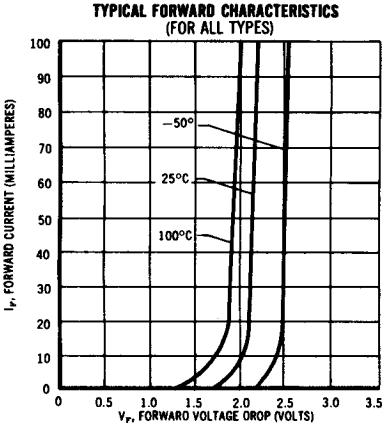
MAXIMUM RATINGS (At 60 cps Sinusoidal Input, Resistive or Inductive Load)

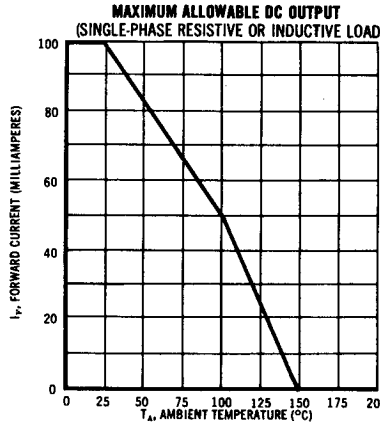
Rating	Symbol	1N3282	1N3283	1N3284	1N3285	1N3286	Unit
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	1000	1500	2000	2500	3000	Volts
RMS Reverse Voltage	V_r	700	1050	1400	1750	2100	Volts
Average Half-Wave Rectified Forward Current (25°C Ambient) (100°C Ambient)	I_O	 100 50	 100 50	 100 50	 100 50	 100 50	 mA mA
Peak Surge Current (1/2-cycle, 60 cps)	$I_{FM(surge)}$	2.5	2.5	2.5	2.5	2.5	Amps
Peak Repetitive Forward Current	$I_{FM(rep)}$	0.50	0.50	0.50	0.50	0.50	Amps
Operating and Storage Temperature Range	T_j, T_{stg}	-65 to + 150					°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Maximum Forward Voltage Drop @ 100 mA, Continuous DC (25°C)	V_F	2.5	Volts
Maximum Full-Cycle Average Forward Voltage Drop @ Rated Current (100°C)	$V_{F(AV)}$	1.2	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C) (100°C)	I_R	1.0 10.0	μA
Maximum Full-Cycle Average Reverse Current @ Max Rated PIV and Current (as Half-Wave Rectifier, Resistive Load, 100°C)	$I_{R(AV)}$	10.0	μA
Typical Thermal Resistance, Junction to Air Ambient	θ_{JA}	400	°C/W

1N3282 thru 1N3286 (continued)





1N3491 thru 1N3495

FORMERLY

MR322 thru MR326

I_O = 25 A
V_R — to 400 V



CASE 43

Low-cost, medium-current, silicon rectifiers in hermetically sealed, press-fit case. Designed for industrial and commercial applications requiring operation under severe environmental conditions. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

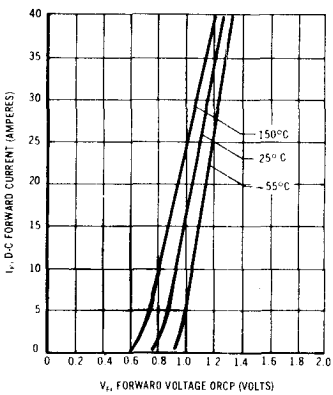
Rating	Symbol	1N3491 MR322	1N3492 MR323	1N3493 MR324	1N3494 MR325	1N3495 MR326	Unit
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current With Resistive Load 100°C 150°C	I_O	 25 18	 25 18	 25 18	 25 18	 25 18	Amps
Peak Repetitive Forward Current (60 cps & 25°C Case Temp.)	$I_{FM(rep)}$	75	75	75	75	75	Amps
Peak One Cycle Surge Current (60 cps & 25°C Case Temp.)	$I_{FM(surge)}$	300	300	300	300	300	Amps
Operating Junction Temperature	T_J	-65 to +175					°C
Storage Temperature	T_{stg}	-65 to +175					°C

1N3491 thru 1N3495 (continued)

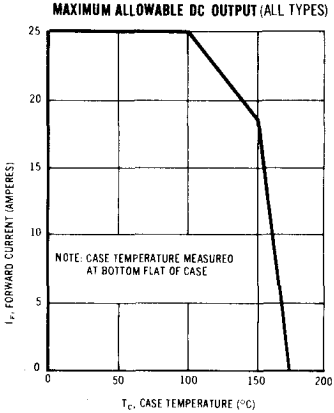
ELECTRICAL CHARACTERISTICS (At 25°C case temperature unless otherwise specified)

Characteristic	Symbol	1N3491 MR322	1N3492 MR323	1N3493 MR324	1N3494 MR325	1N3495 MR326	Unit
Maximum Forward Voltage at 100 Amp DC Forward	V_F	1.5	1.5	1.5	1.5	1.5	Volts
Maximum Full-Cycle Average Forward Voltage Drop @ Rated Current and Voltage	$V_{F(AV)}$	0.7	0.7	0.7	0.7	0.7	Volts
Maximum Reverse Current at Rated DC Reverse Voltage	I_R	1.0	1.0	1.0	1.0	1.0	mAdc
Maximum Full-Cycle Average Reverse Current at Rated Current and Voltage (as Half-Wave Rectifier, Resistive Load, 150°C Case)	$I_{R(AV)}$	10	10	8	6	4	mAdc
Thermal Resistance	θ_{JC}	1					°C/W

TYPICAL FWD CHARACTERISTICS (ALL TYPES)



MAXIMUM ALLOWABLE DC OUTPUT (ALL TYPES)

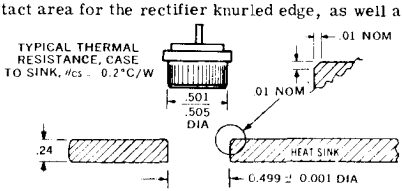


MR322-MR326 and 1N3491-1N3495 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

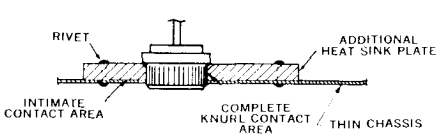
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat skin surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier- heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.



HEAT SINK MOUNTING

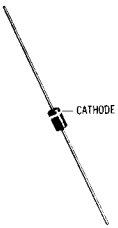


THIN-CHASSIS MOUNTING

USN 1N3611 thru USN 1N3613

I_O = 1 A
V_R — to 600 V

CASE 59



Subminiature silicon rectifier with glass passivated surface in void-free, flame-proof, silicone polymer case. Tested in accordance with MIL-S-19500/228 for military applications requiring up to 1 ampere output at 100°C.

MAXIMUM RATINGS

(At 60 cps Sinusoidal Input, Resistive or Inductive Load)

Characteristic	Symbol	USN 1N3611	USN 1N3612	USN 1N3613	Unit
Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(wkg)}$ V_R	200	400	600	Volts
Peak Repetitive Reverse Voltage	$V_{RM(rep)}$	240	480	720	Volts
Average Rectified Forward Current T_A = 100°C T_A = 150°C	I_O	← 1.0 → ← 0.3 →			Adc
Non-Repetitive Peak Surge Current (1/2 cycle, 60 cps)	$I_{FM(surge)}$	← 10 →			Amps
Operating and Storage Temperature Range	T_A, T_{stg}	← -65 to +175 →			°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Minimum	Maximum	Unit
Forward Voltage (I_F = 1.0 Adc, T_A = 100°C)	V_F	0.6	1.2	Vdc
Reverse Current (V_R = 200 Vdc) USN 1N3611 (V_R = 400 Vdc) USN 1N3612 (V_R = 600 Vdc) USN 1N3613	I_R	— — —	5 5 5	μAdc
Reverse Current at Rated $V_{RM(rep)}$ ($V_{RM(rep)}$ = 240 Vdc) USN 1N3611 ($V_{RM(rep)}$ = 480 Vdc) USN 1N3612 ($V_{RM(rep)}$ = 720 Vdc) USN 1N3613	I_R	— — —	100 100 100	μAdc
High Temperature Operation: Reverse Current @ T_A = 150°C (V_R = 200 Vdc) USN 1N3611 (V_R = 400 Vdc) USN 1N3612 (V_R = 600 Vdc) USN 1N3613	I_R	— — —	300 300 300	μAdc

1N3649 thru 1N3650

Obsolete, discontinued types, replace with devices from the 1N4719 series.

1N3659 thru 1N3663

$I_O = 30$ A
V_R — 400 V



CASE 43

Low-cost silicon rectifiers in hermetically sealed, press-fit case, designed for operation under severe environmental conditions. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

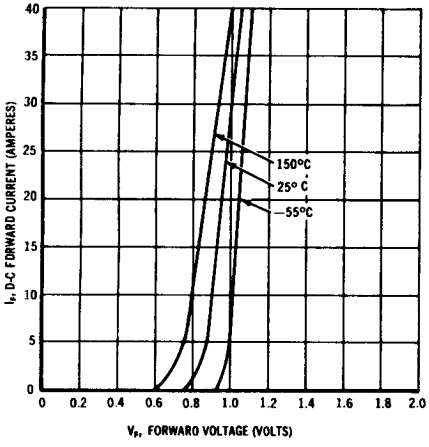
MAXIMUM RATINGS at 25°C Case Temp. Unless Otherwise Indicated

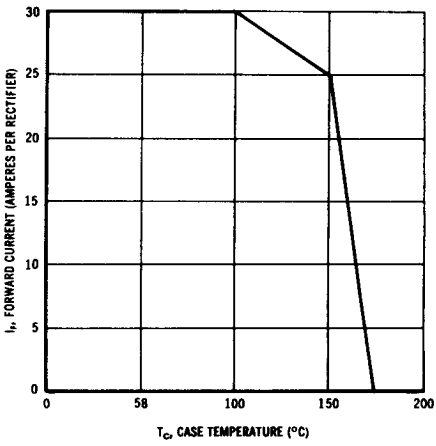
Rating	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Units
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	50	100	200	300	400	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
Average Half-Wave Rectified Forward Current with Resistive Load @ 100°C case @ 150°C case	I_O	 30 25	 30 25	 30 25	 30 25	 30 25	 Amps Amps
Peak One Cycle Surge Current (150°C case temp, 60 cps)	$I_{FM(surge)}$	400	400	400	400	400	Amps
Operating Junction Temperature	T_J		−65 to +175				°C
Storage Temperature	T_{stg}		−65 to +200				°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	1N3659 1N3659R	1N3660 1N3660R	1N3661 1N3661R	1N3662 1N3662R	1N3663 1N3663R	Unit
Maximum Forward Voltage at 25 Amp DC Forward Current	V_F	1.2	1.2	1.2	1.2	I.2	Volts
Maximum Full Cycle Average Forward Voltage Drop @ Rated PIV and Current	$V_{F(AV)}$	0.7	0.7	0.7	0.7	0.7	Volts
Maximum Full Cycle Average Reverse Current @ Rated PIV and Current (as half-wave rectifier, resistive load, 150°C)	$I_{R(AV)}$	5.0	4.5	4.0	3.5	3.0	mA
Thermal Resistance	θ_{JC}			1			C/W

1N3659 thru 1N3663 (continued)



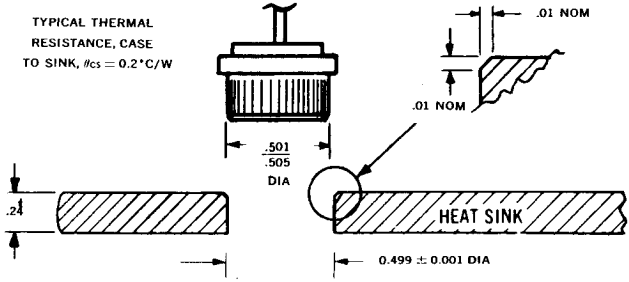


1N3659-1N3663 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

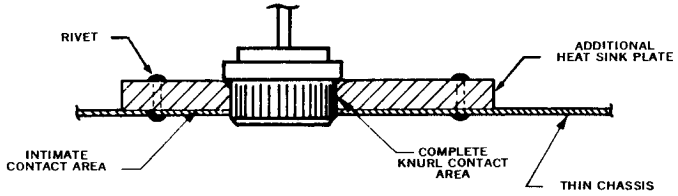
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat skin surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier- heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.



HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

1N3879 thru 1N3883
6 AMPERES

1N3889 thru 1N3893
12 AMPERES

I_O = 6 and 12 A
V_R — to 400 V



CASE 56A
(DO-4)

Fast recovery silicon power rectifiers designed for high-frequency power supply, inverter, and converter applications. Typical recovery time of 100 nsec extends practical frequency limit of current rectification to more than 300,000 cps thus permitting the design of power supplies with smaller, lighter, and less expensive associated components. Cathode connected to case, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	1N3879 1N3889	1N3880 1N3890	1N3881 1N3891	1N3882 1N3892	1N3883 1N3893	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts

Rating	Symbol	1N3879 thru 1N3883	1N3889 thru 1N3893	Unit
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 100°C)	I_O	6	12	Amperes
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_C = 100°C)	$I_{FM(surge)}$	75	150	Amperes
I^2t Rating (non-repetitive, for t greater than 1 msec and less than 8.3 msec)	I^2t	15	50	$A_{(rms)}^2$ sec

THERMAL CHARACTERISTICS

Characteristic		Symbol	Max Limit	Unit
Maximum Junction Operating Temperature Range Maximum Case Storage Temperature Range		T_J T_{stg}	-65 to +150 -65 to +175	°C
Maximum Steady State DC Thermal Resistance	1N3879-83 1N3889-93	θ_{JC}	5.0 2.5	°C/Watt

1N3879 thru 1N3893 (continued)

ELECTRICAL CHARACTERISTICS

1N3879 thru 1N3883

Characteristic	Symbol	Max Limit	Unit
DC Forward Voltage Drop (I_F = 6.0 Adc, T_C = 25°C)	V_F	1.4	Vdc
Full Cycle Average Reverse Current (I_O = 6.0 Amps and Rated V_r, 60 cps T_C = 100°C, single phase)	$I_{R(AV)}$	3.0	mA
DC Reverse Current (Rated V_R, T_C = 100°C)	I_R	1.0	mA

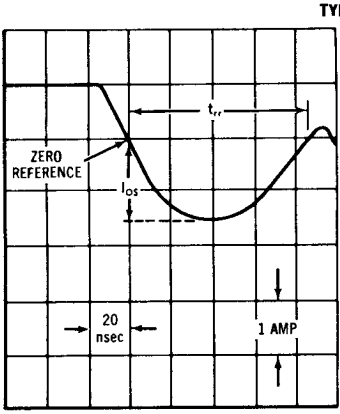
1N3889 thru 1N3893

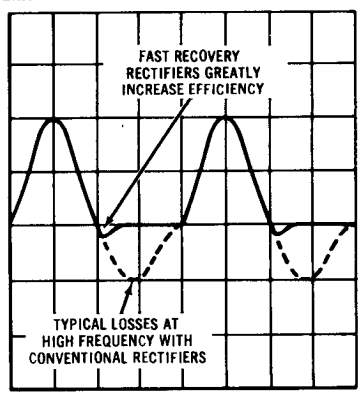
Characteristic	Symbol	Max Limit	Unit
DC Forward Voltage Drop (I_F = 12.0 Adc, T_C = 25°C)	V_F	1.4	Vdc
Full Cycle Average Reverse Current (I_O = 12.0 Amps and Rated V_r, 60 cps T_C = 100°C, single phase)	$I_{R(AV)}$	5.0	mA
DC Reverse Current (Rated V_R, T_C = 100°C)	I_R	3.0	mA

REVERSE RECOVERY TIME CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
Maximum Reverse Recovery Time (I_F = 1 Amp min, see test circuit)	t_{rr}	200	nsec
Maximum Overshoot Current (see test circuit)	I_{os}	2.0	Amps

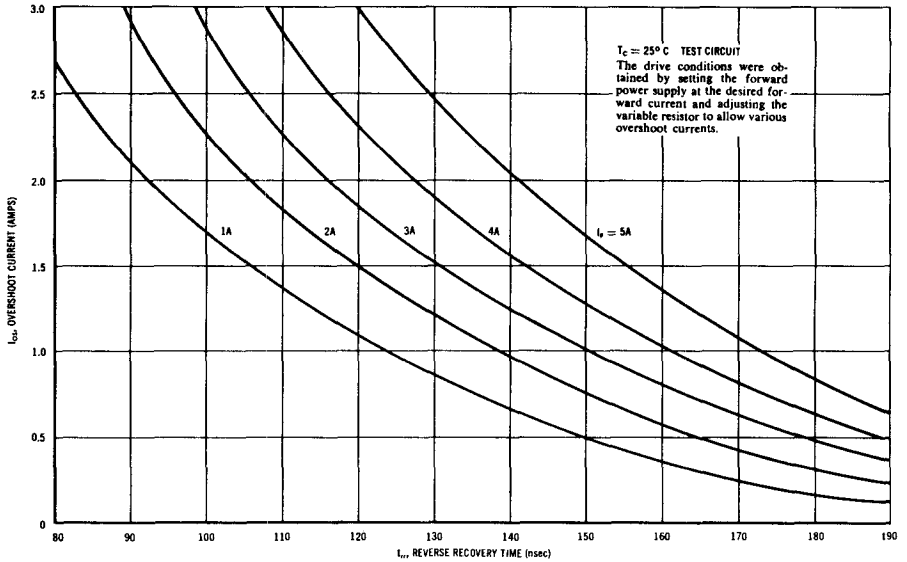
TYPICAL RECOVERY PATTERN



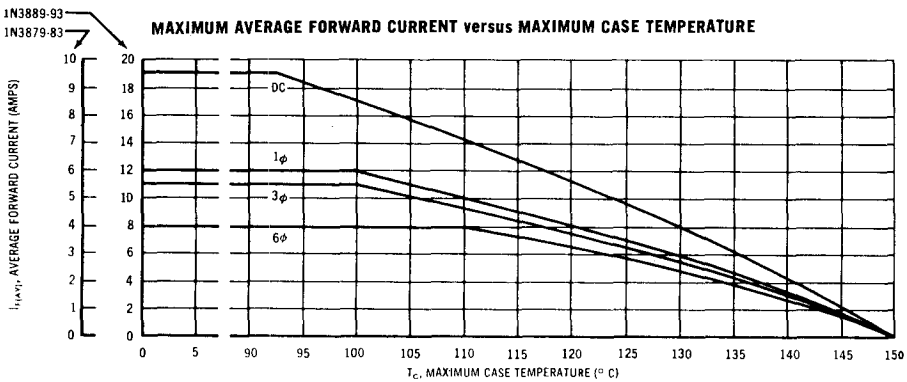


1N3879 thru 1N3893 (continued)

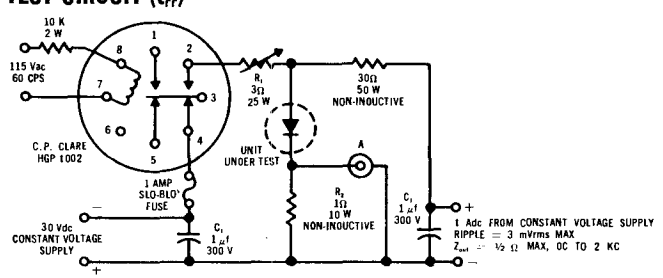
TYPICAL REVERSE RECOVERY TIME-ALL TYPES



MAXIMUM AVERAGE FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM REVERSE RECOVERY TIME TEST CIRCUIT (t_{rr})



A — Tektronix 545A, K Plug-in Pre-Amp, P6000 Probe of Eq.

R_1 — Adjusted for 1.4Ω between point 2 of relay and rectifier. Inductance ≈ 3 μh.

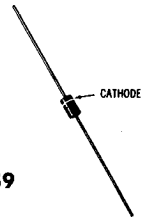
R_2 — Ten 1 W, 10Ω, 1% carbon comp. in parallel.

Tc = 25^{+10}_{-0} °C for rectifiers.

Minimize all lead lengths.

1N4001 thru 1N4007

$I_O = 1$ A
V_R — to 1000 V



CASE 59

Low-current, passivated silicon rectifiers in subminiature void-free, flame-proof silicone polymer case. Designed to operate under military environmental conditions.

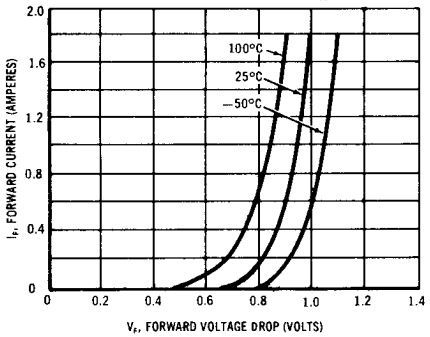
MAXIMUM RATINGS (At 60 cps Sinusoidal, Input, Resistive or Inductive Load)

Rating	Symbol	1N4001	1N4002	1N4003	1N4004	1N4005	1N4006	1N4007	Unit
Peak Repetitive Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ V_R	50	100	200	400	600	800	1000	Volts
RMS Reverse Voltage	V_r	35	70	140	280	420	560	700	Volts
Average Half-Wave Rectified Forward Current (75°C Ambient) (100°C Ambient)	I_O	1000 750	1000 750	1000 750	1000 750	1000 750	1000 750	1000 750	mA mA
Peak Surge Current 25°C (1/2 Cycle Surge, 60 cps) Peak Repetitive Forward Current	$I_{FM(surge)}$ $I_{FM(rep)}$	30 10	30 10	30 10	30 10	30 10	30 10	30 10	Amps Amps
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to + 175							°C

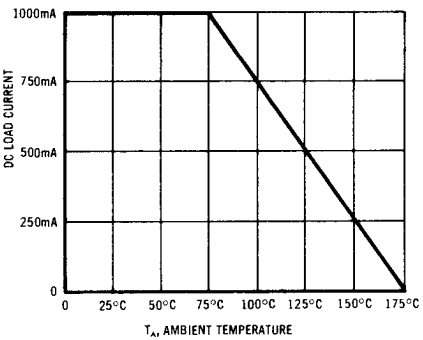
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C)	V_F	1.1	Volts
Maximum Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C)	$V_{F(AV)}$	0.8	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C) (100°C)	I_R	0.01 0.05	mA
Maximum Full-Cycle Average Reverse Current (Max Rated PIV and Current, as Half-Wave Rectifier, Resistive Load, 100°C)	$I_{R(AV)}$	0.03	mA

TYPICAL FORWARD CHARACTERISTICS

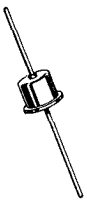


MAXIMUM DC OUTPUT



1N4719 thru 1N4725
1N4997 thru 1N5003
MR1030 thru MR1036, MR1038, MR1040

$I_O = 3$ A
V_R — to 1000 V



CASE 60
1N4719 THRU 1N4725
MR1030A THRU MR1040A



CASE 70
1N4997 thru 1N5003
MR1030B THRU MR1040B

Silicon high-conductance rectifiers available in either axial-lead or single-ended packages. Type numbers shown have cathode connected to case. For anode-to-case connection, add suffix "R" to type number, i. e. 1N4702R

MAXIMUM RATINGS (Both Package Types) $T_A = 25°C$ unless otherwise noted

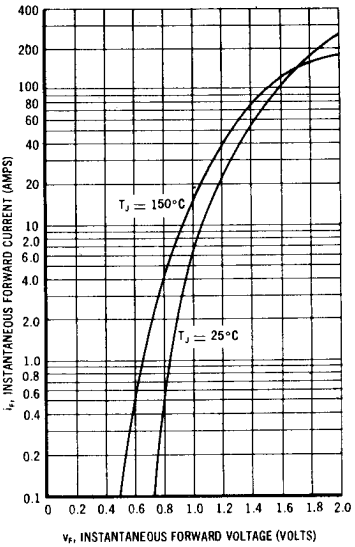
Rating	Symbol	1N4719 MR1030	1N4720 MR1031	1N4721 MR1032	MR1033	1N4722 MR1034	MR1035	1N4723 MR1036	1N4724 MR1038	1N4725 MR1040	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RM} (rep) V_{RM} (wkg) V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RM} (non-rep)	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_A = 75°C) see figure 4	I_O	← 3.0 →									Amps
Peak Repetitive Forward Current (T_A = 75°C)	I_{FM} (rep)	← 25 →									Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C) see figure 1	I_{FM}(surge)	← 300 (for 1/2 cycle) →									Amps
I^2t Rating (non-repetitive, 1 msec <t <8.3 msec)	I^2t	← 185 →									$A_{(rms)}{}^2$sec
Operating and Case Temperature	T_J, Tstg	-65 to + 175									°C
Thermal Resistance	θ_{JA}	30									°C/Watt

1N4719 thru 1N4725 (Continued)

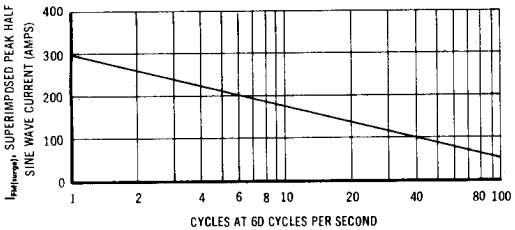
ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max Limit	Unit
Full Cycle Average Forward Voltage Drop (I_O = 3.0 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.45	Volts
DC Forward Voltage Drop (I_F = 3.0 Adc, T_A = 25°C)	V_F	0.9	Volts
Full Cycle Average Reverse Current (I_O = 3.0 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.5	mA

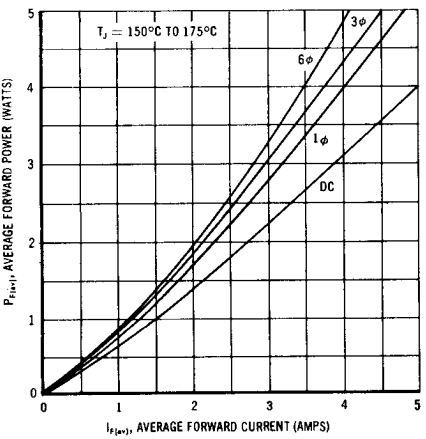
FORWARD VOLTAGE CHARACTERISTICS



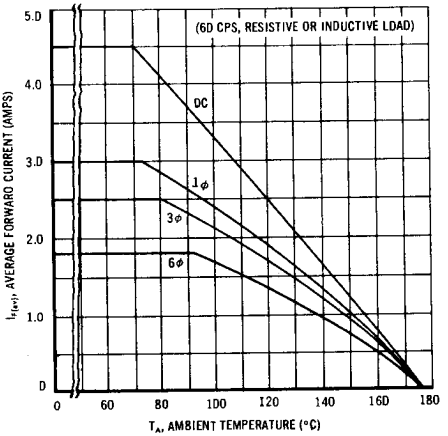
MAXIMUM SURGE CURRENT T_A = 75°C)



MAXIMUM FORWARD POWER DISSIPATION versus AVERAGE FORWARD CURRENT



MAXIMUM FORWARD CURRENT versus AMBIENT TEMPERATURE

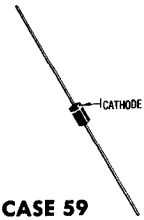


MR322 thru MR326

For Specifications, See 1N3491 Data Sheet

MR990 thru MR994

I_O = 250 mA
V_R to 3000 V



CASE 59

High-voltage, low-current, rectifiers designed for applications where high voltages in subminiature packages are required. These devices feature efficient high-temperature current-handling performance, high surge-current capabilities and surface passivation.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Rating	Symbol	MR990	MR991	MR992	MR993	MR994	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	1000	1500	2000	2500	3000	Volts
RMS Reverse Voltage	V_r	700	1050	1400	1750	2100	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_A = 75°C)	I_O	250					mA
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	2.0					Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 75°C)	$I_{FM(surge)}$	20 (for 1/2 cycle)					Amps
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +150					°C

THERMAL CHARACTERISTICS

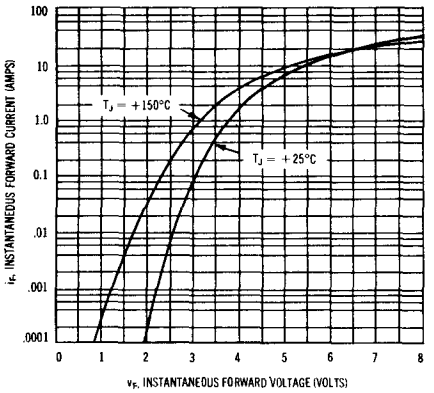
Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX (1 inch lead length)

ELECTRICAL CHARACTERISTICS (At 60 cps Sinusoidal, Resistive or Inductive)

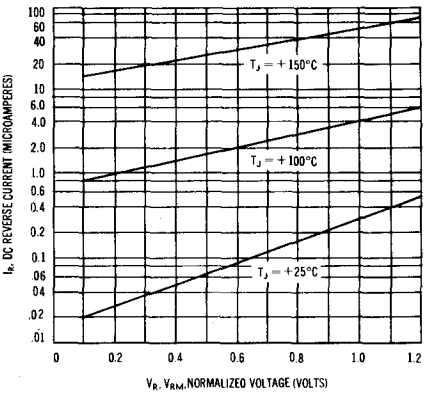
Characteristics	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (I_O = 0.25 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	1.7	Volts
DC Forward Voltage Drop (I_F = 0.25 Adc, T_A = 25°C)	V_F	3.5	Volts
Full Cycle Average Reverse Current (I_O = 0.25 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$I_{R(AV)}$	100	μA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	10	μA

MR990 thru MR994 (continued)

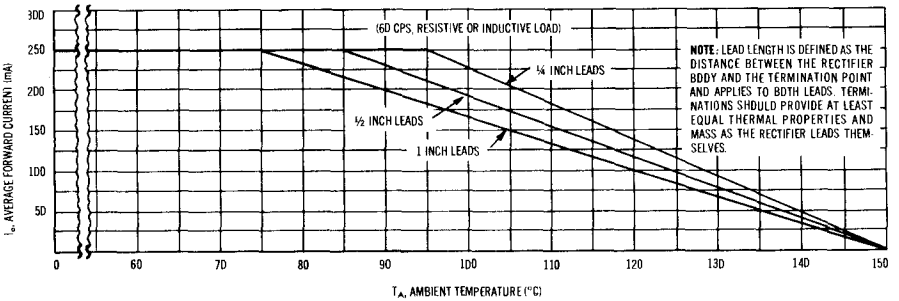
TYPICAL FORWARD CHARACTERISTICS



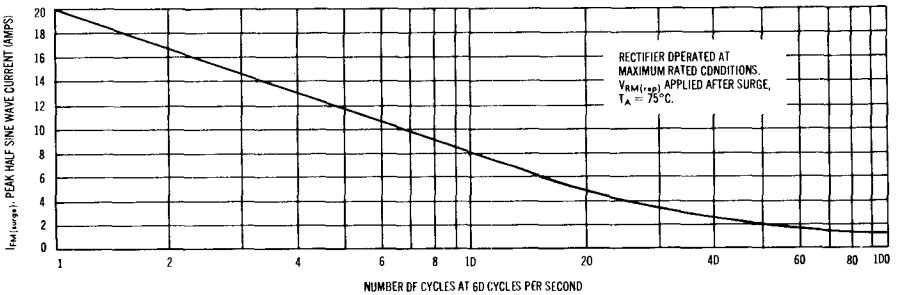
TYPICAL REVERSE CHARACTERISTICS



CURRENT DERATING



MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT



MR1030 thru MR1036
MR1038, MR1040

For Specifications, See 1N4719 Data Sheet.

MR1120 thru MR1126
MR1128
MR1130

$I_O = 12$ A
V_R — to 1000V



CASE 56A
(DO-4)

Medium-current silicon rectifiers feature high surge current capacity, and low forward voltage drop. Devices have cathode to case polarity, but reverse polarity units may be obtained by adding the suffix "R" to the device number i.e. MR1130R.

MAXIMUM RATINGS

Rating	Symbol	MR 1120	MR 1121	MR 1122	MR 1123	MR 1124	MR 1125	MR 1126	MR 1128	MR 1130	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	V_{RM} (rep) V_{RM} (wkg) V_R	50	100	200	300	400	500	600	800	1000	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	V_{RM} (non-rep)	100	200	300	400	500	600	720	1000	1200	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	350	420	560	700	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_O	← 12.0 →									Amps
Peak Repetitive Forward Current (T_C = 150°C)	$I_{FM(rep)}$	← 75 →									Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	← 300 (for 1/2 cycle) →									Amps
I^2t Rating (non-repetitive, 1 msec < t < 8.3 msec)	I^2t	← 375 →									$A(rms)^2sec$
Maximum Junction Operating and Storage Temperature Range	T_J, T_{stg}	← -65 to +190 →									°C

ELECTRICAL CHARACTERISTICS (All Types)

Characteristic	Symbol	Max Limit	Unit
Full Cycle Average Forward Voltage Drop (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
DC Forward Voltage Drop (I_F = 12.0 Adc, T_C = 25°C)	V_F	1.0	Volts
Full Cycle Average Reverse Current (I_O = 12.0 Amps and Rated V_r, T_C = 150°C, Half Wave Rectifier)	$I_{R(AV)}$	1.5	mA
DC Reverse Current (Rated V_R, T_C = 25°C)	I_R	0.5	mA

MR1120 thru MR1126, MR1128, MR1130 (continued)

THERMAL CHARACTERISTICS

Maximum Steady State DC Thermal Resistance, θ_{JC}: 2.5°C/Watt

MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.

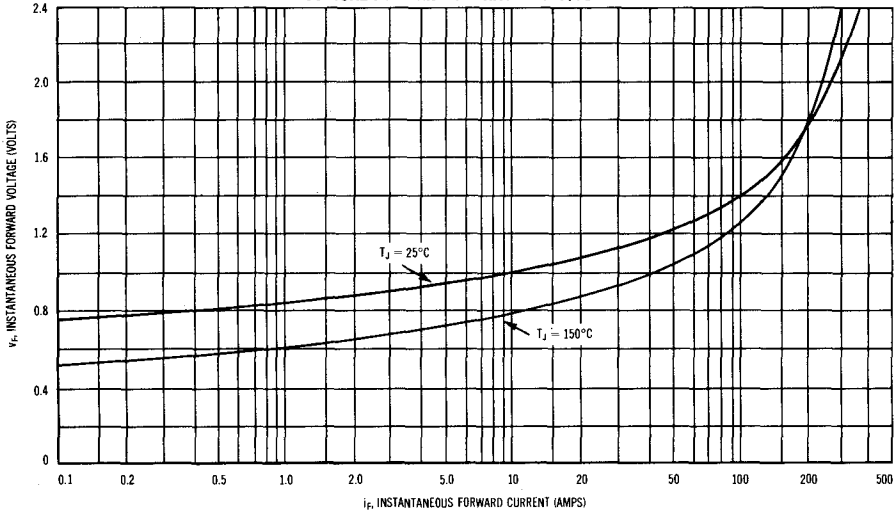
FINISH: All external surfaces corrosion-resistant and the terminal lug is readily solderable.

POLARITY: CATHODE TO CASE (reverse polarity units are available upon request and are designated by an "R" suffix i. e. MR1120R).

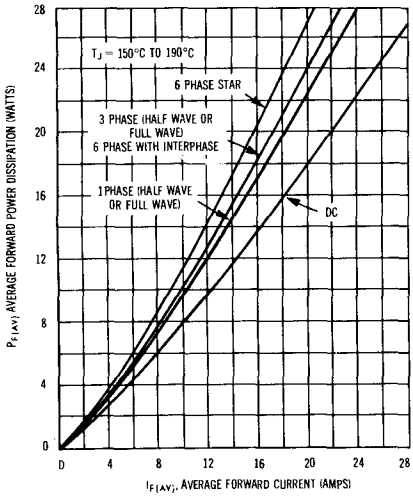
MOUNTING POSITIONS: Any

STUD TORQUE: 15 in-lbs maximum.

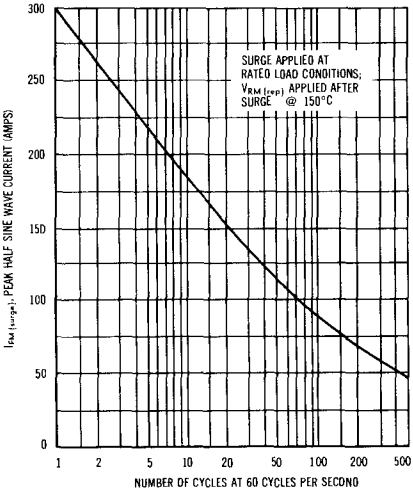
TYPICAL FORWARD CHARACTERISTICS



FORWARD POWER DISSIPATION

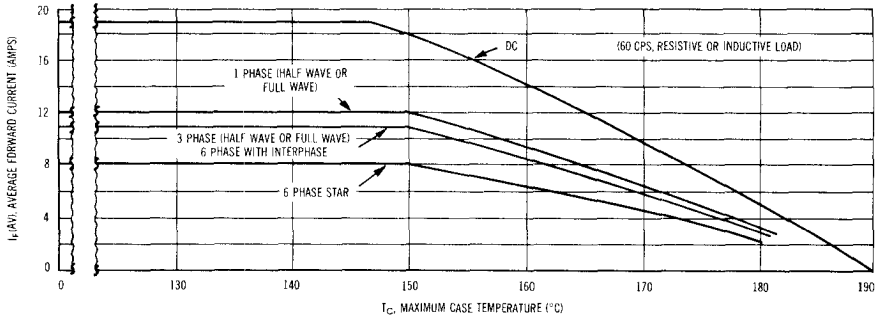


MAXIMUM ALLOWABLE SURGE CURRENT

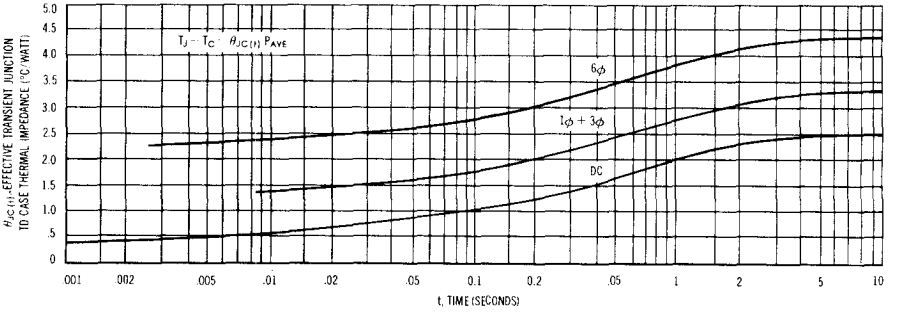


MR1120 thru MR1126, MR1128, MR1130 (continued)

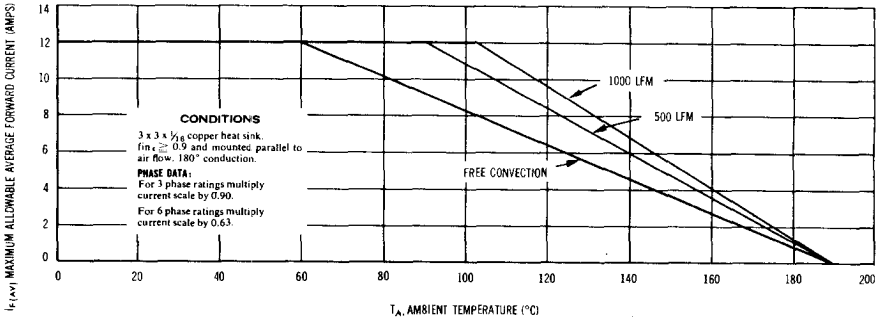
MAXIMUM CURRENT RATINGS



EFFECTIVE TRANSIENT THERMAL IMPEDANCE



CURRENT DERATING DATA



MR1120 thru MR1126, MR1128, MR1130 (continued)

RECTIFIER SUBSTITUTION GUIDE

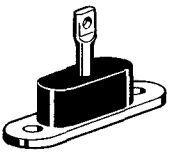
Due to its optimized design, this 12-ampere rectifier series (types MR1120 - MR1130) provides a high performance, economical solution to your specification and procurement requirements. Only nine types, covering the complete voltage range from 50 to 1000 volts, can substitute for a multitude of devices as typified in the table below. This table is only a guide and general reference to the EIA registered types which can be replaced; minor specification variations may exist.

MR1120 50V	MR1121 100V	MR1122 200V	MR1123 300V	MR1124 400V	MR1125 500V	MR1126 600V	MR1128 800V	MR1130 1000V
1N607	1N253	1N254	1N334	1N255	1N554	1N256	1N562	1N563
1N607A	1N338	1N336	1N335	1N332	1N613	1N555	1N3649	1N3650
1N1199	1N339	1N337	1N343	1N333	1N613A	1N614	1N3670	1N3672
1N1199A	1N340	1N345	1N344	1N341	1N1119	1N614A	1N3670A	1N3672A
1N1341	1N348	1N346	1N552	1N342	1N1127	1N1120	1N3671	1N3673
1N1341A	1N349	1N551	1N611	1N553	1N1127A	1N1128	1N3671A	1N3673A
1N1537	1N550	1N609	1N611A	1N612	1N1205	1N1128A	1N3987	1N3989
1N1612	1N608	1N609A	1N1117	1N612A	1N1205A	1N1206	1N3988	1N3990
	1N608A	1N610	1N1125	1N1118	1N1347	1N1206A		
	1N1115	1N610A	1N1125A	1N1126	1N1347A	1N1348		
	1N1200	1N1116	1N1203	1N1126A	1N1543	1N1348A		
	1N1200A	1N1124	1N1203A	1N1204	1N3573	1N1544		
	1N1342	1N1124A	1N1345A	1N1204A		1N1616		
	1N1342A	1N1201	1N1541	1N1346		1N3574		
	1N1538	1N1201A	1N3571	1N1346A				
	1N1613	1N1202		1N1542				
	1N3569	1N1202A		1N1615				
		1N1343		1N3572				
		1N1343A						
		1N1344						
		1N1344A						
		1N1539						
		1N1540						
		1N1614						
		1N3570						

NOTE: While the MR1120 through MR1130 are preferred device types, the above listed EIA types are also available upon request.

MR1200 thru MR1209

I_O = 50 A
V_R = to 600 V



CASE 100

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1200	MR 1201	MR 1202	MR 1203	MR 1205	MR 1207	MR 1208	MR 1209	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, see Figure 3) T_C = 150°C	I_O	50								Amperes
Non-Repetitive Peak Surge Current (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	800 (for 1/2 cycle) 500 (for six consecutive cycles)								Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	1,300								$A_{(rms)}{}^2sec$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	10	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.60	°C/Watt

MR1200 thru MR1209 (continued)

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATION:

MR1200FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE TO CASE.
Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1205FLR.

MOUNTING POSITION: Any.

MOUNTING BOLT TORQUES:

For Flat Mounted "FL" rectifiers use 8-32 bolts torqued to 30 in-lbs min., 40 in-lbs max. Use an alternating procedure when torquing the two bolts and do not tighten one bolt completely without tightening the other.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

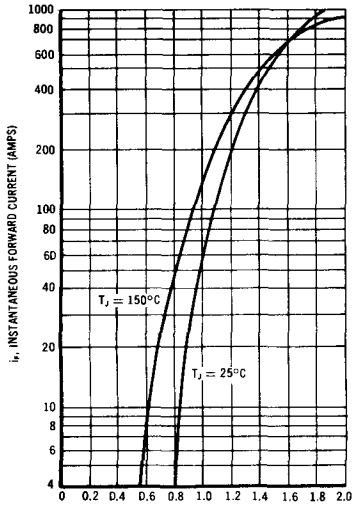


FIGURE 2 — FORWARD POWER DISSIPATION

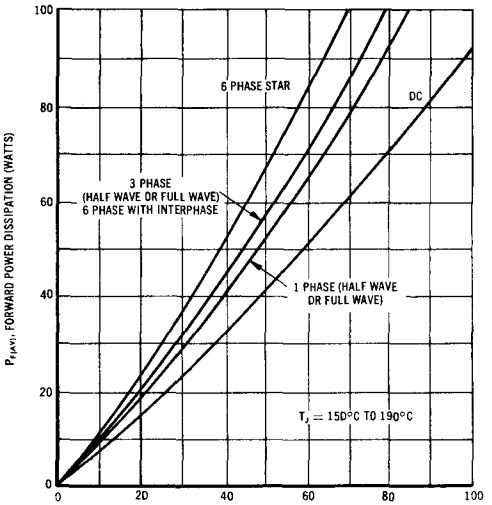
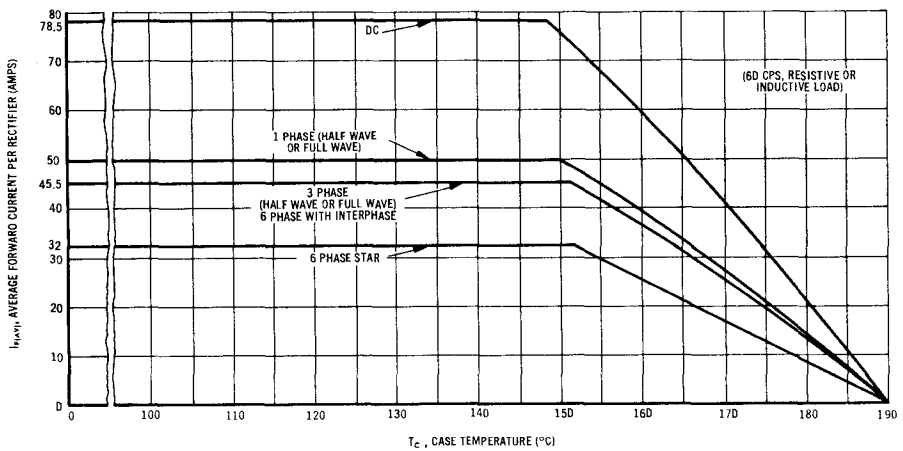


FIGURE 3 — MAXIMUM CURRENT RATINGS



MR1200 thru MR1209 (continued)

FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

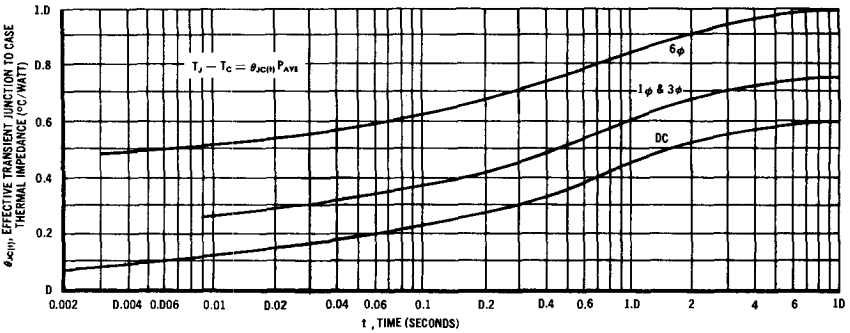


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

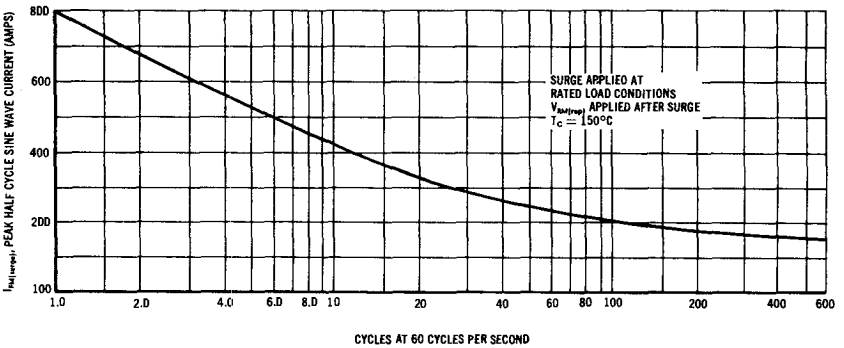
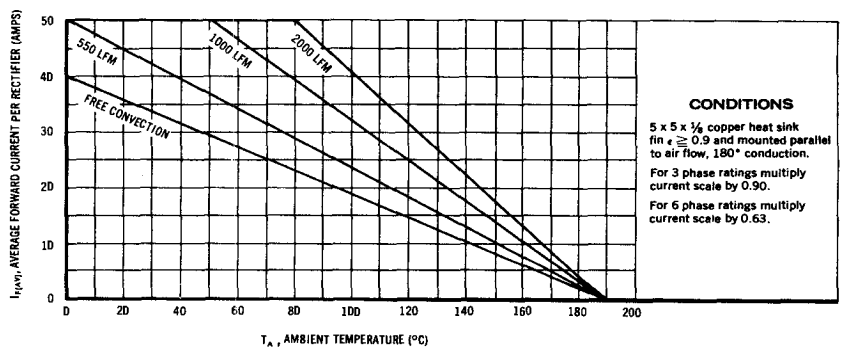


FIGURE 6 — CURRENT DERATING DATA



MR 1210 thru MR 1219

I_O = 100 A
V_R — to 600 V



SL CASE 101



SB CASE 102

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in two package styles having identical ratings and characteristics. Desired package can be selected by adding suffix "SB" or "SL" to type number.

MAXIMUM RATINGS (All Package Types)

Rating	Symbol	MR 1210	MR 1211	MR 1212	MR 1213	MR 1215	MR 1217	MR 1216	MR 1219	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, see Figure 3) T_C = 135°C T_C = 150°C	I_O	← 100 → ← 80 →								Amperes
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	← 2,000 (for 1/2 cycle) → ← 1,200 (for six consecutive cycles) →								Amperes
I^2t Rating (non-repetittve, for t greater than 1 ms and less than 8.3 ms)	I^2t	← 8,300 →								$A_{(rms)}{}^2$sec
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	← -65 to +190 →								°C

ELECTRICAL CHARACTERISTICS (All Package Types)

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	15	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.40	°C/Watt

MR1210 thru MR1219 (continued)

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1210SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1210SL rectifiers are designed for stud mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE TO CASE. Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1215SLR.

MOUNTING POSITION: Any.

STUD MOUNTING TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 25 in-lbs min., 30 in-lbs max.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

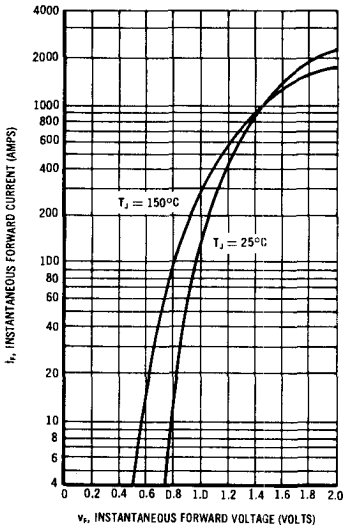


FIGURE 2 — FORWARD POWER DISSIPATION

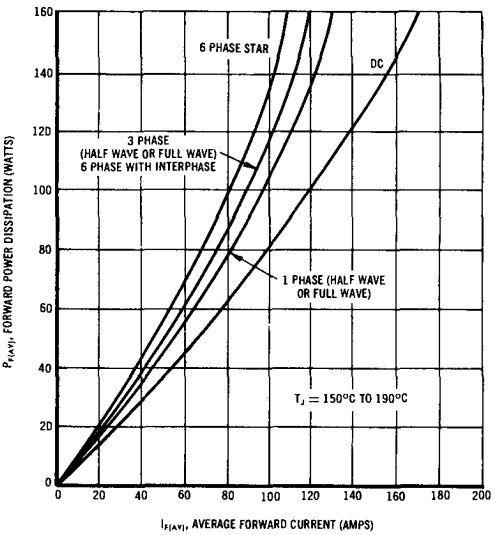
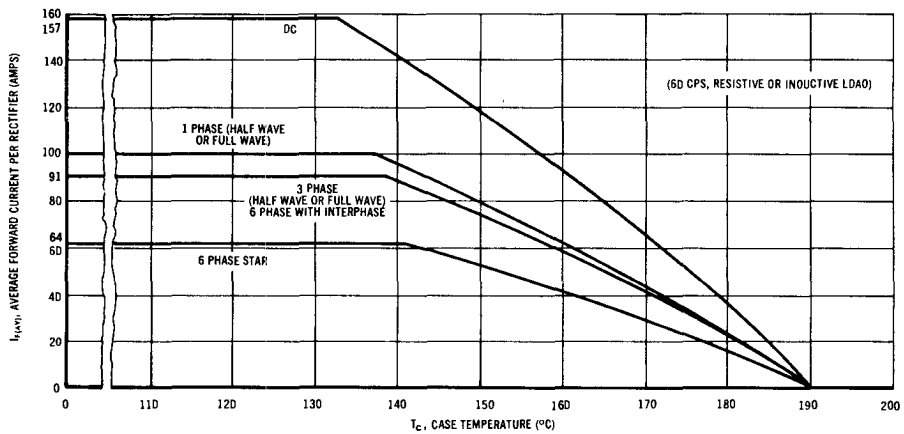


FIGURE 3 — MAXIMUM CURRENT RATINGS



MR1210 thru MR1219 (continued)

FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

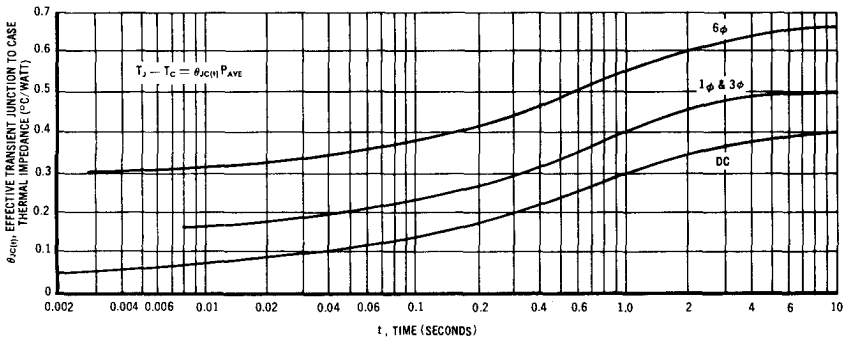


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

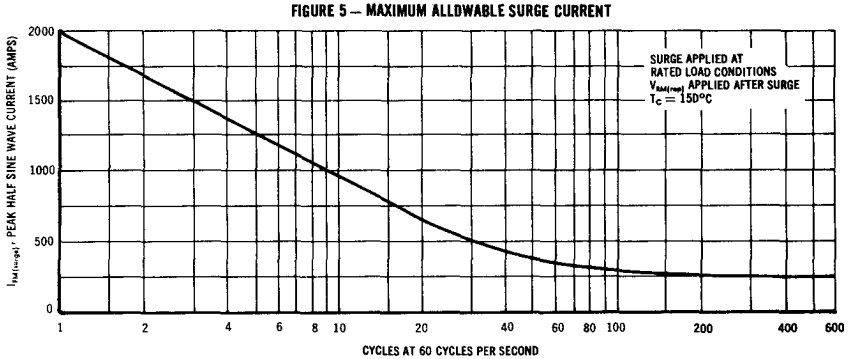
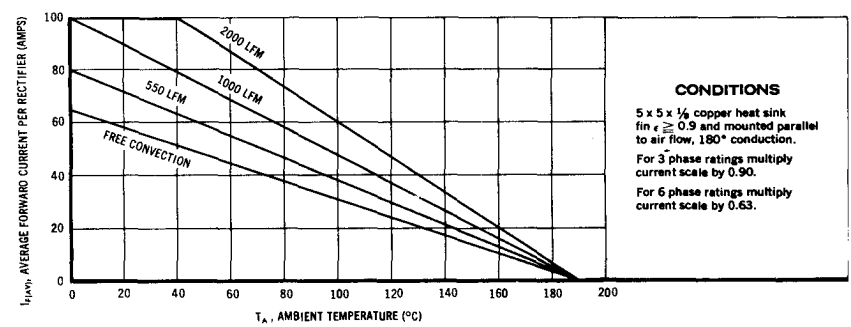
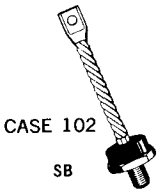


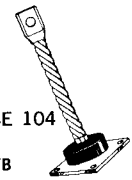
FIGURE 6 — CURRENT DERATING DATA



MR1220 thru MR1229

I_O = 200 A
V_R — to 600 V


CASE 102
SB


CASE 104
FB


SL CASE 101


FL CASE 103

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1220	MR 1221	MR 1222	MR 1223	MR 1225	MR 1227	MR 1228	MR 1229	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, see Figure 3) T_C = 135°C T_C = 150°C	I_O	200 160								Amperes
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	3,600 (for 1/2 cycle) 2,000 (for six consecutive cycles)								Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	27,000								$A_{(rms)}{}^2sec$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	20	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.20	°C/Watt

MR1220 thru MR1229 (continued)

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1220SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1220FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1220SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1220FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE TO CASE.

Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1225FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.

For Flat Mounted "FB" and "FL" rectifiers use No. 10 bolts torqued to 25 in-lbs min., 30 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

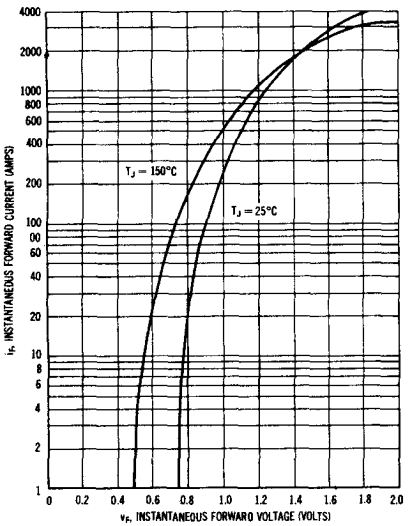


FIGURE 2 — FORWARD POWER DISSIPATION

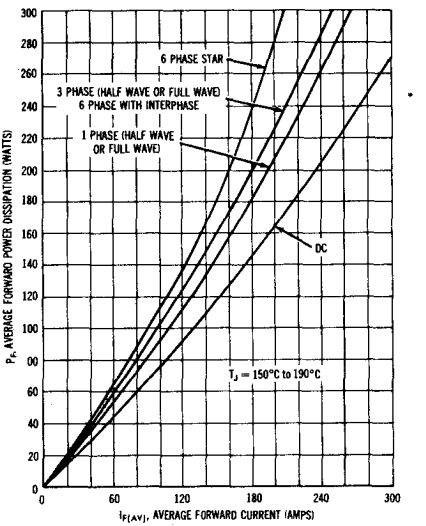
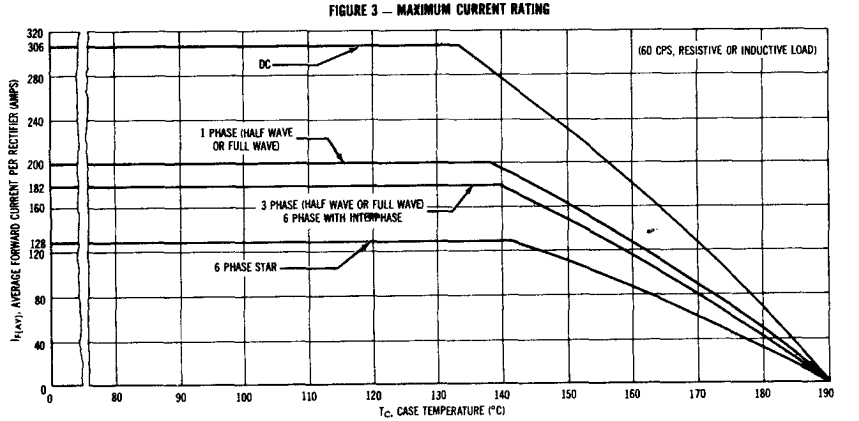


FIGURE 3 — MAXIMUM CURRENT RATING



MR1220 thru MR1229 (continued)

FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

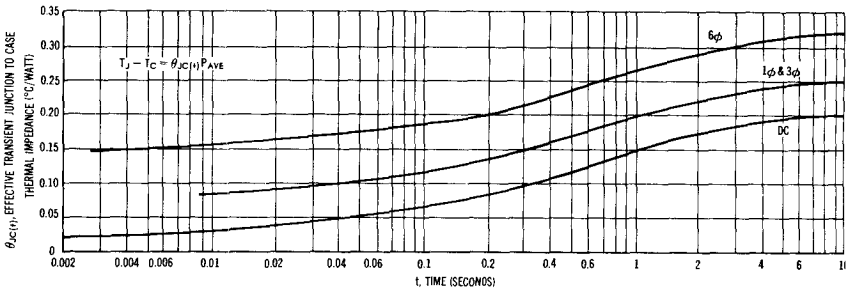


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

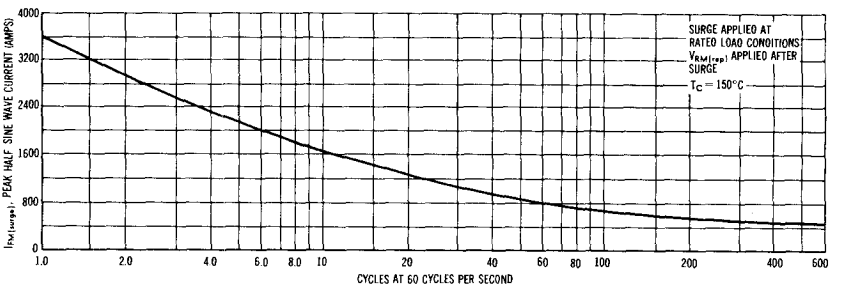
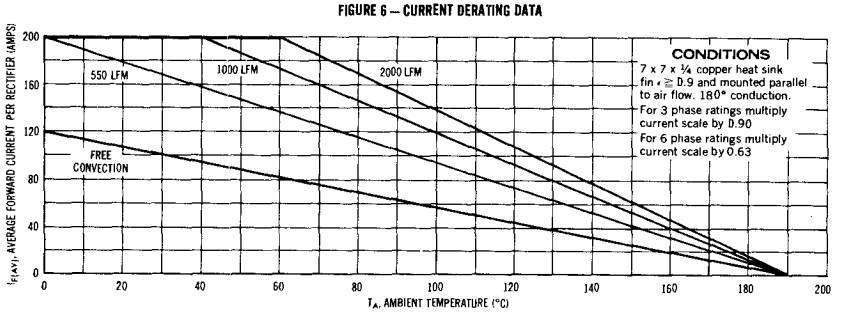


FIGURE 6 — CURRENT DERATING DATA



MR1230 thru MR1239

I_O = 300 A
V_R = to 600 V


CASE 102
SB


CASE 104
FB


SL CASE 101


FL CASE 103

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

Rating	Symbol	MR 1230	MR 1231	MR 1232	MR 1233	MR 1235	MR 1237	MR 1238	MR 1239	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, see Figure 3) T_C = 135°C T_C = 150°C	I_O	300 240								Amperes
Non-Repetitive Peak Surge Currents (surge applied at rated load conditions, see Figure 5) T_C = 150°C	$I_{FM(surge)}$	5,000 (for 1/2 cycle) 3,000 (for six consecutive cycles)								Amperes
I^2t Rating (non-repetitive, for t greater than 1 ms and less than 8.3 ms)	I^2t	52,000								$A_{(rms)}{}^2sec$
Operating and Storage Junction Temperature Range (see Figure 4 for other conditions)	T_J, T_{stg}	-65 to +190								°C

ELECTRICAL CHARACTERISTICS

Characteristics and Conditions	Symbol	Max	Unit
Full Cycle Average Forward Voltage Drop (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_O and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	35	mA

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.12	°C/Watt

MR1230 thru MR1239 (continued)

MECHANICAL CHARACTERISTICS

PACKAGE CONFIGURATIONS:

MR1230SB rectifiers are designed for stud mounting and have a flexible braided lead terminal.

MR1230FB rectifiers are designed for flat mounting and have a flexible braided lead terminal.

MR1230SL rectifiers are designed for stud mounting and have a solid lug terminal.

MR1230FL rectifiers are designed for flat mounting and have a solid lug terminal.

All units have a plated copper base and terminal. Molded external case with internal hermetically sealed, metallic case rectifier cells.

POLARITY:

Standard polarity devices are CATHODE TO CASE.
Reverse polarity devices are ANODE TO CASE and are designated by an "R" suffix i.e. MR1235FLR.

MOUNTING POSITION: Any.

STUD AND MOUNTING BOLT TORQUES:

For Stud Mounted "SB" and "SL" rectifiers, 300 in-lbs min., 400 in-lbs max.
For Flat Mounted "FB" and "FL" rectifiers use ¼ inch bolts torqued to 60 in-lbs min., 80 in-lbs max. Use an alternating procedure when torquing the four bolts and do not tighten one bolt completely without tightening the others.

FIGURE 1 — MAXIMUM FORWARD VOLTAGE DROP

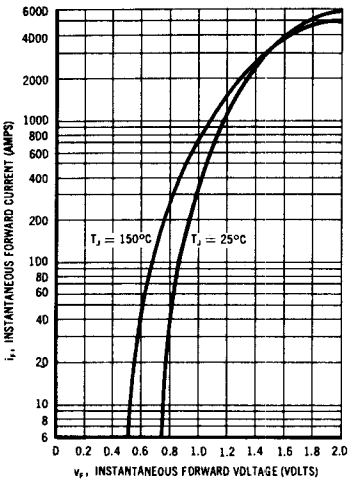


FIGURE 2 — FORWARD POWER DISSIPATION

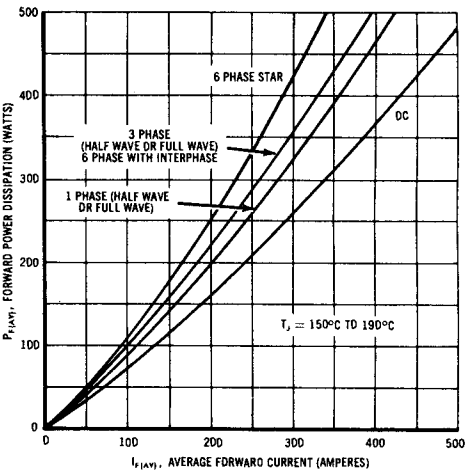
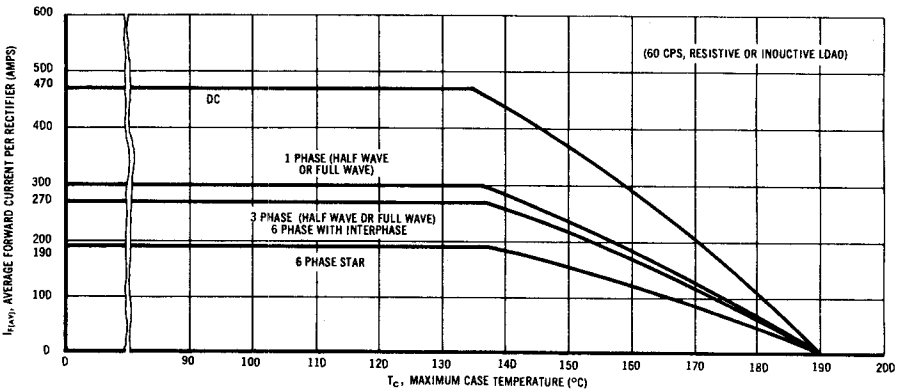


FIGURE 3 — MAXIMUM CURRENT RATINGS



MR1230 thru MR1239 (continued)

FIGURE 4 — EFFECTIVE TRANSIENT THERMAL IMPEDANCE

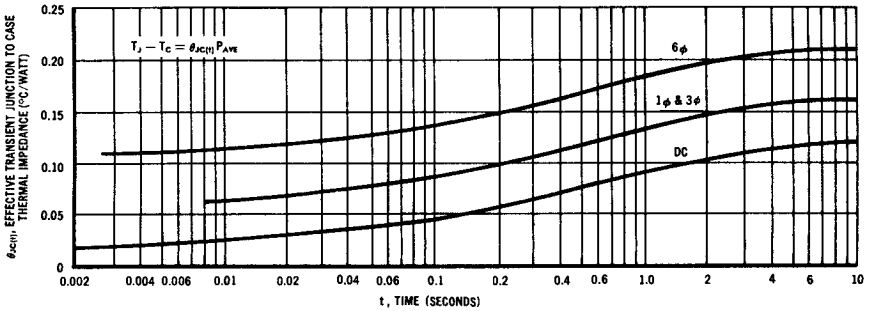


FIGURE 5 — MAXIMUM ALLOWABLE SURGE CURRENT

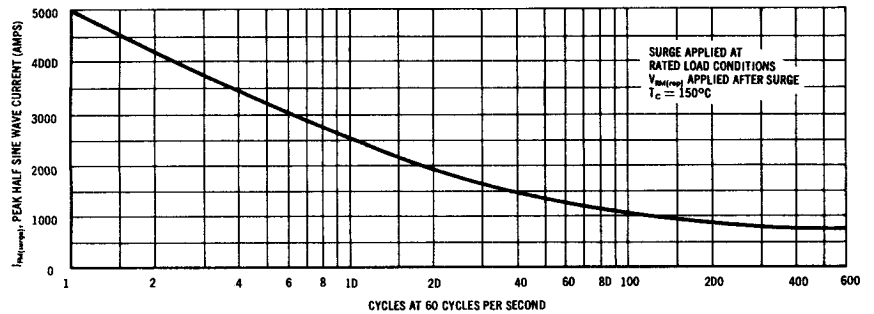
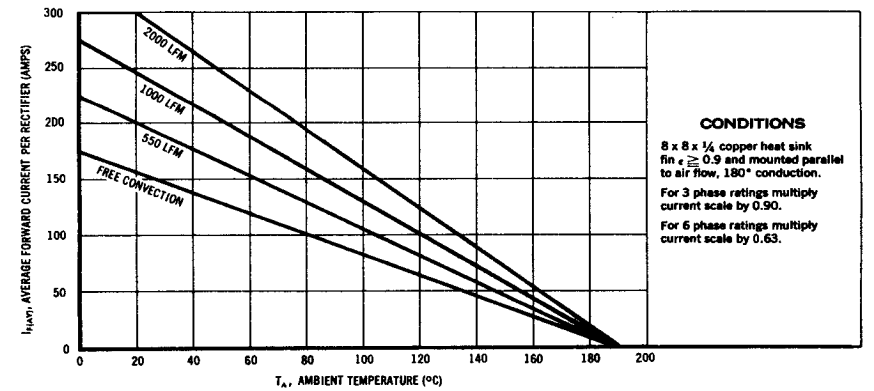


FIGURE 6 — CURRENT DERATING DATA



MR1240 thru MR1249

I_O = 400 A
V_R — to 600 V









Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number. Available in a variety of packages, all of which have the same ratings and characteristics. Desired package can be selected by adding suffix "SB", "FB", "SL", or "FL" to type number.

MAXIMUM RATINGS

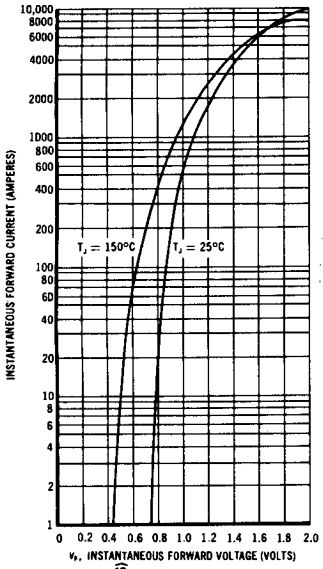
Rating	Symbol	MR 1240	MR 1241	MR 1242	MR 1243	MR 1245	MR 1247	MR 1248	MR 1249	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one halfwave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_O	← 400 →								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	← 8,000 (for 1/2 cycle) → ← 4,500 (for six consecutive 1/2 cycles) →								Amperes
I^2t Rating (non-repetitive, for t greater than 1 msec and less than 8.3 msec)	I^2t	← 133,000 →								$A_{(rms)}{}^2$sec
Operating and Case Temperature	T_J, T_{stg}	-85 to +190								°C
Thermal Resistance	θ_{JC}	0.075								°C/Watt

ELECTRICAL CHARACTERISTICS

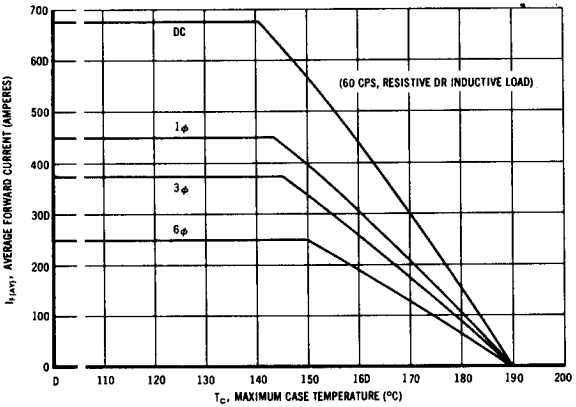
Characteristic and Conditions	Symbol	Maximum Limit	Units
Full Cycle Average Forward Voltage Drop (rated I_o and V_r, single phase, 60 cps, T_C = 150° C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_o and V_r, single phase, 60 cps, T_C = 150° C)	$I_{R(AV)}$	50	mA

MR1240 thru MR1249 (continued)

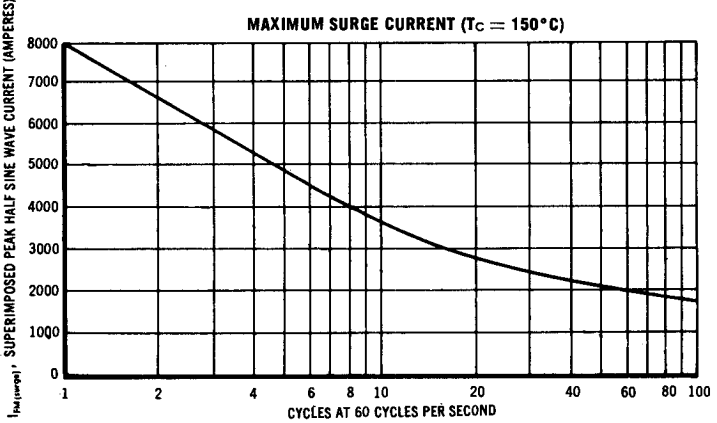
FORWARD VOLTAGE CHARACTERISTICS



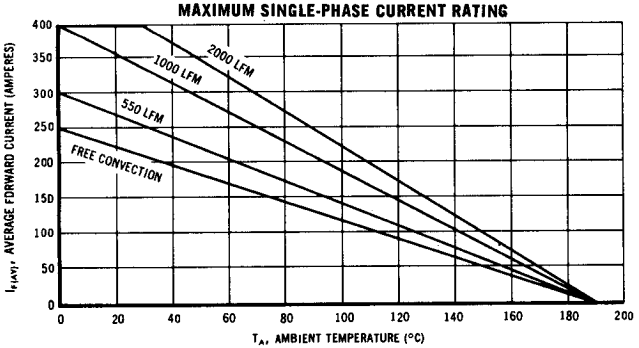
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT (T_C = 150°C)



MAXIMUM SINGLE-PHASE CURRENT RATING



CONDITIONS

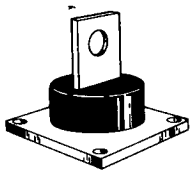
8 x 8 x ¼ copper heat sink fin$\epsilon \geqq 0.9$ and mounted parallel to air flow. 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1260 thru MR1269

I_O = 650 A
V_R — to 600 V



CASE 103

Silicon power rectifiers designed with double-case, multi-cell construction for extreme reliability and ruggedness. Standard cathode-to-case polarity, but available with reverse polarity by adding suffix "R" to type number.

MAXIMUM RATINGS

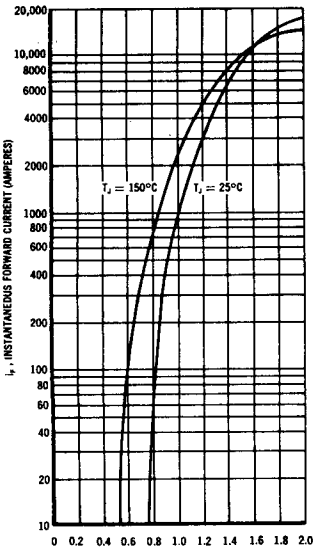
Rating	Symbol	MR 1260	MR 1261	MR 1262	MR 1263	MR 1265	MR 1267	MR 1268	MR 1269	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	150	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_o	← 650 →								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	← 12,000 (for 1/2 cycle) → ← 8,000 (for six consecutive 1/2 cycles) →								Amperes
I^2t Rating (non-repetitive, for t greater than 1 msec and less than 8.3 msec)	I^2t	← 300,000 →								$A_{(rms)}{}^2$sec
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190								°C
Thermal Resistance	θ_{JC}	0.045								°C/Watt

ELECTRICAL CHARACTERISTICS

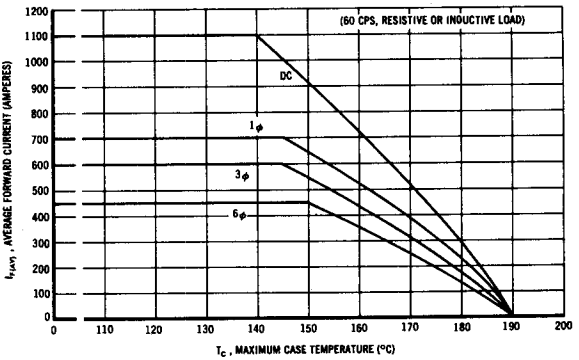
Characteristic and Conditions	Symbol	Maximum Limit	Units
Full Cycle Average Forward Voltage Drop (rated I_o and V_r, single phase, 60 cps, T_C=150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_o and V_r, single phase, 60 cps, T_C=150°C)	$I_{R(AV)}$	100	mA

MR1260 thru MR1269 (continued)

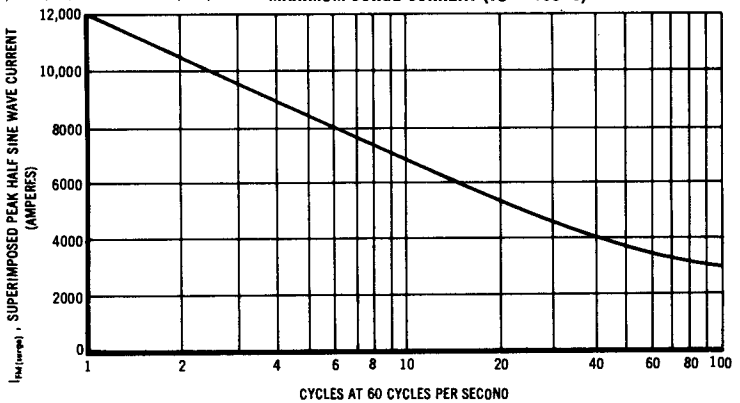
FORWARD VOLTAGE CHARACTERISTICS



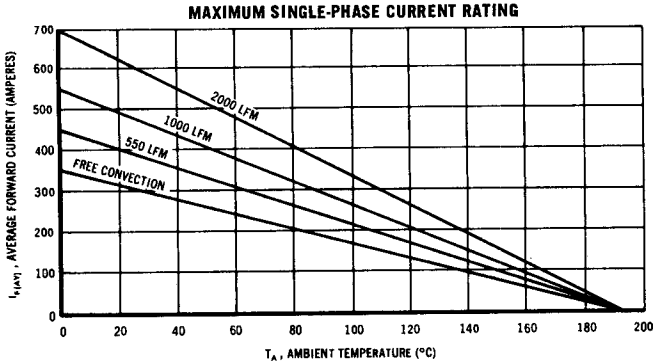
MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE



MAXIMUM SURGE CURRENT ($T_C = 150°C$)



MAXIMUM SINGLE-PHASE CURRENT RATING



CONDITIONS

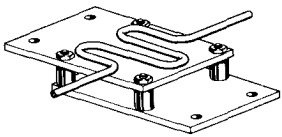
10 x 10 x ¼ copper heat sink fin $\epsilon \geqq 0.9$ and mounted parallel to air flow, 180° conduction.

For 3 phase ratings multiply current scale by 0.85.

For 6 phase ratings multiply current scale by 0.60.

MR1290 thru MR1299

I_O = 1000 A
V_R — to 600 V



CASE 105

Silicon power rectifiers designed with multi-cell construction for extreme reliability and ruggedness. Standard polarity is cathode-to-water-cooled case, but reverse polarity devices are available designated by an "R" suffix. i.e. MR1295R

MAXIMUM RATINGS

Rating	Symbol	MR 1290	MR 1291	MR 1292	MR 1293	MR 1295	MR 1297	MR 1298	MR 1299	Units
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	150	200	300	400	500	600	Volts
Non-Repetitive Peak Reverse Voltage (one half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	250	300	400	500	600	720	Volts
RMS Reverse Voltage	V_r	35	70	105	140	210	280	350	420	Volts
Continuous Average Rectified Forward Current (single phase, resistive load, 60 cps, T_C = 150°C)	I_o	← 1000 →								Amperes
Non-Repetitive Peak Surge Currents (superimposed on rated current at rated voltage, T_C = 150°C)	$I_{FM(surge)}$	← 18,000 (for 1/2 cycle) → ← 13,500 (for six consecutive 1/2 cycles) →								Amperes
Operating and Storage Temperature	T_J, T_{stg}	-65 to +190								°C
Thermal Resistance DC 1 and 3 phase 6 phase	θ_{JC}	0.035 0.045 0.060								°C/Watt

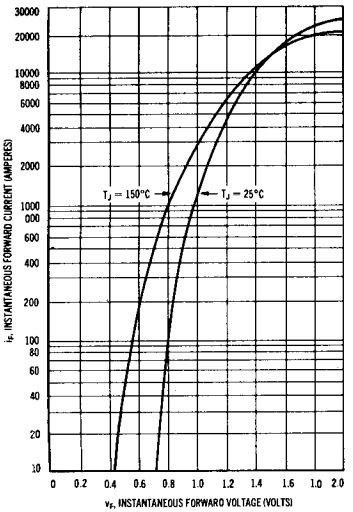
Case Temperature Reference Point: T_C measured at center edge of the water cooled mounting bus.

ELECTRICAL CHARACTERISTICS

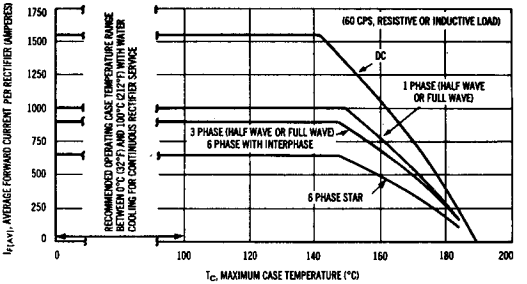
Characteristic and Conditions	Symbol	Maximum Limit	Units
Full Cycle Average Forward Voltage Drop (rated I_o and V_r, single phase, 60 cps, T_C = 150°C)	$V_{F(AV)}$	0.4	Volts
Full Cycle Average Reverse Current (rated I_o and V_r, single phase, 60 cps, T_C = 150°C)	$I_{R(AV)}$	0.2	Amperes

MR1290 thru MR1299 (Continued)

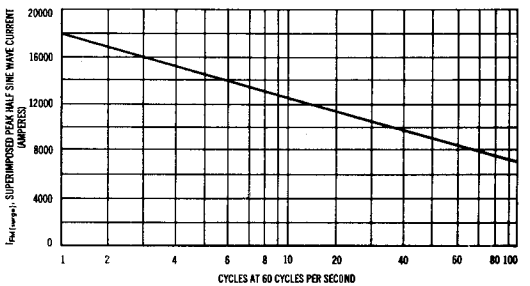
FORWARD VOLTAGE CHARACTERISTICS



MAXIMUM FORWARD CURRENT versus MAXIMUM CASE TEMPERATURE (100% DUTY)



MAXIMUM SURGE CURRENT



TYPICAL COOLING RATES AT RATED LOAD CONDITIONS

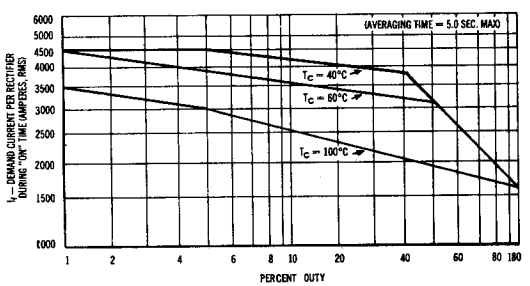
Inlet Water Temperature (°C)	Minimum Water Flow Required (Gallons/Hour)	Approx. Water Temp. Rise at Specified Flow Rate (°C)
15	2	10
50	5	8
75	10	5

NOTE: Water flow rates may be decreased at lighter load demands provided maximum case temperatures are not exceeded. In some applications where cooling systems are operated in series, it may be desirable to increase flow rates in order to minimize water temperature rises.

COOLING REQUIREMENTS

Type of Cooling — Water
Min Inlet Water Temp. — 0°C
Max Inlet Water Temp. — 75°C

MAXIMUM RMS DEMAND CURRENT versus PERCENT DUTY



NOTE:

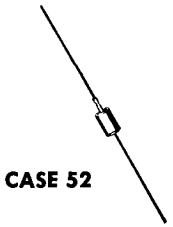
Curves apply to normal rectifier service conditions with maintained Rectifier Case Temperature (T_C) equal to or less than the values specified.

To determine the Maximum Average Current [$I_{F(AV)}$] per rectifier, multiply the RMS Current [I_f] rating by the factor given for the operating condition.

- $I_{F(AV)} = .64I_f$ for Single Phase
- $I_{F(AV)} = .57I_f$ for Three Phase and Six Phase with interphase
- $I_{F(AV)} = .40I_f$ for Six Phase Star

MR1337-1 thru MR1337-5

$I_O = 1$ A
V_R — to 400 V



CASE 52

Fast recovery silicon rectifiers designed for high-frequency power supply, inverter, and converter applications. Typical recovery time of 100 nsec extends practical frequency limit of current rectification to more than 300,000 cps thus permitting the design of power supplies with smaller, lighter, and less expensive associated components.

MAXIMUM RATINGS

Rating	Symbol	MR 1337-1	MR 1337-2	MR 1337-3	MR 1337-4	MR 1337-5	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	50	100	200	300	400	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	100	200	300	400	500	Volts
RMS Reverse Voltage	V_r	35	70	140	210	280	Volts
		All Types					
Average Rectified Forward Current (single-phase resistive load) Figure 2	I_O	T_A=25°C: 1.0 T_A=75°C: 0.75					Amperes
Non-Repetitive Peak Surge Current Figure 3 (superimposed on rated current at rated voltage, T_A = 75 °C)	$I_{FM(surge)}$	30					Amperes
Peak Repetitive Forward Current (T_A = 75°C)	$I_{FM(rep)}$	4.0					Amperes
I^2t Rating (non-repetitive, for t greater than 1 msec and less than 8.3 msec)	I^2t	3.75					$A_{(rms)}^2$ sec
Maximum Junction Operating Temperature Range	T_J	-65 to +150					°C
Maximum Case Storage Temperature Range	T_{stg}	-65 to +175					°C
Maximum Steady State DC Thermal Resistance	θ_{JA}	100					°C/Watt

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS
(FOR ALL TYPES)

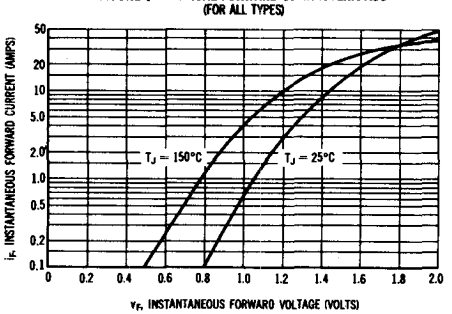
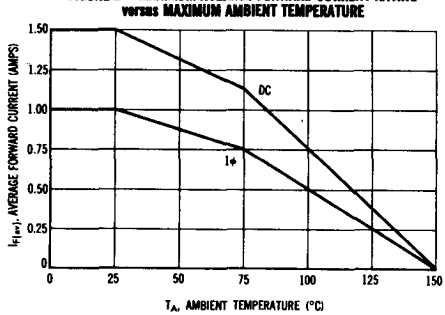


FIGURE 2 — MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE

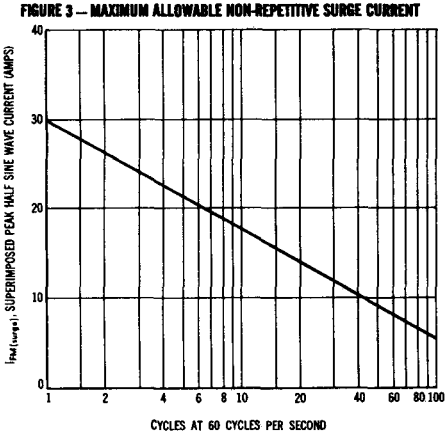


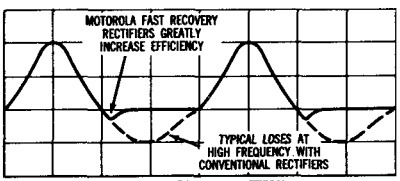
MR1337-1 thru MR1337-5 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Max Limit	Unit
DC Forward Voltage Drop (I_F = 1.0 Adc, T_A = 25°C)	V_F	1.1	Vdc
Full Cycle Average Forward Voltage Drop (I_O = 0.75 Amps and Rated V_r, T_A = 75°C, Half Wave Rectifier)	$V_{F(AV)}$	0.55	Volts
Full Cycle Average Reverse Current (I_O = 0.75 Amp and Rated V_r, T_A = 75°C, single phase)	$I_{R(AV)}$	0.75	mA
DC Reverse Current (Rated V_R, T_A = 25°C)	I_R	0.25	mA
Maximum Reverse Recovery Time (I_F = 1 Amp min)	t_{rr}	200	nsec
Maximum Overshoot Current	I_{os}	2.0	Amps

FIGURE 3 — MAXIMUM ALLOWABLE NON-REPETITIVE SURGE CURRENT (SUPERIMPOSED ON RATED CONDITIONS, $V_{RWM(pk)}$ APPLIED AFTER SURGE, T_A = 75°C)





TYPICAL RECOVERY PATTERN

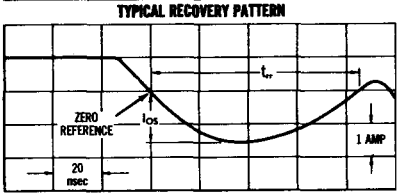
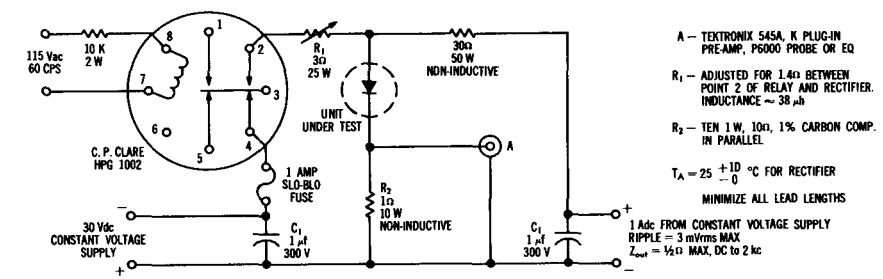


FIGURE 4 — t_{rr} TEST CIRCUIT



MR2261 thru MR2265

$I_O = 25$ A
V_R — to 50 V



CASE 43

These press-fit silicon rectifiers, designed for all medium-current industrial and commercial applications, feature rugged construction for operation under severe conditions. Millions are in use in automotive applications. Cathode to case polarity, but reverse polarity devices may be obtained by adding an "R" suffix to the type number i. e. MR2262R.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	MR 2261	MR 2262	MR 2263	MR 2264	MR 2265	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	10	20	30	40	50	Volts
RMS Reverse Voltage	V_r	7	14	21	28	35	Volts
Average Rectified Forward Current (single phase, resistive load, 60 cps, $T_C = 100°C$)	I_O	← 25 →					Amps
Peak Repetitive Forward Current ($T_A = 75°C$)	$I_{FM(rep)}$	← 100 →					Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_C = 100°C$)	$I_{FM(surge)}$	← 300 (for 1/2 cycle) →					Amps
Operating and Storage Temperature Range	T_J, T_{stg}	← -65 to +175 →					°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Case: $\theta_{JC} = 1.3°C/W$ MAX

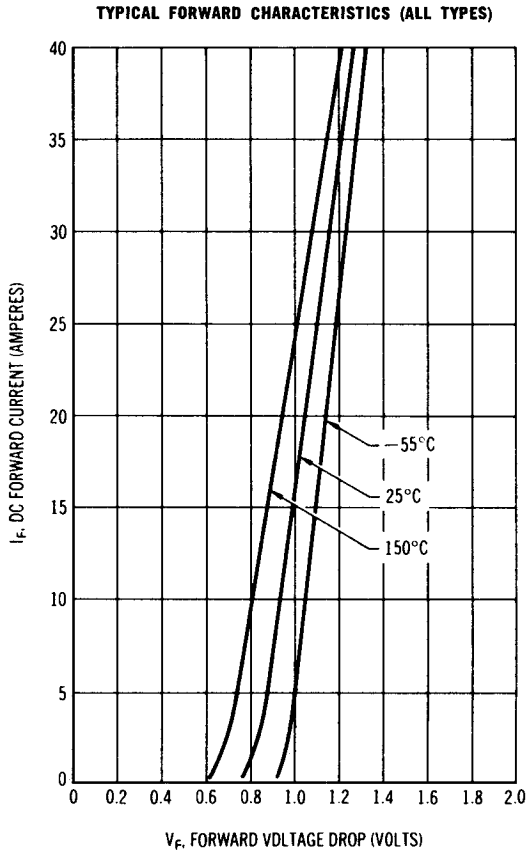
MECHANICAL CHARACTERISTICS

CASE: Welded, hermetically sealed construction.
FINISH: All external surfaces corrosion-resistant and lead readily solderable.
WEIGHT: 9 grams (approx.)
POLARITY: CATHODE TO CASE (reverse polarity units are available upon request and are designated by an "R" suffix i. e. MR2262R).
MOUNTING POSITIONS: Any

ELECTRICAL CHARACTERISTICS all types ($T_A = 25°C$ unless otherwise noted)

Characteristics	Symbol	Max Limit	Unit
Full Cycle Average Forward Voltage Drop ($I_O = 25$ Amps and Rated V_r, $T_C = 100°C$, Half Wave Rectifier)	$V_{F(AV)}$	0.70	Volts
DC Forward Voltage Drop ($I_F = 25$ Adc, $T_A = 25°C$)	V_F	1.5	Volts
Full Cycle Average Reverse Current ($I_O = 25$ Amps and Rated V_r, $T_C = 100°C$, Half Wave Rectifier)	$I_{R(AV)}$	10.0	mA
DC Reverse Current (Rated V_R, $T_A = 25°C$)	I_R	1.0	mA

MR2261 thru MR2265 (continued)



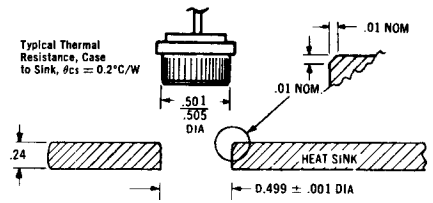
MOUNTING INSTRUCTIONS

MR2261 thru MR2265 rectifiers are designed for press-fitted mounting in a heat sink. Recommended procedures for this type of mounting are as follows:

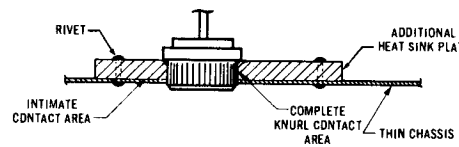
1. Drill a hole in the heat sink 0.499 ± .001 inch in diameter.
2. Break the hole edge as shown to prevent shearing off the knurled edge of the rectifier when it is pressed into the hole.
3. The depth of the break should be 0.010 inch maximum to retain maximum heat sink surface contact with the knurled rectifier surface.
4. Width of the break should be 0.010 inch as shown.

These procedures will allow proper entry of the rectifier knurled surface, provide good rectifier-heat sink surface contact, and assure reliable rectifier operation. If the break is made too deep, thereby reducing contact area for heat transfer, reliability of operation will be impaired.

These devices can be mounted in a thin chassis by inserting the rectifier through an additional heat sink plate which is mounted in intimate contact with the upper side of the chassis. This provides additional contact area for the rectifier knurled edge, as well as additional heat sink capacity.



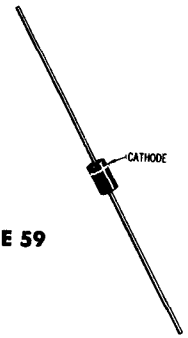
HEAT SINK MOUNTING



THIN-CHASSIS MOUNTING

MR2266
MR2273

$I_O = 1$ A
V_R to 800 V



CASE 59

High-voltage, axial-lead, silicon rectifiers, designed for television "damper" diode service, feature subminiature packages, high current-handling capability, excellent reliability, and economy. Flame-proof silicone polymer case.

MAXIMUM RATINGS

Rating	Symbol	MR2273	MR2266	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	200	800	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	140	560	Volts
Average Rectified Forward Current (single-phase, resistive load, 60 cps) (75°C Ambient) (100°C Ambient)	I_O	1.0 0.75	1.0 0.75	Amps
Peak Repetitive Forward Current (T_A = 25°C)	$I_{FM(rep)}$	10		Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, T_A = 25°C)	$I_{FM(surge)}$	30 (for 1/2 cycle)		Amps
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		°C

THERMAL CHARACTERISTICS

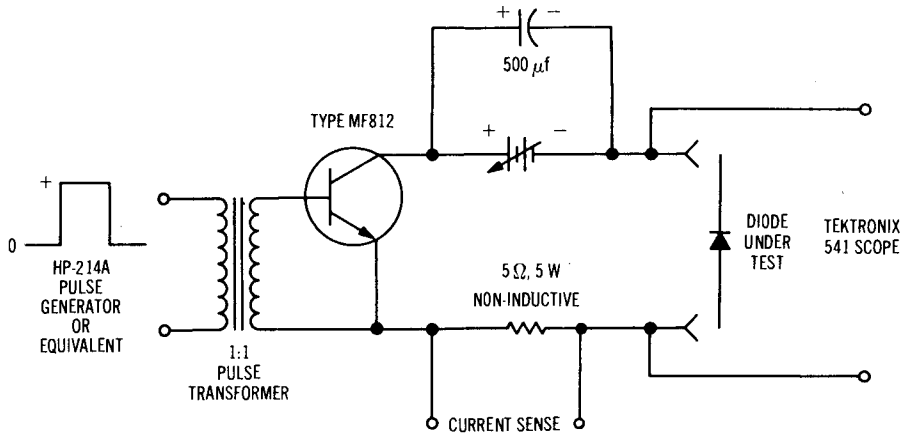
Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Value	Unit
Full-Cycle Average Forward Voltage Drop (Rated Current @ 25°C, sine wave operation)		$V_{F(AV)}$	0.8	Volts
DC Forward Voltage Drop (1 Amp Continuous DC, 25°C)		V_F	1.1	Volts
DC Reverse Current @ Rated V_r	(25°C) (100°C)	I_R	0.01 0.05	mA
Typical Forward Peak Voltage Overshoot (Figure 1, Figure 2)	MR2266, I_F = 2 A	V_{fp}	10	Volts
	MR2273, I_F = 5 A	V_{fp}	28	Volts

MR2266, MR2273 (continued)

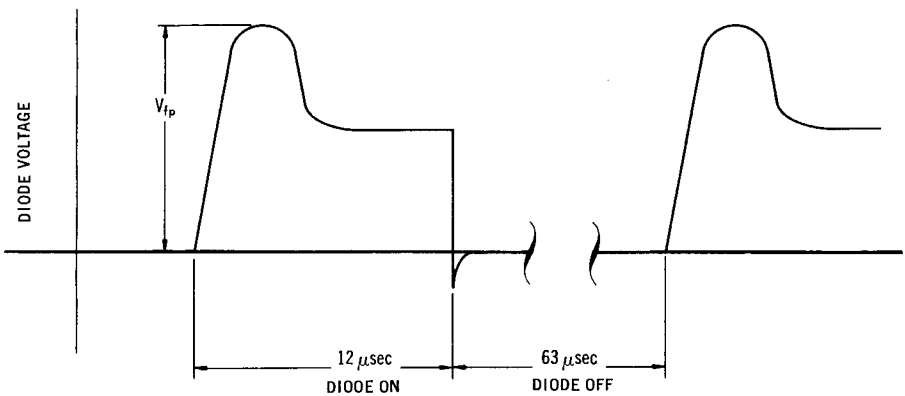
FIGURE 1 — FDRWARD PEAK VOLTAGE OVERSHOOT TEST CIRCUIT



TEST PROCEDURE:

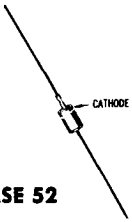
1. Adjust input pulse from generator to saturate MF812 transistor
2. Adjust battery voltage for the specified forward current after the voltage overshoot.
   I_F = 2 Amps, for MR2266
   I_F = 5 Amps, for MR2273
3. Read peak voltage overshoot across diode under test. (See Waveform Diagram).

FIGURE 2 — DIODE UNDER TEST, WAVEFORM DIAGRAM



MR2271

$I_O = 1$ A
$V_R = 300$V



CASE 52

Fast recovery silicon rectifier designed for video power supply applications. Typical recovery time of 200 nsec extends practical frequency limit of current rectification to more than 150,000 cps. Cathode is connected to case.

MAXIMUM RATINGS

Rating	Symbol	Rating	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	300	Volts
Non-Repetitive Peak Reverse Voltage (half-wave, single phase, 60 cycle peak)	$V_{RM(non-rep)}$	400	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	210	Volts
Average Rectified Forward Current (Sine wave operation) (single-phase resistive load) $T_A = 25°C$ $T_A = 75°C$	I_O	1.0 0.75	Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75°C$)	$I_{FM(surge)}$	30 (for 1/2 cycle) @ 60 cps	Amps
Peak Repetitive Forward Current ($T_A = 75°C$)	$I_{FM(rep)}$	4.0	Amps
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +150	°C

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: $\theta_{JA} = 100^{O}C/W$ MAX

ELECTRICAL CHARACTERISTICS

Characteristics	Symbol	Value	Unit
Maximum DC Forward Voltage Drop ($I_F = 1.0$ Adc, $T_A = 25°C$)	V_F	1.1	Vdc
Maximum Full Cycle Average Forward Voltage Drop ($I_O = 0.75$ Amps and Rated V_r, $T_A = 75°C$, Half Wave Rectifier, 60 cps)	$V_{F(AV)}$	0.55	Volts
Maximum Full Cycle Average Reverse Current ($I_O = 0.75$ Amp and Rated V_r, $T_A = 75°C$, single phase, 60 cps)	$I_{R(AV)}$	0.75	mA
Maximum DC Reverse Current (Rated V_R, $T_A = 25°C$)	I_R	0.25	mA
Maximum Reverse Recovery Time ($I_{RR} = 50$ mA) Test Circuit Figure 3	t_{rr}	200	nsec
Typical Rectification Efficiency Test Circuit Figure 6	RE	90	%

MR2271 (continued)

FIGURE 1

FORWARD CHARACTERISTICS

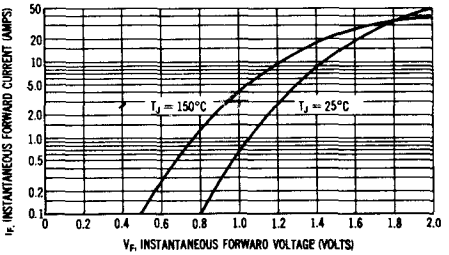


FIGURE 2

MAXIMUM AVERAGE FORWARD CURRENT RATING versus MAXIMUM AMBIENT TEMPERATURE

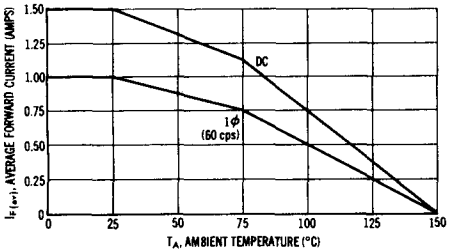


FIGURE 3

RECOVERY TIME TEST CIRCUIT

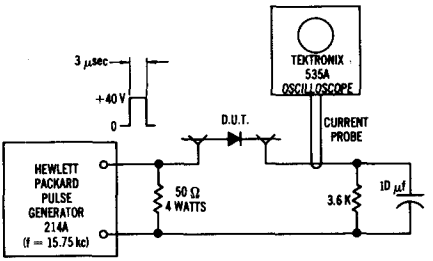


FIGURE 4

DIODE CURRENT WAVEFORM IN CIRCUIT OF FIGURE 6

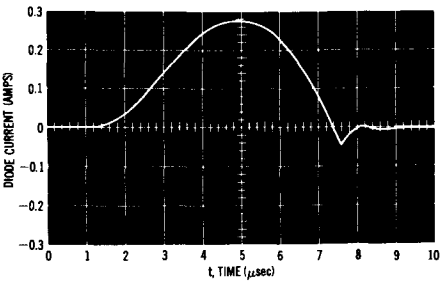


FIGURE 5

RECOVERY WAVEFORM IN CIRCUIT

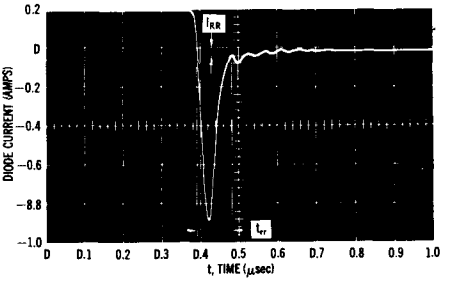
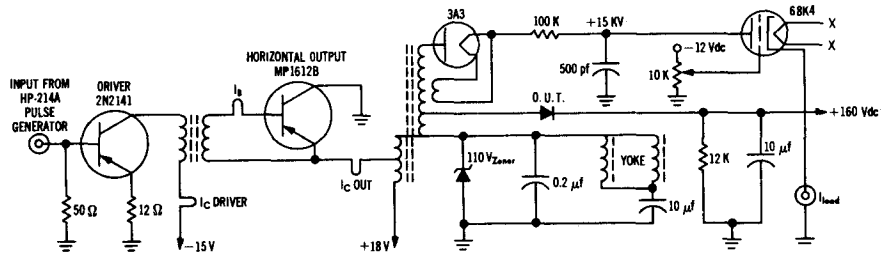


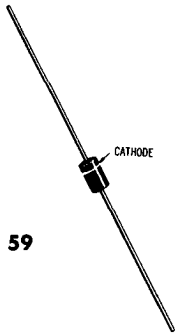
FIGURE 6

LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MR2272

$I_O = 1$ A
$V_R = 400$ V



CASE 59

Subminiature axial-lead silicon rectifier designed for video power-supply applications in low-voltage television receivers where video supply-voltage is obtained from horizontal deflection system.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Rating	Symbol	Rating	Unit
Peak Repetitive Reverse Voltage Working Peak Reverse Voltage DC Blocking Voltage	$V_{RM(rep)}$ $V_{RM(wkg)}$ V_R	400	Volts
RMS Reverse Voltage (Sine wave operation)	V_r	280	Volts
Average Rectified Forward Current (Sine wave operation) (75°C Ambient) (100°C Ambient)	I_O	 1.0 0.75	Amps
Peak Repetitive Forward Current ($T_A = 75°C$)	$I_{FM(rep)}$	10	Amps
Non-Repetitive Peak Surge Current (superimposed on rated current at rated voltage, $T_A = 75°C$)	$I_{FM(surge)}$	30 (for 1/2 cycle) @ 60 cps	Amps
Juction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175	°C

THERMAL CHARACTERISTICS

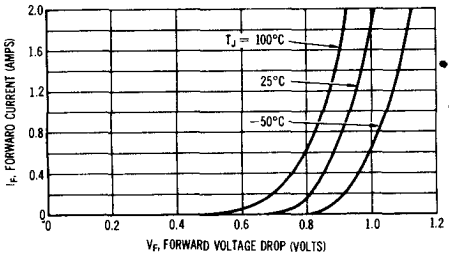
Thermal Resistance, Junction to Ambient: $\theta_{JA} = 100°C/W$ MAX

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

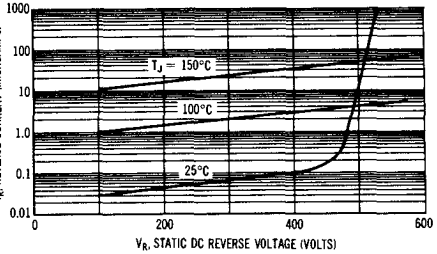
Characteristics	Symbol	Value	Unit
Maximum Forward Voltage Drop (1 Amp Continuous DC, 25°C)	V_F	1.1	Volts
Maximum Full Cycle Average Forward Voltage Drop ($I_O = 0.75$ Amps and Rated V_r, $T_A = 75°C$, Half Wave Rectifier, 80 cps)	$V_{F(AV)}$	0.5	Volts
Maximum Reverse Current @ Rated DC Voltage (25°C)	I_R	0.01	mA
Maximum Reverse Recovery Time ($I_{RR} = 0.5$ Amp) Test Circuit Figure 4 - Typical Waveform Figure 6	t_{rr}	1.5	μsec
Rectification Efficiency (Typical) Test Circuit Figure 7 - Typical Waveform Figure 5	RE	55	%

MR2272 (continued)

TYPICAL FORWARD CHARACTERISTICS

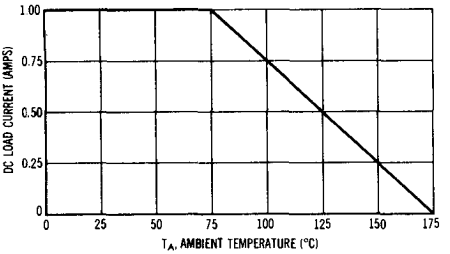


TYPICAL REVERSE CHARACTERISTICS

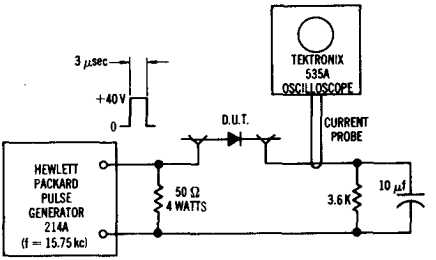


MAXIMUM ALLOWABLE DC OUTPUT

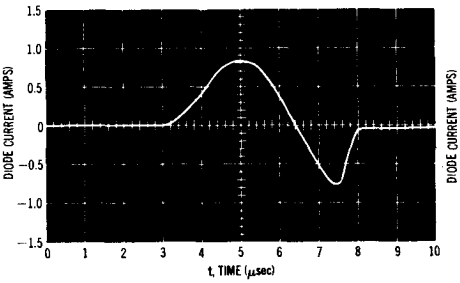
(Sine Wave Operation, Resistive or Inductive Load)



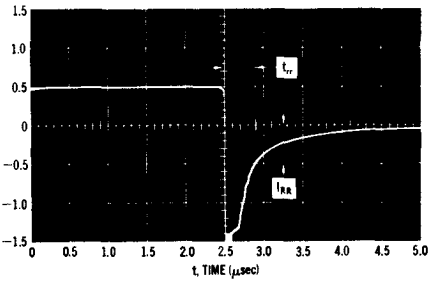
RECOVERY TIME TEST CIRCUIT



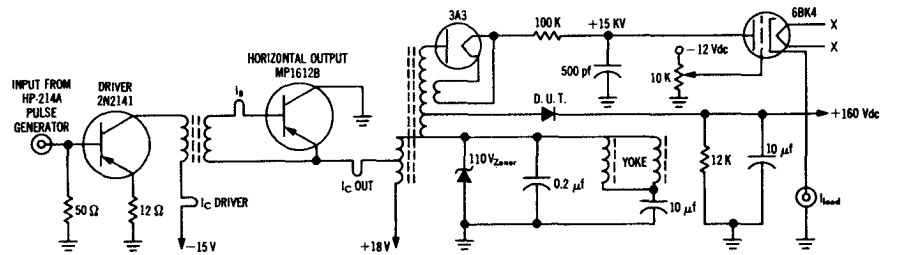
DIODE CURRENT WAVEFORM IN VIDEO SUPPLY OPERATION



TYPICAL RECOVERY WAVEFORM IN CIRCUIT



LOW VOLTAGE HORIZONTAL DEFLECTION TEST CIRCUIT



MR2273

For Specifications, See MR2266 Data Sheet

ADDITIONS AND MODIFICATIONS

SILICON RECTIFIER ASSEMBLIES

Devices included in this section:

MOLDED BRIDGES

MDA942 Series
MDA952 Series
MDA962 Series
MDA1491 Series
MDA1505 Series
MDA1591 Series

MINIATURE BRIDGE ASSEMBLIES

MDA920 Series
MDA930 Series
MDA940 Series
MDA950 Series

HIGH-VOLTAGE MOLDED ASSEMBLIES

1N1730
1N1731
1N1732
1N1733
1N1734
1N2382
1N2383
1N2384
1N2385
MDA1330H
MDA1331H
MDA1332H
MDA1333H

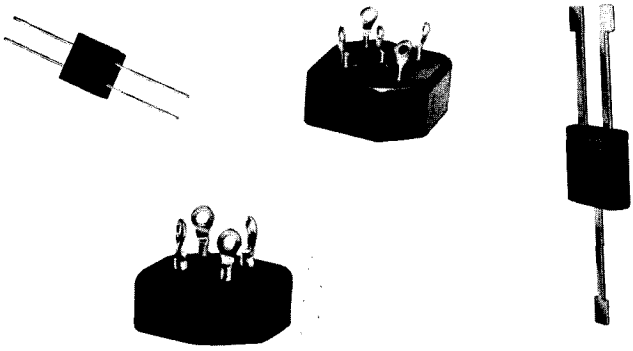
For case outline dimensions, see page 1-186.

SILICON RECTIFIER ASSEMBLIES

Silicon rectifiers are available as individual cells with a wide variety of current and voltage ratings, as described in the rectifier section of this manual. In addition, these devices are available in standard and custom assemblies, which greatly increase the range of applications that can be satisfied with single-unit preassembled devices.

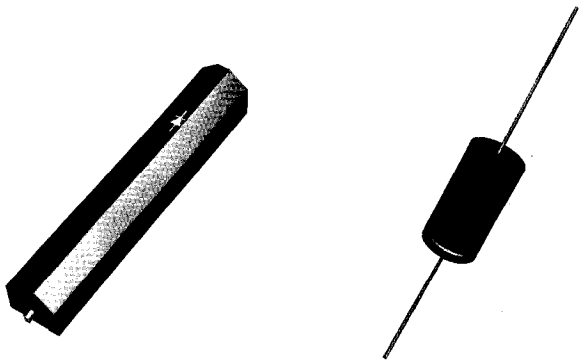
Included in these standard assemblies are:

Medium and low current rectifier bridge circuit configurations



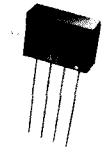
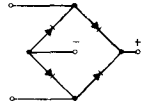
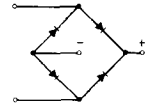
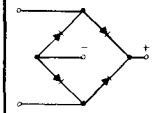
and

Series-connected high-voltage rectifier assemblies.

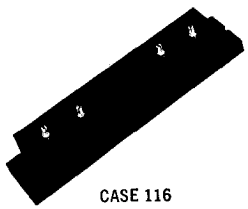
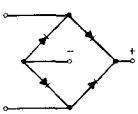
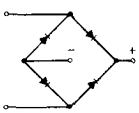
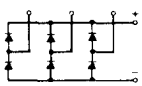
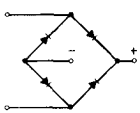
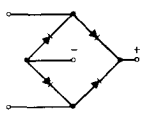


Custom assemblies, including both zener diode and rectifier assemblies, can be obtained inexpensively in quantity by specifying the type of devices needed (from a large selection of individual diodes and rectifiers) and the desired circuit configuration.

RECTIFIER BRIDGE ASSEMBLIES — QUICK SELECTION GUIDE

V_{RM} VOLTS	1 AMP †		1.5 AMP		1.5 AMP
	 CASE 108	 CASE 109	 CASE 110	 CASE 111	 CASE 112
	SINGLE PHASE FULL WAVE BRIDGE 		 SINGLE PHASE FULL WAVE BRIDGE		 SINGLE PHASE FULL WAVE BRIDGE
25 V	MDA920-1	MDA920A-1			
50 V	MDA920-2	MDA920A-2	MDA942-1	MDA942A-1	MDA1491-1
100 V	MDA920-3	MDA920A-3	MDA942-2	MDA942A-2	MDA1491-2
200 V	MDA920-4	MDA920A-4	MDA942-3	MDA942A-3	MDA1491-3
300 V	MDA920-5	MDA920A-5	MDA942-4	MDA942A-4	MDA1491-4
400 V	MDA920-6	MDA920A-6	MDA942-5	MDA942A-5	MDA1491-5
600 V	MDA920-7	MDA920A-7	MDA942-6	MDA942A-6	MDA1491-6

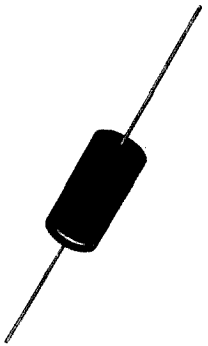
† Also available in voltage doubler and center tap configurations from 25 to 600 volts!

4 AMP	6 AMP	8 AMP	10 AMP	16 AMP
 CASE 112	 CASE 113	 CASE 115	 CASE 114	 CASE 116
 SINGLE PHASE FULL WAVE BRIDGE	 SINGLE PHASE FULL WAVE BRIDGE	 THREE PHASE FULL WAVE BRIDGE	 SINGLE PHASE FULL WAVE BRIDGE	 SINGLE PHASE FULL WAVE BRIDGE
MDA1591-1	MDA952-1	MDA1505-1	MDA962-1	MDA972-1
MDA1591-2	MDA952-2	MDA1505-2	MDA962-2	MDA972-2
MDA1591-3	MDA952-3	MDA1505-3	MDA962-3	MDA972-3
MDA1591-4	MDA952-4	MDA1505-4	MDA962-4	MDA972-4
MDA-1591-5	MDA952-5	MDA1505-5	MDA962-5	MDA972-5
MDA1591-6	MDA952-6	MDA1505-6		

HIGH VOLTAGE SILICON RECTIFIERS MOLDED ASSEMBLIES

1N1730 thru 1N1734
1N2382 thru 1N2385

I_O — to 0.2 A
V_P — to 10,000 V



Standard single-phase, half-wave, high-voltage silicon rectifier assemblies.

MAXIMUM RATINGS (covering all devices in the table below)

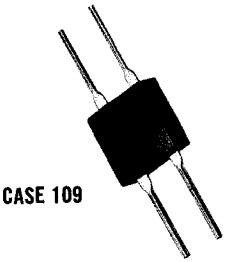
Max. DC Reverse Current @ Rated Peak Reverse Voltage 25°C	10 μA
100°C	100 μA
Max. Surge Current (8 ms)	2.5A
Operating Temperature	-55°C to +150°C

ELECTRICAL CHARACTERISTICS

Rectifier Types	V_{RM} (rep)	Avg. Rectified Fwd. Current – mA @25°C	Avg. Rectified Fwd. Current – mA @100°C	Max. RMS Input Voltage	Max. DC Fwd. Voltage @ 100mA @ 25°C	Case Dimensions L	Case Dimensions Dia.	Lead Dimensions L	Lead Dimensions Dia.
1N1730	1000	200	100	700	5	.5	.375	1.250	.030
1N1731	1500	200	100	1050	5	.5	.375	1.250	.030
1N1732	2000	200	100	1400	9	1.0	.375	1.250	.030
1N1733	3000	150	75	2100	12	1.0	.375	1.250	.030
1N1734	5000	100	50	3500	18	1.0	.5	1.250	.030
1N2382	4000	150	75	2800	18	1.5	.5	1.250	.030
1N2383	6000	100	50	4200	27	1.5	.5	1.250	.030
1N2384	8000	70	35	5600	27	1.5	.5	1.250	.030
1N2385	10000	70	35	7000	39	2.0	.5	1.250	.030

MINIATURE DIODE ASSEMBLIES

MDA920 SERIES
MDA930 SERIES
MDA940 SERIES
MDA950 SERIES





Miniature Integral Diode Assemblies (MIDA)are low-current rectifier circuit configurations designed with a high output-current/size ratio for applications where space is at a premium. MIDA packages are available with flat ribbon leads and with round leads. For round leads, add suffix "A" to type number. Example, MDA920A-1.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Maximum Forward Voltage Drop per Cell (I_F = 500 mA Continuous)	V_F	1.2	Vdc
Maximum Reverse Current* (Figure 2) (V_R = Rated V_{RM}) 25°C 100°C	I_R*	60 600	μAdc

*2 cells in parallel - MDA920 series
1 cell - MDA930, MDA940, and MDA950 series

MECHANICAL CHARACTERISTICS

CASE: Transfer molded plastic encapsulation.

FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Embossed symbol on 4-lead devices.
Terminal designation by color dots on 3-lead devices:
AC input — yellow
+DC output — red
—DC output — white

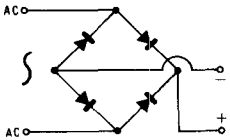
MOUNTING POSITION: Any.

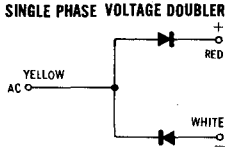
WEIGHT (approx.): 0.4 gram.

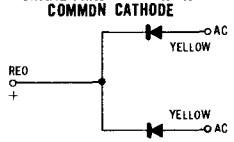
MINIATURE DIODE ASSEMBLIES (continued)

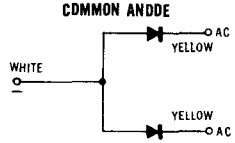
MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

TYPE NO.	SCHEMATIC DIAGRAM	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) V_{RM} Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) V_{in} Volts	DC OUTPUT VOLTAGE Res. Load V_{out} Volts	DC OUTPUT VOLTAGE Cap. Load V_{out} Volts	DC OUTPUT CURRENT @ 75°C AMBIENT I_{out} Amps	PEAK FULL WAVE ONE CYCLE SURGE CURRENT NON-REPETITIVE (SINUSOIDAL 60 cps) $I_{FM(surge)}$ Amps	PEAK FULL WAVE REPETITIVE FORWARD CURRENT (NONSINUSOIDAL 60 cps) $I_{FM(rep)}$ Amps
MDA920-1	A	25	18	15	25	1.0	32.0	5.0
-2		50	35	30	50			
-3		100	70	62	100			
-4		200	140	124	200			
-5		300	210	185	300			
-6		400	280	250	400			
-7		600	420	380	600			
MDA930-1	B	25	9	—	25	0.5	32.0	5.0
-2		50	18	—	50			
-3		100	35	—	100			
-4		200	70	—	200			
-5		300	105	—	300			
-6		400	140	—	400			
-7		600	210	—	600			
MDA940-1	C	25	9	8	13	1.0	32.0	5.0
-2		50	18	15	25			
-3		100	35	30	50			
-4		200	70	62	100			
-5		300	105	92	150			
-6		400	140	125	200			
-7		600	210	190	300			
MDA950-1	D	25	9	8	13	1.0	32.0	5.0
-2		50	18	15	25			
-3		100	35	30	50			
-4		200	70	62	100			
-5		300	105	92	150			
-6		400	140	125	200			
-7		600	210	190	300			

A


B


C


D


MINIATURE DIODE ASSEMBLIES (continued)

FIGURE 1 — TYPICAL FORWARD CHARACTERISTICS

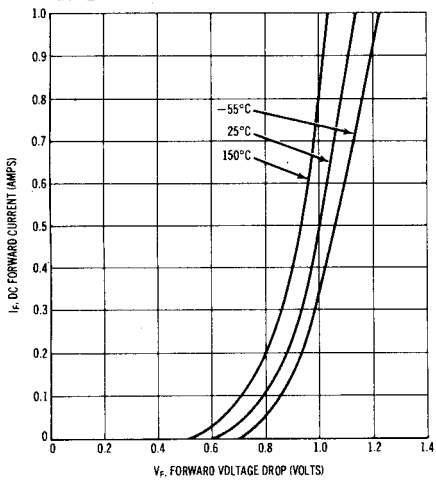


FIGURE 2 — TYPICAL REVERSE CHARACTERISTICS

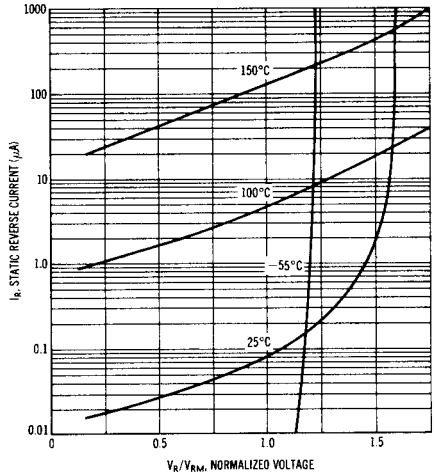


FIGURE 3 — MAX ALLOWABLE SURGE CURRENT

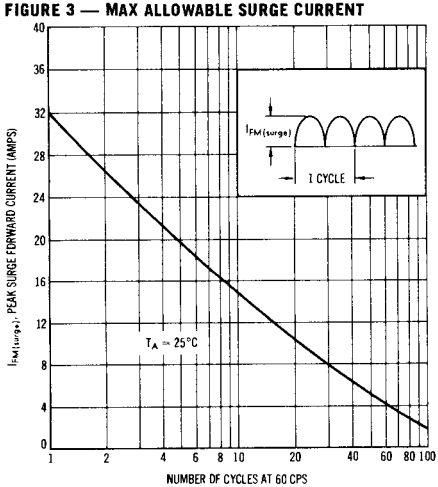
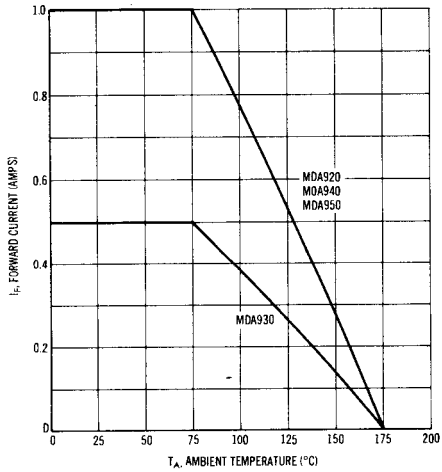


FIGURE 4 — MAX ALLOWABLE DC OUTPUT CURRENT



MOLDED ASSEMBLY RECTIFIER BRIDGES

Single-Phase Full-Wave Bridge

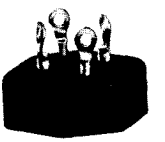
MDA942 SERIES (1.5 AMPS DC)
MDA952 SERIES (6.0 AMPS DC)
MDA962 SERIES (10.0 AMPS DC)
MDA972 SERIES (16.0 AMPS DC)
MDA1491 SERIES (1.5 AMPS DC)
MDA1591 SERIES (4.0 AMPS DC)

Three-Phase Full-Wave Bridge

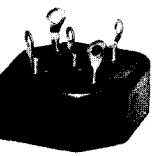
MDA1505 SERIES (8.0 AMPS DC)



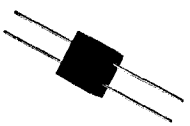
MDA952
CASE 113



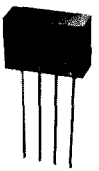
MDA962
CASE 114



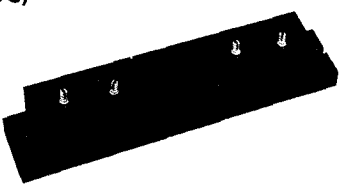
MDA1505
CASE 115



MDA942
CASE 110



MDA942A
CASE 111



MDA972
CASE 116



MDA1491
MDA1591
CASE 112

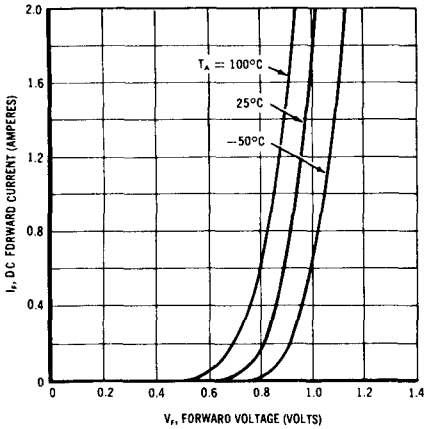
Molded assembly rectifier bridges are individual hermetically sealed rectifiers interconnected and encapsulated in molded assemblies for use as single-phase and three-phase full-wave bridge configurations, with output current from 1.5 to 16 amps, peak reverse voltage from 50 to 600 volts.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

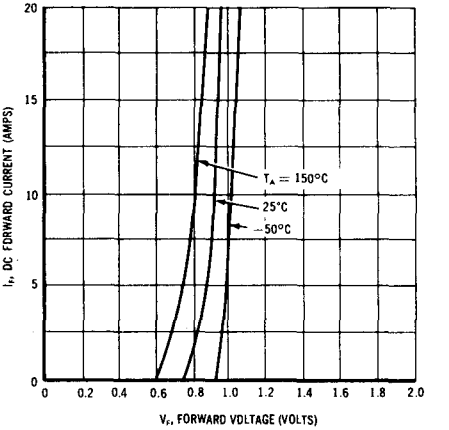
Characteristic		Symbol	Rating	Unit
Maximum Forward Voltage Drop per Cell		V_F		Vdc
(I_F = 0.75 Adc)	MDA942 series		1.1	
(I_F = 3.0 Adc)	MDA952 series		1.0	
(I_F = 5.0 Adc)	MDA962 series		1.0	
(I_F = 5.0 Adc)	MDA972 series		1.0	
(I_F = 0.75 Adc)	MDA1491 series		1.1	
(I_F = 4.0 Adc)	MDA1505 series		1.0	
(I_F = 2.0 Adc)	MDA1591 series		1.0	
Maximum Reverse Current per Cell		I_R		mAdc
(V_R = Rated V_{RM})	MDA942 series		0.01	
	MDA952 series		1.0	
	MDA962 series		1.0	
	MDA972 series		1.0	
	MDA1491 series		0.01	
	MDA1505 series		1.0	
	MDA1591 series		1.0	

RECTIFIER BRIDGES (continued)

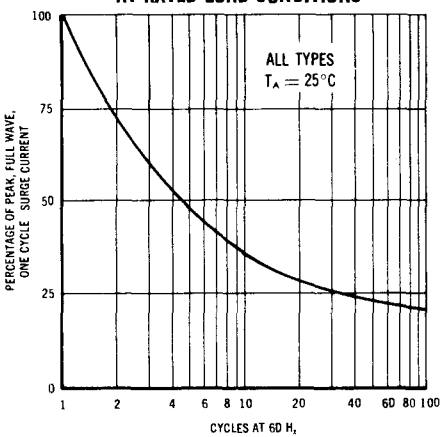
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA942 & MDA1491 SERIES)



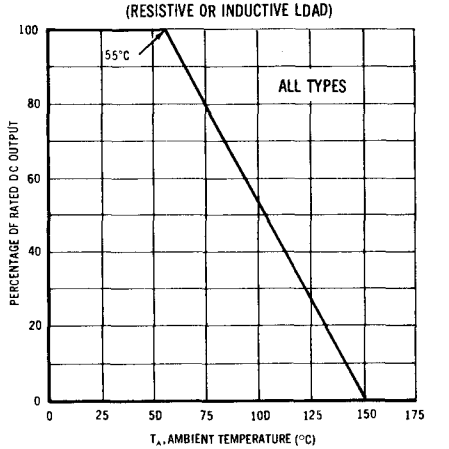
TYPICAL FORWARD CHARACTERISTICS
PER CELL (MDA952, MDA962, MDA972, MDA1505 & MDA1591 SERIES)



MAXIMUM ALLOWABLE FULL WAVE SURGE CURRENT AT RATED LOAD CONDITIONS



MAXIMUM ALLOWABLE DC OUTPUT
(RESISTIVE OR INDUCTIVE LOAD)



MECHANICAL CHARACTERISTICS

CASE: Molded plastic encapsulation, hermetically sealed individual rectifier cells.

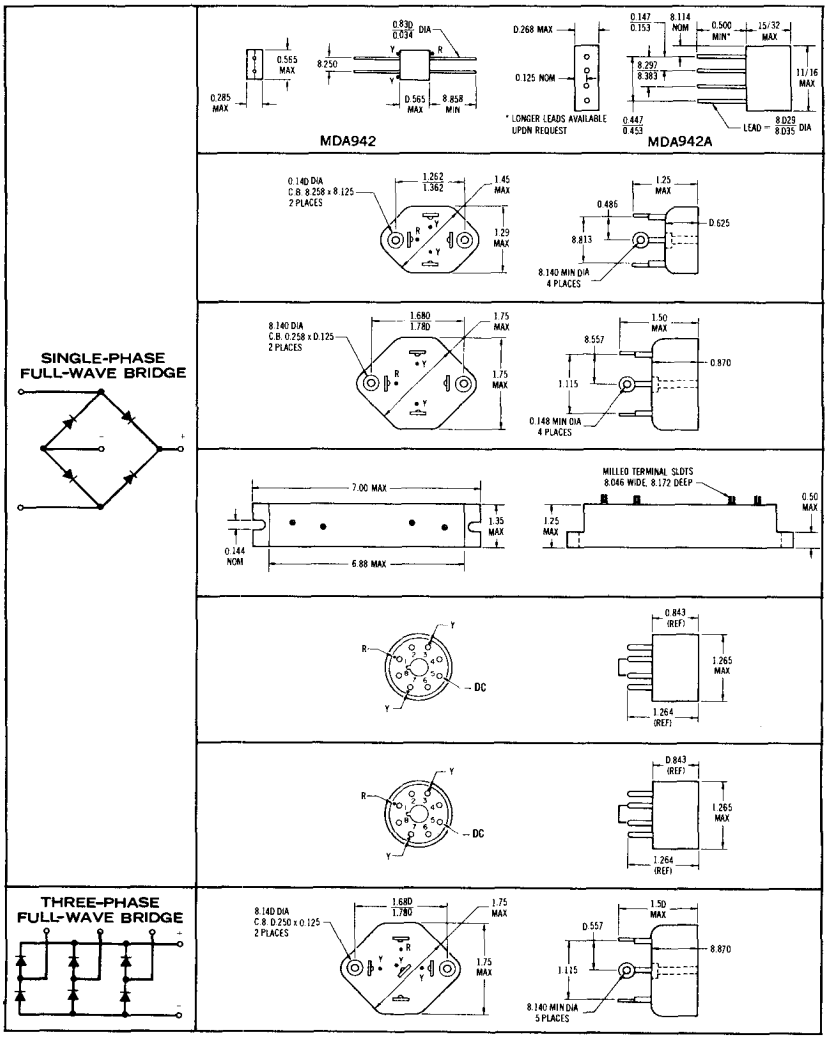
FINISH: All external surfaces are corrosion-resistant, terminals are readily solderable.

POLARITY: Terminal designation by color dots:
AC input — yellow
+DC output — red
−DC output — not marked

MOUNTING POSITION: Any

WEIGHT: (approx.)
MDA942, MDA942A — 3.8 grams
MDA952 — 35 grams
MDA962, MDA1505 — 92 grams
MDA972 — 340 grams
MDA1491 — 33 grams
MDA1591 — 39 grams

RECTIFIER BRIDGES (continued)



RECTIFIER BRIDGES (continued)

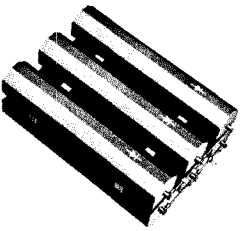
MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

TYPE NO.	PEAK REVERSE VOLTAGE PER CELL (DC or RECURRENT) Volts	SINE WAVE RMS INPUT VOLTAGE (LINE to LINE) Volts	DC OUTPUT VOLTAGE		DC OUTPUT CURRENT @ 55°C AMBIENT Amps	PEAK FULL WAVE ONE CYCLE SURGE CURRENT (60 Hz) Amps	PEAK FULL WAVE RECURRENT FORWARD CURRENT (60 Hz) Amps
			Res. Load Volts	Cap. Load Volts			
MDA942-1	50	35	30	50	1.50	25	6.0
-2	100	70	62	100	1.50	25	6.0
-3	200	140	124	200	1.50	25	6.0
-4	300	210	185	300	1.50	25	6.0
-5	400	280	250	400	1.50	25	6.0
-6	600	420	380	600	1.50	25	6.0
MDA952-1	50	35	30	50	6.00	150	35
-2	100	70	62	100	6.00	150	35
-3	200	140	124	200	6.00	150	35
-4	300	210	185	300	6.00	150	35
-5	400	280	250	400	6.00	150	35
-6	600	420	380	600	6.00	150	35
MDA962-1	50	35	30	50	10.0	250	60
-2	100	70	62	100	10.0	250	60
-3	200	140	124	200	10.0	250	60
-4	300	210	185	300	10.0	250	60
-5	400	280	250	400	10.0	250	60
MDA972-1	50	35	30	50	16.0	250	60
-2	100	70	62	100	16.0	250	60
-3	200	140	124	200	16.0	250	60
-4	300	210	185	300	16.0	250	60
-5	400	280	250	400	16.0	250	60
MDA1491-1	50	35	30	50	1.50	25	6.0
-2	100	70	62	100	1.50	25	6.0
-3	200	140	124	200	1.50	25	6.0
-4	300	210	185	300	1.50	25	6.0
-5	400	280	250	400	1.50	25	6.0
-6	600	420	380	600	1.50	25	6.0
MDA1591 -1	50	35	30	50	4.00	100	25
-2	100	70	62	100	4.00	100	25
-3	200	140	124	200	4.00	100	25
-4	300	210	185	300	4.00	100	25
-5	400	280	250	400	4.00	100	25
-6	600	420	380	600	4.00	100	25
MDA1505 -1	50	35	47	50	8.00	200	45
-2	100	70	95	100	8.00	200	45
-3	200	140	190	200	8.00	200	45
-4	300	210	285	300	8.00	200	45
-5	400	280	380	400	8.00	200	45
-6	600	420	570	600	8.00	200	45

Maximum Operating and Storage Temperature: -65°C to +150°C (All Types)

HIGH VOLTAGE SILICON RECTIFIER MOLDED ASSEMBLIES

MDA1330H
MDA1331H
MDA1332H
MDA1333H



I_O — to 2.5 A
$V_{RM(rep)}$ = 5000 and 10,000 VOLTS



Compensated series-connected rectifier cells for high-voltage single-phase, half-wave circuit applications. Each cell in the series string is shunted by a high-voltage capacitor and resistor for equal voltage distribution.

MAXIMUM RATINGS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Peak Repetitive Reverse Voltage ① (Rated Current, Over Operating Temperature Range)	$V_{RM(rep)}$	5,000	10,000	5,000	10,000	Volts
RMS Reverse Voltage (Rated Current Over the Complete Operating Temperature Range)	V_r	3,500	7,000	3,500	7,000	Volts
DC Blocking Voltage ② (Over Operating Temperature Range)	V_R	3,000	6,000	3,000	6,000	Volts
Average Half Wave Rectified Forward Current (Resistive Load, 180° Conduction Angle, 60cps, Free Convection Cooling) T_A = 40°C	I_O	1.0	1.0	2.5	2.5	Amps
T_A = 100°C		0.3	0.3	0.5	0.5	
Peak 1 Cycle Surge Current (T_A = 40°C, Superimposed on Rated Current at Rated Voltage)	$I_{FM(surge)}$	25	25	250	250	Amps
Operating Frequency Range	← DC to 400 →					eps
Operating and Storage Temperature Range	← -55 to +110 →					°C

① $V_{RM(rep)}$ ratings of 5,000 or 10,000 volts peak are both the maximum repetitive and non-repetitive ratings. Where voltage transient suppresion is employed, these assemblies can be reliably operated at the maximum ratings.

② The DC Blocking Voltage rating (V_R), is established by the continuous power dissipation ratings of the shunting resistors and is not a function of the series rectifiers.

ELECTRICAL CHARACTERISTICS

Rating	Symbol	MDA1330H	MDA1331H	MDA1332H	MDA1333H	Units
Maximum Full-Cycle Average Forward Voltage Drop (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$V_{F(AV)}$	5.0	10.0	5.0	10.0	Volts
Maximum Full-Cycle Average Reverse Current (Half-Wave, Resistive Load, Rated Current and Voltage, T_A=40°C)	$I_{R(AV)}$	0.2	0.2	3.0	3.0	mA

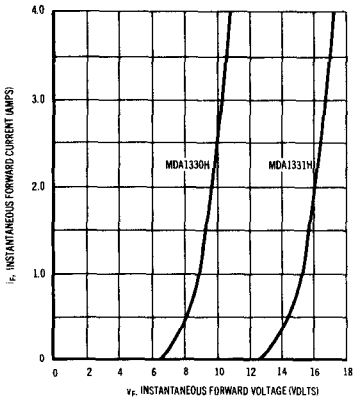
Note: Ambient temperatures are measured at the cold air source point i.e. immediately below the rectifier legs under convection cooling and on the cool air side with forced air cooling.

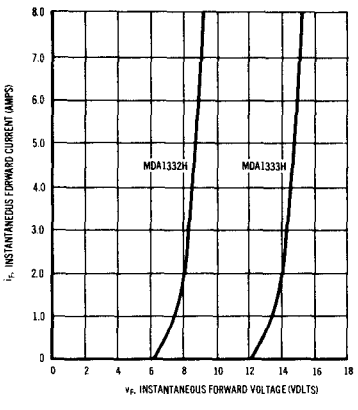
HIGH VOLTAGE SILICON RECTIFIERS (continued)

ELECTRICAL DESIGN NOTES

1. For single-phase full-wave circuits using "Series 1300" stacks, multiply the current ratings given for the half-wave by two.
2. For three-phase full-wave and half-wave circuits, multiply given current ratings for single-phase half-wave by two and one half.
3. For capacitive loads, sufficient surge and capacitor inrush current protection must be employed. Recurrent peak currents up to six times the single-phase average output current ratings can be safely sustained when the average value of these peaks are held at or below the rated average output. Non-repetitive peak currents must be held to the maximum surge ratings.

TYPICAL FORWARD CHARACTERISTICS
($T_J = 25°C$)

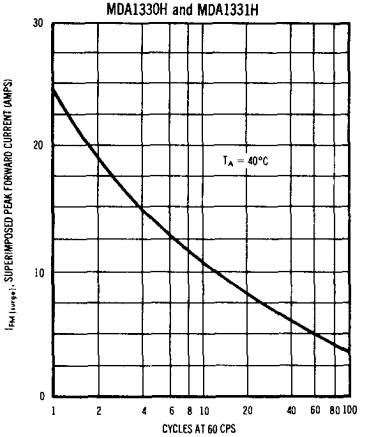




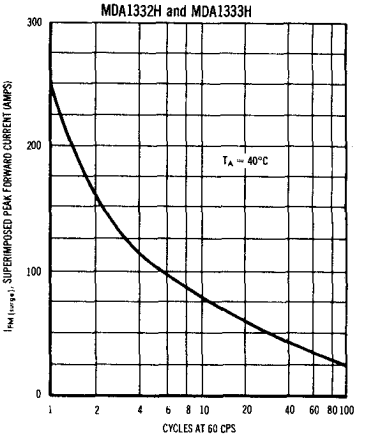
HIGH VOLTAGE SILICON RECTIFIERS (continued)

MAXIMUM SURGE CURRENT
RATED CONDITIONS

MDA1330H and MDA1331H

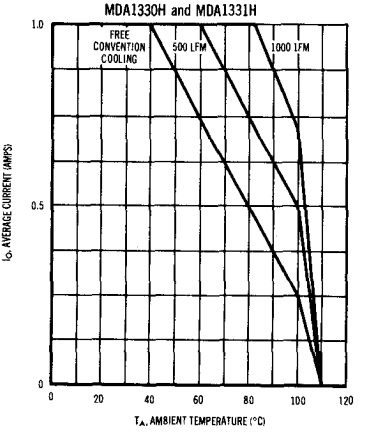


MDA1332H and MDA1333H

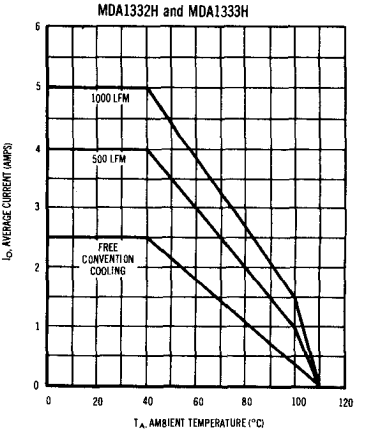


MAXIMUM AVERAGE HALF-WAVE RECTIFIED CURRENT
(RESISTIVE OR INDUCTIVE LOAD, 180° CONDUCTION ANGLE, 60 CPS)

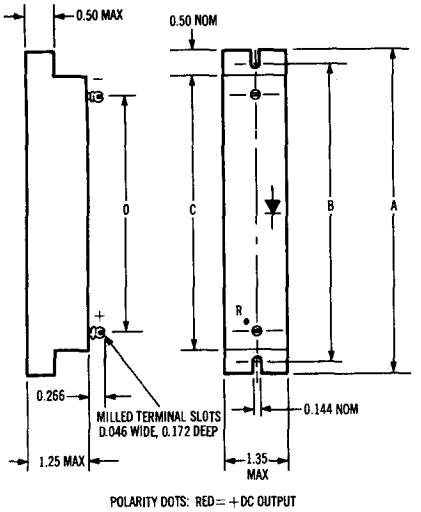
MDA1330H and MDA1331H



MDA1332H and MDA1333H



MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1330H AND MDA1331H RECTIFIER LEGS.

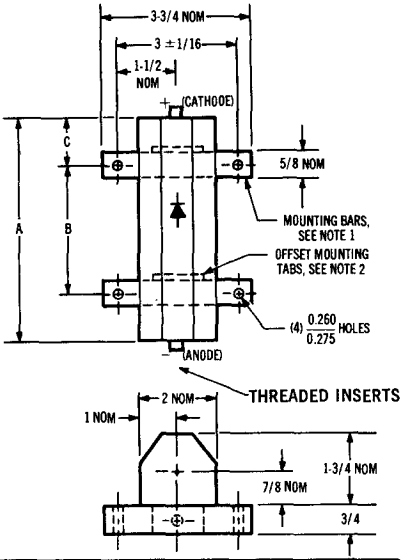


POLARITY DOTS: RED = + DC OUTPUT

Device	A Dim	B Dim	C Dim	D Dim
MDA1330H	4.25max	3.70±0.05	3.25max	3.00nom
MDA1331H	7.00max	6.39±0.05	6.00max	5.25nom

NOTES: These basic rectifier legs are suitable for chassis mounting and connection into multiple leg circuits. Center tapped versions of the MDA1330H and MDA1331H are also available for use in lower voltage, Center tapped and Voltage Doubler applications. The center tapped versions of the MDA1330H and MDA1331H are designated by a different suffix letter as follows: instead of "H" specify
"C" for common cathode, center tap
"U" for common anode, center tap
"D" for voltage doubler.

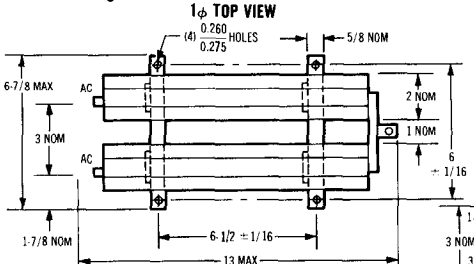
MECHANICAL DESIGN INFORMATION AND OUTLINE DIMENSIONS FOR THE BASIC MDA1332H AND MDA1333H RECTIFIER LEGS.

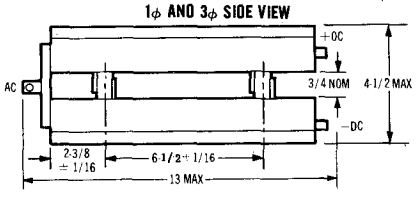


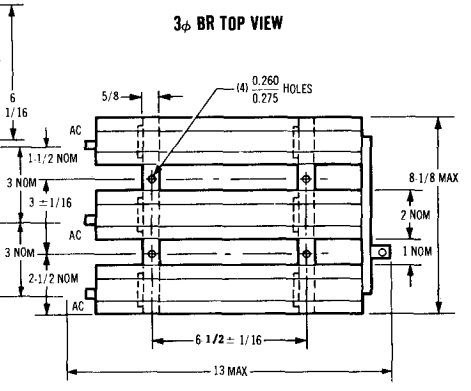
Device	A Dim	B Dim	C Dim
MDA1332H	5-5/8 nom	3-1/4 1/16	1-1/8 nom
MDA1333H	11-1/4 nom	6-1/2±1/16	2-3/8 nom

NOTE 1. Insulated mounting bars are supplied with all Series 1300 stacks and the single unit bar is shown above. For multiple leg circuits, mounting bars are available in lengths suitable for 2 or 3 legs mounted side by side. In addition, the mounting arrangement used is also suitable for mounting legs top and bottom on the same bar with stand-offs employed for support of the assembly.

NOTE 2. Offset mounting taps are used to provide more compact multiple leg assemblies. When top & bottom or side by side mounting is employed, reverse polarity legs are often required in some circuits. Legs of reverse polarity to that shown above are designated by an "R" suffix, i.e. MDA1332HR.







ADDITIONS AND MODIFICATIONS

THYRISTORS

Including

SILICON CONTROLLED RECTIFIERS

4-LAYER DIODES

BILATERAL TRIGGER FOR THYRISTORS

THYRISTORS AND TRIGGERS

Thyristors are defined as semiconductor devices with four or more alternately doped semiconductor layers. This category includes such classifications as SCRs, Four-Layer Diodes and other switchback devices used primarily for power control and trigger applications.

Another device that falls into this applications category is the Three-Layer Trigger Diode. This device is included in this section for convenience, though not a Thyristor by definition.

All devices characterized in this section are SCRs, with the following exceptions:

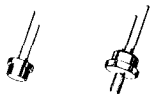
FOUR-LAYER DIODES	TYPE NO.	PAGE NO.
	M4L2052	5-44
	M4L2053	5-44
	M4L2054	5-44
	M4L3052	5-46
	M4L3053	5-46
	M4L3054	5-46

THREE-LAYER DIODE	TYPE NO.	PAGE NO.
	MT32	5-49

THYRISTOR QUICK SELECTION

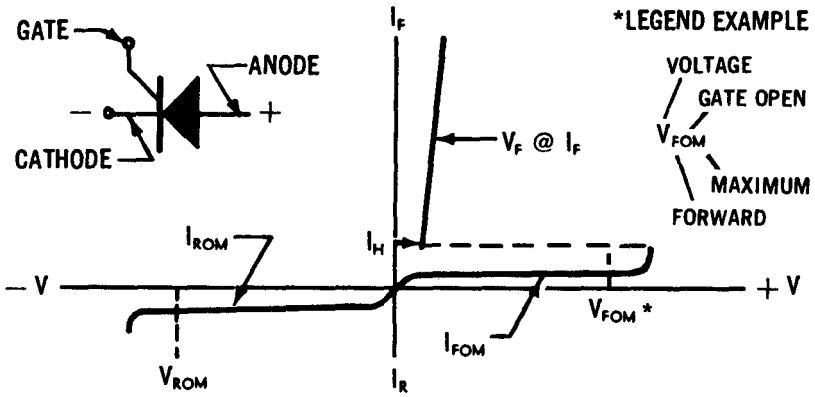
BLOCKING VOLTAGE (DC OR PEAK) VOLTS	FORWARD CURRENT RMS (AMPS)								
	1.6	2	8						16
									
	TO-5 CASE 31A	7/16" STUD CASE 63	STEEL CAN AND VARIATIONS (SOLDER MOUNT, STUD MOUNT, AND LEAD MOUNT TYPES) CASE 85	CASE 85L	CASE 86	CASE 86L	CASE 87L	CASE 88L	TO-48 CASE 64
25	MCR914-1	MCR846-1	2N4151	2N4159	2N4167	2N4175	2N4183	2N4191	2N1842 2N1842A
50	2N1595	MCR846-2	2N4152	2N4160	2N4168	2N4176	2N4184	2N4192	2N1843 2N1843A
100	2N1596	MCR846-3	2N4153	2N4161	2N4169	2N4177	2N4185	2N4193	2N1844 2N1844A
150									2N1845 2N1845A
200	2N1597	MCR846-4	2N4154	2N4162	2N4170	2N4178	2N4186	2N4194	2N1846 2N1846A
250									2N1847 2N1847A
300	2N1598		2N4155	2N4163	2N4171	2N4179	2N4187	2N4175	2N1848 2N1848A
400	2N1599		2N4156	2N4164	2N4172	2N4180	2N4188	2N4196	2N1849 2N1849A
500			2N4157	2N4165	2N4173	2N4181	2N4189	2N4197	2N1850 2N1850A
600			2N4158	2N4166	2N4174	2N4182	2N4190	2N4198	
700									
800									

GUIDE (SCR TYPES) PREFERRED TYPES

FORWARD CURRENT RMS (AMPS)					AMPS PEAK PULSE MODULATORS		BLOCKING VOLTAGE (DC OR PEAK) VOLTS
18		20	25		100	1000	
							
PRESS FIT PRESS FIT STUD CASE 62	CASE 68	TO-41 CASE 61	TO-48 CASE 64	TO-41 CASE 61	7/16" STUD CASE 63	TO-48 CASE 64	
MCR808-1	MCR1308-1	MCR649-1	2N681 MCR1907-1*	2N2573			25
MCR808-2	MCR1308-2	MCR649-2	2N682 MCR1907-2*	2N2574			50
MCR808-3	MCR1308-3	MCR649-3	2N683 MCR1907-3*	2N2575			100
			2N684				150
MCR808-4	MCR1308-4	MCR849-4	2N685 MCR1907-4*	2N2576			200
			2N686				250
MCR808-5	MCR1308-5	MCR649-5	2N687 MCR1907-5*	2N2577	2N4199 MCR729-5	MCR1718-5	300
MCR808-6	MCR1308-6	MCR649-6	2N688 MCR1907-6*	2N2578	2N4200 MCR729-6	MCR1718-6	400
		MCR649-7	2N689	2N2579	2N4201 MCR729-7	MCR1718-7	500
					2N4202 MCR729-8	MCR1718-8	600
					2N4203 MCR729-9		700
					2N4204 MCR729-10		800

*Fast turnoff types, $t_{off} \leq 12\ \mu sec$

SCR SYMBOLS AND DEFINITIONS



The following list represents the symbols and definitions of electrical characteristics and maximum ratings for Thyristors (SCRs).

These symbols are listed in sequence as they appear in the Maximum Ratings tables:

$V_{ROM(rep)}$	PEAK REVERSE BLOCKING VOLTAGE, GATE OPEN - The maximum allowable value of reverse voltage (repetitive or continuous dc) which can be applied between anode and cathode (anode negative) with lhe gate open for stated conditions.
V_{RXM}	PEAK REVERSE BLOCKING VOLTAGE - Same as V_{ROM} except that the gate terminal is returned to the cathode through a stated impedance and/or bias voltage.
$V_{ROM(non-rep)}$	NON-REPETITIVE PEAK REVERSE BLOCKING VOLTAGE - The maximum value of reverse voltage which can be applied between anode and cathode (anode negative) under transient conditions (5 ms or less) with the gate open.
I_f	FORWARD CURRENT, RMS - The RMS value of forward anode current during the "on" state. RMS value is the same for all conduction angles.
$I_{FM(pulse)}$	REPETITIVE PULSE CURRENT - Repetitive peak forward anode current after application of gate signal for specified pulse conditions. (Used primarily with pulse modulator type thyristors.)
di/dt	CURRENT APPLICATION RATE - Rate of change with time of forward anode current during turn-on of device under stated conditions.
I^2t	CIRCUIT FUSING CONSIDERATIONS - A measure of the maximum non-recurrent RMS forward current capacity for pulse durations less than 8.3 milliseconds. I is in RMS amperes, and t is pulse duration in seconds. The same conditions as listed for $I_{FM(surge)}$ apply.
$I_{FM(surge)}$	PEAK FORWARD SURGE CURRENT - The maximum forward current having a single forward cycle (8.3 milliseconds duration) in a 60 Hz single-phase resistive load system. The surge may be preceded and followed by maximum rated voltage, current, and junction temperature conditions, and maximum allowable gate power may be concurrently dissipated. However, limitations on anode current during turn-on should not be exceeded.
$P_{F(AV)}$	AVERAGE FORWARD POWER - Average (dc equivalent) value of power dissipation between anode and cathode. (Used primarily with pulse modulator type thyristors.)
P_{GFM}	PEAK GATE POWER - The maximum instantaneous value of gate power dissipation permitted.

SCR SYMBOLS AND DEFINITIONS (continued)

$P_{GF(AV)}$ AVERAGE FORWARD GATE POWER - The value of maximum allowable gate power dissipation averaged over a full cycle.

I_{GFM} PEAK FORWARD GATE CURRENT - The maximum instantaneous value of current which may flow between gate and cathode.

V_{GFM} PEAK FORWARD GATE VOLTAGE - The maximum instantaneous voltage between the gate terminal and the cathode terminal resulting from the flow of forward gate current.

V_{GRM} PEAK REVERSE GATE VOLTAGE - The maximum instantaneous voltage which may be applied between the gate terminal and the cathode terminal when the junction between the gate region and the adjacent cathode region is reverse biased.

T_C CASE TEMPERATURE - Temperature of case measured at convenient reference point on case near location of silicon die. Under operating conditions, T_C is lower than T_J.

T_J OPERATING JUNCTION TEMPERATURE RANGE - Allowable operating junction temperature range in which device may operate effectively.

T_{stg} STORAGE TEMPERATURE RANGE - Allowable range of temperature in which devices may be "stored" (non-operating).

These symbols are listed in sequence as they appear in the Electrical Characteristics tables:

V_{FOM} PEAK FORWARD BLOCKING VOLTAGE, GATE OPEN - The peak repetitive forward voltage which may be applied to the thyristor between anode and cathode (anode positive) with the gate open at stated conditions.

V_{FXM} PEAK FORWARD BLOCKING VOLTAGE - Same as V_{FOM} except that the gate terminal is returned to the cathode through a stated impedance and/or bias voltage.

I_{FOM} PEAK FORWARD BLOCKING CURRENT, GATE OPEN - The maximum current through the thyristor when the device is in the "off" state for a stated anode-to-cathode voltage (anode positive) and junction temperature with the gate open.

I_{FXM} PEAK FORWARD BLOCKING CURRENT - Same as I_{FOM} except that the gate terminal is returned to the cathode through a stated impedance and/or bias voltage.

I_{ROM} PEAK REVERSE BLOCKING CURRENT - The maximum current through the thyristor when the device is in the reverse blocking state (anode negative) for a stated anode-to-cathode voltage and junction temperature with the gate open.

I_{RXM} PEAK REVERSE BLOCKING CURRENT - Same as I_{ROM} except that the gate terminal is returned to the cathode through a stated impedance and/or bias voltage.

I_{GT} GATE TRIGGER CURRENT (Continuous dc) - The minimum dc gate current required to cause switching from the "off" state to the "on" state at a stated condition.

V_{GT} GATE TRIGGER VOLTAGE (Continuous dc) - The dc voltage between the gate and the cathode required to produce the dc gate trigger current.

I_{HO} HOLDING CURRENT - That value of forward anode current below which the controlled rectifier switches from the conducting state to the forward blocking condition with the gate open, at stated conditions.

I_{HX} HOLDING CURRENT (Gate connected) - That value of forward anode current below which the controlled rectifier switches from the conducting state to the forward blocking condition with the gate terminal returned to the cathode terminal thru specified impedance and/or bias voltage.

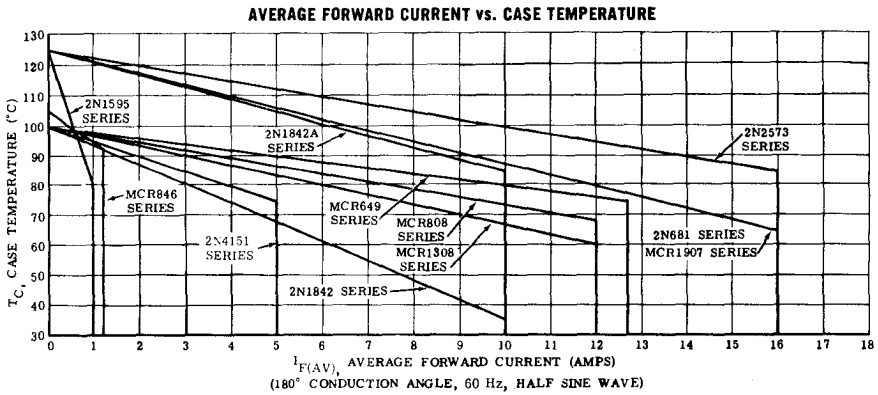
V_F FORWARD "ON" VOLTAGE - The voltage measured between anode and cathode during the "on" condition for specified conditions of anode current and temperature.

$V_{F(on)}$ DYNAMIC FORWARD "ON" VOLTAGE - The voltage measured between anode and cathode at a specified time after turn-on function has been initiated at stated conditions.

SCR SYMBOLS AND DEFINITIONS (continued)

t_{on}	TURN-ON TIME - The time interval between initiation of gate signal and 90% point of leading edge of forward anode current waveform.
Δt_{on}	TURN-ON TIME VARIATION - Variation of turn-on time over stated temperature range or ranges.
t_r	RISE TIME - Time interval required for the leading edge of the forward anode current waveform to rise from 10% to 90% of its maximum value during device turn-on.
t_{off}	TURN-OFF TIME - The time interval required for the gate to regain control of forward blocking characteristics after interruption of forward anode current.
t_d	DELAY TIME - Time interval during turn-on between initiation of gate pulse and a rise of the leading edge of the forward-current waveform to 10% of its maximum value.
dv/dt	FORWARD VOLTAGE APPLICATION RATE (V/μs) - A rate of applied forward voltage in excess of this value may cause premature, nondestructive turn-on of the Thyristor.
θ_{JC}	THERMAL RESISTANCE (Junction to case) - The temperature rise per unit of power dissipation of a junction above the temperature of the case under conditions of thermal equilibrium.
θ_{CA}	THERMAL RESISTANCE (Case to ambient) - The temperature rise per unit of power dissipation of the device case above the ambient temperature at stated conditions.

SIMPLIFIED SCR QUICK SELECTION GUIDE



2N681 thru 2N689

I_f = 25 A RMS
$V_{ROM(rep)}$ = 25-500 V



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 25 amperes at junction temperatures up to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic		Symbol	Rating	Units
Peak Reverse Blocking Voltage* †		$V_{ROM(rep)}$*†		Volts
	2N681		25	
	2N682		50	
	2N683		100	
	2N684		150	
	2N685		200	
	2N686		250	
	2N687		300	
	2N688		400	
	2N689		500	
Peak Reverse Blocking Voltage* (Transient) (non-recurrent t = 5 ms max.)		$V_{ROM(non-rep)}$*		Volts
	2N681		35	
	2N682		75	
	2N683		150	
	2N684		225	
	2N685		300	
	2N686		350	
	2N687		400	
	2N688		500	
	2N689		600	
Forward Current RMS (all conduction angles)		I_f	25	Amps
Peak Forward Surge Current (One cycle, 60 Hz, T_J = -65 to +125°C)		$I_{FM(surge)}$	200	Amps
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)		I^2t	165	A^2s
Peak Gate Power-Forward		P_{GFM}	5.0	Watts
Average Gate Power-Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current-Forward		I_{GFM}	2.0	Amps
Peak Gate Voltage-Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-65 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Stud Torque		—	30	in.-lb.

†V_{ROM} for all types can be applied on a continuous dc basis without incurring change.

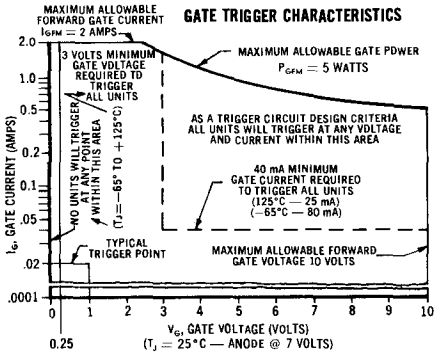
* $V_{ROM(rep)}$ ratings apply for zero or negative gate voltage.

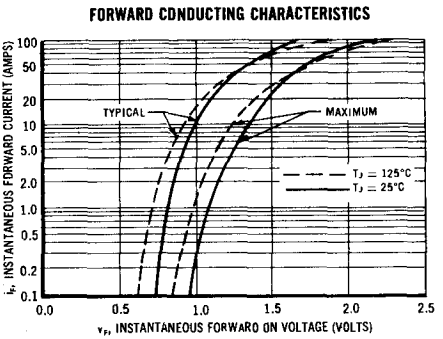
2N681 thru 2N689 (continued)

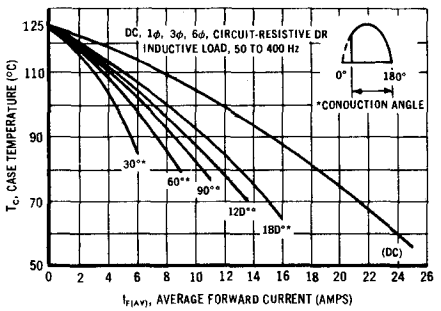
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

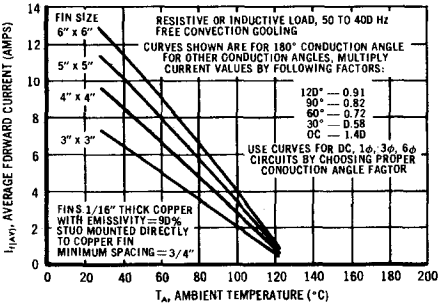
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 125°C)	2N681	V_{FOM}	25	—	—	Volts
	2N682		50	—	—	
	2N683		100	—	—	
	2N684		150	—	—	
	2N685		200	—	—	
	2N686		250	—	—	
	2N687		300	—	—	
	2N688		400	—	—	
	2N689		500	—	—	
Peak Forward or Reverse Blocking Current (T_J = 125°C)	2N681 - 2N684	I_{FOM} I_{ROM}	—	—	10.0	mA
	2N685		—	—	10.0	
	2N686		—	—	10.0	
	2N687		—	—	10.0	
	2N688		—	—	8.0	
	2N689		—	—	6.0	
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	10	25	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	0.25	—	3.0	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 20 Adc)		V_F	—	1.1	1.5	Volts
Turn-On Time (I_F = 10A, I_G = 200 mA)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A; I_R = 10 A, dv/dt = 30 V/μs min, T_J = 125°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

2N681 thru 2N689 (continued)









2N1595 thru 2N1599

I_f = 1.6 A RMS
$V_{ROM(rep)}$ = 50-400 V



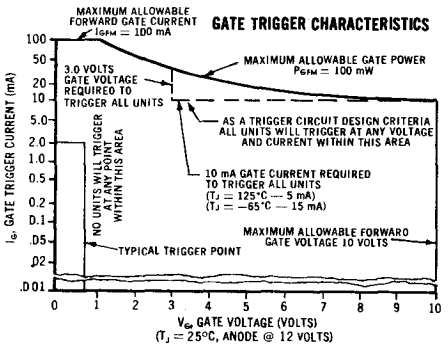
CASE 31A
(TO-5)

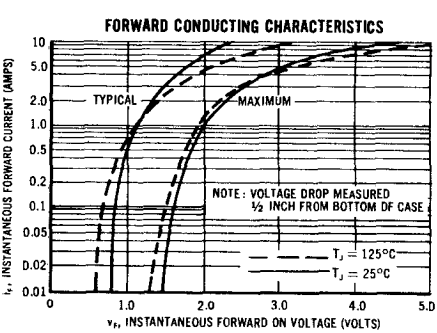
Industrial-type, low-current silicon controlled rectifiers in a three-lead package ideal for printed-circuit applications. Current handling capability of 1.6 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage* 2N1595 2N1596 2N1597 2N1598 2N1599	$V_{ROM(rep)}$*	50 100 200 300 400	Volts
Forward Current RMS (All Conduction Angles)	I_f	1.6	Amps
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	15	Amps
Peak Gate Power - Forward	P_{GFM}	0.1	Watt
Average Gate Power - Forward	$P_{GF(AV)}$	0.01	Watt
Peak Gate Current - Forward	I_{GFM}	0.1	Amp
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.





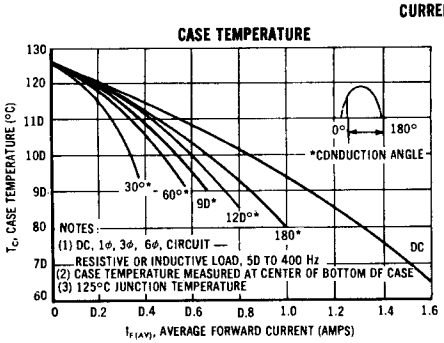
2N1595 thru 2N1599 (continued)

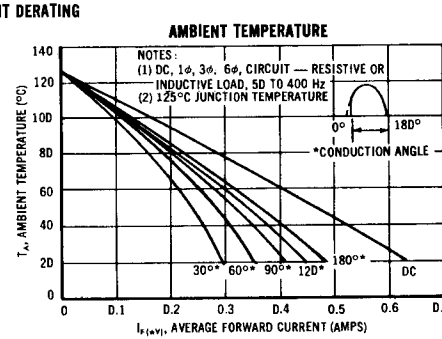
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C)	2N1595	V_{FOM}*	50	—	—	Volts
	2N1596		100	—	—	
	2N1597		200	—	—	
	2N1598		300	—	—	
	2N1599		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)		I_{FOM}	—	—	1.0	mA
Peak Reverse Blocking Current (Rated V_{ROM}, T_J = 125°C)		I_{ROM}	—	—	1.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 12 Ω)		I_{GT}	—	2.0	10.0	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 12 Ω)		V_{GT}	—	0.7	3.0	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 12Ω, T_J = 125°C)		V_{GNT}	0.2	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	5.0	—	mA
Forward On Voltage (I_F = 1 Adc)		V_F	—	1.1	2.0	Volts
Turn-On Time (t_d + t_r) (I_G = 10 mA, I_F = 1A)		t_{on}	—	0.8	—	μs
Turn-Off Time (I_F = 1 A, I_R = 1 A, dv/dt = 20 V/μs, T_J = 125°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	10	—	μs

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

CURRENT DERATING





2N1842 thru 2N1850

I_f = 16 A RMS
$V_{ROM(rep)}$ = 25-500 V



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 100°C.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Characteristic		Symbol	Rating	Units
Peak Reverse Blocking Voltage*		$V_{ROM(rep)}$*		Volts
	2N1842		25	
	2N1843		50	
	2N1844		100	
	2N1845		150	
	2N1846		200	
	2N1847		250	
	2N1848		300	
	2N1849		400	
	2N1850		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)		$V_{ROM(non-rep)}$		Volts
	2N1842		35	
	2N1843		75	
	2N1844		150	
	2N1845		225	
	2N1846		300	
	2N1847		350	
	2N1848		400	
	2N1849		500	
	2N1850		600	
Forward Current RMS (All Conduction Angles)		I_f	16	Amps
Circuit Fusing Considerations (T_J = -40 to +100°C, t ≦ 8.3 ms)		I^2t	60	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)		$I_{FM(surge)}$	125	Amps
Peak Gate Power - Forward		P_{GFM}	5.0	Watts
Average Gate Power Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward		I_{FGM}	2.0	Amps
Peak Gate Voltage - Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-40 to +100	°C
Storage Temperature Range		T_{stg}	-40 to +125	°C
Stud Torque		—	30	in.-lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

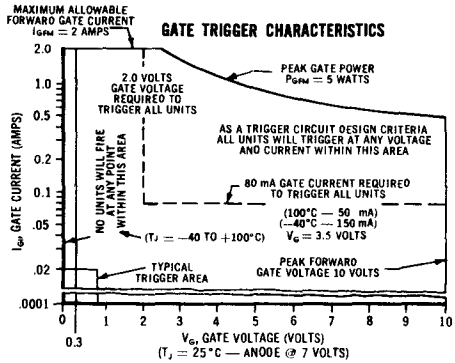
2N1842 thru 2N1850 (continued)

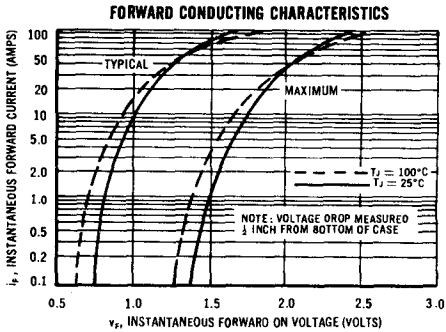
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

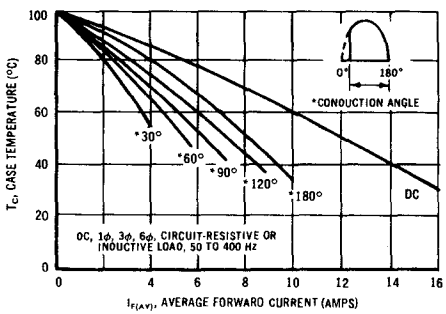
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 100°C)	2N1842	V_{FOM}*	25	—	—	Volts
	2N1843		50	—	—	
	2N1844		100	—	—	
	2N1845		150	—	—	
	2N1846		200	—	—	
	2N1847		250	—	—	
	2N1848		300	—	—	
	2N1849		400	—	—	
	2N1850		500	—	—	
Peak Forward or Reverse Blocking Current (Rated V_{FOM} or V_{ROM} gate open, T_J = 100°C)		I_{FOM}, I_{ROM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	—	0.8	2.0	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 100°C)		V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 16 Adc)		V_F	—	1.1	1.8	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10 A)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A; dv/dt = 20 V/μs, T_J = 100°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, T_J = 100°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

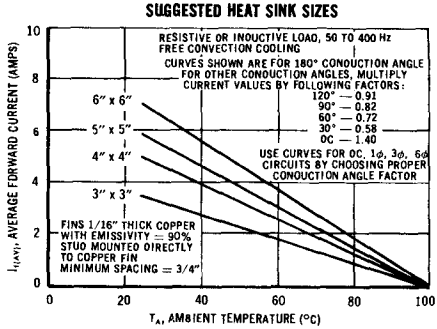
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative voltage.

2N1842 thru 2N1850 (continued)









2N1842A thru 2N1850A

I_f = 16 A RMS
$V_{ROM(rep)}$ = 25-500 V



CASE 64
(TO-48)

Industrial-type, silicon controlled rectifiers in a stud package with current handling capability to 16 amperes at junction temperatures to 125°C.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic		Symbol	Rating	Units
Peak Reverse Blocking Voltage*		$V_{ROM(rep)}$*		Volts
	2N1842A		25	
	2N1843A		50	
	2N1844A		100	
	2N1845A		150	
	2N1846A		200	
	2N1847A		250	
	2N1848A		300	
	2N1849A		400	
	2N1850A		500	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms max.)		$V_{ROM(non-rep)}$		Volts
	2N1842A		35	
	2N1843A		75	
	2N1844A		150	
	2N1845A		225	
	2N1846A		300	
	2N1847A		350	
	2N1848A		400	
	2N1849A		500	
	2N1850A		600	
Forward Current RMS		I_f	16	Amps
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)		$I_{FM(surge)}$	125	Amps
Circuit Fusing Considerations (T_J = -65 to +125°C, t ≦ 8.3 ms)		I^2t	60	A^2s
Peak Gate Power - Forward		P_{GFM}	5.0	Watts
Average Gate Power - Forward		$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward		I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward		V_{GFM}	10	Volts
Reverse		V_{GRM}	5.0	
Operating Junction Temperature Range		T_J	-65 to +125	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Stud Torque		—	30	in.-lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

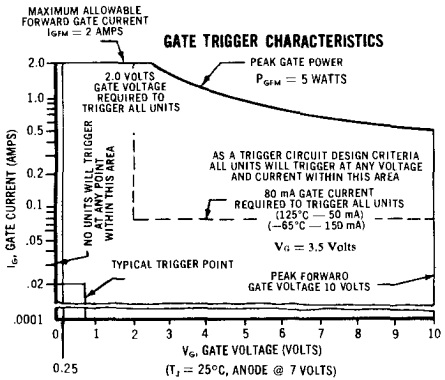
2N1842 A thru 2N1850A (continued)

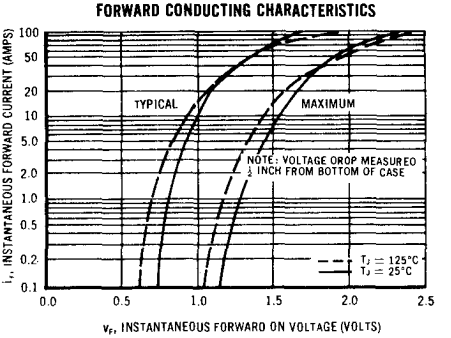
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

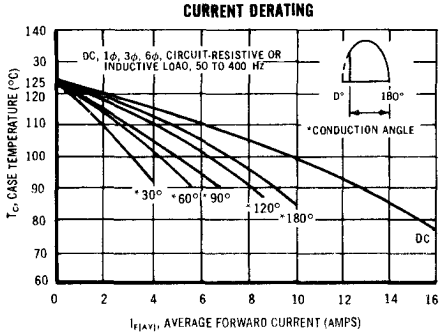
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C)	2N1842A	V_{FOM}*	25	—	—	Volts
	2N1843A		50	—	—	
	2N1844A		100	—	—	
	2N1845A		150	—	—	
	2N1846A		200	—	—	
	2N1847A		250	—	—	
	2N1848A		300	—	—	
	2N1849A		400	—	—	
	2N1850A		500	—	—	
Peak Forward or Reverse Blocking Current (V_{FOM}, OR V_{ROM}, gate open, T_J = 125°C)		I_{FOM}, I_{ROM}	—	—	6.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)		I_{GT}	—	15	80	mA
Gate Trigger Voltage (Anode Voltage = 7 Vdc, R_L = 50 Ω)		V_{GT}	—	0.8	2.0	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50 Ω, T_J = 125°C)		V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 16 Adc)		V_F	—	1.1	1.6	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10 A)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 125°C)		t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	2.0	°C/W

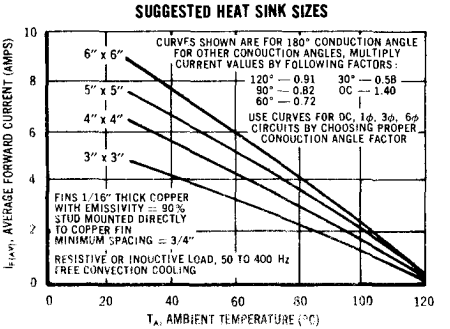
*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.
Ratings apply for zero or negative gate voltage.

2N1842A thru 2N1850A (continued)



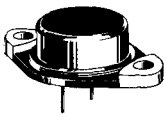






2N2573 thru 2N2579

I_f = 25 A RMS
$V_{ROM(rep)}$ = 25-500 V



Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance.

CASE 61 (TO-41) **CASE 54** (TO-3)

For units with pins (TO-3) specify devices MCR649AP-1(2N2573) thru MCR649AP-7(2N2579).

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
2N2573		25	
2N2574		50	
2N2575		100	
2N2576		200	
2N2577		300	
2N2578		400	
2N2579		500	
Forward Current RMS (all conduction angles)	I_f	25	Amps
Circuit Fusing Considerations (T_J = -65° to +125°C, t ≤ 8.3 ms)	I^2t	275	A^2s
Peak Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	260	Amps
Peak Gate Power - Forward	P_{GFM}	5	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage. V_{ROM} ratings apply for zero or negative gate voltage.

2N2573 thru 2N2579 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

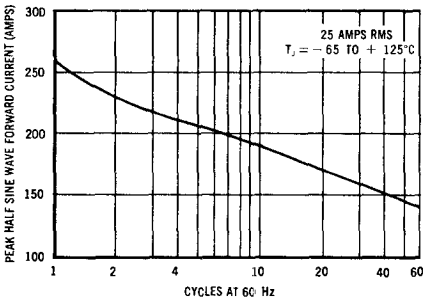
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C)	2N2573	V_{FOM}*	25	—	—	Volts
	2N2574		50	—	—	
	2N2575		100	—	—	
	2N2576		200	—	—	
	2N2577		300	—	—	
	2N2578		400	—	—	
	2N2579		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)		I_{FOM}	—	0.6	5.0	mA
Peak Reverse Blocking Current (Rated V_{ROM}, T_J = 125°C)		I_{ROM}	—	0.6	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)		I_{GT}	—	20	40	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 Ω)		V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 100Ω, T_J = 125°C)		V_{GNT}	0.3	—	3.5	
Forward On Voltage (I_F = 20 Adc)		V_F	—	1.1	1.4	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)		I_{HO}	—	20	—	mA
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10A)		t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 125°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)		t_{off}	—	30	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)		dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case)		θ_{JC}	—	1.0	1.5	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

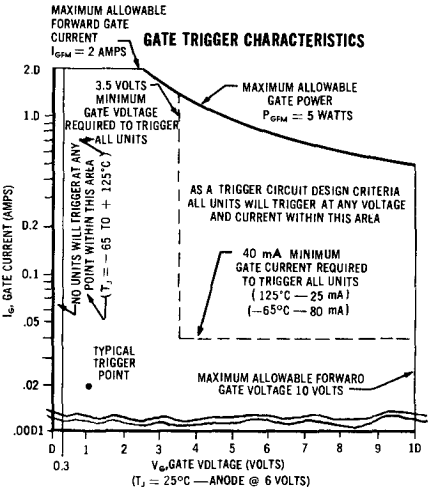
V_{FOM} ratings apply for zero or negative gate voltage.

2N2573 thru 2N2579 (continued)

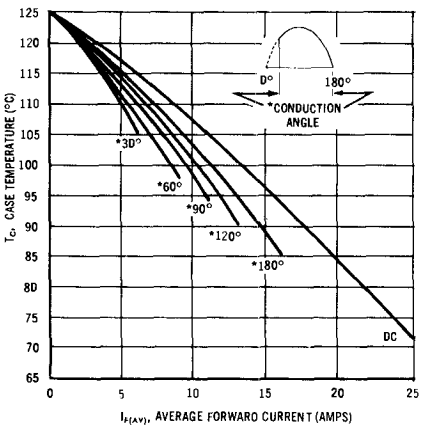
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



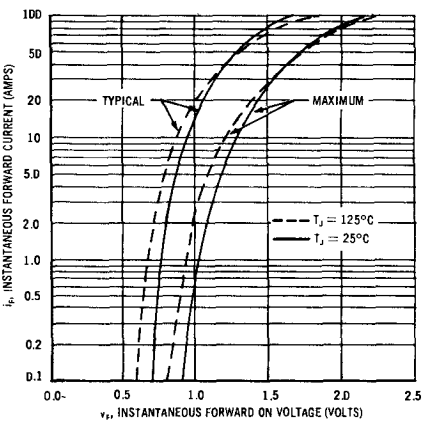
GATE TRIGGER CHARACTERISTICS



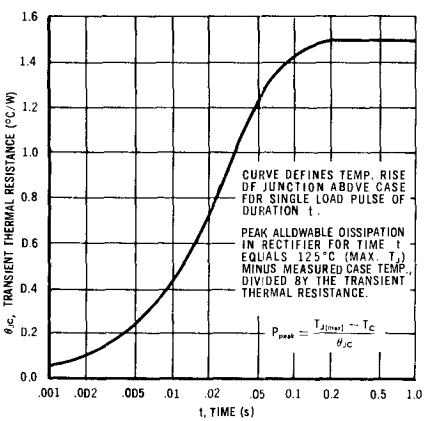
MAXIMUM ALLOWABLE CASE TEMPERATURE



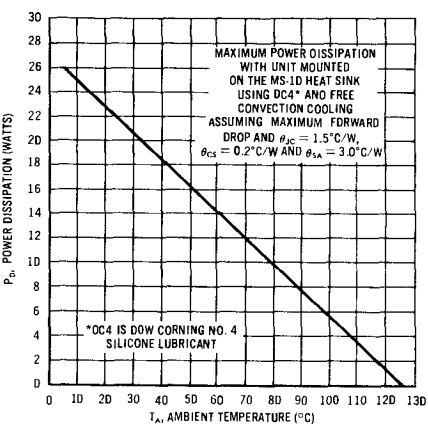
LOW CURRENT LEVEL



MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE

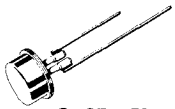


2N4151 thru 2N4198
(MCR2304, 2305, 2604, 2605)

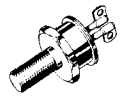
I_f = 8 A RMS
$V_{ROM(rep)}$ = 25-600 V



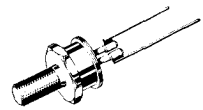
CASE 85
2N4151-58
(MCR2304 series)



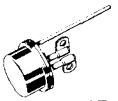
CASE 85L
2N4159-66
(MCR2304L series)



CASE 86
2N4167-74
(MCR2305 series)



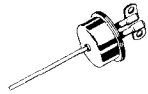
CASE 86L
2N4175-82
(MCR2305L series)



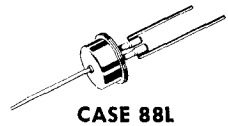
CASE 87
(MCR2604 series)



CASE 87L
2N4183-90
(MCR2604L series)



CASE 88
(MCR2605 series)



CASE 88L
2N4191-98
(MCR2605L series)

Silicon controlled rectifiers for applications requiring current up to 8 amperes with blocking voltages up to 400 volts. Available in a variety of economical packages for mounting versatility. Other types available upon special request.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage* MCR2304 -1	$V_{ROM(rep)}$	20	Volts
MCR2304 -2		50	
MCR2304 -3		100	
MCR2305 -4		200	
MCR2305 -5		300	
MCR2604 -6		400	
MCR2605 -7		500	
MCR2605 -8		600	
Forward Current RMS (All Conduction Angles)	I_f	8	Amps
Circuit Fusing Considerations (T_J = -40 +100°C; t ≤ 8.3 ms)	I^2t		A^2s
Forward Polarity		40	
Reverse Polarity		25	
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$		Amps
Forward Polarity		100	
Reverse Polarity		80	
Peak Gate Power - Forward	P_{GFM}	5	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque (MCR2305 Types)	—	15	in.-lb.

2N4151 thru 2N4198 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

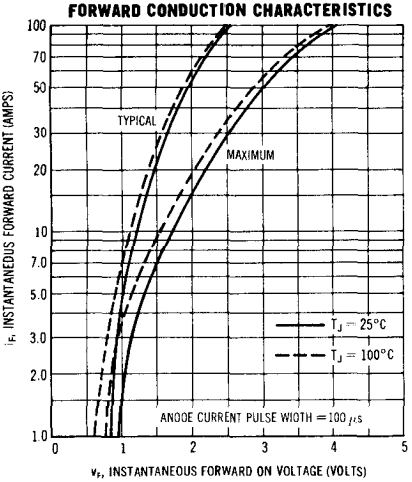
Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 100°C)	-1	V_{FOM}*	20	—	—	Volts
	-2		50	—	—	
	-3		100	—	—	
MCR2304	-4		200	—	—	
MCR2305	-5		300	—	—	
MCR2604	-6		400	—	—	
MCR2605	-7		500	—	—	
	-8		600	—	—	
Peak Forward Blocking Current (Rated V_{FOM} @ T_J = 100°C, gate open)		I_{FOM}	—	—	2	mAdc
Peak Reverse Blocking Current (Rated V_{ROM} @ T_J = 100°C, gate open)		I_{ROM}	—	—	2	mAdc
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)		I_{GT}	—	10	20	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100Ω)		V_{GT}	—	0.6	1.5	Volts
(Anode Voltage = rated V_{FOM}, R_L = 100 Ω, T_J = 100°C)		V_{GNT}	0.2	—	—	
Holding Current (Anode Voltage = 7 Vdc, gate open)		I_{HO}	—	10	25	mA
Forward On Voltage (I_F = 5 Adc)		V_F	—	1.0	1.3	Volts
Turn-On Time ($t_d + t_r$) (I_F = 5 Adc, I_G = 20 mAdc)		t_{on}	—	1	—	μs
Turn-Off Time (I_F = 5 Adc, I_R = 5 Adc)		t_{off}	—	12	—	μs
(I_F = 5 Adc, I_R = 5 Adc, T_J = 100°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)			—	16	—	
Forward Voltage Application Rate (T_J = 100°C, gate open)		dv/dt	—	50	—	V/μs
Thermal Resistance, Junction to Case		θ_{JC}				°C/W
MCR2304, MCR2604, MCR2605 Types			—	1.5	2.7	
MCR2305 Types			—	1.8	3.0	
Thermal Resistance, Case to Ambient** MCR2304, MCR2604, MCR2605 Types		θ_{CA}	—	50	80**	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage. These devices should never be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

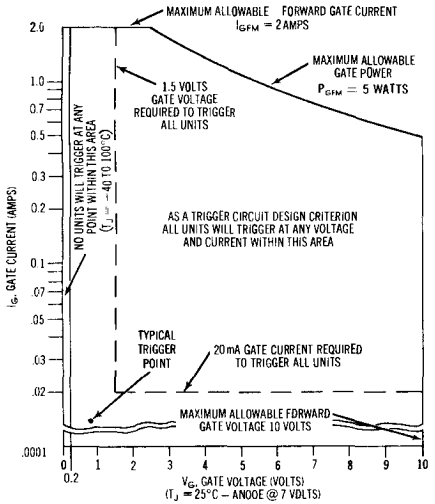
**Applies for the worst-case conditions of: (a) highest θ_{CA} package configuration, (b) leads terminated at end points, (c) temperature measured at hottest spot on device (center of case bottom), and (d) still air mounting.

2N4151 thru 2N4198 (continued)

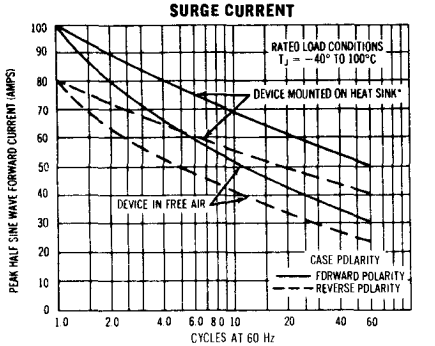
FORWARD CONDUCTION CHARACTERISTICS



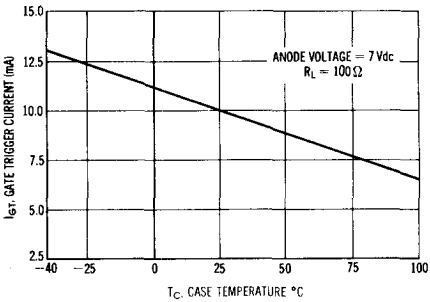
GATE TRIGGER CHARACTERISTICS



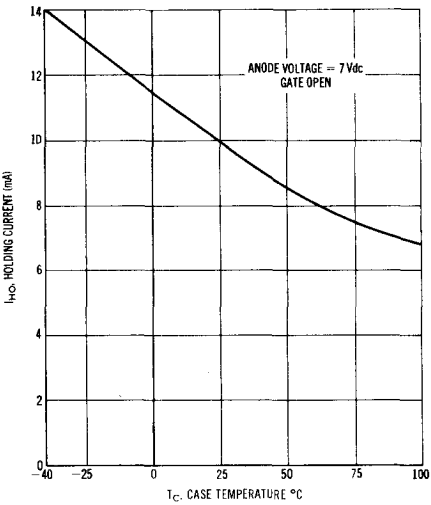
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



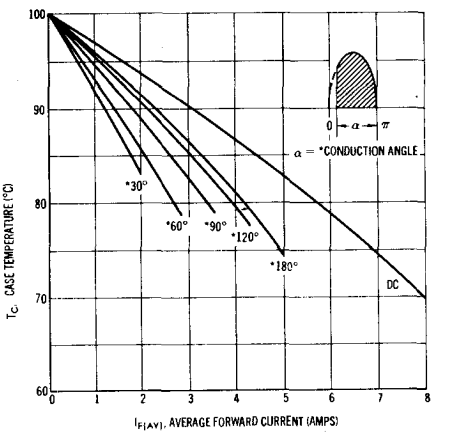
TYPICAL GATE TRIGGER CURRENT versus TEMPERATURE



TYPICAL HOLDING CURRENT versus TEMPERATURE



CURRENT DERATING HALF WAVE



2N4199 thru 2N4204

$I_{FM(pulse)}$ = 100 A
V_{ROM} = 300-800 V
Pulse Repetition Rates — to 10,000 pps



CASE 63

Premium, fast switching, high-voltage Silicon Controlled Rectifiers especially designed for pulse modulator applications in radar and other similar equipment with guaranteed critical parameters.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*	50	Volts
Forward Current RMS	I_f	2	Amps
Repetitive Pulse Current (PW = 10 μs)	$I_{FM(pulse)}$	100	Amps
Current Application Rate**	di/dt**	5000	A/μs
Average Forward Power (T_C = 85°C max.)	$P_{F(AV)}$	5	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1	Watt
Peak Gate Current - Forward	I_{GFM}	5	Amps
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +105	°C
Stud Torque	—	15	in.-lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher V_{ROM} rated units available on request.

**Minimum Gate Trigger Pulse: 200 mA, 1μs, wide, 20 ns rise time.

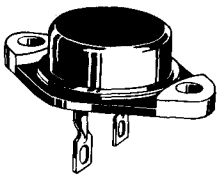
2N4199 thru 2N4204 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 105°C)	V_{FOM}				Volts
2N4199		300	—	—	
2N4200		400	—	—	
2N4201		500	—	—	
2N4202		600	—	—	
2N4203		700	—	—	
2N4204		800	—	—	
Peak Forward Blocking Current (Rated V_{FOM}, T_J = 105°C, gate open)	I_{FOM}	—	0.2	2	mA
Gate Trigger Current (Continuous dc)	I_{GT}				mA
(Anode Voltage = 7 Vdc, R_L = 100 ohms)		—	15	50	
(Anode Voltage = 7 Vdc, R_L = 100 ohms, T_C = -65°C)		—	—	100	
Gate Trigger Voltage (Continuous dc) (Anode Voltage = rated V_{FOM}, R_L = 100 ohms, T_C = 105°C)	V_{GT}	0.2	—	—	Volts
(Anode Voltage = 7 Vdc, R_L = 100 ohms)		—	0.8	1.5	
(Anode Voltage = 7 Vdc, R_L = 100 ohms, T_C = -65°C)		—	—	1.8	
Holding Current (Anode Voltage = 7 Vdc, gate open, T_J = 105°C)	I_{HO}	3	7	—	mA
Forward On Voltage (I_f = 2 Adc)	V_F	—	1.1	1.5	Volts
Dynamic Forward On Voltage (0.5 μs after 50% pt) Forward Current: 30A pulse (0.1μfd. cap. dis. ckt.) Gate Pulse: 200 mA, 1 μs wide, 20 ns rise time	$V_{F(on)}$	—	15	25	Volts
Turn-On Time: Delay Time (All Units)	t_d	—	—	200	ns
Rise Time 2N4199 & 2N4200	t_r	—	—	200	ns
2N4201		—	—	150	
2N4202		—	—	130	
2N4203 & 2N4204		—	—	100	
Test Conditions: Forward Current = 30A pulse (0.1 μfd. cap. dis. ckt.) Applied Forward Voltage = rated V_{FOM} Gate Trigger Pulse: 200 mA, 1 μs wide, 20 ns rise time					
Turn-On Time Variation (T_J = -65 to 105°C)	Δt_{on}	—	±100	—	ns
Pulse Turn-Off Time	$t_{off(pulse)}$	—	15	20	μs
Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5 A; Rep. Rate = 100 pps; Duty Cycle = 0.05%; Forward Voltage = rated V_{FOM}; T_C = 85°C; dv/dt = 250 V/ μs; Reverse anode voltage applied during turn off interval = 0 V; Reverse gate bias during turn off interval = -6 V; Gate Trigger Pulse: 200 mA, 1 μs wide, 20 ns rise time. Turn off time measured from 90% pt. of forward, current decay to 10% pt. of reapplied forward voltage.					
Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	250	—	—	V/ μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3	°C/W

MCR649-1 thru MCR649-7

I_f = 20 A RMS
V_{ROM} = 25-500 V



CASE 61 (TO-41) **CASE 54** (TO-3)

Industrial-type, silicon controlled rectifiers in a "diamond" package for applications requiring a high surge-current rating or low thermal resistance. For units with pins (TO-3) specify devices MCR649P-1 thru MCR649P-7.

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage* MCR649-1	V_{ROM}*	25	Volts
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
-7		500	
Forward Current RMS (All Conduction Angles)	I_f	20	Amps
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≤ 8.3 ms)	I^2t	275	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	260	Amps
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

*V_{ROM} for all types can be applied on a continuous dc basis without incurring damage.

V_{ROM} ratings apply for zero or negative gate voltage.

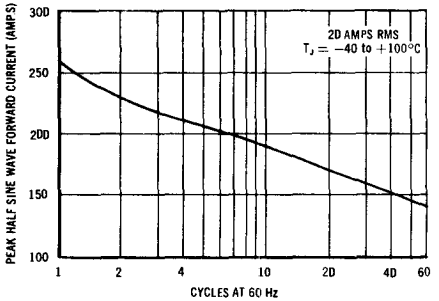
MCR649-1 thru MCR649-7 (continued)

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

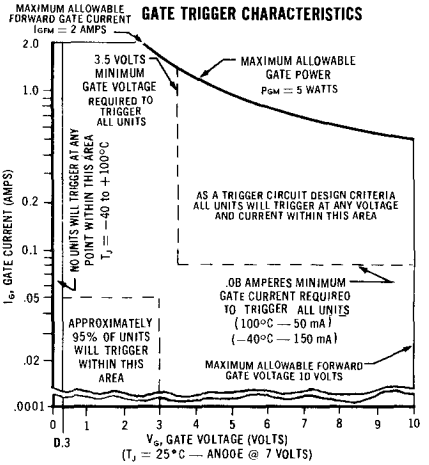
Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage (T_J = 100°C) MCR649-1	V_{FOM}	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
-7		500	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 100°C)	I_{FOM}	—	—	5.0	mA
Peak Reverse Blocking Current (Rated V_{FOM} with gate open, T_J = 100°C)	I_{ROM}	—	—	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	I_{GT}	—	30	80	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	1.0	3.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 100°C)	V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	20	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.1	1.5	Volts
Turn-On Time (t_d + t_r) (I_G = 50 mA, I_F = 10 A)	t_{on}	—	1.0	—	ns
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/ μs min, T_J=100°C) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	25	—	μs
Forward Voltage Application Rate (Gate open, T_J = 100°C)	dv/dt				V/ μs
MCR649-1 thru MCR649-4		—	20	—	
MCR649-5 thru MCR649-7		—	30	—	
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.5	°C/W

MCR649-1 thru MCR649-7 (continued)

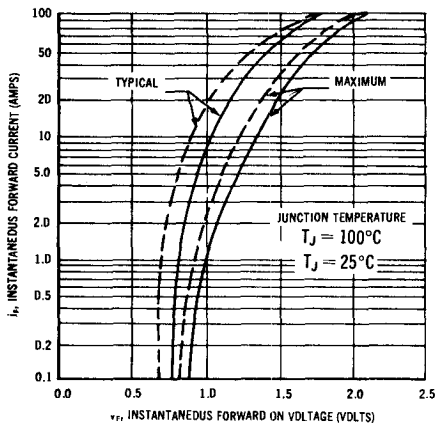
MAXIMUM ALLOWABLE NON-RECURRENT SURGE CURRENT



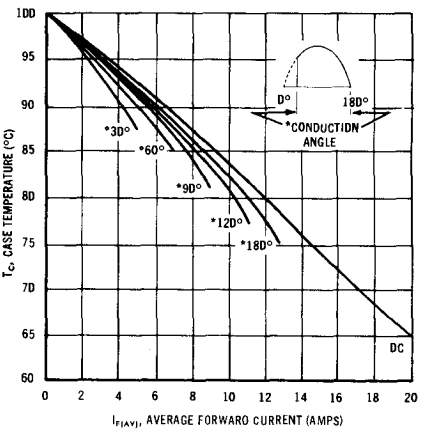
GATE TRIGGER CHARACTERISTICS



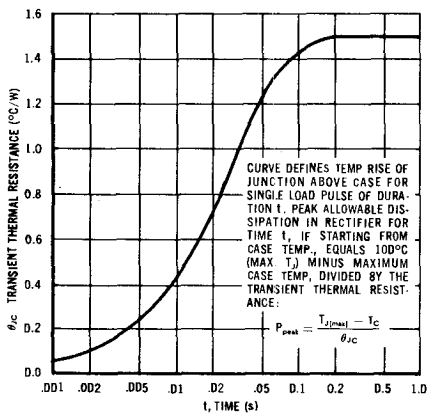
LOW CURRENT LEVEL



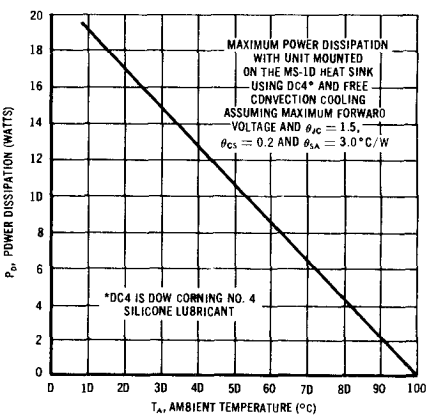
MAXIMUM ALLOWABLE CASE TEMPERATURE



MAXIMUM TRANSIENT THERMAL RESISTANCE JUNCTION TO CASE



POWER DERATING CURVE



MCR729-5 thru MCR729-10

$I_{FM(pulse)}$ = 100 A
V_{ROM} = 300-800 V
Pulse Repetition Rates — to 10,000 pps



CASE 63

Fast-switching, high-voltage silicon controlled rectifier especially designed and characterized for radar, proximity fuse, beacon and similar pulse applications.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*	50	Volts
Forward Current RMS	I_f	2	Amps
Repetitive Pulse Current (PW = 10 μs)	$I_{FM(pulse)}$	100	Amps
Average Forward Power	$P_{F(AV)}$	5	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1	Watt
Peak Gate Current - Forward	I_{GFM}	5	Amps
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to+ 105	°C
Storage Temperature Range	T_{stg}	-65 to+150	°C
Stud Torque	—	15	in.-lb.

*Characterized for unilateral applications where reverse blocking capability is not important. Higher V_{ROM} rated units available on request.

MCR729-5 thru MCR729-10 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 105°C)	MCR729-5	V_{FOM}*	300	—	—	Volts
	-6		400	—	—	
	-7		500	—	—	
	-8		600	—	—	
	-9		700	—	—	
	-10		800	—	—	
Peak Forward Blocking Current (Rated V_{FOM}, T_J = 105°C, gate open)		I_{FOM}	—	0.2	2	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)		I_{GT}	—	10	50	mAdc
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 100 ohms)		V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, gate open)		I_{HO}	5	15	—	mA
Forward On Voltage (I_f = 2 Adc)		V_F	—	1.1	1.5	Volts
Dynamic Forward On Voltage (0.5 μs after 50% pt, I_G = 200 mA, I_{pulse} = 30 Amps)		$V_{F(on)}$	—	15	25	Volts
Turn-On Time (t_d + t_r) (I_G = 200 mA)		t_{on}				ns
(I_{pulse} = 30 Amps peak)			—	200	—	
(I_{pulse} = 100 Amps peak)			—	400	—	
Turn-On Time Variation (T_J = +25°C to +105°C and -65°C to +25°C)		Δt_{on}	—	±500	—	ns
Pulse Turn-Off Time		$t_{off(pulse)}$	—	15	—	μs

Test Conditions: PFN discharge; Forward Current = 30 A pulse; Reverse Current = 5 A;
Rep. Rate = 100 pps; Duty cycle = 0.05%; Forward Voltage = rated V_{FOM};
T_C = 85°C; dv/dt = 250 V/μs; Reverse anode voltage applied during turn-off interval = rated V_{FOM};
Reverse gate bias during turn-off interval = -6 V;
Gate Trigger Pulse: 200 mA, 1 μs wide, 2 ns rise time.
Turn-off time measured from 90% pt. of forward, current decay to 10% pt. of reapplied forward voltage.

Forward Voltage Application Rate (T_J = 105°C, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3	°C/W

*Other voltage units available upon request.

MCR808, R series
MCR1308, R series

I_f = 18 A RMS
$V_{ROM(rep)}$ = 25-400 V



CASE 68
(MCR1308, R)



CASE 62
(MCR808, R)

Low-cost, silicon controlled rectifiers available in two package styles and reverse polarity for versatile, economical, general-purpose applications. For reverse polarity (Cathode-to-case) add suffix "R" (e.g. MCR808R, MCR1308R).

MAXIMUM RATINGS (T_J = 100°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
MCR808 -1		25	
MCR808 -2		50	
MCR808R -3		100	
MCR1308 -4		200	
MCR1308R -5		300	
MCR1308R -6		400	
Forward Current RMS (All Conduction Angles)	I_f	18	Amps
Circuit Fusing Considerations (T_J = -40 to +100°C; t ≤ 8.3 ms)	I^2t	235	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -40 to +100°C)	$I_{FM(surge)}$	225	Amps
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-40 to +100	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C
Stud Torque-MCR1308 and MCR1308R	—	30	in.-lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR808, R, MCR1308, R (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 100°C)	V_{FOM}*				Volts
MCR808 -1		25	—	—	
MCR808 -2		50	—	—	
MCR808R -3		100	—	—	
MCR1308 -4		200	—	—	
MCR1308R -5		300	—	—	
-6		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 100°C)	I_{FOM}	—	1	8.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 100°C)	I_{ROM}	—	1	5.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	0.7	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 100°C)	V_{GNT}	0.3	—	—	
Holding Current (Anode Voltage = 7 Vdc Gate Open)	I_{HO}	—	8.0	—	mA
Forward On Voltage (I_F = 18 Adc)	V_F	—	1.1	1.6	Volts
Turn-On Time (t_d + t_r) (I_F = 18 Adc, I_G = 50 mAdc)	t_{on}	—	1.0	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs)	t_{off}	—	20	—	μs
(I_F = 10 A, I_R = 10 A, dv/dt = 20 V/μs, T_J = 100°C)		—	30	—	
(V_{FXM} = rated voltage)					
(V_{RXM} = rated voltage)					
Forward Voltage Application Rate (T_J = 100°C, gate open)	dv/dt	—	30	—	V/μs
Thermal Resistance (Junction to Case) MCR808, MCR808R	θ_{JC}	—	1.0	1.6	°C/W
MCR1308, MCR1308R		—	1.4	2.0	

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

PRESS IN MOUNTING

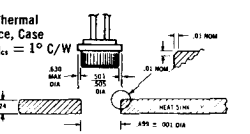
1. Heat Sink Hole — To provide good SCR heat sink surface contact, the diameter of the heat sink hole should be 0.499 ±.001 inch. The edge of the hole into which the SCR will be pressed should be slightly beveled to aid in starting and to prevent shearing off of the package knurl. The depth and width of this beveled break should be 0.010 nominal.

2. Hardness of Heat Sink Material — If the SCR is pressed into a heat sink material which is harder than the case of the SCR, degradation of voltage characteristics can occur because of stresses placed on the package and consequently on the silicon die inside. Therefore, the following hardnesses for the heat sink material are recommended:
   Copper — less than 50 on the Rockwell F scale (the MCR808 case is 50 or greater)
   Aluminum — less than 65 on the Brinell scale.

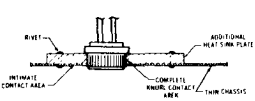
3. Press-In Force — The recommended press-in force is between 250 and 1000 pounds per square inch. It is extremely important that this force be applied only to the external annular ring portion of the device. If pressure is applied to the glass-to-metal seal portion of the device, stresses can result which crack the glass and/or break the hermetic seal.

Typical Thermal Resistance, Case to Sink θ_{cs} = 1° C/W

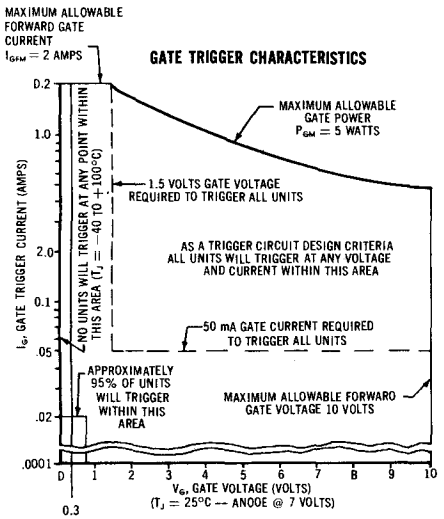
HEAT SINK MOUNTING

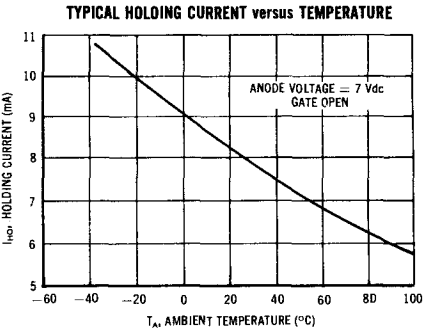


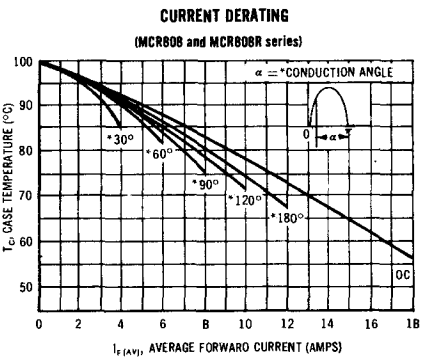
THIN-CHASSIS MOUNTING

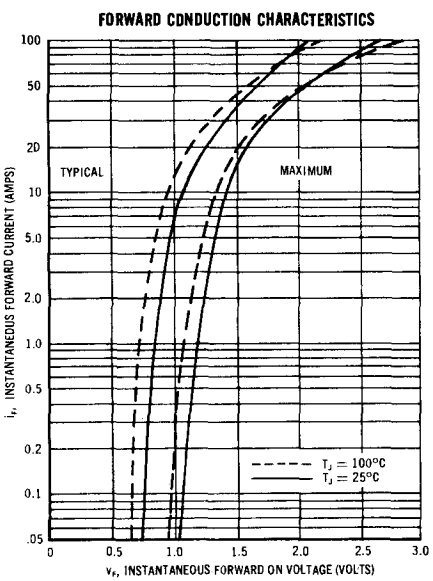


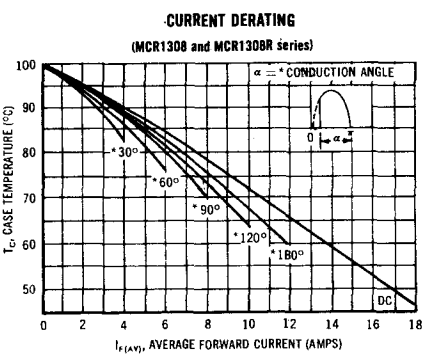
MCR808, R, MCR1308, R (continued)











MCR846 series

I_f = 2 A RMS
$V_{ROM(rep)}$ = 25-200 V



CASE 63

Silicon controlled rectifiers for low-power switching and control applications requiring blocking to 200 volts and load currents to 2 amps.

MAXIMUM RATINGS (T_J = 105°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage MCR846-1 -2 -3 -4	$V_{ROM(rep)}$	 25 50 100 200	Volts
Forward Current RMS (all conduction angles)	I_f	2.0	Amps
Circuit Fusing Considerations (T_J = -65 to +105°C; t ≦ 8.3 ms)	I^2t	35	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +105°C)	$I_{FM(surge)}$	30	Amps
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current - Forward	I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward Reverse	V_{GFM} V_{GRM}	10 10	Volts
Operating Junction Temperature Range	T_J	-65 to +105	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	15	in.-lb.

MCR846 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage ($T_J = 105°C$) MCR846-1	V_{FOM}	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, $T_J = 105°C$)	I_{FOM}	—	—	2.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, $T_J = 105°C$)	I_{ROM}	—	—	2.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\Omega$)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, $R_L = 100\Omega$)	V_{GT}	—	0.8	1.5	Volts
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	15	—	mA
Forward On Voltage ($I_F = 2$ Adc)	V_F	—	1.3	1.6	Volts
Turn-On Time ($t_d + t_r$) ($I_G = 50$ mA, $I_F = 2$ A)	t_{on}	—	0.5	—	μs
Turn-Off Time ($I_F = 2$ A, $I_R = 10$ A, dv/dt = 50 V/μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage)	t_{off}	—	6	—	μs
Forward Voltage Application Rate ($T_J = 105°C$, gate open)	dv/dt	50	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	3	°C/W

MCR1308, R series

For Specifications, See MCR808 Data Sheet.

MCR1718-5 thru MCR1718-8

I_f = 25 A RMS
$V_{ROM(rep)}$ = 300-600 V
$I_{FM(pulse)}$ = 1000 A



CASE 63

Fast-switching, high-voltage silicon controlled rectifiers for pulse modulator applications requiring blocking to 600 volts and repetitive pulse currents to 1000 amps.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
MCR1718-5		300	
-6		400	
-7		500	
-8		600	
Peak Reverse Blocking Voltage (Transient) (Non-Recurrent 5 ms (max.)	$V_{ROM(non-rep)}$		Volts
MCR1718-5		400	
-6		500	
-7		600	
-8		700	
Forward Current RMS	I_f	25	Amps
Peak Repetitive Pulse Current (1-10 μs Pulse Width)	$I_{FM(pulse)}$	1000	Amps
Current Application Rate (up to 1000 Adc peak)	di/dt	1000	A/μs
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≦ 1.0 ms)	I^2t	250	A^2s
Dynamic Average Power (T_C = 65°C)	$P_{F(AV)}$	30	Watts
Peak Gate Power - Forward	P_{GFM}	20	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	1.0	Watt
Peak Gate Current - Forward	I_{GFM}	5.0	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	10	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in.-lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1718-5 thru MCR1718-8 (continued)

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1718-5	V_{FOM}*	300	—	—	Volts
-6		400	—	—	
-7		500	—	—	
-8		600	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	8.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	8.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	I_{GT}	—	10	50	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω, T_C = 25°C)	V_{GT}	—	0.8	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open, T_C = 25°C)	I_{HO}	5	15	—	mA
(Anode Voltage = 7 Vdc, Gate Open, T_J = 125°C)		—	6	—	
Forward On Voltage (I_F = 25 Adc)	V_F	—	1.1	1.3	Volts
Dynamic Forward On Voltage (I_{GT} = 500 mA, I_{pulse} = 500 Amps)	$V_{F(on)}$				Volts
(1.0 μs after start (10% pt.) of I_{pulse})		—	30	—	
(5.0 μs after start (10% pt.) of I_{pulse})		—	5	—	
Pulse Turn-Off Time (I_F = 500A, I_R = 10 A, dv/dt = 20 V/ μs) (V_{FXM} = rated voltage) (V_{RXM} = rated voltage) (Conductive Charging Circuit - Circuit dependent)	t_{off}	—	20	—	μs
Forward Voltage Application Rate (Gate Open, T_J = 125°C)	dv/dt	—	100	—	V/ μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	—	2.0	°C/W

*V_{FOM} for all types can be supplied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1907-1 thru MCR1907-6

I_f = 25 A RMS
$V_{ROM(rep)}$ = 25-400 V



CASE 64
(TO-48)

Fast turn-on, fast turn-off silicon controlled rectifiers for high-frequency applications requiring blocking to 400 volts and load currents to 25 amps.

MAXIMUM RATINGS (T_J = 125°C unless otherwise noted)

Characteristic	Symbol	Rating	Units
Peak Reverse Blocking Voltage*	$V_{ROM(rep)}$*		Volts
MCR1907-1		25	
-2		50	
-3		100	
-4		200	
-5		300	
-6		400	
Peak Reverse Blocking Voltage (Non-Recurrent 5 ms (max.)	$V_{ROM(non-rep)}$		Volts
MCR1907-1		35	
-2		75	
-3		150	
-4		300	
-5		400	
-6		500	
Forward Current RMS (All Conduction Angles)	I_f	25	Amps
Circuit Fusing Considerations (T_J = -65 to +125°C; t ≤ 8.3 ms)	I^2t	75	A^2s
Peak Forward Surge Current (One Cycle, 60 Hz, T_J = -65 to +125°C)	$I_{FM(surge)}$	150	Amps
Peak Gate Power - Forward	P_{GFM}	5.0	Watts
Average Gate Power - Forward	$P_{GF(AV)}$	0.5	Watt
Peak Gate Current — Forward	I_{GFM}	2.0	Amps
Peak Gate Voltage - Forward	V_{GFM}	10	Volts
Reverse	V_{GRM}	5.0	
Operating Junction Temperature Range	T_J	-65 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C
Stud Torque	—	30	in.-lb.

*$V_{ROM(rep)}$ for all types can be applied on a continuous dc basis without incurring damage. Ratings apply for zero or negative gate voltage.

MCR1907-1 thru MCR1907-6 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

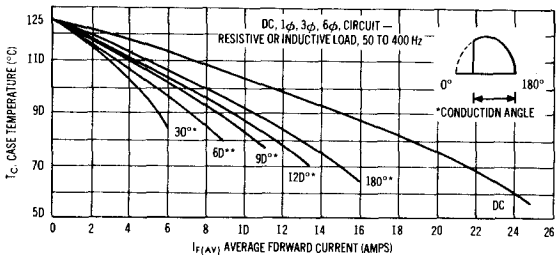
Characteristic	Symbol	Min	Typ	Max	Units
Peak Forward Blocking Voltage* (T_J = 125°C) MCR1907-1	V_{FOM}*	25	—	—	Volts
-2		50	—	—	
-3		100	—	—	
-4		200	—	—	
-5		300	—	—	
-6		400	—	—	
Peak Forward Blocking Current (Rated V_{FOM} with gate open, T_J = 125°C)	I_{FOM}	—	—	4.0	mA
Peak Reverse Blocking Current (Rated V_{ROM} with gate open, T_J = 125°C)	I_{ROM}	—	—	4.0	mA
Gate Trigger Current (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50Ω)	I_{GT}	—	15	30	mA
Gate Trigger Voltage (Continuous dc) (Anode Voltage = 7 Vdc, R_L = 50 Ω)	V_{GT}	—	—	1.5	Volts
(Anode Voltage = Rated V_{FOM}, R_L = 50Ω, T_J = 125°C)	V_{GNT}	0.25	—	—	
Holding Current (Anode Voltage = 7 Vdc, Gate Open)	I_{HO}	—	12	—	mA
Forward On Voltage (I_F = 20 Adc)	V_F	—	1.4	1.7	Volts
Turn-On Time (I_G = 200 mA, I_F = 10 A)	t_{on}	—	0.5	—	μs
Turn-Off Time (I_F = 10 A, I_R = 10 A, dv/dt = 30 V/μs min.) (V_{FXM} = rated voltage) T_J = 125°C (V_{RXM} = rated voltage)	t_{off}	—	—	12	μs
Forward Voltage Application Rate (T_J = 125°C, gate open)	dv/dt	30	—	—	V/μs
Thermal Resistance (Junction to Case)	θ_{JC}	—	1.0	1.7	°C/W

*V_{FOM} for all types can be applied on a continuous dc basis without incurring damage.

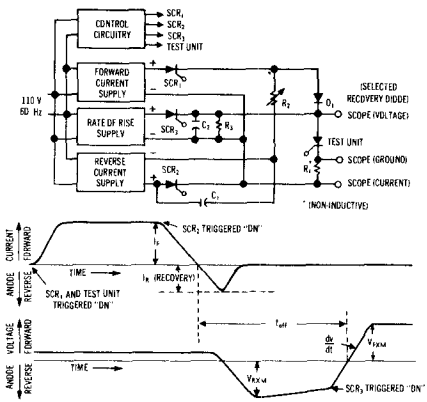
Ratings apply for zero or negative gate voltage. These devices should never be tested with a constant current source for forward or reverse blocking capability such that the voltage applied exceeds the rated blocking voltage.

MCR1907-1 thru MCR1907-6 (continued)

CURRENT DERATING



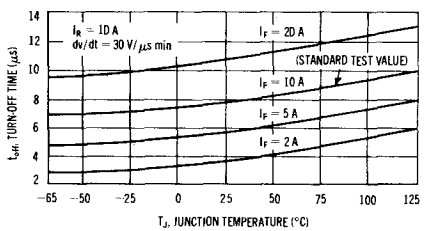
TURN-OFF TIME TEST CIRCUIT †



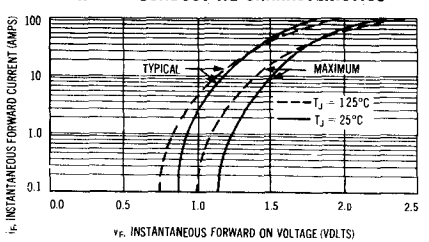
Forward conduction current is passed through the device (SCR_1 and test device triggered on). The anode is then driven negative (SCR_2 triggered on), causing reverse current to flow. The anode-to-cathode potential goes negative with a decrease in reverse current. Forward voltage is then applied to the anode of the device (SCR_3 triggered on). The device has fully recovered when it regains its ability to block the reapplied forward voltage.

† Consult manufacturer for further circuit information.

TYPICAL TURN-OFF TIME versus PEAK FORWARD CURRENT AND JUNCTION TEMPERATURE



FORWARD CONDUCTING CHARACTERISTICS



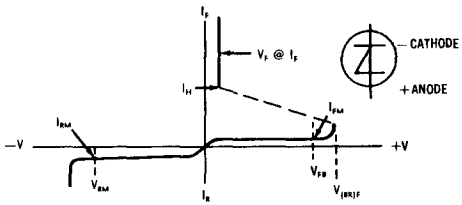
MCR2304 series
MCR2305 series
MCR2604 series
MCR2605 series

For Specifications See 2N4151 Data Sheet.

4-LAYER DIODES

These 4-layer diodes are forward breakover devices designed for low-voltage, two-terminal switching and triggering applications. These devices are recommended for logic circuit applications, as pulse generators, memory and relay drivers and relay replacements as well as for alarm circuits, multivibrators, ring counters, signal switching and SCR trigger circuits. Polarity band indicates cathode.

4-LAYER DIODE SYMBOLS AND DEFINITIONS



dv/dt — FORWARD VOLTAGE APPLICATION RATE (V/μs) - The rate of rise of forward voltage.

$I_{(BR)F}$ — FORWARD BREAKOVER (SWITCHING) CURRENT - The value of anode current at the instant the device switches from the blocking to the "on" state, specified at a particular junction temperature.

I_F — FORWARD CURRENT - The continuous or dc value of forward current during the "on" state.

I_{FM} — PEAK FORWARD BLOCKING CURRENT - The peak anode current when the 4-layer diode is in the "off" state for a stated anode-to-cathode voltage and junction temperature.

I_H — HOLDING CURRENT - That value of forward anode current below which the 4-layer diode switches from the conducting state to the forward blocking condition.

I_{pulse} — PEAK PULSE CURRENT - The peak repetitive current that can flow through the device for the time duration stated and staying within the P_D rating.

I_{RM} — PEAK REVERSE BLOCKING CURRENT - The peak current when the 4-layer diode is in the reverse blocking state for a stated anode-to-cathode voltage and junction temperature.

P_D — STEADY STATE POWER DISSIPATION

T_A — AMBIENT TEMPERATURE

T_J — JUNCTION TEMPERATURE

T_{stg} — STORAGE TEMPERATURE

t_{on} — TURN-ON TIME - The time interval between the 90% point (90% of forward blocking voltage) and the point 10% above the "on" voltage under stated conditions.

t_{off} — TURN-OFF TIME - The time interval required for the device to regain control of its forward blocking state to the low-impedance "on" state, specified at a particular junction temperature.

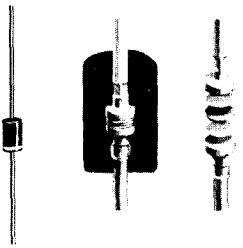
$V_{(BR)F}$ — FORWARD BREAKOVER (SWITCHING) VOLTAGE - The positive dc anode voltage with respect to cathode required to switch the device from the high impedance blocking state to the low-impedance "on" state, specified at a particular junction temperature.

V_F — FORWARD VOLTAGE - The forward voltage across the device in the "on" state under stated conditions of current and temperature.

V_{FB} — FORWARD BLOCKING VOLTAGE - The anode-to-cathode dc voltage when the 4-layer diode is in the "off" state.

$V_{RM(rep)}$ — PEAK REVERSE VOLTAGE - The maximum allowable instantaneous value of reverse voltage (repetitive or continuous dc) which can be applied to the device at a stated temperature without damage to the device.

M4L2052
M4L2053
M4L2054



CASE 59

$V_{(BR)F}$ = 8-12 V
$V_{RM(rep)}$ = 10-12 V
I_F = 500 mA
P_D = 750 mW

PNPN 4-layer diodes for low-voltage switching and triggering applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Peak Reverse Blocking Voltage M4L2052 M4L2053 M4L2054	$V_{RM(rep)}$	 10 11 12	Volts
Continuous Forward Current	I_F	500	mA
Steady State Power Dissipation $T_A = 25^oC$ Derate above 25°C	P_D	750 10	mW mW/°C
Peak Pulse Current (10 μs maximum pulse width)	I_{pulse}	100	Amps
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

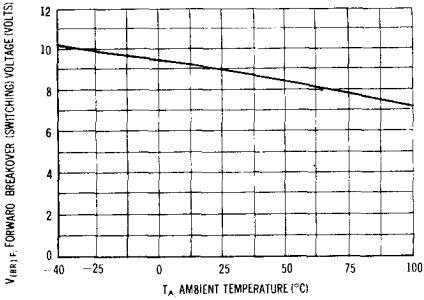
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Breakover (Switching) Voltage M4L2052 M4L2053 M4L2054	$V_{(BR)F}$	 8 9 10	 — — —	 10 11 12	Volts
Forward Breakover (Switching) Current	$I_{(BR)F}$	—	15	50	μA
Forward Blocking Current (Measured at 75% of $V_{(BR)F}$)	I_{FM}	—	1	5	μA
Reverse Blocking Current (at rated $V_{RM\ rep}$)	I_{RM}	—	—	10	μA
Holding Current	I_H	—	3	15	mA
Forward On Voltage (I_F = 500 mAdc)	V_F	—	1.1	1.5	Volts
Turn On Time (at rated $V_{(BR)F}$, I_F = 1 A peak)	t_{on}	—	60*	—	ns
Turn Off Time (I_F = 100 mA, V_F applied = 5 V, V_R applied = 5 V, dv/dt = 5 V/μ sec, typical I_H of units tested = 5 mA)	t_{off}	—	2*	—	μs

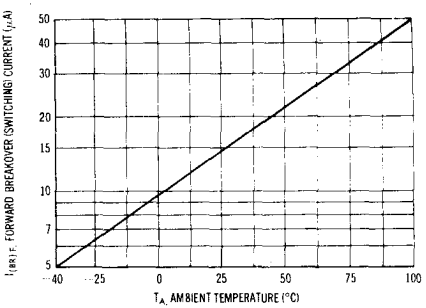
*Time depends on a wide variety of circuit conditions. Consult manufacturer for further information.

M4L2052, M4L2053, M4L2054 (continued)

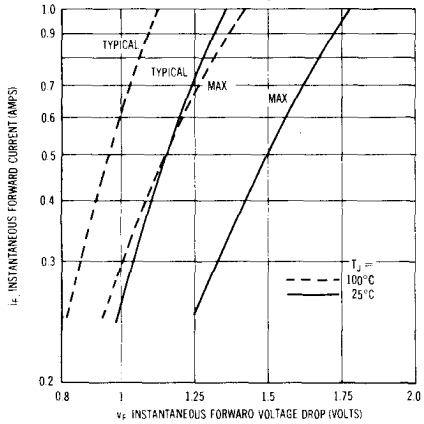
TYPICAL FORWARD BREAKOVER (SWITCHING) VOLTAGE versus TEMPERATURE



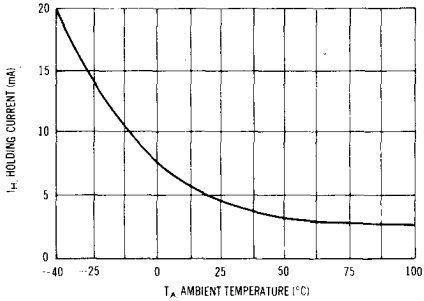
TYPICAL FORWARD BREAKOVER (SWITCHING) CURRENT versus TEMPERATURE



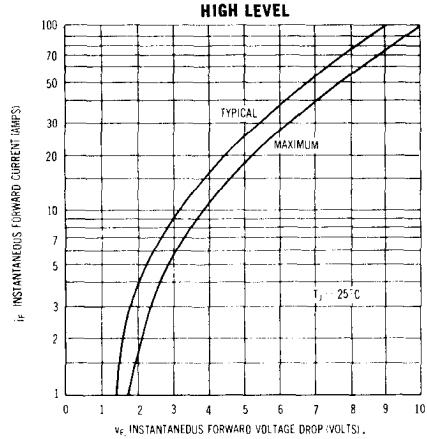
FORWARD CONDUCTION CHARACTERISTICS LOW LEVEL



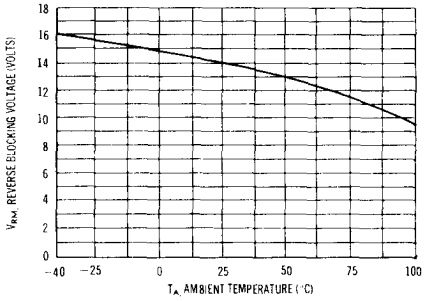
TYPICAL HOLDING CURRENT versus TEMPERATURE



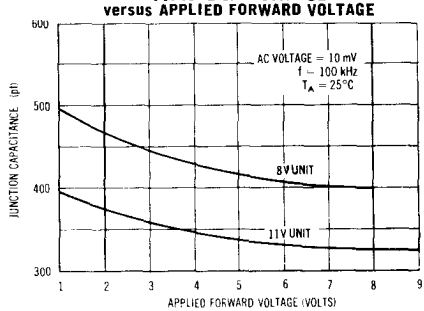
HIGH LEVEL



TYPICAL REVERSE BLOCKING VOLTAGE versus TEMPERATURE

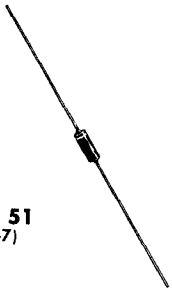


TYPICAL CAPACITANCE versus APPLIED FORWARD VOLTAGE



M4L3052 thru M4L3054
NOW 1N5158 thru 1N5160

$V_{(BR)F}$ = 8-12V
$V_{RM(rep)}$ = 10-12V
I_F = 150 mA
P_D = 150 mW



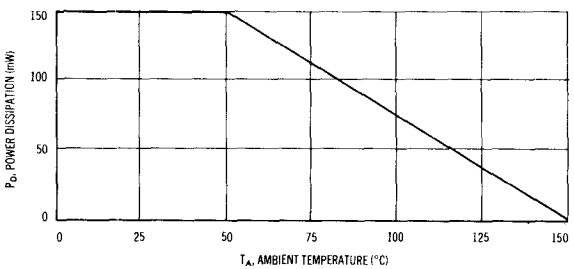
CASE 51
(DO-7)

PNPN 4-layer diodes, two-terminal, fast switching devices specifically designed for low voltage applications such as logic circuits, pulse generators, memory and relay devices, relay replacement, alarm circuit, multivibrators, ring counters, and signal switching circuits. These devices feature low breakover (switching) voltage, fast switching speeds, low junction capacitance, low breakover currents, and sub-miniature package.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Peak Reverse Blocking Voltage M4L3052 M4L3053 M4L3054	$V_{RM(rep)}$	 10 11 12	Volts
Continuous Forward Current	I_F	150	mA
Steady State Power Dissipation @ T_A = 50°C Derate above 50°C	P_D	150 1.5	mW mW/°C
Peak Pulse Current (50 μs maximum pulse width)	I_{pulse}	 10	Amps
Operating Junction Temperature Range	T_J	-65 to +150	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

POWER-TEMPERATURE DERATING CURVE



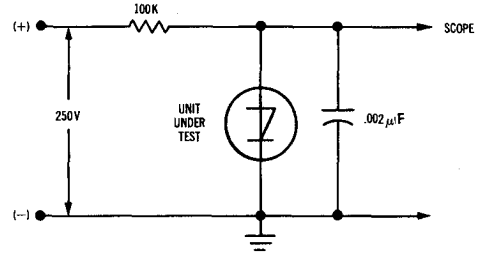
M4L3052 thru M4L3054 (continued)

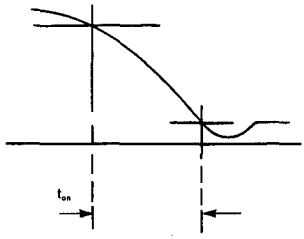
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Forward Breakover (Switching) Voltage M4L3052 M4L3053 M4L3054	$V_{(BR)F}$	 8 9 10	 — — —	 10 11 12	Volts
Forward Breakover (Switching) Current	$I_{(BR)F}$	—	5	50	μA
Forward Blocking Current (Measured at 75% of $V_{(BR)F}$)	I_{FM}	—	1	5	μA
Reverse Blocking Current (Measured at rated $V_{RM(rep)}$)	I_{RM}	—	2	10	μA
Holding Current	I_H	1	4	20	mA
Forward On Voltage (I_F = 150 mAdc)	V_F	—	1.0	1.5	Volts
Junction Capacitance (AC Voltage = 10 mV, V_F = 0, f = 100 kHz)	C_J	—	42	—	pF
Turn-On Time	t_{on}	—	50*	—	ns
Turn-Off Time	t_{off}	—	100*	—	ns

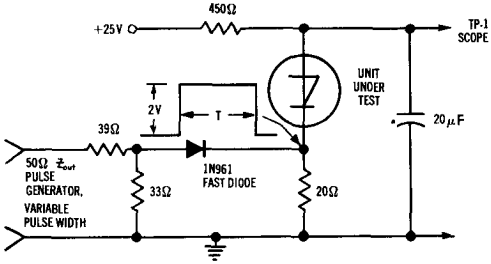
*Time depends on a wide variety of circuit conditions. Consult manufacturer for further information.

TURN-ON TIME TEST CIRCUIT





TURN-OFF TIME TEST CIRCUIT

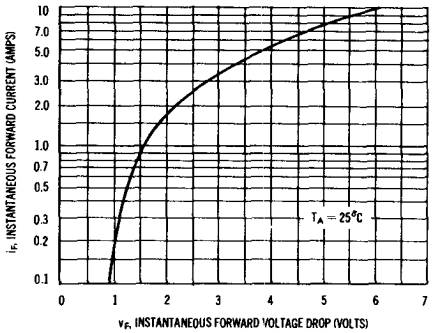




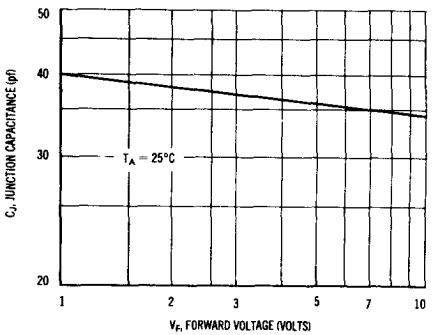
When sawtooth waveform appears at TP-1,
$T = t_{off}$

M4L3052 thru M4L3054 (continued)

TYPICAL FORWARD CONDUCTION CHARACTERISTICS

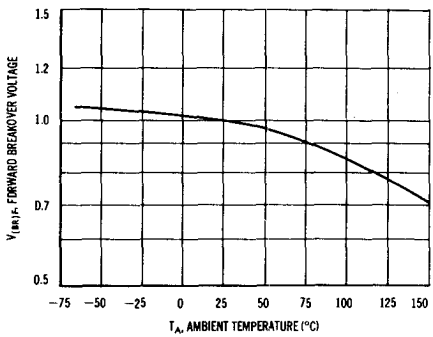


TYPICAL CAPACITANCE

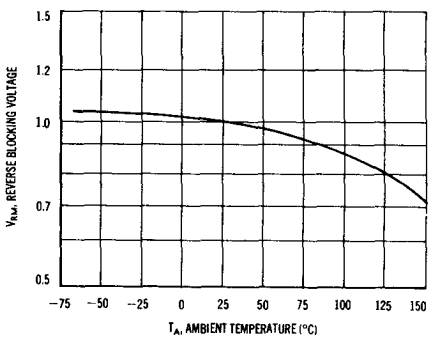


TYPICAL DC CHARACTERISTICS versus TEMPERATURE
(NORMALIZED to 25°C VALUE)

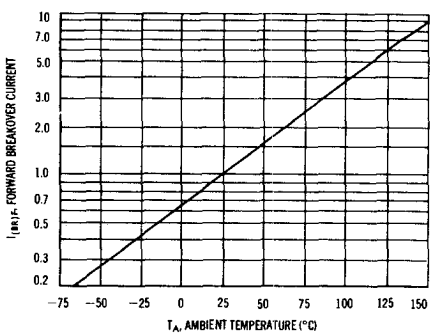
FORWARD BREAKDVER VOLTAGE



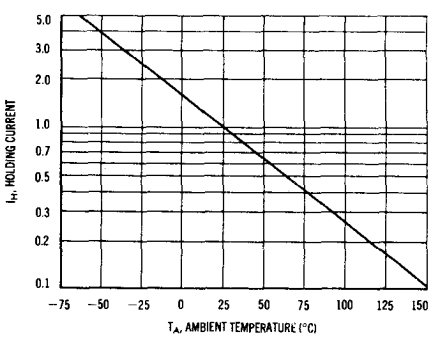
REVERSE BLOCKING VDLTAGE



FORWARD BREAKOVER CURRENT



HDLDING CURRENT



ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

POWER TRANSISTORS

For case outline dimensions, see page 1-186.

HIGH POWER TRANSISTORS

High-power transistors in this section include both germanium and silicon devices. Generally, these transistors are characterized for both amplifier and switching applications requiring power dissipation ratings up to 170 Watts.

The following table lists a number of semiconductor devices that comply with the terms of military specifications, the applicable military specifications and the appropriate page in the data sections of this manual. For additional information, military-type data sheets are available.

POWER TRANSISTORS

JAN 2N174	MIL-S-19500/13B	6-13
JAN 2N297A	MIL-S-19500/36B	6-24
JAN 2N665	MIL-S-19500/58C	6-38
USA 2N1011	MIL-T-19500/67	6-40
USA 2N1120	MIL-T-19500/68	6-47
USN 2N1165	MIL-S-19500/178B	6-49
USN 2N1358	MIL-S-19500/122A	6-13
JAN 2N1412	MIL-S-19500/76B	6-53

GERMANIUM POWER TRANSISTOR SELECTION CHART

3-AMP Also Available as HI-REL Types



TO-3 TO-41†

LOW I_{CBO}
$P_D = 62.5$ W
$f_T = 0.6$ MC
T_J MAX = 110°C

*$I_C = 0.5$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V	45 V	60 V	75 V	90 V
30-60	2N2137 MP2137†	2N2138 MP2138†	2N2139 MP2139†	2N2140 MP2140†	2N2141 MP2141†
50-100	2N2142 MP2142†	2N2143 MP2143†	2N2144 MP2144†	2N2145 MP2145†	2N2146 MP2146†
h_{FE}* \ V_{CBO}	30 V	45 V	60 V	75 V	90 V

3-AMP



TO-3

$P_D = 106$ W
$f_T = 0.35$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 1$ A, $V_{CE} = 4$ V

h_{FE}* \ V_{CES}	40 V	60 V	75 V	100 V	
35-90	2N1359	2N375	2N1362	2N1364	
60-140	2N1360	2N618	2N1363	2N1365	
h_{FE}* \ V_{CBO}	50 V	80 V	100 V	120 V	

5-AMP Also Available as HI-REL Types



TO-3 TO-41†

$P_D = 106$ W
(1) $f_T = 0.35$ MC
(2) $f_T = 0.40$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 3$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V	45 V	60 V	75 V	90 V
20-40(1)	2N1529 MP1529†	2N1530 MP1530†	2N1531 MP1531†	2N1532 MP1532†	2N1533 MP1533†
35-70(1)	2N1534 MP1534†	2N1535 MP1535†	2N1536 MP1536†	2N1537 MP1537†	2N1538 MP1538†
50-100(2)	2N1539 MP1539†	2N1540 MP1540†	2N1541 MP1541†	2N1542 MP1542†	2N1543 MP1543†
75-150(2)	2N1544 MP1544†	2N1545 MP1545†	2N1546 MP1546†	2N1547 MP1547†	2N1548 MP1548†
h_{FE}* \ V_{CBO}	40 V	60 V	80 V	100 V	120 V

5-AMP



TO-36

$P_D = 170$ W
$f_T = 0.3$ MC
T_J MAX = 110°C

*$I_C = 3$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V		45 V		60 V
60-120	2N3311		2N3312		2N3313
100-200	2N3314		2N3315		2N3316
h_{FE}* \ V_{CBO}	30 V		45 V		60 V

7-AMP ECONOMY LINE



TO-3 TO-41†

$P_D = 85$ W
$f_T = 0.7$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 3$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V	45 V	60 V	75 V	
30-60** 35-70	2N3611 MP3611†	2N3612 MP3612†	2N3615** MP3615†	2N3616** MP3616†	
45-90*** 60-120	2N3613 MP3613†	2N3614 MP3614†	2N3617*** MP3617†	2N3618*** MP3618†	
h_{FE}* \ V_{CBO}	40 V	60 V	80 V	100 V	

7-AMP ECONOMY LINE



TO-3

$P_D = 85$ W
$f_T = 0.6$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 3$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V	45 V	60 V	75 V	
30-200	MP2060	MP2061	MP2062	MP2063	
h_{FE}* \ V_{CBO}	40 V	60 V	75 V	90 V	

10-AMP PNIP



TO-3 TO-41†

$P_D = 85$ W
$f_T = 0.70$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 3$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CEO}	80 V		120 V		160 V
20-50	2N2526 MP2526†		2N2527 MP2527†		2N2528 MP2528†
h_{FE}* \ V_{CBO}	80 V		120 V		160 V

15-AMP Also Available as HI-REL Types



TO-36

$P_D = 170$ W
$f_T = 0.30$ MC
$T_{J\,MAX} = 110$°C

*$I_C = 5$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	40 V	50 V	70 V	80 V	
20-40	2N2078	2N2077	2N2076	2N2075	
35-70	2N2082	2N2081	2N2080	2N2079	
h_{FE}* \ V_{CBO}	40 V	50 V	70 V	80 V	

15-AMP



TO-36

$P_D = 150$ W
$f_T = 0.30$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 5$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	40 V	45 V	50 V	70 V	80 V
20-40	2N441	2N442	2N443		
25-50				2N174	2N1100
35-70	2N277	2N278	2N173	2N1099	
h_{FE}* \ V_{CBO}	40 V	50 V	60 V	80 V	100 V

15-AMP Also Available as HI-REL Types



TO-3



TO-41†

$P_D = 106$ W
(1) $f_T = 0.55$ MC
(2) $f_T = 0.40$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 10$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CES}	30 V	45 V	60 V	75 V	
10-30 (1)	2N1549 MP1549†	2N1550 MP1550†	2N1551 MP1551†	2N1552 MP1552†	
30-60 (2)	2N1553 MP1553†	2N1554 MP1554†	2N1555 MP1555†	2N1556 MP1556†	
50-100 (2)	2N1557 MP1557†	2N1558 MP1558†	2N1559 MP1559†	2N1560 MP1560†	
h_{FE}* \ V_{CBO}	40 V	60 V	80 V	100 V	

20-AMP



TO-3



TO-41†

$P_D = 85$ W
$f_T = 18$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 10$ A, $V_{CE} = 2$ V

h_{FE}* \ V_{CEO}	50 V		75 V		100 V
25-100	2N2832 MP2832†		2N2833 MP2833†		2N2834 MP2834†
h_{FE}* \ V_{CBO}	80 V		120 V		140 V

25-AMP Also Available as HI-REL Types



TO-3



TO-41†

$P_D = 106$ W
$f_T = 0.40$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 25$ A, $V_{CE} = 1$ V

h_{FE}* \ V_{CES}	35 V		60 V		75 V
15-65	2N1162 2N1163†		2N1164 2N1165†		2N1166 2N1167†
h_{FE}* \ V_{CBO}	50 V		80 V		100 V

25-AMP



TO-8

$P_D = 75$ W
$f_T = 30$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 10$ A, $V_{CE} = 2$ V
**$I_C = 25$ A, $I_B = 2.5$ A

h_{FE}* \ $V_{CE(sat)}$**		0.5 V	
75 min		2N2912	
h_{FE}* \ V_{CBO}		15 V	

30-AMP Also Available as HI-REL Types



TO-36

$P_D = 170$ W
$f_T = 0.3$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 5$ A, $V_{CE} = 2$ V
($h_{FE} = 15$ min @ $I_C = 25$ A)

h_{FE}* \ V_{CES}	45 V		60 V		75 V
50-100	2N2152		2N2153		2N2154
80-160	2N2156		2N2157		2N2158
h_{FE}* \ V_{CBO}	45 V		60 V		75 V

50-AMP

LOW $V_{CE(sat)}$
$P_D = 170$ W
$f_T = 0.30$ MC
$T_{J\,MAX} = 110°C$



TO-36

*$I_C = 20$ A, $V_{CE} = 2$ V
($h_{FE} = 20$ min @ $I_C = 50$ A)
**$I_C = 50$ A, $I_B = 5$ A

h_{FE}* \ $V_{CE(sat)}$**		0.1 V	
40-130		2N2728	
h_{FE}* \ V_{CBO}		15 V	

60-AMP Also Available as HI-REL Types



TO-36

$P_D = 170$ W
$f_T = 0.30$ MC
$T_{J\,MAX} = 110°C$

*$I_C = 15$ A, $V_{CE} = 2$ V
($h_{FE} = 12$ min @ $I_C = 50$ A)

h_{FE}* \ V_{CES}	45 V		60 V		75 V
30-60	MP500		MP501		MP502
50-100	MP504		MP505		MP506
h_{FE}* \ V_{CBO}	45 V		60 V		75 V

SILICON POWER TRANSISTOR SELECTION CHARTS

(For Safe Operating Area Curves, see pages 6-7 and 6-8)

Indicated current ratings are recommended operating current ratings rather than absolute maximum values.

100-mA NPN



TO-66

f_T = 15 MHz
P_D = 12.5 W
T_J Max = 175°C
*V_{CE} = 10 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 1 mA	
		225 V	300 V
30-150	0.05	MJ3201	MJ3202

250-mA NPN



TO-66

f_T = 15 MHz
P_D = 20 W
T_J Max = 175°C
*V_{CE} = 10 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 5 mA	
		225 V	300 V
25-200	0.05	MJ2251	MJ2252
48-208 25	0.1 .250	2N3738	2N3739

1-Amp NPN



TO-66

f_T = 15 MHz
P_D = 20 W
T_J Max = 175°C
*V_{CE} = 5 V
** V_{CE} = 10 V

h_{FE} @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA		
		40 V	60 V	80 V
25-200	0.5 V_{CE} = 4 V	MJ3101	MJ2249	MJ2250
40-160 20	0.5* 1.0**	—	2N3766	2N3767

1-Amp PNP



TO-66

f_T = 3 MHz
P_D = 25 W
T_J Max = 200°C
*V_{CE} = 1 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA		
		40 V	60 V	80 V
20-100 V_{CE}, 4 V	0.25 .5	MJ3701	MJ2253	MJ2254
30-100 10	0.25 1.0	—	2N3740	2N3741

3-Amp PNP



TO-3
① TO-5

f_T = 60 MHz
P_D = 25 W
T_J Max = 175°C
① P_D = 6 W
① T_J Max = 200°C
*V_{CE} = 2 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 20 mA			
		30 V	40 V	45 V	60 V
20-60	1.0	2N3021	—	2N3022	2N3023
25-180	1.8	—	2N3719①	—	2N3728①
50-180	1.0	2N3024	—	2N3025	2N3026

4-Amp NPN



TO-66

f_T = 4 MHz
① P_D = 25 W
⑤ P_D = 30 W
T_J Max = 200°C
④ V_{CE} = 4 V
① V_{CE} = 2 V

h_{FE} @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA		
		40 V	60 V	80 V
25-100①	2.0	2N4231④	2N4232④	2N4233④
25-100⑤	1.5	MJ4101⑧	—	MJ4102⑧

5-Amp NPN



TO-61

f_T = 10 MHz
P_D = 115 W
*V_{CE} = 15 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA
		80 V
20-90	2.0	2N1724

5-Amp PNP



① TO-3

f_T = 4 MHz
P_D = 150 W
T_J Max = 200°C
*V_{CE} = 2 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA	
		60 V	80 V
25-90 15	1.0 3.8	2N3789	2N3790
50-150 30	1.0 3.0	2N3791	2N3792

5-Amp NPN



TO-61
① TO-3

f_T = 10 MHz
P_D = 115 W
T_J Max = 280°C
*V_{CE} = 5 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA		
		60 V	80 V	100 V
15-45	3.0	—	—	2N3489
20-60	3.0	2N3445①	2N3446①	—
		2N3487	2N3488	
30-90	5.0	—	—	2N3492
40-120	5.0	2N3447①	2N3448①	—
		2N3490	2N3491	

5-Amp NPN



TO-3

f_T = 4 MHz
P_D = 150 W
T_J Max = 200°C
*V_{CE} = 2 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA	
		60 V	80 V
25-90 15	1.0 3.0	2N3713	2N3714
50-150 38	1.0 3.0	2N3715	2N3716

8-Amp NPN



TO-3

f_T = 1 MHz
P_D = 120 W
T_J Max = 200°C
*V_{CE} = 4 V

h_{FE}* @ I_C (Amps)		BV_{CEO} @ I_C = 100 mA	
		40 V	60 V
15-60	8.0	MJ2001	MJ2002
20-70	4.0	—	2N3855

All ratings and characteristics shown are at T_C = 25°C unless otherwise noted

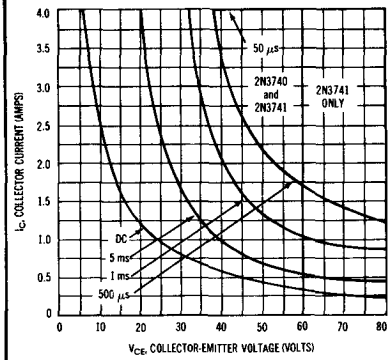
NPN/PNP SILICON POWER TRANSISTOR SAFE OPERATING AREA CURVES

Safe Operating Area Curves have proven a boon to the power transistor circuit designer. These curves not only define the I_C vs. V_{CE} limits under dc steady-state power, but also show the capability of a given transistor type under various pulse conditions. To insure reliable performance, both "safe area" and average "power-temperature" derating criteria must be observed under steady-state as well as pulse conditions.

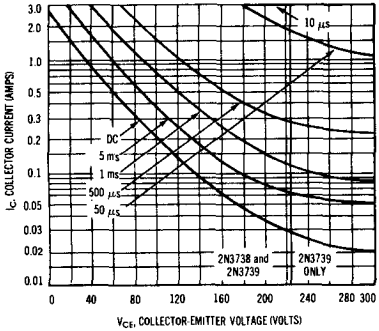
For power-temperature derating curves, see individual data sheets in this section.

All data for curves taken at 25°C

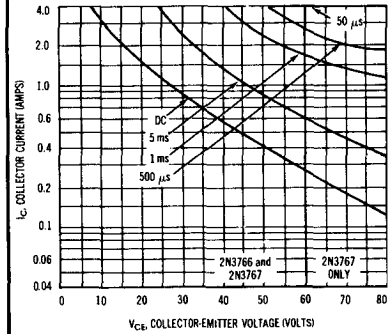
2N3740, 2N3741



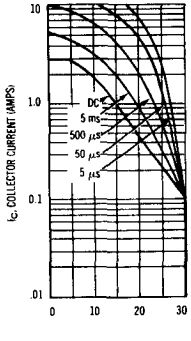
2N3738, 2N3739



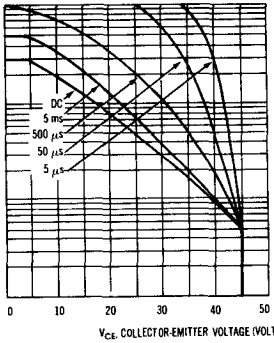
2N3766, 2N3767



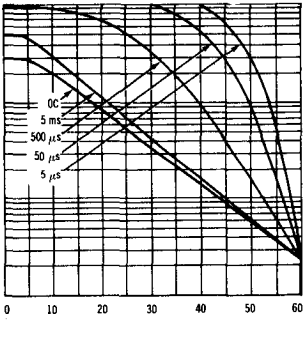
2N3021, 2N3024



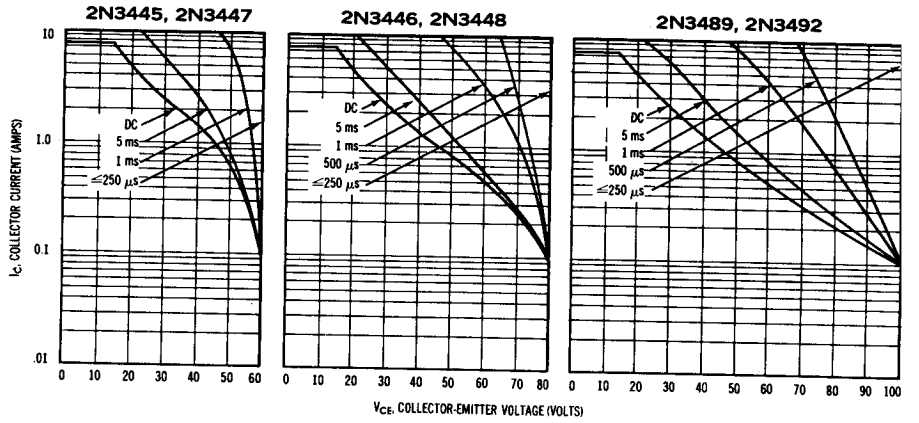
2N3022, 2N3025

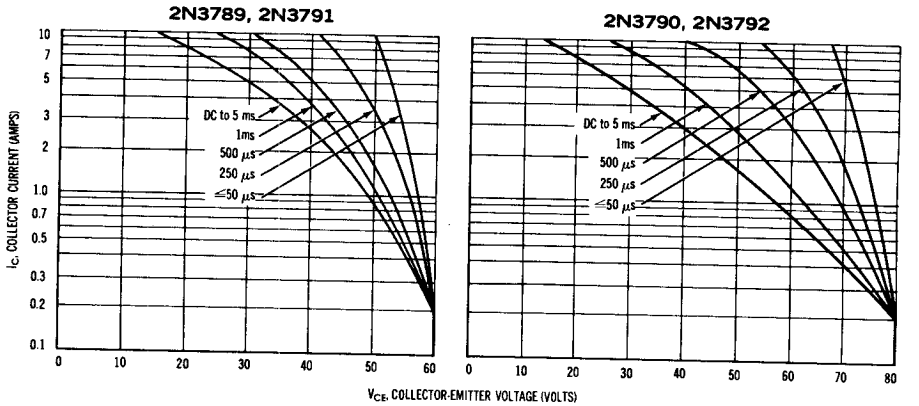


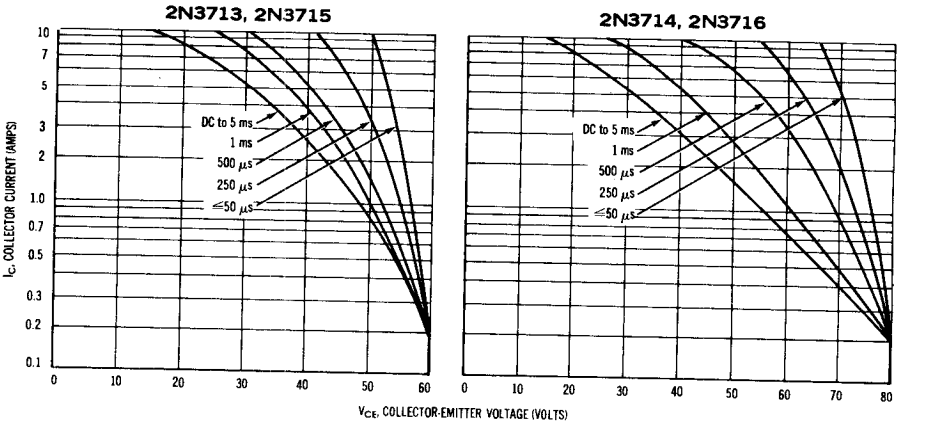
2N3023, 2N3026



V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)


2N3445, 2N3447
2N3446, 2N3448
2N3489, 2N3492
I_C, COLLECTOR CURRENT (AMPS)
10
1.0
0.1
.01
DC
5 ms
1 ms
≤250 μs
500 μs
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80
0 10 20 30 40 50 60 70 80 90 100
V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)


2N3789, 2N3791
2N3790, 2N3792
I_C, COLLECTOR CURRENT (AMPS)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
DC to 5 ms
1ms
500 μs
250 μs
≤50 μs
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80
V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)


2N3713, 2N3715
2N3714, 2N3716
I_C, COLLECTOR CURRENT (AMPS)
10
7
5
3
2
1.0
0.7
0.5
0.3
0.2
0.1
DC to 5 ms
1 ms
500 μs
250 μs
≤50 μs
0 10 20 30 40 50 60
0 10 20 30 40 50 60 70 80
V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)

HOW TO SELECT POWER TRANSISTORS FOR AUDIO AMPLIFIERS

GIVEN: P_O – Desired Power Output

R_L – Load Resistance

V_{CC} – Power Supply Voltage (nominal and maximum)

FIND: Transistors with specifications that meet the requirements.

PROCEDURE:

1. CALCULATE PEAK OPERATING CURRENT, $I_{C(pk)}$

   (a) For Class A, Single-Ended Transformer-Coupled Circuits:

$$I_{C(pk)} = \frac{2\ V_{CC(max)}}{R_L'} \quad \text{where } *R_L' = \frac{V_{CC(nom.)}^2}{2\ P_O}$$

   (b) For Class B, Transformer-Coupled Circuits:

$$I_{C(pk)} = \frac{V_{CC(max)}}{R_L'} \quad \text{where} \quad R_L' = \frac{V_{CC(nom.)}^2}{2\ P_O}$$

   (c) For Class B, Transformerless Output Stage (Two Power Supplies):

$$I_{C(pk)} = \frac{V_{CC(max)}}{R_L}$$

   (d) For Class B, Transformerless Output Stage (Single Power Supply):

$$I_{C(pk)} = \frac{V_{CC(max)}}{2\ R_L}$$

2. DETERMINE TRANSISTOR VOLTAGE RATING

$$BV_{CEO}\ (\text{or } BV_{CES}) \geqq 2\ V_{CC(max)}, \text{ except:}$$

   For Class B, Transformerless Circuit (Single Power Supply):

$$BV_{CEO}\ (\text{or } BV_{CES}) \geqq V_{CC(max)}$$

3. DETERMINE MAXIMUM POWER DISSIPATION

   (a) For Class A, Single-Ended Transformer-Coupled Circuits:

$$P_{D(max)} = V_{CC(max)}\ \frac{I_{PK}}{2}$$

   (b) For Class B, Transformer-Coupled Circuits:

$$P_{D(max)} = \frac{V_{CC(max)}^2}{\pi^2 R_L'}$$

(c) For Transformerless Output Stages (Two Power Supplies):

$$P_{D(max)} = \frac{V_{CC(max)}^2}{\pi^2 R_L}$$

(d) For Transformerless Output Stages (One Power Supply):

$$P_{D(max)} = \frac{V_{CC(max)}^2}{4\pi^2 R_L}$$

4. DETERMINE MAXIMUM JUNCTION TEMPERATURE, T_J
Given: Heat Sink with Specified $\theta_{C\ A}$

Junction temperature, power dissipation, thermal resistance and ambient temperature are related by the following equation:

$$T_{J(max)} = P_{D(max)} (\theta_{J\ C} + \theta_{C\ A}) + T_{A(max)}$$

where $T_{J(max)}$ = maximum junction temperature
$\theta_{J\ C}$ = junction-to-case thermal resistance
$\theta_{C\ A}$ = case-to-ambient thermal resistance (include heat sink and interface)
$T_{A(max)}$ = maximum ambient temperature

$P_{D(max)}$ has been calculated and $T_{A(max)}$ is known. One of the three unknowns can be determined by affixing values to the other two with reference to data sheet or heat sink specifications.

5. From preceding selector guides, select suitable transistors on the basis of $I_{C(pk)}$, Voltage Ratings, P_D, T_J, and $\theta_{J\ C}$.
6. Check appropriate Safe-Area curves to determine maximum operating conditions for the transistors selected. The dc and 5 millisecond curves are usually the limiting curves for audio amplifier applications.
7. Refer to individual data sheets for dynamic transistor characteristics that will permit ultimate selection of desired transistor.

*R_L' is the load which each transistor sees.

For Transformer-Coupled Circuits, $R_L' = (N_1/N_2)^2 R_L$ (Single-Ended Class A), $R_L' = (N_1/N_2)^2 R_L/4$ (push-pull Class B).

HOW TO SELECT POWER TRANSISTORS FOR INVERTER APPLICATIONS

GIVEN: P_O — Desired Power Output

f — Inverter Frequency

V_{CC} — Supply Voltage

FIND: Transistors with specifications that meet the requirements.

PROCEDURE:

1. CALCULATE OPERATING CURRENT, I_{C1}. (Assume conversion efficiency (η) of 80%.)

$$I_{C1} = \frac{1.25\ P_O}{V_{CC}}$$

2. DETERMINE TRANSISTOR BREAKDOWN VOLTAGE

$$BV_{CES}\ (\text{or } BV_{CEO}) \geq 2.5\ V_{CC}$$

3. SELECT TRANSISTORS WITH REQUIRED CURRENT AND VOLTAGE RATINGS
(From previous selector guides.)

   (a) For $f > 3$ kHz, select devices with $f_T > 1$ MHz;

   For $f > 10$ kHz, select devices with $f_T > 4$ MHz.

   NOTE: Germanium transistors are generally advantageous in applications requiring low V_{CC}. Silicon devices are preferred for applications requiring high case temperature.

4. From preliminary choices, select on the basis of other characteristics, as provided in the complete data sheets.

   (a) Safe Operating Area curve (25 μsec) should include the conditions $I_C = I_{C1}$, and $V_{CE} = 2.5\ V_{CC}$ (inductive load line assumed).

   (b) As a relative Figure of Merit, the following expression can be used:

$$F_m = \frac{P_O}{2\ I_{CEX}\ V_{CC} + I_C\ V_{CE(sat)} + \frac{8\ V_{BE(sat)}}{h_{FE(min)}} + 2.5\ V_{CC}\ (t_r + t_f)\ f}$$

The device characteristics used in the expression are normally given in the data sheet specifications.

ADDITIONS AND MODIFICATIONS

2N173 (GERMANIUM)

For Specifications, See 2N277 Data Sheet

2N174 (GERMANIUM)
2N174 JAN
2N1100
2N1358
2N1358 JAN/USA

P_D = 150W
I_E = 15A
V_{CBO} = 80-100V



CASE 5
(TO-36)

PNP germanium power transistors. Power dissipation and junction temperature ratings exceed those of EIA registration.

MAXIMUM RATINGS

Characteristic	Symbol	2N174	2N1100	2N1358	Unit
Collector-Base Voltage	BV_{CBO}	80	100	80	Vdc
Emitter-Base Voltage	BV_{EBO}	60	80	60	Vdc
Emitter Current (Continuous)	I_E	15	15	15	Amps
Base Current (Continuous)	I_B	4	4	4	Amps
Junction and Storage Temperature	T_J, T_{stg}	-65 to +110			°C
Thermal Resistance, Junction to Case	θ_{JC}	0.5			°C/W

2N174, 2N1100, 2N1358 (continued)

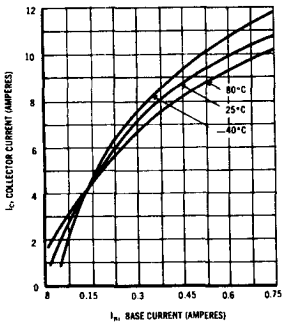
ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				μA
	2N174		-	100	-	
(V_{CB} = -2 volts)	2N1100		-	100	-	
	2N1358		-	100	200	
Collector-Base Cutoff Current		I_{CB}				mA
(V_{EB} = -1.5 volts, V_{CB} = -80 volts)	2N174		-	2	8	
-100	2N1100		-	2	8	
-80	2N1358		-	2	8	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = -60 volts)	2N174		-	1	8	
-80	2N1100		-	1	8	
-60	2N1358		-	1	8	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{CB} = - 80 volts, 71°C)	2N174		-	-	15	
-100	2N1100		-	-	15	
- 60	2N1358		-	4	6	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = -30 volts, 71°C)	2N1358		-	4	6	
Collector-Emitter Voltage		BV_{CES}*				Vdc
(I_C = 300 mA, V_{EB} = 0)	2N174		-70	-	-	
	2N1100		-80	-	-	
	2N1358		-70	-	-	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
(I_C = 1.0 amp, I_B = 0)	2N174		-55	-	-	
1.0 amp, I_B = 0	2N1100		-65	-	-	
300 mA, I_B = 0	2N1358		-40	-	-	
Floating Potential		V_{FE}				volt
(I_E = 0, V_{CB} = - 80 volts)	2N174		-	-	1.0	
-100	2N1100		-	-	1.0	
- 80	2N1358		-	0.15	1.0	
Current Gain		h_{FE}				-
(I_C = 1.2 amps, V_{CB} = -2 volts)	2N1358		40	55	80	
(I_C = 5 amps, V_{CB} = -2 volts)	2N174		25	-	50	
	2N1100		25	-	50	
	2N1358		25	35	-	
(I_C = 12 amps, V_{CB} = -2 volts)	2N174		-	20	-	
	2N1100		-	20	-	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 1.2 amps, V_{CB} = -2 volts)	2N1358		-	0.35	0.5	
(I_C = 5 amps, V_{CB} = -2 volts)	2N174		-	0.65	0.9	
	2N1100		-	0.65	0.9	
	2N1358		-	0.65	0.9	
Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 12 amps, I_B = 2 amps)	2N174		-	0.3	0.9	
	2N1100		-	0.3	0.7	
	2N1358		-	0.3	0.7	
Common-Emitter Current Amplification Cutoff Frequency		f_{ae}				kc
(I_C = 5 amp, V_{CE} = 6 volts)	2N174		-	10	-	
	2N1100					
Common-Base Current Amplification Cutoff Frequency		f_{ab}				kc
(I_C = 1 amp, V_{CB} = -12 volts)	2N1358		100	-	-	
Rise Time ("on" I_C = 12 Adc,		t_r				μsec
I_B = 2 Adc, V_{CE} = -12 volts)	All Types		-	15	-	
Fall Time ("off" I_C = 0,		t_f				μsec
V_{EB} = -6 volts, R_{EB} = 10 ohms)	All Types		-	15	-	

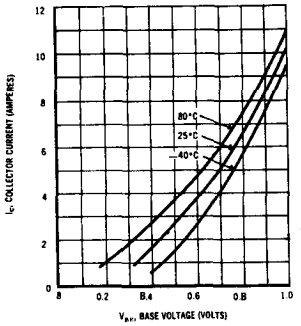
* In order to avoid excessive heating of the collector junction, perform test by the sweep method.

2N174, 2N1100, 2N1358 (continued)

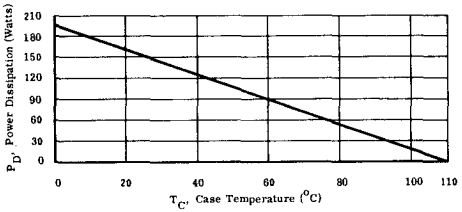
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS



POWER-TEMPERATURE DERATING CURVE

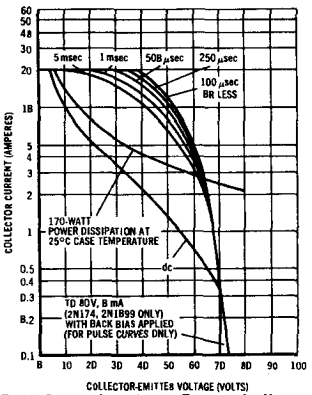


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

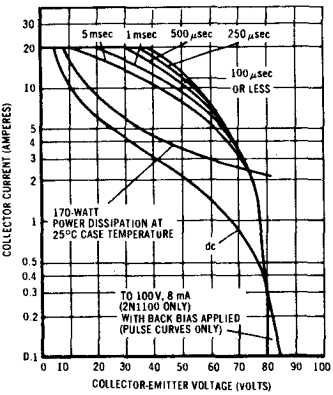
$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

2N174 AND 1358



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

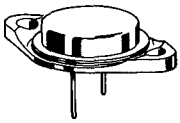
2N1100



(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N176 (GERMANIUM)
2N669

$P_D = 90W$
$I_C = 3 A$
$V_{CBO} = 40 V$

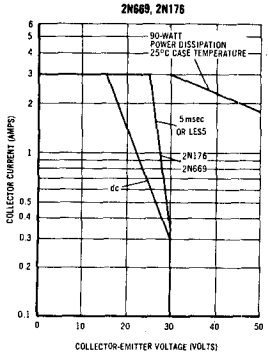


PNP germanium power transistors for economical power switching circuits and commercial grade power amplifier applications.

CASE 11
(TO-3)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector Current (Continuous)	I_C	3	Amps
Storage and Junction Temperature	T_j, T_{stg}	−65 to +100	°C
Collector Dissipation (At 25°C Case Temperature)	P_C	90	Watts
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W



SAFE OPERATING AREAS

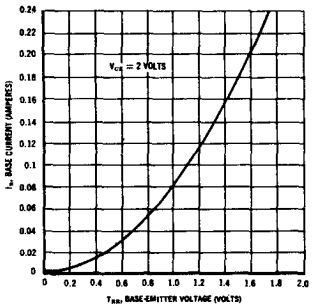
The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N176, 2N669 (continued)

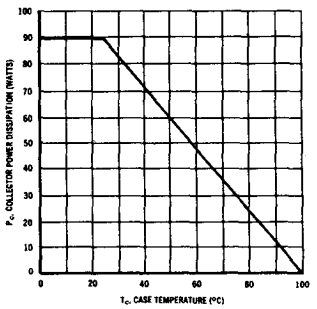
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				
V_{CB} = 30 V, I_E = 0	Both Types		—	—	3	mA
V_{CB} = 2.0 V, I_E = 0			—	50	—	μA
V_{CB} = 30 V, I_E = 0, T_C = 90°C			—	—	20	mA
Emitter-Base Cutoff Current		I_{EBO}				mA
V_{EB} = 10 V, I_C = 0	Both Types		—	—	2	
Collector-Emitter Breakdown Voltage						Vdc
I_C = 330 mA, R_{BE} = 10 Ohms	2N176	BV_{CER}	30	—	—	
	2N669	BV_{CES}	30	—	—	
Collector-Emitter Saturation Voltage		$V_{CE(SAT)}$				Vdc
I_C = 3 A, I_B = 300 mA	Both Types		—	0.4	—	
DC Forward Current Transfer Ratio		h_{FE}				—
V_{CE} = 2.0 V, I_C = 0.5 A	2N176		25	—	—	
	2N669		75	—	250	
Power Gain		G_{PE}				dc
P_o = 2 Watts, V_{CE} = 12 V, I_C = 0.5 Amp, f = 1 kc, R_S = 10 Ohms, R_L = 26.6 Ohms	2N176		34	—	37	
	2N669		38	—	—	
Total Harmonic Distortion (under same conditions of power gain)	Both Types					%
Small-Signal Current Gain Cutoff Frequency		f_{ae}				kc
V_{CE} = 12 V, I_C = 0.5 Amp, f = 1 kc ref	2N176		4	7	—	
	2N669		3	5	—	
Small-Signal Forward-Current Transfer Ratio		h_{FE}				—
V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kc	2N176		—	45	—	
	2N669		—	90	—	
Small-Signal Input Impedance		h_{FE}				Ohms
V_{CE} = 2.0 V, I_C = 0.5 Amp, f = 1 kc	2N176		7	—	25	
	2N669		10	—	50	

INPUT CURRENT versus EMITTER DRIVE VOLTAGE
(Both Types)

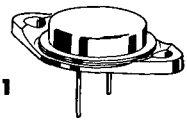


POWER-TEMPERATURE DERATING CURVE
(Both Types)



2N178 (GERMANIUM)
2N554
2N555

$P_D = 40$ W
$I_C = 3$ A
$V_{CBO} = 15$-30 V



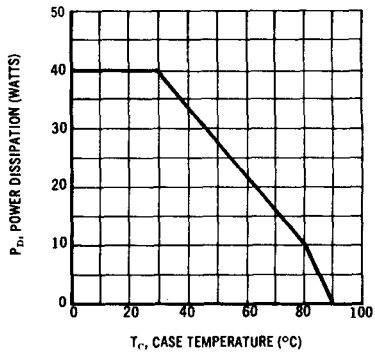
CASE 11
(TO-3)

PNP germanium power transistor for non-critical power amplifier and power switching applications requiring economical components.

MAXIMUM RATINGS

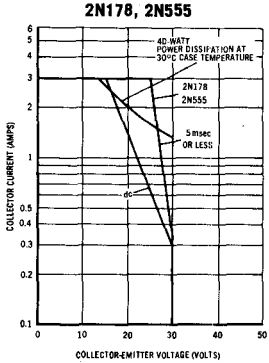
Characteristic	Symbol	2N178	2N554	2N555	Unit
Collector-Base Voltage	V_{CBO}	30	15	30	Vdc
Collector-Emitter Voltage	V_{CER}	30	16	30	Vdc
Emitter-Base Voltage	V_{EBO}	20	15	15	Vdc
Collector Current	I_C	3	3	3	Amps
Junction and Storage Temperature Range	T_J T_{stg}	-40 to +90			°C
Collector Power Dissipation (at T_C = 80°C)	P_D	10	10	10	Watts

POWER-TEMPERATURE DERATING CURVE
(All Types)

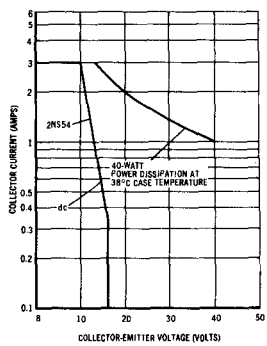


SAFE OPERATING AREAS

2N178, 2N555



2N554



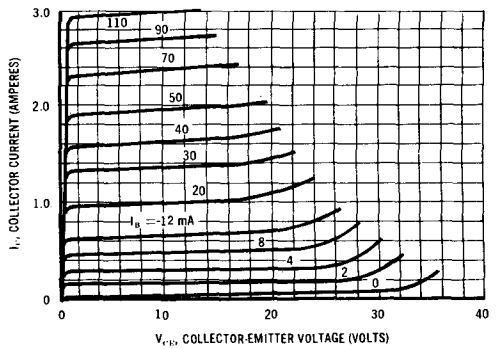
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N178, 2N554, 2N555 (continued)

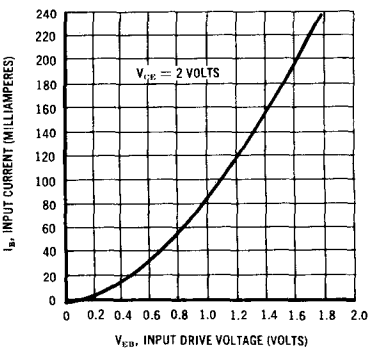
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{CB} = 30 V, I_E = 0)	2N178		-	-	3.0	
(V_{CB} = 15 V, I_E = 0)	2N554			-	10.0	
(V_{CB} = 30 V, I_E = 0)	2N555		-	-	20.0	
Collector-Base Cutoff Current		I_{CBO}				μA
(V_{CB} = 2 V, I_E = 0)	2N178		-	50	-	
Emitter-Base Cutoff Current		I_{EBO}				mA
(V_{EB} = 10 V, I_C = 0)	2N178		-	-	2.0	
Collector-Base Cutoff Current		I_{CBO}				mA
(V_{CB} = 30 V, I_E = 0,						
T_C = 90°C)	2N178		-	-	20.0	
Collector-Emitter Breakdown Voltage		BV_{CER}				Vdc
(I_C = 330 mA, R_{BE} = 10 Ω)	2N178		30	-	-	
	2N554		I6	-	-	
	2N555		30	-	-	
Power Gain		G_e				db
(P_o = 2 Watts; V_{CE} = 12 V, I_C = 0.5 A,	2N178		28	30	33	
f = 1 kc, R_s = 10 Ohms, R_L = 26.6 Ohms)	2N554		20	35	-	
	2N555		25	35	-	
Total Harmonic Distortion						%
(under same conditions as power gain)	2N178		-	-	5	
DC Forward Current Transfer Ratio		h_{FE}				-
(V_{CE} = 2 V, I_C = 0.5 A)	2N178		15	-	45	
	2N554		-	50	-	
	2N555		-	50	-	
Small-Signal Current Gain Cutoff Frequency		f_{ae}				kc
(V_{CE} = 12 V, I_C = 0.5 A,	2N178		5	-	-	
f = I kc rei)	2N554		-	6	-	
	2N555		-	6	-	
Small-Signal Forward Current Transfer-Ratio		h_{fe}				-
(Base Input)						
V_{CE} = 2 V, I_C = 0.5 A,	2N178		-	50	-	
f = 1 kc ref)	2N554		-	55	-	
	2N555		-	55	-	
Small-Signal Input Impedance (Base Input)		h_{ie}				Ohms
(V_{CE} = 2 V, I_C = 0.5 A,	2N178		8	25	-	
f = 1kc)	2N554		-	25	-	
	2N555		-	25	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 3 A, I_B = 300 mA)	All Types		-	0.6	-	

COLLECTOR CHARACTERISTICS



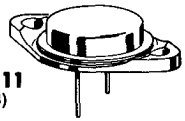
INPUT CURRENT versus INPUT DRIVE VOLTAGE



2N242 (GERMANIUM)

2N307, A

$P_D = 90W$
$I_C = 5\ A$
$V_{CBO} = 35\text{-}45\ V$



CASE 11
(TO-3)

PNP germanium power transistors for general purpose power amplifier and switching applications.

MAXIMUM RATINGS

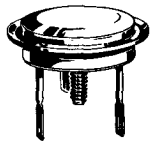
Characteristic	Symbol	2N242	2N307, 307A	Unit
Collector-Base Voltage	V_{CBO}	45	35	Volts
Collector-Emitter Voltage (R_{BE} = 30 Ω)	V_{CER}	-45	—	Volts
Collector-Emitter Voltage	V_{CEO}	—	35	Volts
Emitter-Base Voltage	V_{EBO}	—	10	Volts
Collector Current	I_C	5	5	Amps
Junction Temperature Range	T_J	-65 to +110	-65 to +110	°C
Collector Dissipation (at T_C = 25°C)	P_D	106	106	Watts

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -2 Vdc)	2N307		—	0.5	
(V_{CB} = -25 Vdc)	2N307		—	5	
	2N307A		—	2	
(V_{CB} = -1 Vdc, I_E = 0, T_C = 85°C)	2N242		—	5	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -10 Vdc)	All Types		—	2	
Collector-Emitter Cutoff Current		I_{CER}			mAdc
(V_{CE} = -45 Vdc, R_{BE} = 30 Ω)	2N242		—	5	
(V_{CE} = -25 Vdc, R_{BE} = 30 Ω)	2N242		—	1	
(V_{CE} = -35 Vdc, R_{BE} = 30 Ω)	2N307		—	15	
	2N307A		—	7	
Base-Emitter Voltage		V_{BE}			Vdc
(V_{CE} = -1.5 Vdc, I_C = 1.0 Adc)	2N242		-0.3	-0.8	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2.0 Adc, I_B = 200 mAdc)	2N242		—	-0.8	
(I_C = 0.2 Adc, I_B = 20 mAdc)	2N307		—	-1.0	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N307A		—	-0.8	
DC Current Gain		h_{FE}			—
(V_{CE} = -12 Vdc, I_C = 500 mAdc)	2N242		30	120	
(V_{CE} = -1 Vdc, I_C = 200 mAdc)	2N307		20	—	
	2N307A		30	—	
Common Emitter Cutoff Frequency		f_{ae}			kc
(V_{CE} = -12 V, I_C = 0.5 A)	2N242		5	—	
	2N307A		3.5	—	
(V_{CE} = -6 V, I_C = 1 A)	2N307		3	—	
Power Gain		G_e			db
(I_C = 0.5 A, V_{CE} = -14 V, R_L = 30 Ω, R_g = 10 Ω)	2N242		30		

2N277 (GERMANIUM)
2N278
2N173
2N1099

$P_D = 170$ W
$I_E = 15$ A
$V_{CBO} = 40\text{-}80$ V



CASE 5
(TO-36)

PNP germanium power transistors for general purpose power amplifier and switching applications. Power and temperature ratings exceed EIA registration.

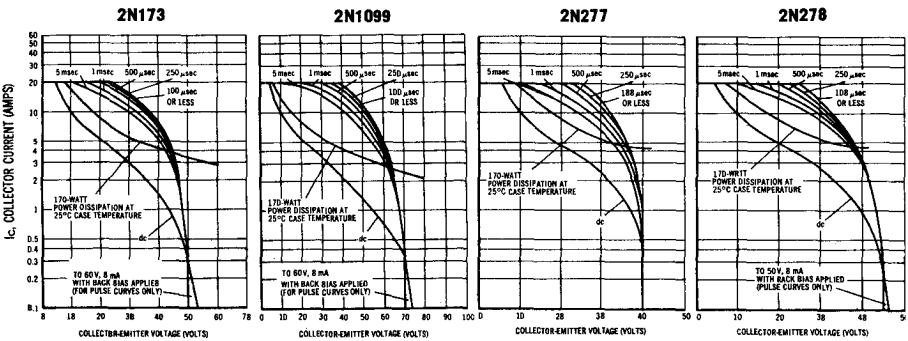
MAXIMUM RATINGS

Characteristic	Symbol	2N277	2N278	2N173	2N1099	Unit
Collector-Base Voltage	V_{CB}	40	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	20	30	40	40	Vdc
Emitter Current-Continuous	I_E	15				Adc
Base Current	I_B	4				Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	170 2				Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N277, 2N278, 2N173, 2N1099 (continued)

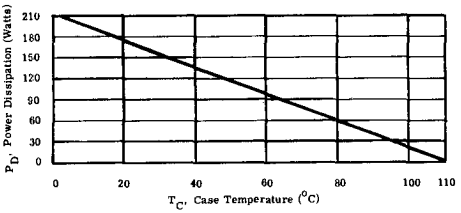
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current V_{CBO} = −2 V	All Types	I_{CBO}	—	100	—	μA
Collector-Base Cutoff Current		I_{CB}				mA
V_{EB} = −1.5 V, V_{CB} = −40 V	2N277		—	2	8	
−50	2N278		—	2	8	
−60	2N173		—	2	8	
−80	2N1099		—	2	8	
Emitter-Base Cutoff Current		I_{EBO}				mA
V_{EBO} = −20 V	2N277		—	1	8	
−30	2N278		—	1	8	
−40	2N173		—	1	8	
−40	2N1099		—	1	8	
Collector-Base Cutoff Current		I_{CBO}				mA
V_{CBO} = −40 V, 71°C	2N277		—	—	15	
−50	2N278		—	—	15	
−60	2N173		—	—	15	
−80	2N1099		—	—	15	
Collector-Emitter Voltage		BV_{CES}*				Vdc
I_C = 300 mA, V_{EB} = 0	2N277		−40	—	—	
	2N278		−45	—	—	
	2N173		−50	—	—	
	2N1099		−70	—	—	
Collector-Emitter Voltage		BV_{CEO}*				Vdc
I_C = 1 Amp, I_B = 0	2N277		−25	—	—	
	2N278		−30	—	—	
	2N173		−45	—	—	
	2N1099		−55	—	—	
Floating Potential		V_{fl}				volt
I_E = 0, V_{CB} = −40 V	2N277		—	0.15	1.0	
−50	2N278		—	0.15	1.0	
−60	2N173		—	0.15	1.0	
−80	2N1099		—	0.15	1.0	
Current Gain		h_{FE}				—
I_C = 5 Amps, V_{CB} = −2 V	All Types		35	—	70	
I_C = 12 Amps, V_{CB} = −2 V			—	25	—	
Base-Emitter Voltage		V_{BE}				Vdc
I_C = 5 Amps, V_{CB} = −2 V	2N277		—	0.65	—	
	2N278		—	0.65	—	
	2N173		—	0.65	—	
	2N1099		—	0.65	0.9	
Saturation Voltage		$V_{CE(SAT)}$				Vdc
I_C = 12 Amps, I_B = 2 Amps	2N277		—	0.3	—	
	2N278		—	0.3	1.0	
	2N173		—	0.3	1.0	
	2N1099		—	0.3	0.7	
Common-Emitter Current Amplification Cutoff Frequency I_C = 5 Amps, V_{CE} = −6 V	All Types	f_{ae}	—	10	—	kc
Rise Time "on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = −12 V	All Types	t_r	—	15	—	μsec
Fall Time "off" I_C = 0, V_{EB} = −6 V, R_{EB} = 10 Ohms		t_f	—	15	—	μsec

* To avoid excessive heating of the collector junction, perform these tests with the sweep method.

2N277, 2N278, 2N173, 2N1099 (continued)

POWER-TEMPERATURE DERATING CURVE

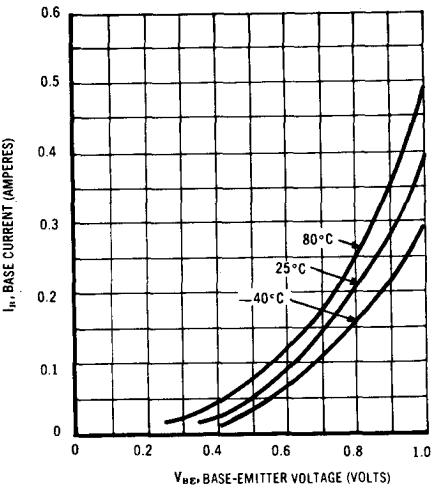


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

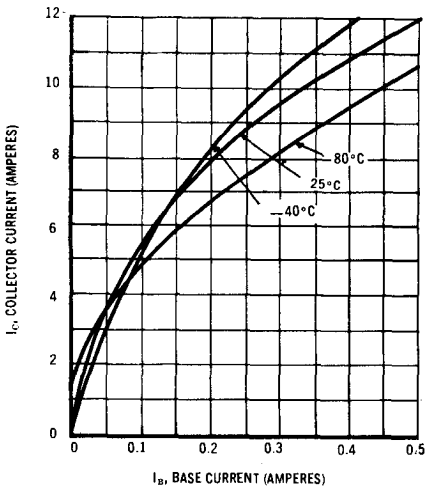
This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

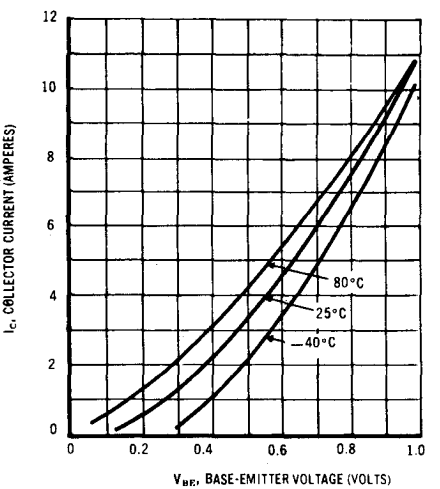
INPUT CHARACTERISTICS



CURRENT TRANSFER CHARACTERISTICS

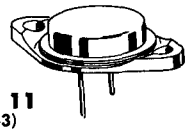


TRANSCONDUCTANCE CHARACTERISTICS



2N297A (GERMANIUM)
2N297A USA/JAN

$P_D = 85$ W
$I_E = 5$ A
$V_{CBO} = 60$ V



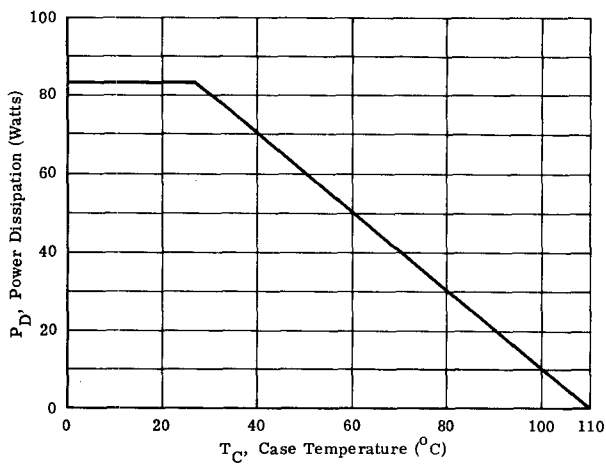
CASE 11
(TO-3)

PNP germanium power transistors for military and industrial power switching and amplifier applications. Operating temperature range and collector dissipation rating exceeds military specifications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEB}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
Emitter Current	I_E	5	Amps
Operating Temperature Range	T_J	−65 to +110	°C
Collector Dissipation at 25°C Case Temperature (θ_{JC} = 1 °C/W max)	P_D	85	Watts

POWER-TEMPERATURE DERATING CURVE



2N297 A (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified

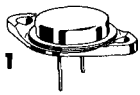
Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 0.5 Adc	h_{FE}	40	100	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 2.0 Adc	h_{FE}	20	—	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 14 Vdc I_C = 0.5 Amp,	f_{ae}	5	—	kc
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 60 Vdc I_E = 0	I_{CBO}	—	3.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 0.5 Adc	I_B	5.0	12.5	mAdc
Base Current V_{CE} = 2 Vdc I_C = 2 Adc	I_B	—	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 2 Adc	V_{EB}	—	1.5	Vdc
Floating Potential V_{CB} = 60 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}	0.0	0.18	Vdc
Collector-Emitter Saturation Voltage I_C = 2 Adc I_B = 200 mAdc	$V_{CE(SAT)}$	0.0	1.0	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	50	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency V_{CE} = 14 Vdc I_C = 0.5 Adc	f_{ae}	5	—	kc
High-Temperature Operation T_C = +71°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	6.0	mAdc

2N307 (GERMANIUM)
2N307A

For Specifications, See 2N242 Data Sheet

2N350A (GERMANIUM)
2N351A
2N376A

$P_D = 90W$
$I_C = 3\text{-}5\ A$
$V_{CBO} = 50\ V$



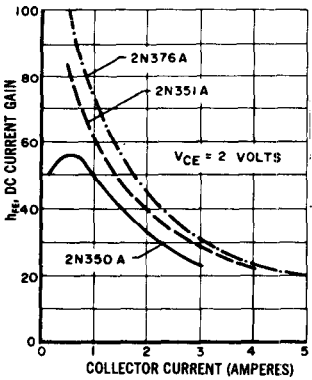
CASE 11
(TO-3)

PNP germanium power transistors for economical power switching applications and for power amplifiers requiring up to 4 watts of output power at relatively low distortion.

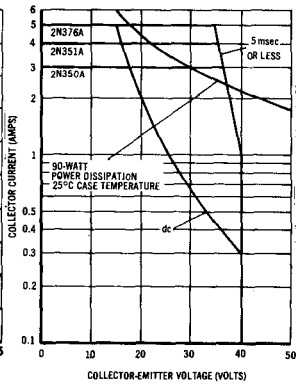
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector Dissipation at 25°C mounting base temperature	P_D	90	Watts
Collector Junction Temperature	T_j	−65 to +100	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.8	°C/W

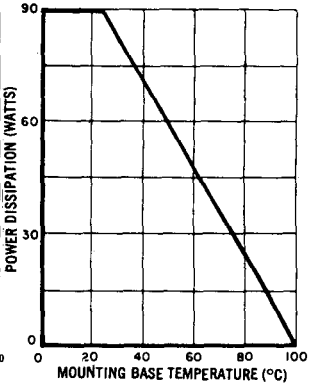
CURRENT GAIN versus COLLECTOR CURRENT (COMMON EMITTER)



SAFE OPERATING AREAS



POWER TEMPERATURE DERATING CURVE



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N350A, 2N351A, 2N376A (continued)

ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

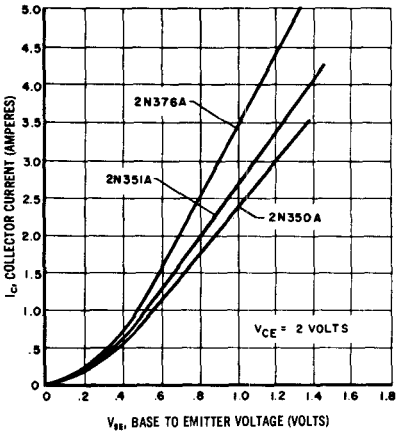
GENERAL	Symbol	Minimum	Typical	Maximum	Unit
Collector Cutoff Current	I_{CBO}				
V_{CB} = 30 V		—	—	3.0	mA
V_{CB} = 2 V		—	50	—	μA
V_{CB} = 30 V, T = 100°C		—	—	30	mA
Emitter Cutoff Current V_{EB} = 10 V	I_{EBO}	—	—	2.0	mA
Collector Breakdown Voltage I_C = 1 A (R_{BE} = 10 Ω) I_C = 330 mA, R_{BE} = 0 (This test should be made under dynamic conditions only)	BV_{CES}	40	—	—	Vdc

ELECTRICAL CHARACTERISTICS (at mounting base temperature 25°C ± 3°C.)

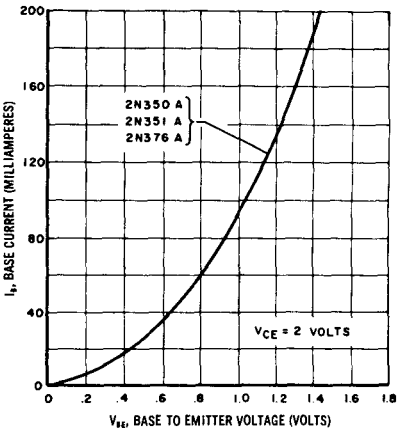
COMMON EMITTER		2N350A			2N351A			2N376A			Unit
	Sym	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Power Gain (± 0.5 db) P_o = 4 Watts, V_{CE} = 12 V, I_C = 0.7 A, f = 1 kc	G_{PE}	30	—	33	32	—	35	34	—	37	db
Total Harmonic Distortion under same conditions as power gain		—	—	7%	—	—	7%	—	—	7%	
DC Forward Current Gain V_{CE} = 2 V, I_C = 0.7 A	h_{FE}	20	—	60	25	—	90	35	—	120	
Current Gain Frequency Cutoff V_{CE} = 12 V, I_C = 0.7 A, f = 1 kc ref	f_{ae}	5	—	—	5	—	—	5	—	—	kc
Small-Signal Forward Current Gain f = 1 kc, V_{CE} = 2 V, I_C = 0.7 A	h_{fe}	—	30	—	—	45	—	—	60	—	
Small-Signal Input Impedance f = 1 kc, V_{CE} = 2 V, I_C = 0.7 A	h_{ie}	5	—	17	6	—	20	7	—	25	Ohms
Collector Saturation Voltage I_C = 3 A, I_B = 300 mA	$V_{CE(SAT)}$	—	0.8	1.75	—	—	—	—	—	—	Vdc
Base-Emitter Voltage I_C = 3 A, I_B = 300 mA	V_{BE}	—	1.0	2.00	—	—	—	—	—	—	Vdc
Collector Saturation Voltage I_C = 4 A, I_B = 400 mA	$V_{CE(SAT)}$	—	—	—	—	0.8	1.75	—	—	—	Vdc
Base-Emitter Voltage I_C = 4 A, I_B = 400 mA	V_{BE}	—	—	—	—	1.0	2.00	—	—	—	Vdc
Collector Saturation Voltage I_C = 5 A, I_B = 500 mA	$V_{CE(SAT)}$	—	—	—	—	—	—	—	0.8	1.75	Vdc
Base-Emitter Voltage I_C = 5 A, I_B = 500 mA	V_{BE}	—	—	—	—	—	—	—	1.0	2.00	Vdc

2N350A, 2N351A, 2N376A (continued)

OUTPUT CURRENT versus EMITTER-DRIVE VOLTAGE

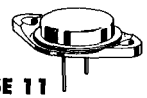


INPUT CURRENT versus EMITTER-DRIVE VOLTAGE



2N375 (GERMANIUM)
2N618
2N1359
2N1360
2N1362 thru 2N1365

P_D = 106 W
I_C = 3 A
V_{CBO} = 50-120 V



CASE 11
(TO-3)

PNP germanium power transistors for general purpose switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N1359 2N1360	2N375 2N618	2N1362 2N1363	2N1364 2N1365	Unit
Collector-Emitter Voltage	V_{CES}	40	60	75	100	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	120	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	60	Vdc
Collector Current-Continuous Peak	I_C	3 10				Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	106 1.25				Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110				°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

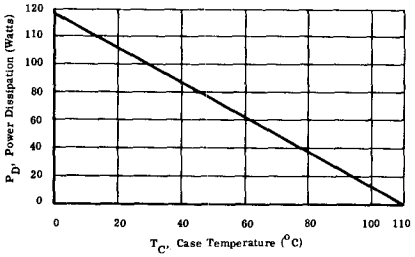
2N375, 2N618, 2N1359, 2N1360, 2N1362 thru 2N1365 (continued)

ELECTRICAL CHARACTERISTICS (At = 25°C unless otherwise noted)

Characteristic	Types	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current	2N1359, 2N1360	I_{CBO}				mA
(V_{CB} = 40 V, I_E = 0)			--	--	3.0	
(V_{CB} = 50 V, I_E = 0)			--	--	20.0	
(V_{CB} = 60 V, I_E = 0)	2N375, 2N618		--	--	3.0	
(V_{CB} = 80 V, I_E = 0)			--	--	20.0	
(V_{CB} = 75 V, I_E = 0)	2N1362, 2N1363		--	--	3.0	
(V_{CB} = 100 V, I_E = 0)			--	--	20.0	
(V_{CB} = 100 V, I_E = 0)	2N1364, 2N1365		--	--	3.0	
(V_{CB} = 120 V, I_E = 0)			--	--	20.0	
Collector-Base Cutoff Current at Tc = +90°C V_{CB} = 1/2 BV_{CES} rating	All Types	I_{CBO}	--	--	20	mA
Emitter-Base Cutoff Current						
(V_{EB} = 12 V, I_C = 0)	All Types	I_{EBO}	--	--	0.5	mA
(V_{EB} = 25 V, I_C = 0)	2N1359, 2N1360		--	--	20	
(V_{EB} = 50 V, I_C = 0)	2N1362, 2N1363		--	--	20	
(V_{EB} = 60 V, I_C = 0)	2N1364, 2N1365		--	--	20	
Collector-Emitter Breakdown Voltage						Vdc
I_C = 500 mA, V_{EB} = 0)	2N1359, 2N1360	BV_{CES}	40	--	--	
	2N375, 2N618		60	--	--	
	2N1362, 2N1363		75	--	--	
	2N1364, 2N1365		100	--	--	
DC Current Transfer Ratio		h_{FE}				--
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		35	55	90	
	2N1360, 618, 1363, 65		60	90	140	
(V_{CE} = 4 V, I_C = 1.0A)	2N1359, 375, 1362, 64		15	22	--	
	2N1360, 618, 1363, 65		20	35	--	
Transconductance						mhos
(V_{CE} = 4 V, I_C = 1.0A)	2N375	g_{FE}	0.8	1.25	2.2	
	2N618		1.0	1.6	2.5	
	2N1359, 2N1362, 2N1364		0.8	1.25	--	
	2N1360, 2N1363, 2N1365		1.0	1.6	--	
Frequency Cutoff		f_{ae}				kc
(V_{CE} = 4 V, I_C = 1 A)	2N375		7	10	--	
(V_{CE} = 4 V, I_C = 1 A)	2N618		5	8.5	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1359, 2N1362, 2N1364		7	10	--	
(V_{CE} = 4 V, I_C = 3 A)	2N1360, 2N1363, 2N1365		5	8.5	--	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 2.0 A, I_C = 200mA)	2N1359, 375, 1362, 64		--	0.4	1.0	
	2N1360, 618, 1363, 65		--	0.3	0.8	
Base-Emitter Drive Voltage		V_{BE}				Vdc
(I_C = 2.0A, I_B = 200 mA)	2N1359, 375, 1362, 64		--	0.7	--	
	2N1360, 618, 1363, 65		--	0.6	--	
Collector-Emitter Punch-Through Voltage		V_{EBF}				Vdc
(V_{CB} = 50 V, I_C = 0)	2N1359, 2N1360		--	--	1.25	
(V_{CB} = 100 V, I_C = 0)	2N1362, 2N1363		--	--	1.25	
(V_{CB} = 120 V, I_C = 0)	2N1364, 2N1365		--	--	1.25	

2N375 (continued)

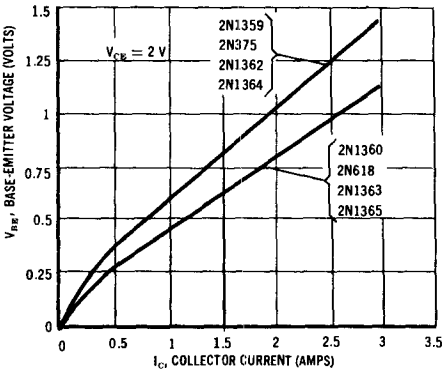
POWER-TEMPERATURE DERATING CURVE



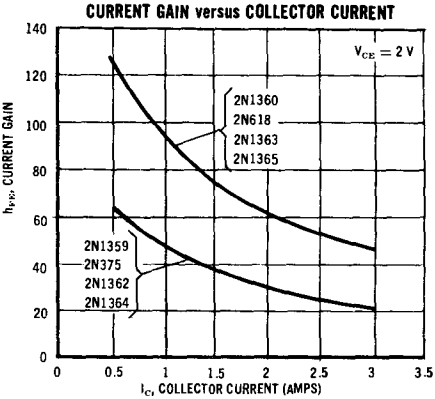
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = Vc \times Ic$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - Tc}{.08}$$

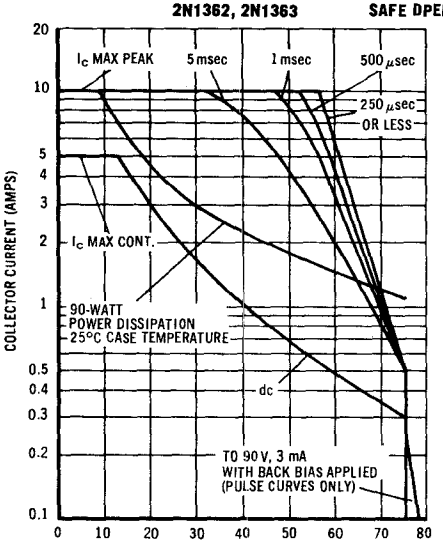
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

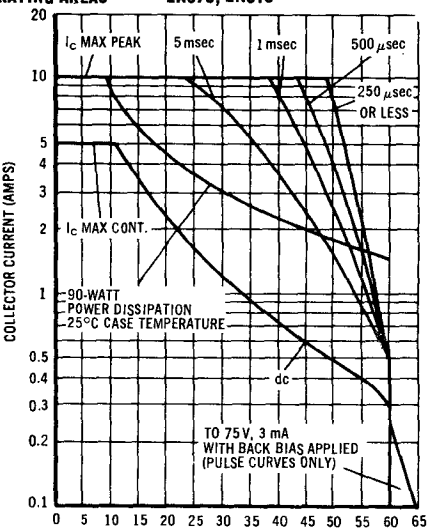


CURRENT GAIN versus COLLECTOR CURRENT



2N1362, 2N1363 SAFE OPERATING AREAS 2N375, 2N618





The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N376A (GERMANIUM)

For Specifications, See 2N350A Data Sheet

2N378 thru 2N380 (GERMANIUM)

2N459, A

$P_D = 106$ W
$I_C = 5$ A
V_{CBO} = to 105 V



CASE 11
(TO-3)

PNP germanium power transistors for general purpose power amplifier and switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N378	2N379	2N380	2N459	2N459A	Unit
Collector-Base Voltage	V_{CBO}	—	—	—	—	105	Volts
Collector-Emitter Voltage (V_{BE} = 1.5 V) (V_{BE} = 1.0 V)	V_{CEX}	 40 —	 80 —	 60 —	 — 105	 — 105	Volts
Collector-Emitter Voltage (R_{BE} = 0)	V_{CES}	—	—	—	70	70	Volts
Collector-Emitter Voltage	V_{CEO}	20	40	30	60	60	Volts
Emitter-Base Voltage	V_{EBO}	—	—	—	10	25	Volts
Collector Current	I_C	5	5	5	5	5	Amps
Junction Temperature Range	T_J	←	—	65 TO +110	—	→	°C
Collector Dissipation (at T_C = 25°C)	P_D	106	106	106	106	106	Watts

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -25 Vdc)	All Types		—	0.5	
(V_{CB} = -25 Vdc, T_C = 85°C)	All Types		—	7.5	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -10 Vdc)	2N380		—	1.5	
	2N459		—	2	
(V_{EB} = -25 Vdc)	2N459A		—	2	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = -40 Vdc, V_{BE} = 1.5 Vdc)	2N378		—	10	
(V_{CE} = -80 Vdc, V_{BE} = 1.5 Vdc)	2N379		—	10	
(V_{CE} = -60 Vdc, V_{BE} = 1.5 Vdc)	2N380		—	10	
(V_{CE} = -105 Vdc, V_{BE} = 1.5 Vdc)	2N459		—	10	
(V_{CE} = -105 Vdc, V_{BE} = 1.0 Vdc)	2N459A		—	10	
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 100 mAdc)	2N378		20	—	
	2N379		40	—	
	2N380		30	—	
	2N459, 2N459A		60	—	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 2 Adc, V_{CE} = -2 Vdc)	2N378		—	-1.6	
	2N379, 2N459, 2N459A		—	-1.3	
	2N380		—	-1.0	

2N378, thru 2N380 2N459, 2N459 A

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 2 Adc, I_B = 0.2 Adc)	2N378-2N380, 2N459		—	1.0	
	2N459A		—	0.3	
DC Current Gain		h_{FE}			—
(I_C = 2 Adc, V_{CE} = 2 Vdc)	2N378		40	80	
	2N379, 2N459		20	70	
	2N380		30	70	
	2N459A		40	70	
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N459A		20	—	
Common Emitter Cutoff Frequency		f_{ae}			kc
(I_C = 1 A, V_{CE} = -2 V)	2N378-2N380, 2N459		5	—	
(I_C = 2 A, V_{CE} = -2 V)	2N459A		5	—	

2N441 (GERMANIUM)
2N442
2N443

CASE 5
(TO-36)



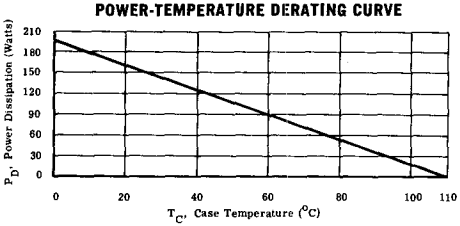
P_D = 150 W
I_E = 15 A
V_{CBO} = 40-60 V

PNP germanium power transistors for power switching and amplifier applications. Power and temperature ratings exceed EIA registration.

MAXIMUM RATINGS

Characteristic	Symbol	2N441	2N442	2N443	Unit
Collector-Base Voltage	V_{CB}	40	50	60	Vdc
Collector-Emitter Voltage	V_{CES}	40	45	50	Vdc
Emitter-Base Voltage	V_{EBO}	20	30	40	Vdc
Emitter Current (continuous)	I_E	15	15	15	Amps
Base Current (continuous)	I_B	4	4	4	Amps
Junction and Storage Temperature	T_{stg}	−65 to +110			°C/W
Thermal Resistance	θ_{JC}	0.5			°C/W

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$P_D \text{ allowable} = \frac{110^\circ - T_C}{0.5}$$

2N441 thru 2N443 (continued)

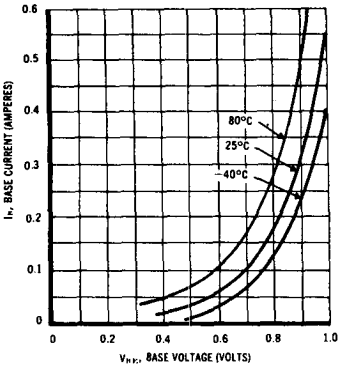
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current V_{CBO} = −2 V	All Types	I_{CBO}	—	100	—	μA
Collector-Base Cutoff Current V_{EB} = −1.5 V, V_{CB} = −40 V	2N441	I_{CB}	—	2	8	mA
−50	2N442		—	2	8	
−60	2N443		—	2	8	
Collector-Base Cutoff Current T_B = 71°C, V_{CBO} = −40 V	2N441	I_{CBO}	—	—	15	mA
−50	2N442		—	—	15	
−60	2N443		—	—	15	
Emitter-Base Cutoff Current V_{EBO} = −20 V	2N441	I_{EBO}	—	1	8	mA
−30	2N442		—	1	8	
−40	2N443		—	1	8	
Collector-Emitter Voltage I_C = 300 mA, V_{EB} = 0*	2N441	BV_{CES}	−40	—	—	Vdc
	2N442		−45	—	—	
	2N443		−50	—	—	
Collector-Emitter Voltage I_C = 1 Amp, I_B = 0*	2N441	BV_{CEO}	−25	—	—	Vdc
	2N442		−30	—	—	
	2N443		−45	—	—	
Floating Potential I_E = 0, V_{CB} = −40 V	2N441	V_{BE}	—	—	1.0	volt
−50	2N442		—	—	1.0	
−60	2N443		—	—	1.0	
Current Gain I_C = 5 Amps, V_{CB} = −2V	All Types	h_{FE}	20	—	40	—
I_C = 12 Amps, V_{CB} = −2 V	All Types		—	20	—	
Base-Emitter Voltage I_C = 5 Amps, V_{CB} = −2 V	2N441	V_{BE}	—	0.65	—	Vdc
	2N442		—	0.65	—	
	2N443		—	0.65	0.9	
Saturation Voltage I_C = 12 Amps, I_B = 2 Amps	2N441	$V_{CE(SAT)}$	—	0.3	—	Vdc
	2N442		—	0.3	—	
	2N443		—	0.3	1.0	
Common-Emitter Current Amplification Cutoff Frequency I_C = 5 Amps, V_{CE} = −6 V	All Types	f_{ae}	—	10	—	kc
Rise Time "on" I_C = 12 Adc, I_B = 2 Adc, V_{CE} = −12 V	All Types	t_r	—	15	—	μsec
Fall Time "off" I_C = 0, V_{EB} = −6 V, R_{EB} = 10 Ohms	All Types	t_f	—	15	—	μsec

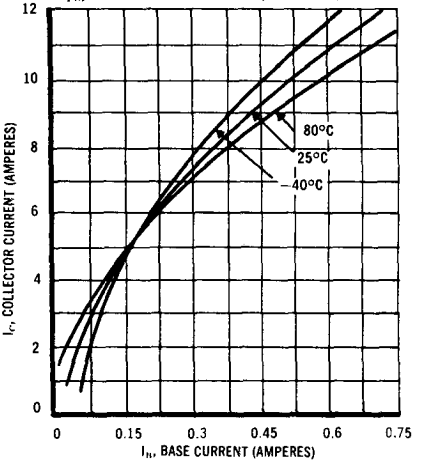
* To avoid excessive heating of the collector junction, perform test with the sweep method.

2N441 thru 2N443 (continued)

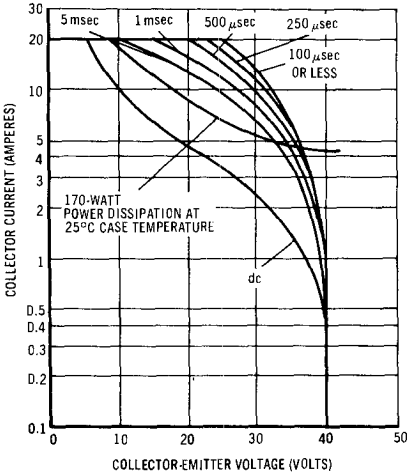
INPUT CHARACTERISTICS



h_{FE}, CURRENT TRANSFER CHARACTERISTICS



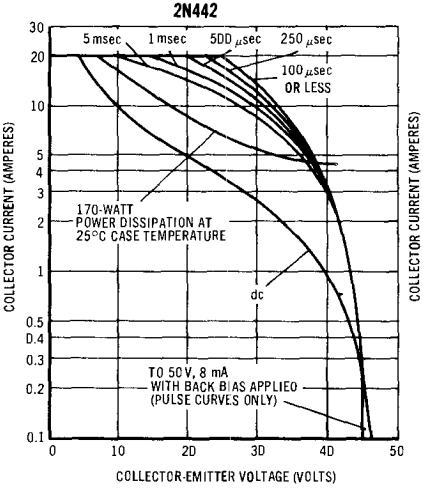
2N441



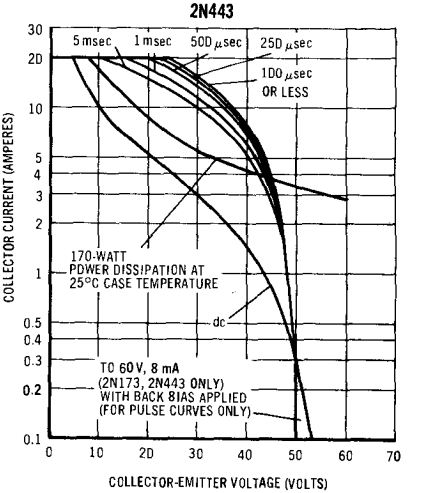
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N442

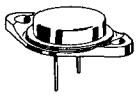


2N443



2N456A (GERMANIUM)
2N457A
2N458A

$P_D = 85$ W
$I_C = 7$ A
$V_{CB} = 40\text{-}80$ V



CASE 11
(TO-3)

PNP high-current germanium power transistors for industrial and general power amplifier and switching applications.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	2N456A	2N457A	2N458A	Unit
Collector-Base Voltage	V_{CB}	40	60	80	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EB}	← 20 →			Volts
Collector Current	I_C	← 7 →			Amps
Base Current	I_B	← 3 →			Amps
Operating Junction and Storage Temperature Range	T_J, T_{stg}	← -65 to +110 →			°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	← 85 → ← 1 →			Watts W/°C

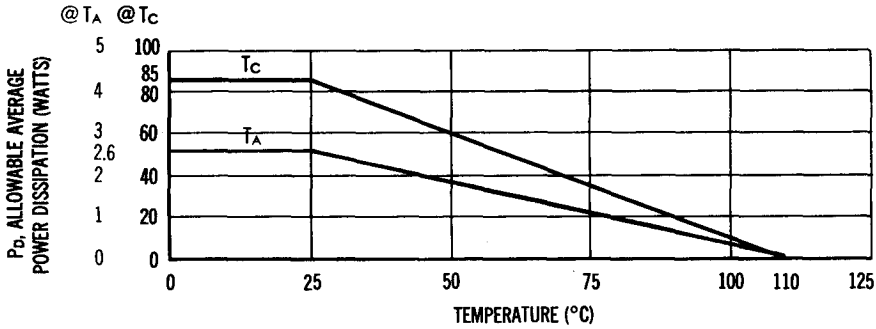
2N456A, 2N457A, 2N458A (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 20 Vdc)	2N456A		—	0.5	
(V_{CB} = 30 Vdc)	2N457A		—	0.5	
(V_{CB} = 40 Vdc)	2N458A		—	0.5	
(V_{CB} = 40 Vdc)	2N456A		—	2	
(V_{CB} = 60 Vdc)	2N457A		—	2	
(V_{CB} = 80 Vdc)	2N458A		—	2	
(V_{CB} = 40 Vdc, T_C = +71°C)	2N456A		—	10	
(V_{CB} = 60 Vdc, T_C = +71°C)	2N457A		—	10	
(V_{CB} = 80 Vdc, T_C = +71°C)	2N458A		—	10	
Emitter-Base Cutoff Current (V_{EB} = 20 Vdc)	All Types	I_{EBO}	—	2	mAdc
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 200 mAdc)	2N456A		20	—	
	2N457A		30	—	
	2N458A		40	—	
Base-Emitter Voltage (I_C = 5 Adc, V_{CE} = 1.5 Vdc)	All Types	V_{BE}	—	1.5	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 500 mAdc)	All Types	$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	All Types		40	—	
(I_C = 3 Adc, V_{CE} = 1.5 Vdc)	All Types		35	—	
(I_C = 5 Adc, V_{CE} = 1.5 Vdc)	All Types		30	90	
(I_C = 7 Adc, V_{CE} = 1.5 Vdc)	All Types		22	—	
Current Gain-Bandwidth Product (I_C = 1 Adc, V_{CE} = 2 Vdc)	All Types	f_T	200	—	kc
Input Impedance (I_C = 5 Adc, V_{CE} = 1.5 Vdc)	All Types	h_{ie}	—	28	ohms

2N456A, 2N457A, 2N458A (continued)

POWER-TEMPERATURE DERATING CURVE



2N459, A (GERMANIUM)

For Specifications, See 2N378-380 Data Sheet

2N554 (GERMANIUM)
2N555

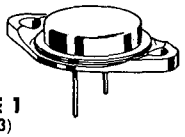
For Specifications, See 2N178 Data Sheet

2N618 (GERMANIUM)

For Specifications, See 2N375 Data Sheet

2N665 – JAN (GERMANIUM)

$P_D = 35$ W
$I_E = 5$ A
$V_{CBO} = 80$ V



CASE 1
(TO-3)

PNP germanium power transistors for driver and power output amplifier and power switching applications in military and industrial equipment.

MAXIMUM RATINGS

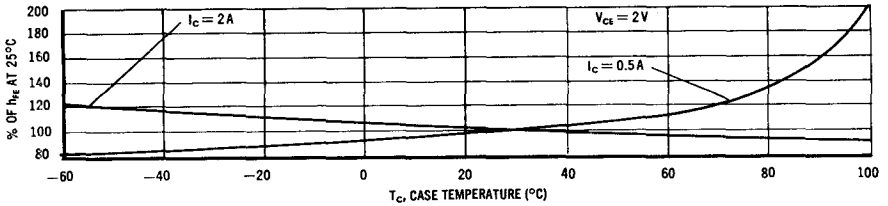
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	80	Vdc
Emitter-Base Voltage	V_{EBO}	40	Vdc
DC Collector Current MIL-S-19500/58C Motorola Unit	I_C	 2 3	Amps
DC Emitter Current	I_E	5	Amps
Collector Junction Temperature	T_J	-65 to +95	°C
Collector Dissipation Derate above 25°C	P_D	35 0.5	Watts W/°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Emitter Cutoff Current (V_{EBO} = -40 Vdc, I_C = 0)	I_{EBO}	—	-2	mAdc
Collector Cutoff Current (V_{CBO} = -2 Vdc, I_E = 0) (V_{CBO} = -60 Vdc, I_E = 0) (V_{CBO} = -80 Vdc, I_E = 0)	I_{CBO}	 — — —	 -.05 -2 -10	mAdc
DC Current Gain (V_{CE} = -2 Vdc, I_C = -0.5 Adc) (V_{CE} = -2 Vdc, I_C = -2 Adc)	h_{FE}	 40 20	 80 —	—
Emitter-Base Voltage (V_{CE} = -2 Vdc, I_C = -2 Adc)	V_{EB}	—	1.5	Vdc
Floating Potential (V_{CB} = -80 Vdc, voltmeter input resistance = 10 megohms min, t ≈ 1 sec)	V_{EBF}	—	-1	Vdc
Collector-Emitter Saturation Voltage (I_C = -3 Adc, I_B = -220 mAdc)	$V_{CE\,(sat)}$	—	-0.9	Vdc
Collector-Emitter Voltage (I_C = -300 mAdc, I_B = 0)	V_{CEO}	-40	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer-Ratio Cutoff Frequency (V_{CE} = -14 Vdc, I_C = -2 Adc)	f_{hfe}	 20	 —	kc
Emitter Cutoff Current (V_{EBO} = -30 Vdc, I_C = 0, T_C = +71°C min)	I_{EBO}	—	-2	mAdc
Collector Cutoff Current (V_{CBO} = -30 Vdc, I_E = 0, T_C = +71°C min)	I_{CBO}	—	-2	mAdc

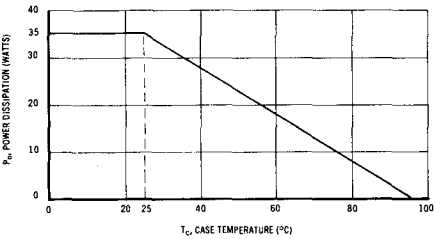
2N665 (continued)

h_{FE} versus TEMPERATURE

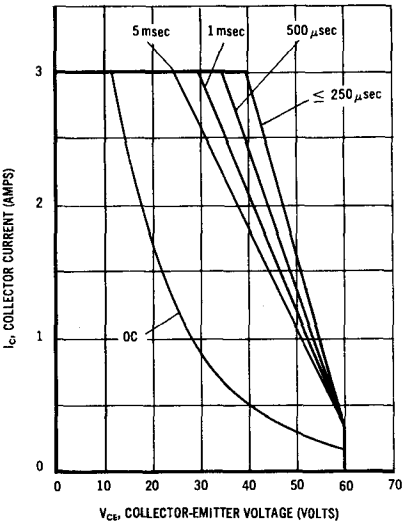


The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREA

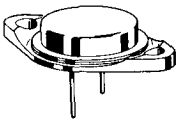


2N669 (GERMANIUM)

For Specifications, See 2N176 Data Sheet

2N1011 (GERMANIUM)
2N1011 JAN/USA

$P_D = 90W$
$I_E = 5A$
$V_{CBO} = 80 V$



CASE 11
(TO-3)

PNP germanium power transistors for general purpose power amplifier and switching applications in military and industrial equipment. Operating temperature range and power dissipation exceed military specifications.

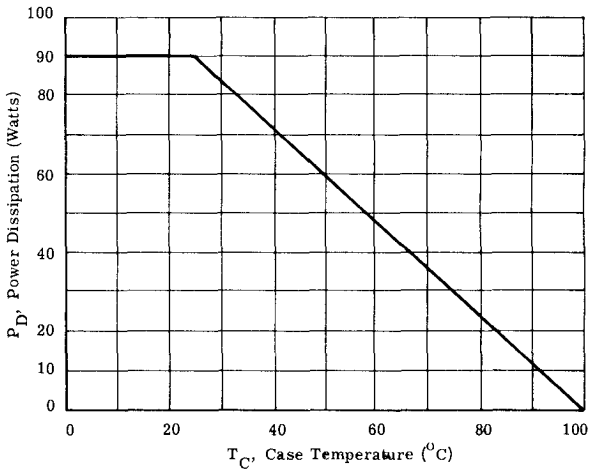
MAXIMUM RATINGS

Characteristic	Symbol	2N1011	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Collector Current	I_E	5	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 1.2	Watts $W/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

POWER-TEMPERATURE DERATING CURVE



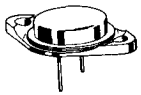
2N1011 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
DC Current Transfer Ratio V_{CE} = 2 V I_C = 1.0 Adc	h_{FE}	—	150	—
DC Current Transfer Ratio V_{CE} = 2 V I_C = 3.0 Adc	h_{FE}	30	75	—
Small-Signal Current Transfer Ratio Cutoff Frequency V_{CE} = 2 Vdc I_C = 3 Amps	f_{ae}	5	—	kc
Emitter-Base Cutoff Current V_{EB} = 40 Vdc I_C = 0	I_{EBO}	—	3.0	mAdc
Collector-Base Cutoff Current V_{CB} = 2 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector-Base Cutoff Current V_{CB} = 80 Vdc I_E = 0	I_{CBO}	—	15.0	mAdc
Base Current V_{CE} = 2 Vdc I_C = 1 Adc	I_B	6.7	—	mAdc
Base Current V_{CE} = 2 Vdc I_C = 3 Adc	I_B	40	100	mAdc
Emitter-Base Voltage V_{CE} = 2 Vdc I_C = 3 Adc	V_{EB}	—	2.0	Vdc
Floating Potential V_{CB} = 50 Vdc (Voltmeter input resistance = 10 Megohm min)	V_{fl}	—	1.0	Vdc
Collector-Emitter Saturation Voltage I_C = 3 Adc I_B = 200 mAdc	$V_{CE(SAT)}$	—	1.5	Vdc
Collector-Emitter Voltage I_C = 300 mAdc I_B = 0	BV_{CEO}	40	—	Vdc
Collector-Emitter Voltage I_C = 300 mAdc V_{EB} = 0	BV_{CES}	80	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency V_{CE} = 2 Vdc I_C = 3 Adc	f_{ae}	5	—	kc
High-Temperature Operation T_C = +90°C min Collector Cutoff Current V_{CB} = 30 Vdc I_E = 0	I_{CBO}	—	20	mAdc

2N1021 (GERMANIUM)
2N1022

$P_D = 85$ W
$I_C = 5$ A
$V_{CBO} = 100$-120 V

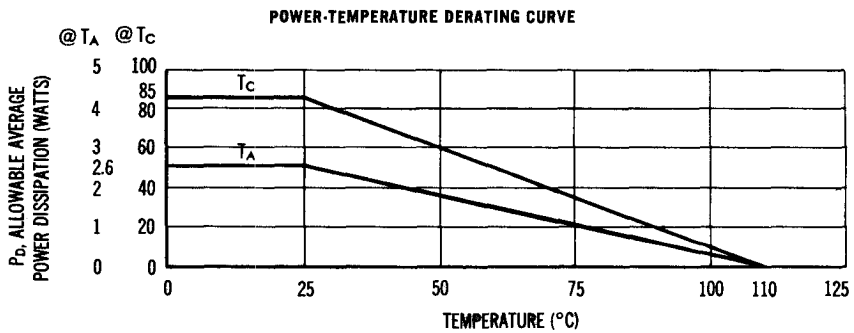


CASE 1
(TO-3)

PNP germanium power transistor for industrial and general purpose power amplifier and switching applications.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	2N1021	2N1022	Unit
Collector-Base Voltage	V_{CB}	100	120	Volts
Collector-Emitter Voltage	V_{CEX}	100	120	Volts
Collector-Emitter Voltage	V_{CEO}	← 50 →		Volts
Emitter-Base Voltage	V_{EB}	← 30 →		Volts
Collector Current	I_C	← 5 →		Amps
Operating Junction and Storage Temperature Range	T_J, T_{stg}	← -65 to +110 →		°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	← 85 → ← 1 →		Watts W/°C



2N1021, 2N1022 (continued)

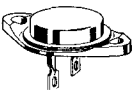
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc)	2N1021		—	0.5	
(V_{CB} = 60 Vdc)	2N1022		—	0.5	
(V_{CB} = 100 Vdc)	2N1021		—	2	
(V_{CB} = 120 Vdc)	2N1022		—	2	
(V_{CB} = 50 Vdc, T_C = +55°C)	2N1021		—	8	
(V_{CB} = 60 Vdc, T_C = +55°C)	2N1022		—	8	
Collector-Emitter Breakdown Voltage* (I_C = 200 mAdc)	Both Types	BV_{CEO}*	50	—	Vdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 10 Vdc)	Both Types		—	0.5	
(V_{EB} = 30 Vdc)	Both Types		—	2	
Base-Emitter Voltage (V_{CE} = -1.5 Vdc, I_C = 1.0 Adc)	Both Types	V_{BE}	—	3	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 500 mAdc)	Both Types	$V_{CE(sat)}$	—	0.5	Vdc
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	Both Types		40	—	
(I_C = 3 Adc, V_{CE} = 1.5 Vdc)	Both Types		35	—	
(I_C = 5 Adc, V_{CE} = 1.5 Vdc)	Both Types		30	90	
(I_C = 7 Adc, V_{CE} = 1.5 Vdc)	Both Types		22	—	
Input Impedance (I_C = 1.0 Adc, V_{CE} = 1.5 Vdc)	Both Types	h_{ie}	—	28	ohms
Current Gain-Bandwidth Product (I_C = 1.0 Adc, V_{CE} = 2 Vdc)	Both Types	f_T	200	—	kc

*Sweep Test: 1/2 sine wave, 60 cps.

2N1073, A, B (GERMANIUM)

$P_D = 85\,W$
$I_C = 10\,A$
$V_{CER} = 40\text{-}120\,V$



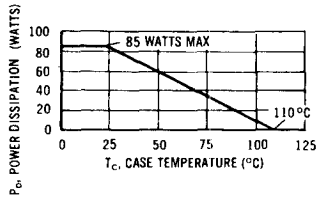
CASE 4
(TO-41)

PNP germanium power transistors for high-voltage power switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N1073	2N1073A	2N1073B	Unit
Collector-Emitter Voltage	V_{CER}	40	80	120	Vdc
Collector-Base Voltage	V_{CB}	40	80	120	Vdc
Emitter-Base Voltage	V_{EB}	1.5	1.5	1.5	Vdc
Collector Current (Cont)	I_C	10	10	10	Amps
Base Current (Cont)	I_B	5	5	5	Amps
Emitter Reverse Current (Surge 60 cps Recurrent)	I_E	1.5	1.5	1.5	Amps
Storage and Operating Temperature	T_{stg} T_J	-65 to +110			°C
Collector Dissipation (25°C Mtg. Case Temp.)	P_D	85	85	85	Watts

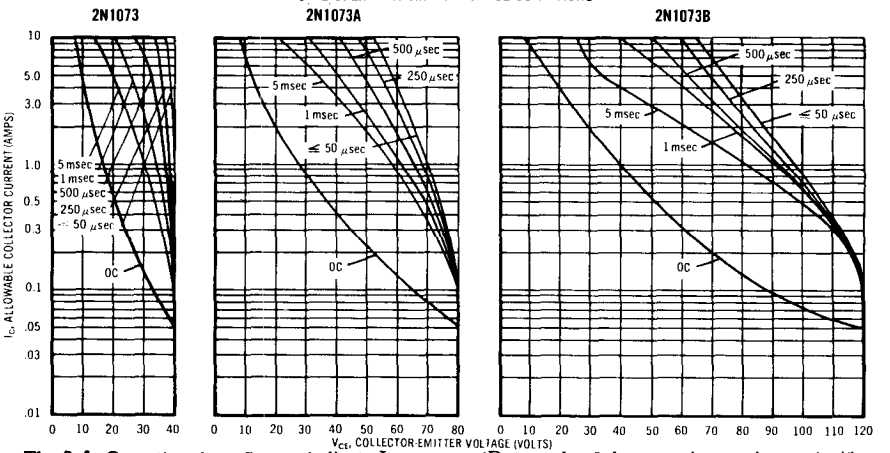
POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

$$\text{Allowable } P_D = \frac{110^\circ - T_C}{1.0} \text{ Watts}$$

SAFE OPERATING AREAS – PULSE CONDITIONS



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

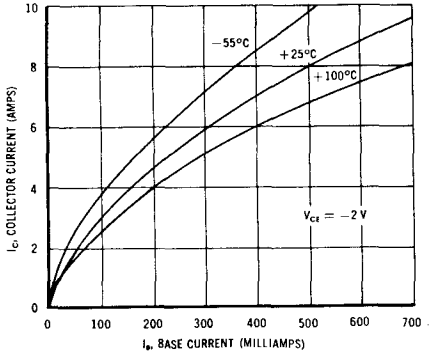
2N1073, A, B (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

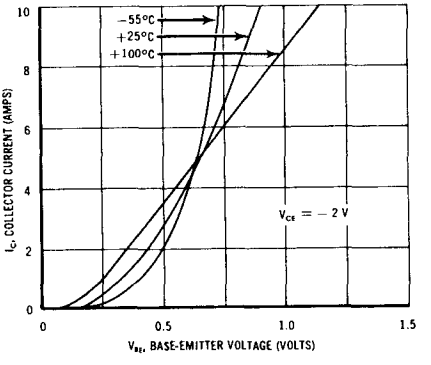
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 25 Vdc, I_E = 0)	2N1073		—	—	1	
(V_{CB} = 25 Vdc, I_E = 0, T_C = 85°C)	2N1073		—	—	15	
(V_{CB} = 40 Vdc, I_E = 0)	2N1073		—	—	20	
(V_{CB} = 60 Vdc, I_E = 0)	2N1073A		—	—	1	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 85°C)	2N1073A		—	—	15	
(V_{CB} = 80 Vdc, I_E = 0)	2N1073A		—	—	20	
(V_{CB} = 100 Vdc, I_E = 0,	2N1073B		—	—	2	
(V_{CB} = 100 Vdc, I_E = 0, T_C = 85°C)	2N1073B		—	—	20	
(V_{CB} = 120 Vdc, I_E = 0)	2N1073B		—	—	20	
(V_{CB} = 2 Vdc, I_E = 0)	All Types		—	—	0.3	
Emitter-Base Leakage Current		I_{EBO}				mAdc
(V_{EB} = 0.75 Vdc)			—	—	50.	
Emitter Floating Potential		V_{EBF}				Vdc
(V_{CE} = 40 Vdc)	2N1073		—	—	-1.0	
(V_{CE} = 80 Vdc)	2N1073A		—	—	-1.0	
(V_{CE} = 120 Vdc)	2N1073B		—	—	-1.0	
Collector-Emitter Breakdown Voltage*		BV_{CER}*				Vdc
(I_C = 50 mAdc, R_{BE} = 100 Ω)	2N1073		40	—	—	
	2N1073A		80	—	—	
	2N1073B		120	—	—	
DC Current Gain		h_{FE}				—
(I_C = 5 Adc, V_{CE} = -2.0 Vdc)			20	—	60	
Small Signal Current Gain		h_{fe}				—
(I_C = 0.5 Adc, V_{CE} = 12 Vdc, f = 30 kc)			—	15	—	
Base Input Voltage		V_{BE}				Vdc
(V_{CE} = 2.0 Vdc, I_C = 5 Adc)			—	—	1.0	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)			—	0.5	1.0	
Rise Time		t_r	—	5.5	—	μsec
Storage Time		t_s	—	1.2	—	μsec
Fall Time		t_f	—	2.0	—	μsec

*To avoid excessive heating of collector junction, perform this test with a sweep method.

COLLECTOR CURRENT versus BASE CURRENT

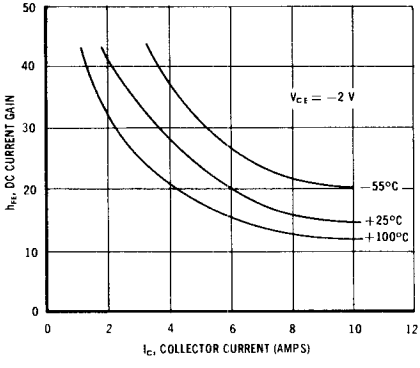


COLLECTOR CURRENT versus DRIVE VOLTAGE

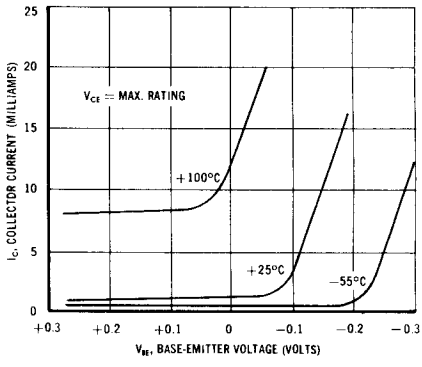


2N1073, A, B (continued)

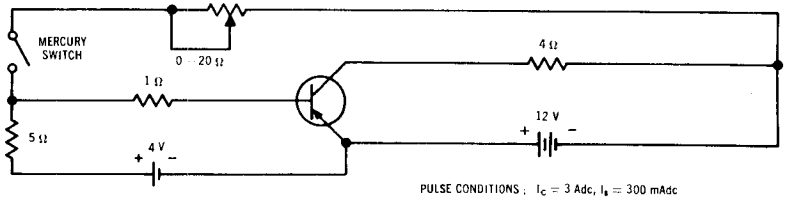
DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus DRIVE VOLTAGE



SWITCHING TEST CIRCUIT



PULSE CONDITIONS: $I_C = 3$ Adc, $I_B = 300$ mAdc

2N1099 (GERMANIUM)

For Specifications, See 2N277 Data Sheet

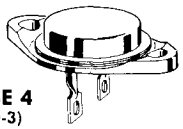
2N1100 (GERMANIUM)

For Specifications, See 2N174 Data Sheet

2N1120 (GERMANIUM)

2N1120 USA/JAN

$P_D = 90W$
$I_E = 15A$
$V_{CBO} = 80V$



CASE 4
(TO-3)

PNP germanium power transistors for military and industrial power applications.

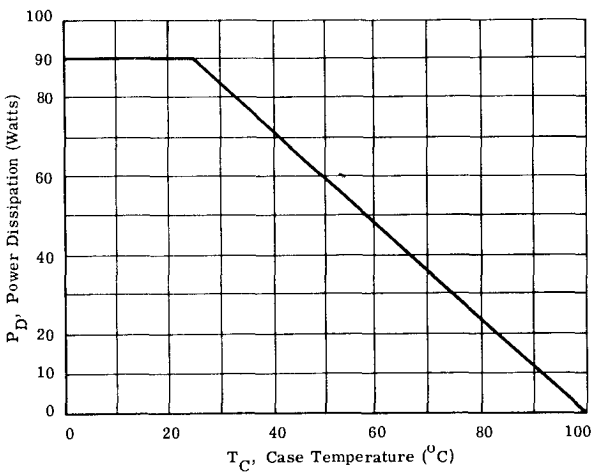
MAXIMUM RATINGS

Characteristic	Symbol	2N1120	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	70	Vdc
Collector-Base Voltage	V_{CB}	80	Vdc
Emitter-Base Voltage	V_{EB}	40	Vdc
Emitter Current	I_E	15	Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	90 1.2	Watts $W/^oC$
Operating Junction Temperature Range	T_J	-65 to +100	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.8	$^oC/W$

POWER-TEMPERATURE DERATING CURVE



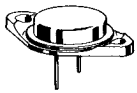
2N1120 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, I_B = 0)	BV_{CEO}	40	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 300 mAdc, V_{BE} = 0)	BV_{CES}	70	-	Vdc
Floating Potential (V_{CB} = 80 Vdc, I_E = 0) (Voltmeter Input Resistance = 10 meg. min.)	V_{EBF}	-	1.0	Vdc
Collector Cutoff Current (V_{CB} = 2 Vdc, I_E = 0)	I_{CBO}	-	0.3	mAdc
(V_{CB} = 30 Vdc, I_E = 0)			20	
(V_{CB} = 80 Vdc, I_E = 0)		-	15	
Emitter Cutoff Current (V_{BE} = 40 Vdc, I_C = 0)	I_{EBO}	-	5.0	mAdc
Base Current (V_{CE} = 2 Vdc, I_C = 5 Adc)	I_B	50	-	mAdc
(V_{CE} = 2 Vdc, I_C = 10 Adc)		200	500	
ON CHARACTERISTICS				
DC Current Gain (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	h_{FE}	-	100	-
(I_C = 10.0 Adc, V_{CE} = 2.0 Vdc)		20	50	
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	$V_{BE(sat)}$	-	1.5	Vdc
Base-Emitter On Voltage (I_C = 10 Adc, V_{CE} = 2 Vdc)	$V_{BE(on)}$	-	2.0	Vdc
SMALL SIGNAL CHARACTERISTICS				
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 2.0 Vdc)	$f_{\alpha e}$	3	-	kHz

2N1162 thru 2N1167 (GERMANIUM)
2N1162A thru 2N1167A HI-REL
2N1165 USN/JAN

$P_D = 106$ W
$I_C = 25$ A
$V_{CB} = 50\text{-}100$ V



PNP germanium power transistors for switching and amplifier applications in high reliability equipment.

CASE 3,4
(TO-3,41)

TO-3 package (without lugs)
even numbered types.

TO-41 package (with lugs)
odd numbered types.

MAXIMUM RATINGS

Apply also to standard, non-A series

Characteristic	Symbol	2N1162A 2N1163A	2N1164A 2N1165A	2N1166A 2N1167A	Unit
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Collector-Emitter Voltage	V_{CES}	35	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	40	50	Vdc
Total Device Dissipation @ 25°C Derate above 25°C	P_D	106 1.25			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			°C

2N1162 thru 2N1167 (continued)

GROUP A ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

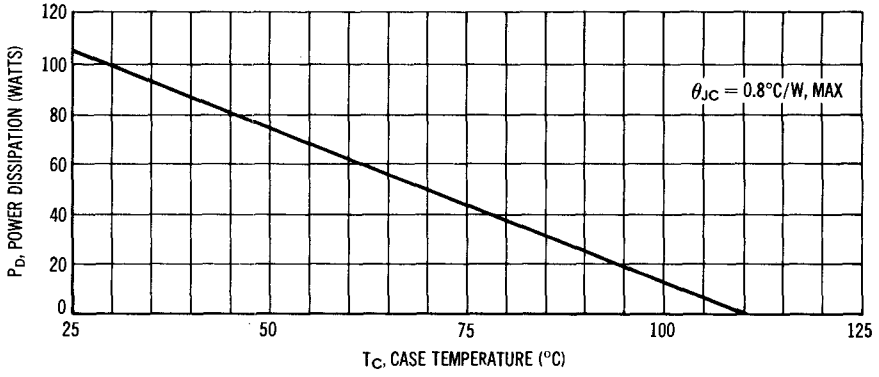
Characteristic		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = $BV_{CBO(max)}$, I_E = 0)	All Types	I_{CBO1}	—	3	15	mA
Collector Cutoff Current		I_{CBO}				
(V_{CB} = 2 V, I_E = 0)	All Types		—	125	225	μA
(V_{CB} = 15 V, I_E = 0, T_C = 90°C)	2N1162A-3A*		—	10	20	mA
(V_{CB} = 30 V, I_E = 0, T_C = 90°C)	2N1164A-7A*		—	10	20	mA
Collector-Emitter Breakdown Voltage** (I_C = 500 mA, V_{EB} = 0)	2N1162A-3A*	BV_{CES}**	35	—	—	Vdc
	2N1164A-5A*		60	—	—	
	2N1166A-7A*		75	—	—	
Emitter Cutoff Current (V_{EB} = 12 V, I_C = 0)	All Types	I_{EBO}	—	0.5	1.2	mA
DC Forward Current Gain†						—
(V_{CE} = 1 V, I_C = 25 A)	All Types	h_{FE1}†	15	25	—	
(V_{CE} = 2 V, I_C = 5 A)	All Types	h_{FE}	—	65	125	
Collector-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	All Types	$V_{CE(sat)}$	—	0.3	0.8	volts
Base-Emitter Saturation Voltage (I_C = 25 A, I_B = 1.6 A)	All Types	$V_{BE(sat)}$	—	0.7	1.7	volts
Common Emitter-Cutoff Frequency (V_{CE} = 2 V, I_C = 2 A)	All Types	f_{ae}	—	4	—	kHz

*Characteristics apply also to corresponding, non-A type numbers
**Sweep Method: 1/2 cycle sine wave, 60 cps

SWITCHING CHARACTERISTICS (Typical)

Saturated Collector Current	Pulsed Drive Base Current		Response times in μs		
	On	Off	$t_d + t_r$	t_s	t_f
5 amps	330 mA	100 mA	11	5	17
10 amps	660 mA	200 mA	15	4	20
25 amps	1650 mA	500 mA	19	3	18

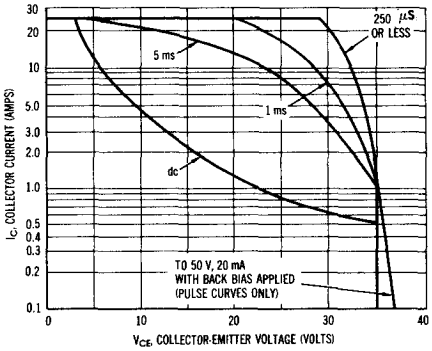
FIGURE 1 — POWER TEMPERATURE DERATING CURVE

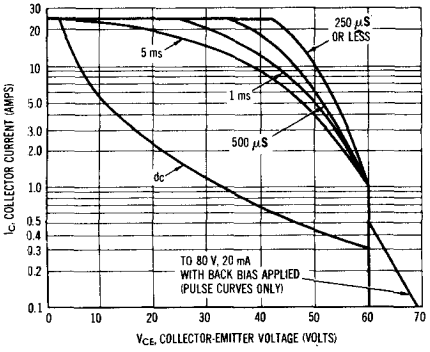


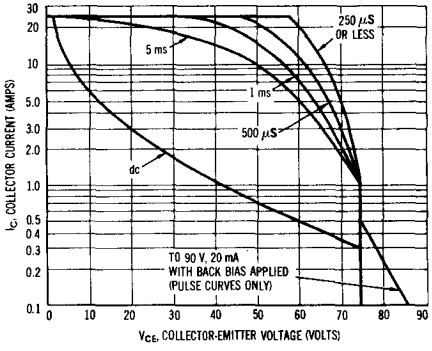
2N1162 thru 2N1167 (continued)

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.







LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE

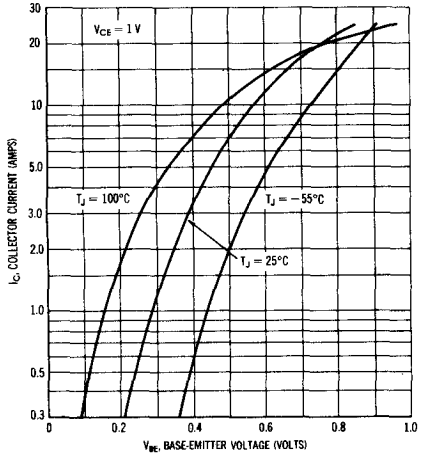
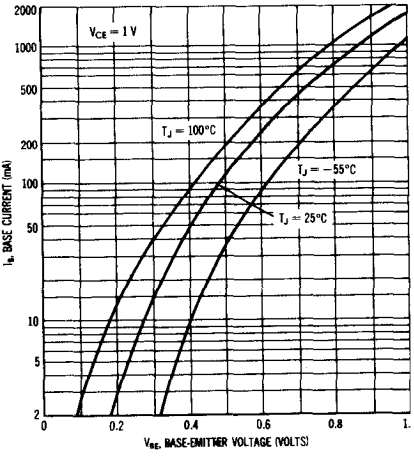


FIGURE 4 — INPUT ADMITTANCE



2N1162 thru 2N1167 (continued)

FIGURE 5 – CURRENT GAIN

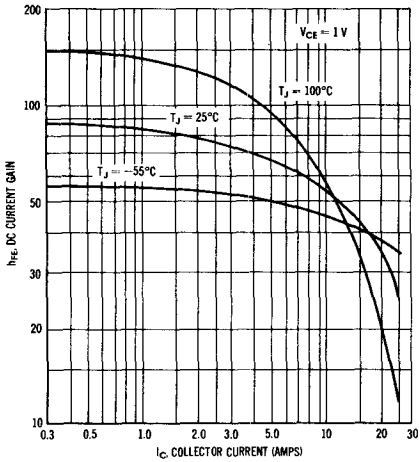
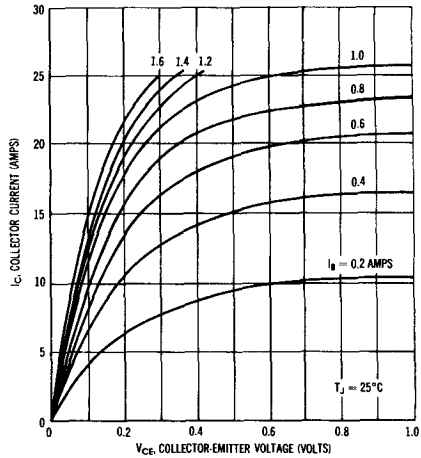


FIGURE 6 – SATURATION REGION



2N1358 (GERMANIUM)
2N1358 JAN/USA

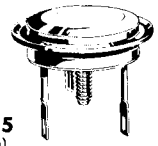
For Specifications, See 2N174 Data Sheet

2N1359 (GERMANIUM)
2N1360
2N1362 thru 2N1365

For Specifications, See 2N375 Data Sheet

2N1412 (GERMANIUM)
2N1412 USN/JAN

$P_D = 150W$
$I_E = 15\ A$
$V_{CBO} = 100\ V$



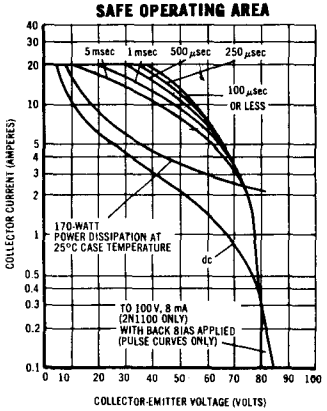
CASE 5
(TO-36)

PNP germanium power transistors for high-voltage power amplifier and switching applications in military and industrial equipment.

MAXIMUM RATINGS

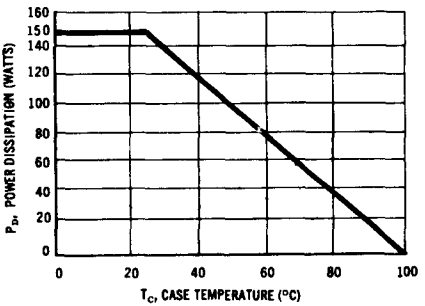
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	100	Vdc
Collector-Emitter Voltage	V_{CES}	80	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	60	Vdc
Emitter Current (Continuous)	I_E	15	Amps
Base Current (Continuous)	I_B	4	Amps
Junction & Storage Temperature	T_{stg}	-65 to +100	^oC
Thermal Resistance	θ_{JC}	0.5	$^oC/W$

SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 150 Watts at case temperatures of 25°C and is 0 Watts at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_C}{0.5}$$

(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N1412 (continued)

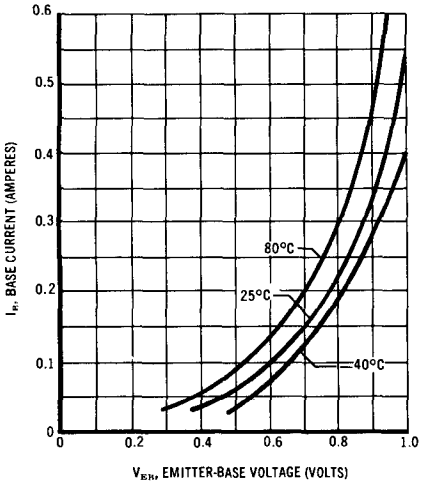
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Minimum	Maximum	Unit
Emitter Cutoff Current V_{EB} = −2.0 Vdc I_C = 0	I_{EBO}	—	200	μAdc
Emitter Cutoff Current V_{EB} = −60 Vdc I_C = 0	I_{EBO}	—	10	mAdc
Collector Cutoff Current V_{CB} = −2.0 Vdc I_E = 0	I_{CBO}	—	200	μAdc
Collector Cutoff Current V_{CB} = −100 Vdc I_E = 0	I_{CBO}	—	10	mAdc
Emitter-Base Voltage V_{CE} = −2.0 Vdc I_C = −1.2 Adc	V_{EB}		0.5	Vdc
Emitter-Base Voltage V_{CE} = −2.0 Vdc I_C = −5.0 Adc	V_{EB}		0.9	Vdc
Floating Potential V_{CB} = −100 Vdc I_E = 0 (Voltmeter input resistance = 10 Megohm min)	V_{fl}		1.0	Vdc
Collector-Emitter Saturation Voltage I_C = −12 Adc I_B = −2.0 Adc	$V_{CE(SAT)}$		0.7	Vdc
Forward Current Transfer Ratio* V_{CE} = −2.0 Vdc I_C = −15 Adc	h_{FE}	10	—	—
Forward Current Transfer Ratio V_{CE} = −2.0 Vdc I_C = −5.0 Adc	h_{FE}	25	50	—
Collector-Emitter Breakdown Voltage* I_C = −1 Adc I_B = 0	BV_{CEO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* V_{EB} = 0 I_C = 300 mA	BV_{CES}	80	—	Vdc
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency V_{CE} = −12 Vdc I_C = −5.0 Adc	f_{ae}	5	—	kc
High-Temperature Operation Emitter Cutoff Current T_C = +71°C min V_{EB} = −30 Vdc	I_{EBO}	—	6.0	mAdc
Collector Cutoff Current V_{CB} = −30 Vdc I_E = 0	I_{CBO}	—	6.0	mAdc

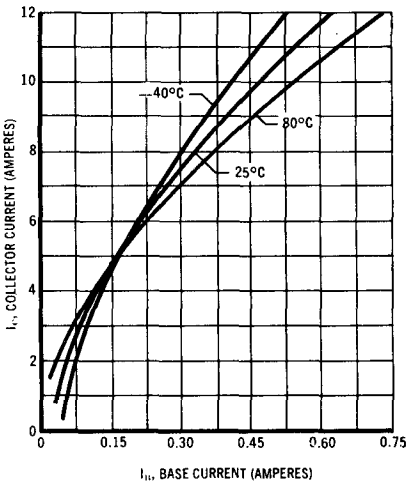
*Test by sweep method with a short duty cycle (about 1%) to avoid excessive heating.

2N1412 (continued)

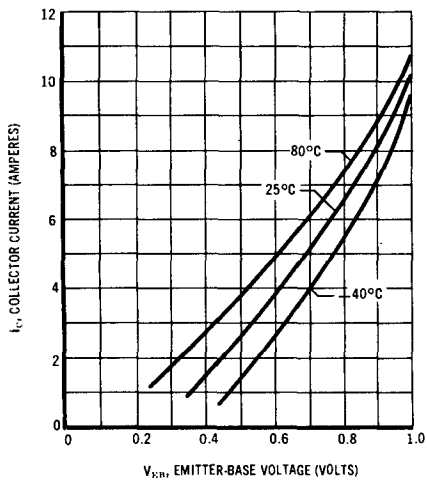
INPUT CHARACTERISTICS



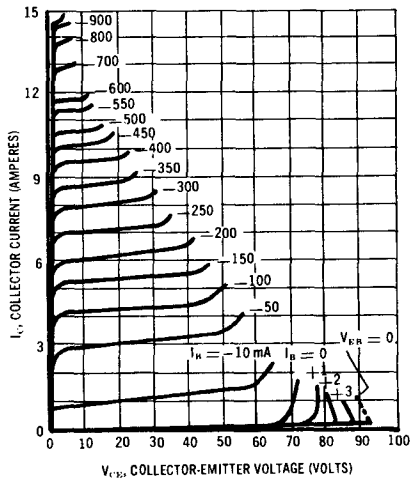
CURRENT TRANSFER CHARACTERISTICS



TRANSCONDUCTANCE CHARACTERISTICS

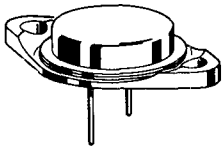


OUTPUT CHARACTERISTICS



2N1529 thru 2N1538 (GERMANIUM)
2N1529A thru 2N1532A, 2N1534A thru 2N1537A, HI-REL

$P_D = 106W$
$I_C = 5\ A$
$V_{CBO} = 40\text{-}120\ V$



PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.

CASE 11,16
(TO-3,41)

For units with solder lugs attached, specify devices MP1529A etc. (TO-41 package)

MAXIMUM RATINGS

Characteristic	Symbol	2N1529 2N1534	2N1530 2N1535	2N1531 2N1536	2N1532 2N1537	2N1533 2N1538	Unit
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	80	100	120	Vdc
Collector-Base Voltage	V_{EBO}	20	30	40	50	60	Vdc
Collector Current (Continuous)	I_C	5	5	5	5	5	Amps
Collector Current (Peak)	I_C	10	10	10	10	10	Amps
Junction Temperature Range	T_J	-65 to +110					°C
Total Device Dissipation (25°C Case Temperature)	P_D	106	106	106	106	106	Watts
Thermal Resistance	θ_{JC}	0.8					°C/W

2N1529 thru 2N1538 (continued)

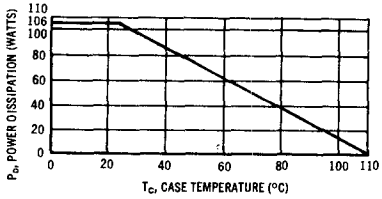
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise specified.)

Characteristics apply to corresponding "A" type numbers also.

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO1}			mA
(V_{CB} = 25V)	2N1529, 2N1534		—	2.0	
(V_{CB} = 40V)	2N1530, 2N1535		—	2.0	
(V_{CB} = 55V)	2N1531, 2N1536		—	2.0	
(V_{CB} = 65V)	2N1532, 2N1537		—	2.0	
(V_{CB} = 80V)	2N1533, 2N1538		—	2.0	
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 2V)	All Types		—	0.2	
(V_{CB} = 1 2 BV_{CES} rating; T_C = +90°C)	All Types		—	20	
Emitter-Base Cutoff Current		I_{EBO}			mA
(V_{EB} = 12V)	All Types		—	0.5	
Collector-Emitter Breakdown Voltage		BV_{CES}			volts
(I_C = 500 mA, V_{EB} = 0)	2N1529, 2N1534		30	—	
	2N1530, 2N1535		45	—	
	2N1531, 2N1536		60	—	
	2N1532, 2N1537		75	—	
	2N1533, 2N1538		90	—	
Collector-Emitter Leakage Current		I_{CEX}			mA
(V_{BE} = 1V; V_{CE} @ rated BV_{CBO})	All Types		—	20	
Collector-Emitter Breakdown Voltage		BV_{CEO}			volts
(I_C = 500 mA, I_B = 0)	2N1529, 2N1534		20	—	
	2N1530, 2N1535		30	—	
	2N1531, 2N1536		40	—	
	2N1532, 2N1537		50	—	
	2N1533, 2N1538		60	—	
Collector-Base Breakdown Voltage		BV_{CBO}			volts
(I_C = 20 mA)	2N1529, 2N1534		40	—	
	2N1530, 2N1535		60	—	
	2N1531, 2N1536		80	—	
	2N1532, 2N1537		100	—	
	2N1533, 2N1538		120	—	
Current Gain		h_{FE1}			—
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1532		20	40	
	2N1534 - 2N1537		35	70	
	2N1529 - 2N1533		20	40	
	2N1534 - 2N1538		35	70	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1532		—	1.7	
	2N1534 - 2N1537		—	1.5	
	2N1529 - 2N1533		—	1.7	
	2N1534 - 2N1538		—	1.5	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			volts
(I_C = 3A, I_B = 300 mA)	2N1529 - 2N1532		—	1.5	
	2N1534 - 2N1537		—	1.2	
	2N1529 - 2N1533		—	1.5	
	2N1534 - 2N1538		—	1.2	
Transconductance		g_{FE}			mhos
(V_{CE} = 2V, I_C = 3A)	2N1529 - 2N1532		1.2	—	
	2N1534 - 2N1537		1.5	—	
	2N1529 - 2N1533		1.2	—	
	2N1534 - 2N1538		1.5	—	

2N1529 thru 2N1538 (continued)

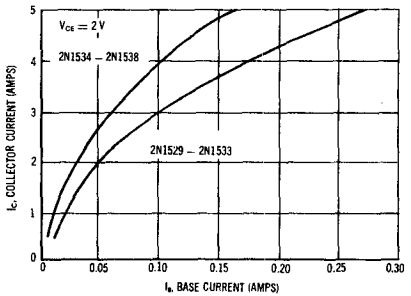
POWER-TEMPERATURE DERATING CURVE



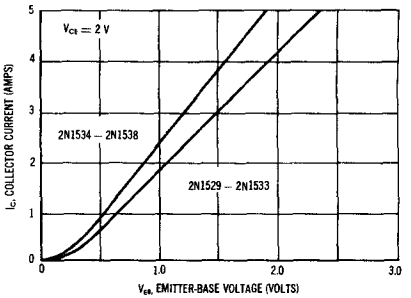
The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d.c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^\circ - Tc}{.08}$$

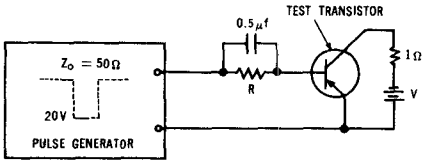
COLLECTOR CURRENT versus BASE CURRENT



COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



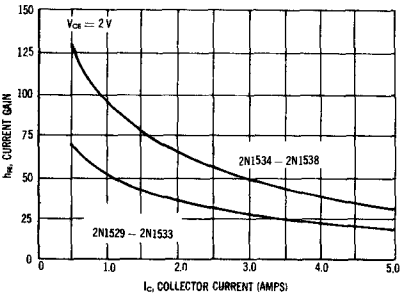
SWITCHING TIME MEASURING CIRCUIT



TYPICAL SWITCHING CHARACTERISTICS

	I_C (Amps)	V (Volts)	R (ohms)	$t_d + t_r$ (μsec)	t_s (μsec)	t_f (μsec)
2N1529-33	3	3	65	10	2	5
2N1534-38	3	3	100	8	3	5

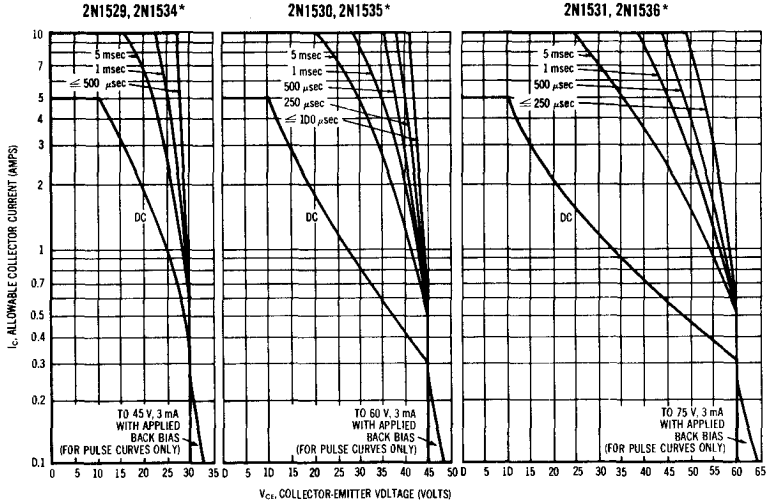
DC CURRENT GAIN versus COLLECTOR CURRENT

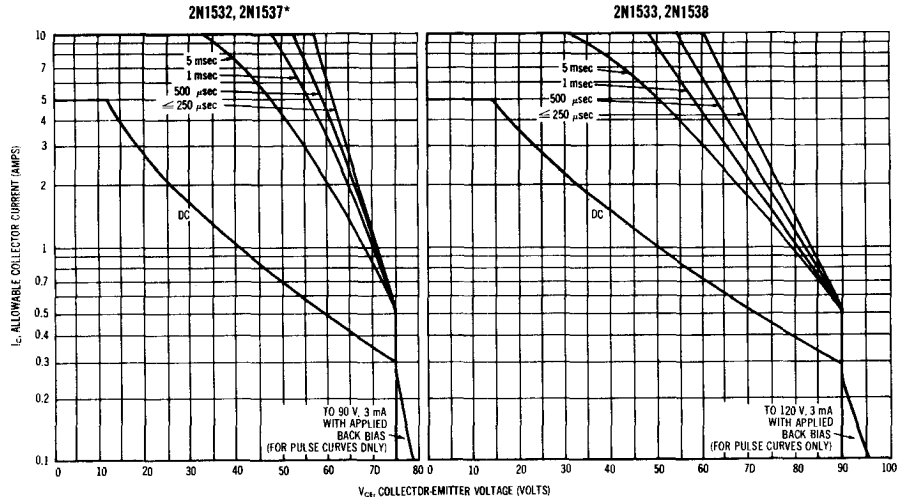


2N1529 thru 2N1538 (continued)

SAFE OPERATING AREAS — PULSE CONDITIONS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

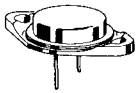




*Characteristics apply to corresponding "A" type numbers also.

2N1539 thru 2N1548 (GERMANIUM)
2N1539A thru 2N1542A, 2N1544A thru 2N1547A, HI-REL

$P_D = 106W$
$I_C = 5\ A$
$V_{CBO} = 40\text{-}120\ V$



CASE 3,4
(TO-3,41)

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.

For units with solder lugs attached, specify devices MP1539A etc. (TO-41 package)

*Apply to corresponding "Hi-Rel" Series Also

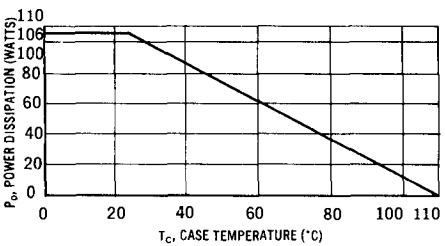
MAXIMUM RATINGS

Characteristics	Symbol	2N1539 * 2N1544 *	2N1540 * 2N1545 *	2N1541 * 2N1546 *	2N1542 * 2N1547 *	2N1543 2N1548	Unit
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	120	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	40	50	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	80	100	120	Vdc
Emitter-Base Voltage	V_{EBO}	20	30	40	50	60	Vdc
Collector Current (Continuous)	I_C	5	5	5	5	5	Amps
Collector Current (Peak)	I_C	10	10	10	10	10	Amps
Collector Junction Temperature Range	T_J	-65 to +110					°C
Collector Dissipation (25°C Case Temp.)	P_D	106	106	106	106	106	Watts
Thermal Resistance	θ_{JC}	0.8					°C/W

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d. c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = Vc \times Ic$ hyperbolic curve. This curve has a value of 106 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that

$$P_D \text{ allowable} = \frac{110^{\circ} - Tc}{0.8}$$

POWER-TEMPERATURE DERATING CURVE



2N1539 thru 2N1548 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C case temperature unless otherwise specified)

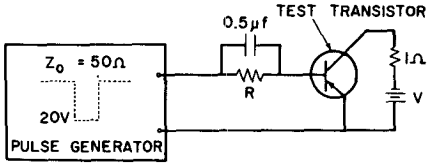
Parameter	Symbol	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO1}			mA
(V_{CB} = 25 V) 2N1539, 2N1544		—	2.0	
(V_{CB} = 40 V) 2N1540, 2N1545		—	2.0	
(V_{CB} = 55 V) 2N1541, 2N1546		—	2.0	
(V_{CB} = 65 V) 2N1542, 2N1547		—	2.0	
(V_{CB} = 80 V) 2N1543, 2N1548		—	2.0	
Collector-Base Cutoff Current	I_{CBO}			mA
(V_{CB} = 2 V) All Types		—	0.2	
(V_{CB} = 1/2 BV_{CES} rating, All Types T_C = 90°C)		—	20	
Emitter-Base Cutoff Current	I_{EBO}			mA
(V_{EB} = 12 V) All Types		—	0.5	
Collector-Emitter Breakdown Voltage ‡	BV_{CES}‡			volts
(I_C = 500 mA)				
2N1539, 2N1544		30	—	
2N1540, 2N1545		45	—	
2N1541, 2N1546		60	—	
2N1542, 2N1547		75	—	
2N1543, 2N1548		90	—	
Collector-Emitter Leakage Current	I_{CEX}			mA
(V_{BE} = 1V, V_{CE} @ rated BV_{CBO}) All Types		—	20	
Collector-Emitter Breakdown Voltage ‡	BV_{CEO}‡			volts
(I_C = 500 mA, I_B = 0)				
2N1539, 2N1544		20	—	
2N1540, 2N1545		30	—	
2N1541, 2N1546		40	—	
2N1542, 2N1547		50	—	
2N1543, 2N1548		60	—	
Collector-Base Breakdown Voltage	BV_{CBO}			volts
(I_C = 20 mA)				
2N1539, 2N1544		40	—	
2N1540, 2N1545		60	—	
2N1541, 2N1546		80	—	
2N1542, 2N1547		100	—	
2N1543, 2N1548		120	—	
Current Gain	h_{FE1}			—
(V_{CE} = 2V, I_C = 3 A)				
2N1539 - 2N1542		50	100	
2N1544 - 2N1547		75	150	
2N1543		50	100	
2N1548		75	150	
Base-Emitter Drive Voltage	V_{BE}			volts
(I_C = 3 A, I_B = 300 mA)				
2N1539 - 2N1542		—	0.7	
2N1544 - 2N1547		—	0.5	
2N1543		—	0.7	
2N1548		—	0.5	
Collector Saturation Voltage	$V_{CE(sat)}$			volts
(I_C = 3 A, I_B = 300 mA)				
2N1539 - 2N1542		—	0.3	
2N1544 - 2N1547		—	0.2	
2N1543		—	0.3	
2N1548		—	0.2	
Transconductance	gFE			mhos
(V_{CE} = 2V, I_C = 3 A)				
2N1539 - 2N1542		3.0	—	
2N1544 - 2N1547		5.0	—	
2N1543		3.0	—	
2N1548		5.0	—	
Frequency Cutoff	f_{ae}	Typ		kc
(V_{CE} = 2 V, I_C = 3 A) All Types		4		

Characteristics apply to corresponding, A type numbers also

‡ To avoid excessive heating of collector junction, perform this test with a sweep method

2N1539 thru 2N1548 (continued)

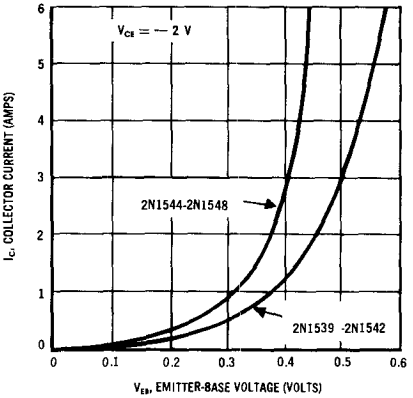
SWITCHING TIME MEASURING UNIT



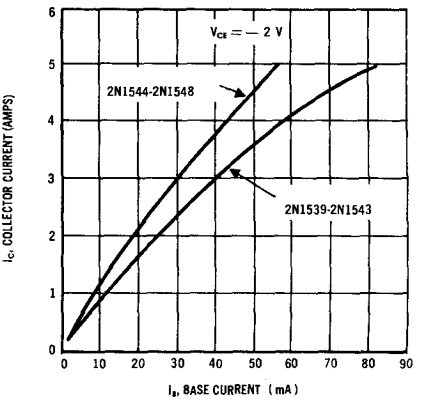
Devices	Conditions*			Typical Switching Times		
	I_C (Amps)	V (Volts)	R (ohms)	$t_d + t_r$ (μsec)	t_s (μsec)	t_f (μsec)
2N1539-43	3	3	165	5	3	5
2N1544-48	3	3	250	5	3	8

*Input Pulse Repetition Rate = 2 kc,
Pulse Width = 50 μsec

COLLECTOR CURRENT versus EMITTER BASE VOLTAGE



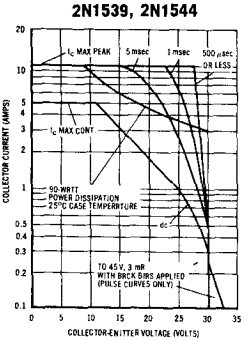
COLLECTOR CURRENT versus BASE CURRENT



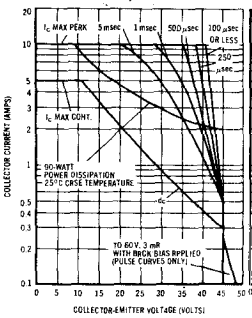
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate $I_C - V_{CE}$ limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

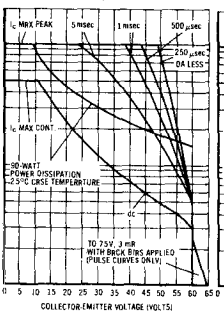
2N1539, 2N1544



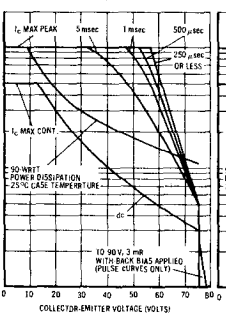
2N1540, 2N1545



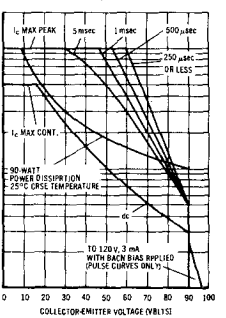
2N1541, 2N1546



2N1542, 2N1547

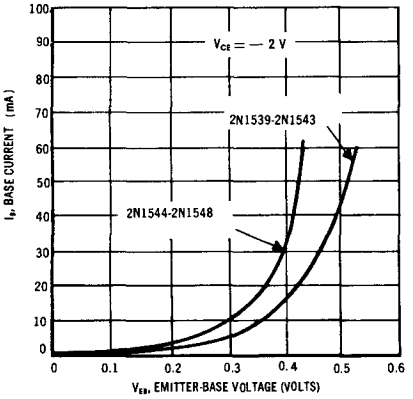


2N1543, 2N1548

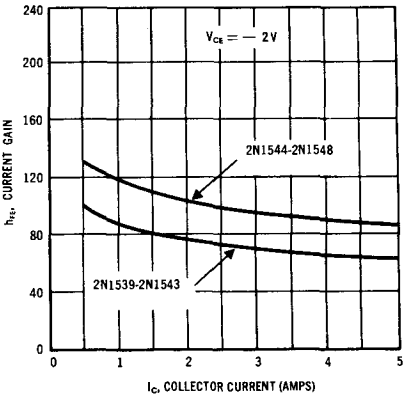


2N1539 thru 2N1548 (continued)

BASE CURRENT versus EMITTER BASE VOLTAGE

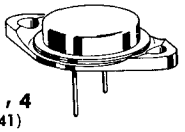


DC CURRENT GAIN versus COLLECTOR CURRENT



2N1549 thru 2N1560 (GERMANIUM)
2N1549A thru 2N1560A, HI-REL

$P_D = 106$W
$I_C = 15$ A
$V_{CBO} = 40$-100 V



CASE 3, 4
(TO-3, 41)

PNP germanium power transistors for switching and amplifier applications in high-reliability equipment.

For units with solder lugs attached, specify devices MP1549A etc. (TO-41 package)

MAXIMUM RATINGS — Apply to corresponding "Hi-Rel" Series Also

Characteristic	Symbol	2N1549 2N1553 2N1557	2N1550 2N1554 2N1558	2N1551 2N1555 2N1559	2N1552 2N1556 2N1560	Unit
Collector-Emitter Voltage	V_{CEX}	40	60	80	100	Vdc
Collector-Emitter Voltage	V_{CES}*	30	45	60	75	Vdc
Collector-Emitter Voltage	V_{CEO}*	20	30	40	50	Vdc
Collector-Base Voltage	V_{CBO}	40	60	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	20	30	40	50	Vdc
Collector Current (Continuous)	I_C	15	15	15	15	Amp
Collector Current (Peak)	I_C	20	20	20	20	Amp
Collector Junction Temperature	T_J	-65 to +110				°C
Collector Dissipation (25 C Case Temp.)	P_D	106	106	106	106	Watts
Thermal Resistance	θ_{JC}	0.8				°C/W

*To avoid excessive heating of collector junction, perform this test with a sweep method.

2N1549 thru 2N1560 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)
Apply to "Hi-Rel" Series Also

Parameter	Symbol	Min	Max	Unit
Collector-Base Cutoff Current	I_{CBO1}			mA
(V_{CB} = 25 V) 2N1549, 2N1553, 2N1557		–	3.0	
(V_{CB} = 40 V) 2N1550, 2N1554, 2N1558		–	3.0	
(V_{CB} = 55 V) 2N1551, 2N1555, 2N1559		–	3.0	
(V_{CB} = 65 V) 2N1552, 2N1556, 2N1560		–	3.0	
Collector-Base Cutoff Current	I_{CBO}			mA
(V_{CB} = 2 V) All Types		–	0.2	
(V_{CB} = 1/2 BV_{CES} rating; T_C = +90°C)		–	20	
Emitter-Base Cutoff Current	I_{EBO}			mA
(V_{EB} = 12 V) All Types		–	0.5	
Collector-Emitter Breakdown Voltage	BV_{CES}			volts
(I_C = 300 mA)				
2N1549, 2N1553, 2N1557		30	–	
2N1550, 2N1554, 2N1558		45	–	
2N1551, 2N1555, 2N1559		60	–	
2N1552, 2N1556, 2N1560		75	–	
Collector-Emitter Leakage Current	I_{CEX}			mA
(V_{BE} = 1 V, V_{CE} @ rated BV_{CBO}) All Types		–	20	
Collector-Emitter Breakdown Voltage*	BV_{CEO}*			volts
(I_C = 300 mA, I_B = 0)				
2N1549, 2N1553, 2N1557		20	–	
2N1550, 2N1554, 2N1558		30	–	
2N1551, 2N1555, 2N1559		40	–	
2N1552, 2N1556, 2N1560		50	–	
Collector-Base Breakdown Voltage	BV_{CBO}			volts
(I_C = 20 mA)				
2N1549, 2N1553, 2N1557		40	–	
2N1550, 2N1554, 2N1558		60	–	
2N1551, 2N1555, 2N1559		80	–	
2N1552, 2N1556, 2N1560		100	–	
Current Gain	h_{FE1}			–
(V_{CE} = 2 V, I_C = 10 A)				
2N1549 - 2N1552		10	30	
2N1553 - 2N1556		30	60	
2N1557 - 2N1560		50	100	
Base-Emitter Drive Voltage	V_{BE}			volts
(I_C = 10 A, I_B = 1 A)				
2N1549 - 2N1552		–	1.3	
2N1553 - 2N1556		–	1.0	
2N1557 - 2N1560		–	0.7	
Collector Saturation Voltage	$V_{CE(sat)}$			volts
(I_C = 10 A, I_B = 1.0 A)				
2N1549 - 2N1552		–	1.0	
2N1553 - 2N1556		–	0.7	
2N1557 - 2N1560		–	0.5	

Characteristics apply to corresponding A type numbers also

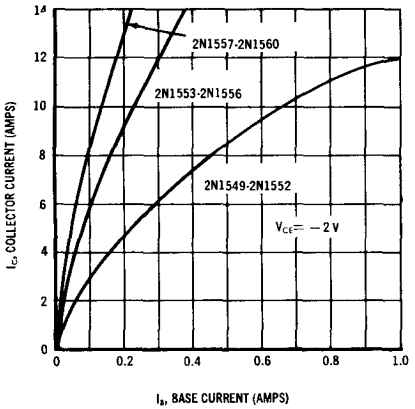
* To avoid excessive heating of collector junction, perform this test with a sweep method

2N1549 thru 2N1560 (continued)

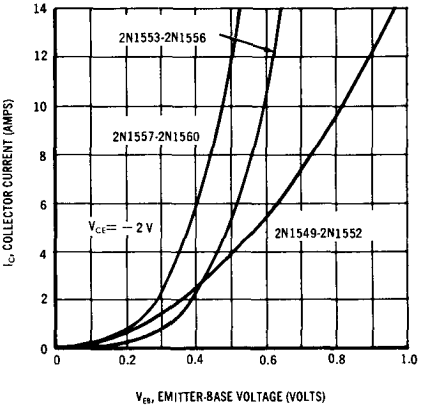
ELECTRICAL CHARACTERISTICS (continued)

Parameter	Symbol	Min	Max	Unit
Transconductance (V_{CE} = 2 V, I_C = 10 A)	g_{FE}			mhos
2N1549 - 2N1552		6	18	
2N1553 - 2N1556		8	30	
2N1557 - 2N1560		12	40	
Frequency Cutoff	f_{ae}	Typ		kc
2N1549 - 2N1552		10		
2N1553 - 2N1556		6		
2N1557 - 2N1560		5		

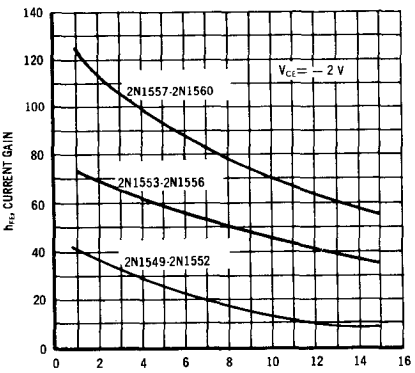
COLLECTOR CURRENT versus BASE CURRENT



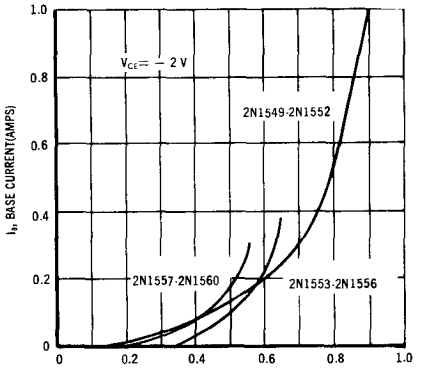
COLLECTOR CURRENT versus EMITTER-BASE VOLTAGE



CURRENT GAIN versus COLLECTOR CURRENT



BASE CURRENT versus EMITTER-BASE VOLTAGE

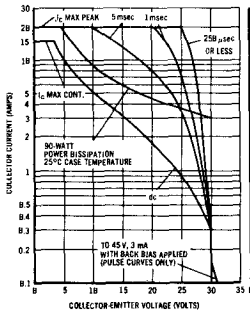


2N1549 thru 2N1560 (continued)

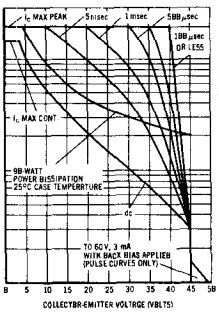
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

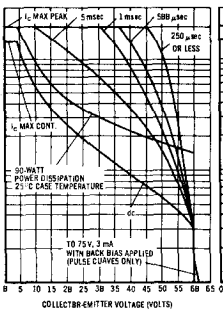
2N1549, 2N1553, 2N1557



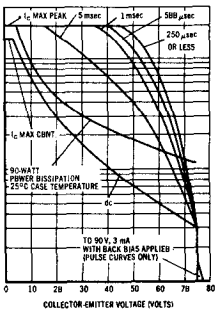
2N1550, 2N1554, 2N1558



2N1551, 2N1555, 2N1559

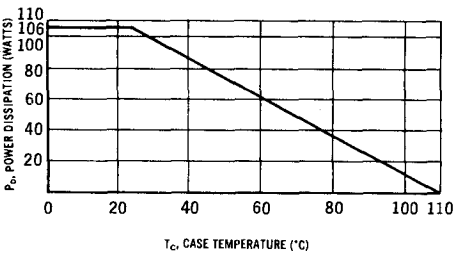


2N1552, 2N1556, 2N1560

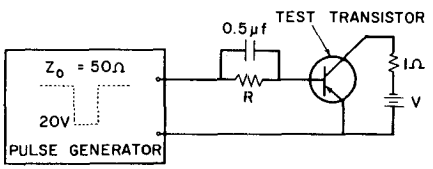


POWER-TEMPERATURE DERATING CURVE

The maximum continuous power is related to maximum junction temperature, by the thermal resistance factor. For d. c. or frequencies below 25 cps the transistor must be operated within the constant $P_D = V_C \times I_C$ hyperbolic curve. This curve has a value of 106 watts at case temperatures of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that P_D allowable $= \frac{110^{\circ} - T_C}{0.8}$



SWITCHING TIME MEASURING UNIT

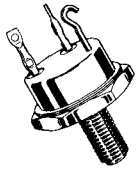


Devices	Conditions*			Typical Switching Times		
	I_C (Amps)	V (Volts)	R (ohms)	$t_d + t_r$ (μsec)	t_s (μsec)	t_f (μsec)
2N1549 -52	10	10	10	5	2	10
2N1553 -56	10	10	30	10	5	25
2N1557 -60	10	10	50	10	5	25

* Input Pulse Repetition Rate = 2 kc, Pulse Width = 50 μsec

2N1724 (SILICON)
2N1725

$V_{CB} = 120$ V
$I_C = 5$ A
$P_D = 117$ W



CASE 9
(TO-61)

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	120	Vdc
Collector-Emitter Voltage	V_{CE}	80	Vdc
Emitter-Base Voltage	V_{EB}	10	Vdc
Collector Current (Continuous)	I_C	5	Adc
Power Dissipation	P_D	1|15	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$
Junction Operating Temperature Range	T_J	-65 to +200	^oC

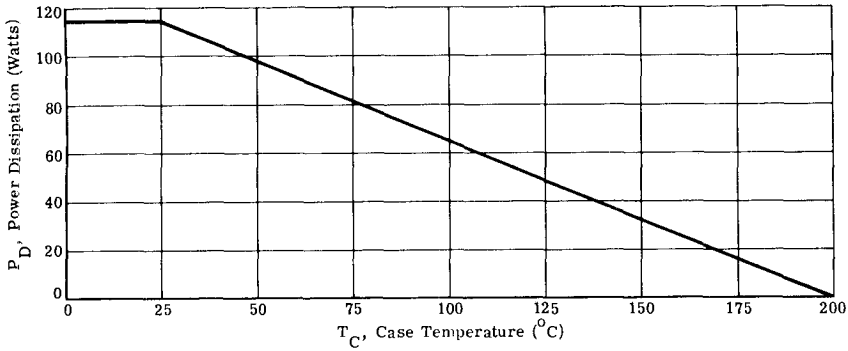
2N1724, 2N1725 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}				mAdc
(V_{EB} = 9 Vdc)	2N1725		-	-	0.5	
(V_{EB} = 10 Vdc)	Both		-	-	10.0	
Collector-Emitter Cutoff Current		I_{CES}				mAdc
(V_{CE} = 60 Vdc, V_{BE} = 0)	Both		-	-	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 0, T_C = 150°C)	Both		-	-	2.0	
(V_{CE} = 120 Vdc, V_{BE} = 0, T_C = 150°C)	Both		-	-	10.0	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 3 Vdc, I_E = 0)	Both		-	-	0.1	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$				Vdc
(I_C = 200 mAdc, I_B = 0)	Both		80	-	-	
DC Current Gain		h_{FE}				
(V_{CE} = 15 Vdc, I_C = 2 Adc)	2N1724		20	40	90	
	2N1725		50	90	150	
(V_{CE} = 15 Vdc, I_C = 2 Adc, T_A = -55°C)	2N1724		12	-	-	
	2N1725		25	-	-	
(V_{CE} = 15 Vdc, I_C = 0.1 Adc)	2N1724		20	-	-	
	2N1725		50	-	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 2 Adc, I_B = 200 mAdc)	Both			0.5	1.0	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 2 Adc, I_B = 200 mAdc)	Both			1.2	2.0	
High Frequency Current Gain		h_{fe}				
(V_{CE} = 15 Vdc, I_C = 0.5 Adc, f = 10 MHz)	Both		1.0	1.6	-	
Common Base Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, f = 0.1 MHz)	Both			260	550	
Switching Times						μsec
(I_C = 2 Adc, I_{B1} = $-I_{B2}$ = 0.2 Adc)						
Delay time plus Rise time		$t_d + t_r$	-	0.15	-	
Storage time		t_s	-	1.3	-	
Fall time		t_f		0.14		

2N1724, 2N1725 (continued)

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREAS

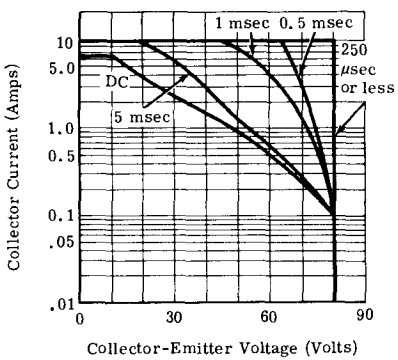
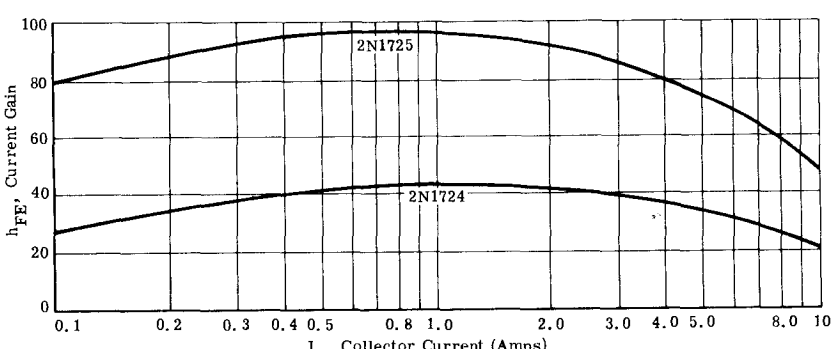


FIGURE 2 — 2N1724, 2N1725

In using these curves the average power derating curve (Fig. 1) must be observed to ensure operation below the maximum junction temperature.

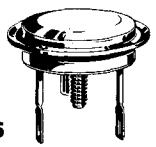
FIGURE 3 — DC CURRENT GAIN versus COLLECTOR CURRENT



2N1970 (GERMANIUM)

$P_D = 170W$
$I_C = 15\ A$
$V_{CBO} = 50\text{-}100\ V$

2N1980 thru 2N1982



CASE 5
(TO-36)

PNP germanium power transistors for general purpose amplifier and switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N1970	2N1980	2N1981	2N1982	Unit
Collector-Base Voltage	V_{CBO}	100	50	70	90	Volts
Collector-Emitter Voltage	V_{CEO}	50	30	40	50	Volts
Emitter-Base Voltage	V_{EBO}	40	20	20	20	Volts
Collector Current	I_C	15	15	15	15	Amps
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	170	Watts
Junction Temperature Range	T_J	-65 to +110				^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -100 Vdc)	2N1970		—	4	
(V_{CB} = -50 Vdc)	2N1980		—	6	
(V_{CB} = -70 Vdc)	2N1981		—	6	
(V_{CB} = -90 Vdc)	2N1982		—	6	
(V_{CB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N1970		—	4	
(V_{EB} = -20 Vdc)	2N1980-2N1982		—	5	
(V_{EB} = -2 Vdc)	2N1980-2N1982		—	0.3	
Collector-Emitter Breakdown Voltage		BV_{CEO}			Vdc
(I_C = 1 Adc, I_B = 0)	2N1970		-50	—	
	2N1980		-30	—	
	2N1981		-40	—	
	2N1982		-50	—	
Base-Emitter Voltage		V_{BE}			Vdc
(V_{CE} = -2 Vdc, I_C = 5 Adc)	2N1970		—	-0.9	
Emitter Floating Potential		V_{EBF}			Vdc
(V_{CB} = -50 Vdc)	2N1980		—	-1.0	
(V_{CB} = -70 Vdc)	2N1981		—	-1.0	
(V_{CB} = -90 Vdc)	2N1982		—	-1.0	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 Adc, I_B = 2 Adc)	2N1970		—	-1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N1980-2N1982		—	-0.5	
DC Current Gain		h_{FE}			—
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N1970		17	40	
	2N1980-2N1982		50	100	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N1970		10	—	
Common Emitter Cutoff Frequency		f_{ae}			kc
(V_{CE} = -4 V, I_C = 5 A)	2N1970		5	—	
(V_{CE} = -5 V, I_C = 2 A)	2N1980-2N1982		3	—	

2N2075 thru 2N2082 (GERMANIUM)

2N2075A thru 2N2082A, HI-REL

$P_D = 170W$
$I_C = 15\ A$
$V_{CBO} = 40\text{-}80V$

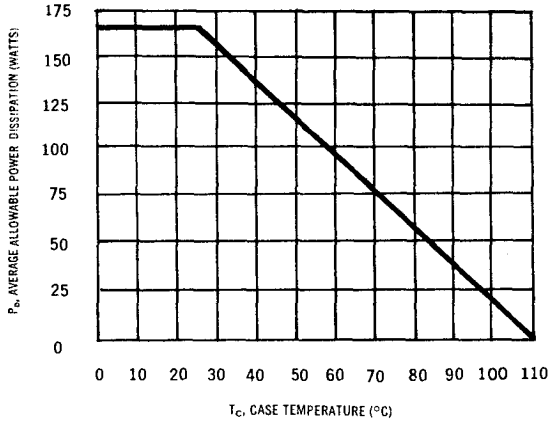


CASE 5
(TO-36)

PNP germanium power transistors for high-power applications in high-reliability equipment.

MAXIMUM RATINGS

CHARACTERISTIC	SYMBOL	2N2078 2N2082	2N2077 2N2081	2N2076 2N2080	2N2075 2N2079	UNIT
Collector-Base Voltage	V_{CBO}	40	50	70	80	Volts
Collector-Emitter Voltage	V_{CES}	40	50	70	80	Volts
Collector-Emitter Voltage	V_{CEO}	25	45	55	65	Volts
Emitter-Base Voltage	V_{EBO}	20	25	35	40	Volts
Collector Current	I_C	15	15	15	15	Amps
Power Dissipation at T_C = 25 C	P_D	170	170	170	170	Watts
Junction Temperature Range	T_J	-65 to + 110				°C
Thermal Resistance, Junction to Case	θ_{JC}	0.5				°C/W



POWER-TEMPERATURE DERATING CURVE

The maximum average power is related to maximum junction temperature by the thermal resistance factor.

This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

2N2075 thru 2N2082 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

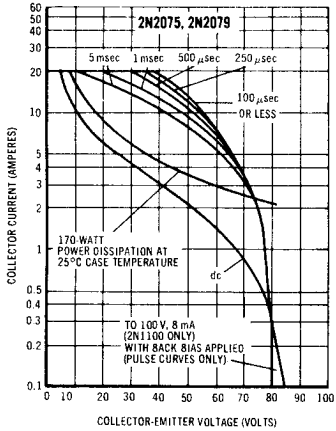
Characteristics apply to corresponding "A" type numbers also.

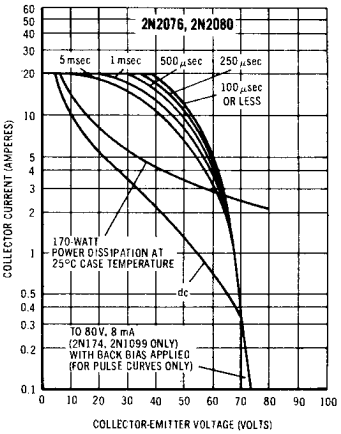
CHARACTERISTIC		SYMBOL	MIN	MAX	UNIT
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = -40 V, V_{EB} = -1.5 V)	2N2078, 2N2082		-	4.0	
(V_{CB} = -50 V, V_{EB} = -1.5 V)	2N2077, 2N2081		-	4.0	
(V_{CB} = -70 V, V_{EB} = -1.5 V)	2N2076, 2N2080		-	4.0	
(V_{CB} = -80 V, V_{EB} = -1.5 V)	2N2075, 2N2079		-	4.0	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = $V_{CB\ max}$, I_E = 0, T_C = +71°C)	All Types		-	15	
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = -2 V, I_E = 0)	All Types		-	200	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -20 V, I_C = 0)	2N2078, 2N2082		-	4.0	
(V_{EB} = -25 V, I_C = 0)	2N2077, 2N2081		-	4.0	
(V_{EB} = -35 V, I_C = 0)	2N2076, 2N2080		-	4.0	
(V_{EB} = -40 V, I_C = 0)	2N2075, 2N2079		-	4.0	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = $V_{EB\ max}$, I_C = 0, T_C = +71°C	All Types		-	15	
Collector-Emitter Breakdown Voltage *		BV_{CES}			Vdc
(I_C = 300 mA, V_{EB} = 0)	2N2078, 2N2082		-40	-	
	2N2077, 2N2081		-50	-	
	2N2076, 2N2080		-70	-	
	2N2075, 2N2079		-80	-	
Collector-Emitter Breakdown Voltage *		BV_{CEO}			Vdc
(I_C = 1.0 A, I_B = 0)	2N2078, 2N2082		-25	-	
	2N2077, 2N2081		-45	-	
	2N2076, 2N2080		-55	-	
	2N2075, 2N2079		-65	-	
Floating Potential		V_{fl}			Vdc
(V_{CB} = -40 V, I_E = 0)	2N2078, 2N2082		-	1.0	
(V_{CB} = -50 V, I_E = 0)	2N2077, 2N2081		-	1.0	
(V_{CB} = -70 V, I_E = 0)	2N2076, 2N2080		-	1.0	
(V_{CB} = -80 V, I_E = 0)	2N2075, 2N2079		-	1.0	
DC Current Transfer Ratio		h_{FE}			
(I_C = 1.2 A, V_{CB} = -2 V)	2N2075 thru 2N2078		25	100	
	2N2079 thru 2N2082		40	160	
(I_C = 5 A, V_{CB} = -2 V)	2N2075 thru 2N2078		20	40	
	2N2079 thru 2N2082		35	70	
(I_C = 12 A, V_{CB} = -2 V)	2N2075 thru 2N2078		8	-	
	2N2079 thru 2N2082		12	-	
(I_C = 5 A, V_{CB} = -2 V, T_C = -55°C)	2N2075 thru 2N2078		15	-	
	2N2079 thru 2N2082		25	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 A, I_B = 2 A)	2N2075 & 76, 2N2079 & 80		-	0.7	
	2N2077 & 78, 2N2081 & 82		-	0.9	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 5 A, V_{CB} = -2 V)	All Types		-	0.9	
Common Emitter Cutoff Frequency		$f_{\alpha e}$			kc
(I_C = 5 A, V_{CE} = -6 V)	All Types		5	-	
Rise Time		t_r	Typ		μsec
("On" I_C = 12 A, V_{CE} = -12 V, I_B = 2 A)	2N2075 thru 2N2078		9		
	2N2079 thru 2N2082		6		
Fall Time		t_f			μsec
("Off" I_C = 0, V_{EB} = -6 V, R_{EB} = 10 Ohms)	2N2075 thru 2N2078		12		
	2N2079 thru 2N2082		13		

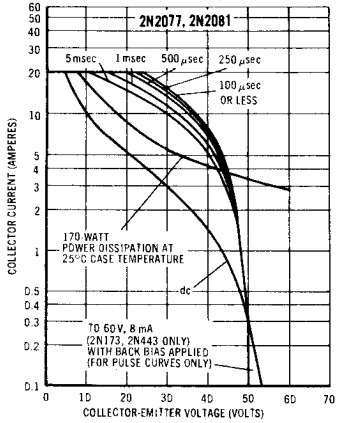
* To avoid excessive heating of collector junction, perform this test with a sweep method.

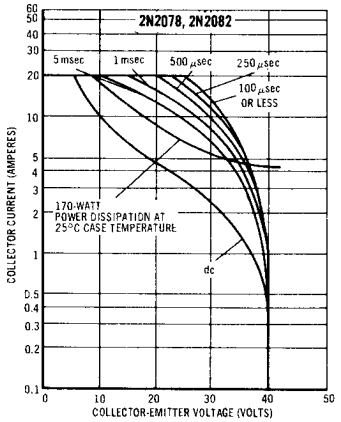
2N2075 thru 2N2082 (continued)

SAFE OPERATING AREAS





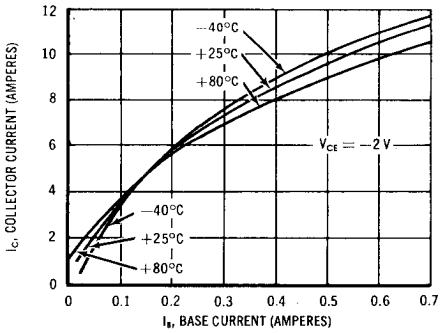




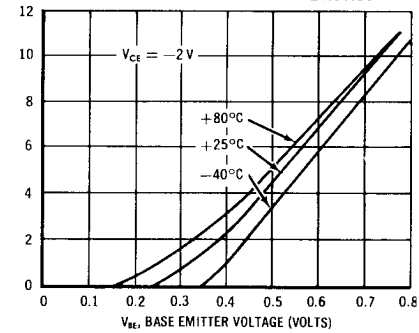
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2075-2N2078

CURRENT TRANSFER CHARACTERISTICS



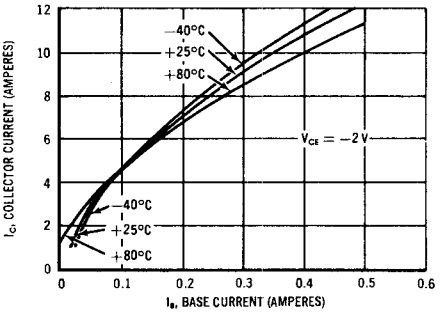
TRANSCONDUCTANCE CHARACTERISTICS



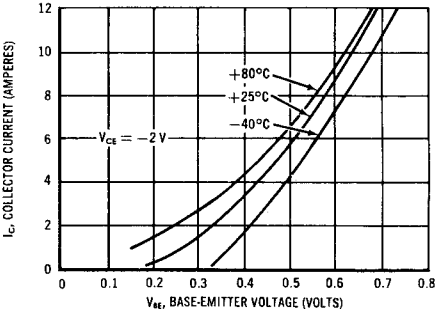
2N2075 thru 2N2082 (continued)

2N2079-2N2082

CURRENT TRANSFER CHARACTERISTICS

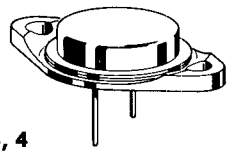


TRANSCONDUCTANCE CHARACTERISTICS



2N2137 thru 2N2146 (GERMANIUM)
2N2137A thru 2N2146A HI-REL

$P_D = 70$ W
$I_C = 3$ A
$V_{CB} = 30$-90 V



CASE 3, 4
(TO-3, 41)

PNP germanium industrial power transistors for driver applications in high reliability equipment.

For units with solder lugs attached, specify devices MP2137A etc. (TO-41 package)

MAXIMUM RATINGS

Apply also to standard, non-A series

Characteristic	Symbol	2N2137A 2N2142A	2N2138A 2N2143A	2N2139A 2N2144A	2N2140A 2N2145A	2N2141A 2N2146A	Unit
Collector-Base Voltage	V_{CB}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CES}	30	45	60	75	90	Vdc
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	65	Vdc
Emitter-Base Voltage	V_{EB}	15	25	30	40	45	Vdc
Total Device Dissipation @ $T_C = 25°C$	P_D	← 70 →					Watts
Derate above 25°C		← 0.833 →					W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	← -65 to +110 →					°C

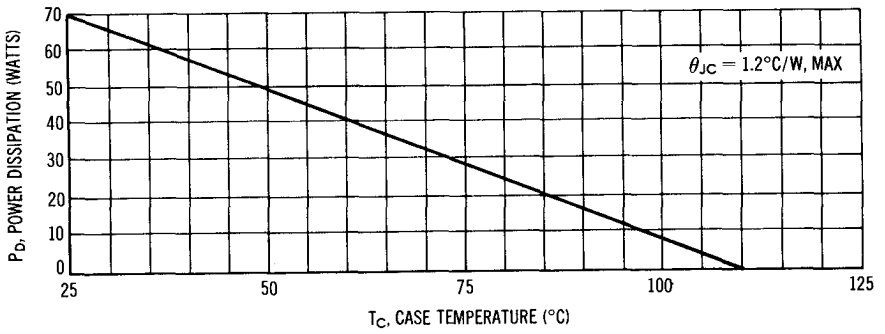
2N2137 thru 2N2146 (continued)

GROUP A ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -2 V, I_E = 0) (V_{CB} = $V_{CB(max)}$, I_C = 0, T_C = +71°C)	All Types	I_{CBO}	— —	0.018 0.75	0.05 5	mAdc
Collector-Base Cutoff Current† (V_{CB} = $V_{CB(max)}$, I_E = 0)	All Types	I_{CBO1}†	—	0.1	2	mAdc
Emitter-Base Cutoff Current (V_{EB} = $V_{EB(max)}$, I_C = 0) (V_{EB} = $V_{EB(max)}$, I_C = 0, T_C = +71°C)	All Types	I_{EBO}	— —	0.08 0.5	2 5	mAdc
Collector-Emitter Breakdown Voltage** (I_C = 300 mA, V_{EB} = 0)	2N2137A, 2N2142A* 2N2138A, 2N2143A* 2N2139A, 2N2144A* 2N2140A, 2N2145A* 2N2141A, 2N2146A*	BV_{CES}**	-30 -45 -60 -75 -90	— — — — —	— — — — —	Vdc
Collector-Emitter Breakdown Voltage** (I_C = 500 mA, I_B = 0)	2N2137A, 2N2142A* 2N2138A, 2N2143A* 2N2139A, 2N2144A* 2N2140A, 2N2145A* 2N2141A, 2N2146A*	BV_{CEO}**	-20 -30 -45 -60 -65	— — — — —	— — — — —	Vdc
Floating Potential (V_{CB} = 30 V, I_E = 0) (V_{CB} = 45 V, I_E = 0) (V_{CB} = 60 V, I_E = 0) (V_{CB} = 75 V, I_E = 0) (V_{CB} = 90 V, I_E = 0)	2N2137A, 2N2142A* 2N2138A, 2N2143A* 2N2139A, 2N2144A* 2N2140A, 2N2145A* 2N2141A, 2N2146A*	V_{EBF}	— — — — —	— — — — —	1.0 1.0 1.0 1.0 1.0	Vdc
DC Current Gain (I_C = 0.5 A, V_{CE} = 2 V)† (I_C = 2.0 A, V_{CE} = 2 V)	2N2137A-2N2141A* 2N2142A-2N2146A* 2N2137A-2N214IA* 2N2142A-2N2146A*	h_{FE1}† h_{FE}	30 50 15 25	45 70 22 33	60 100 — —	—
Collector-Emitter Saturation Voltage (I_C = 2.0 A, I_B = 200 mA)	All Types	$V_{CE(sat)}$	—	0.12	0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 2.0 A, I_B = 200 mA)	All Types	$V_{BE(sat)}$	—	0.75	1.2	Vdc
Common Emitter Cutoff Frequency (I_C = 2.0 A, V_{CE} = 6 V)	All Types	f_{ae}	12	20	—	kHz

*Characteristics apply also to corresponding, non-A type numbers
**Sweep method: 1/2 cycle sine wave, 60 cps
†Subscript 1 indicates tests performed under Hi Rel Acceptance Tests

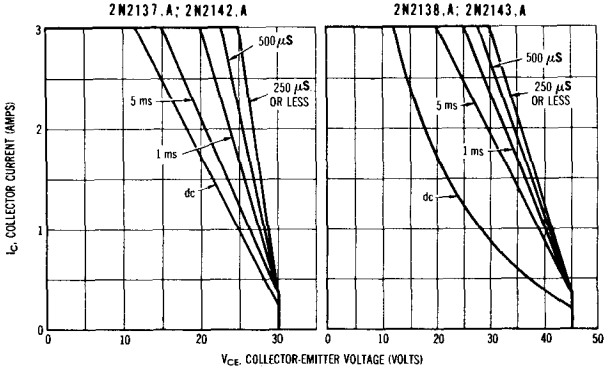
FIGURE 1 — POWER TEMPERATURE OERATING CURVE

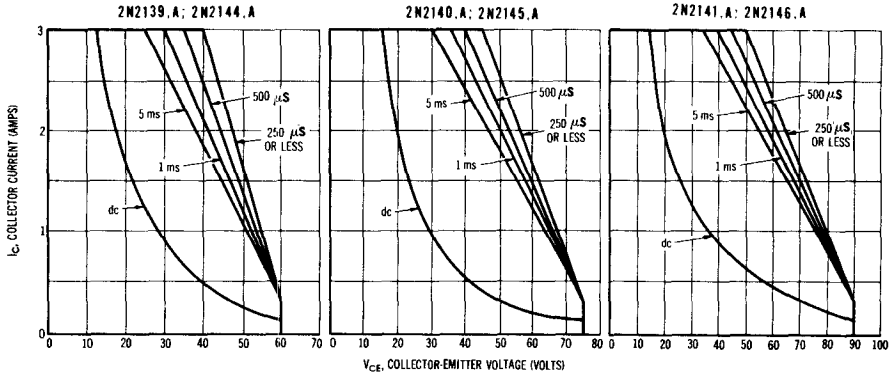


2N2137 thru 2N2146 (continued)

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

The active region safe operating area curves indicate I_C-V_{CE} limits to be observed in order to avoid secondary breakdown. (Secondary breakdown is independent of temperature and duty cycle.) These curves do not define operation in the avalanche region. To insure operation below the maximum junction temperature, power derating must be observed for both steady state and pulse conditions.





LARGE SIGNAL CHARACTERISTICS

FIGURE 3 — TRANSCONDUCTANCE (ALL TYPES)

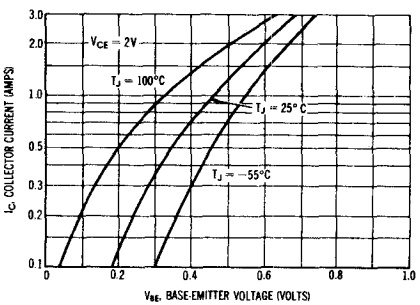
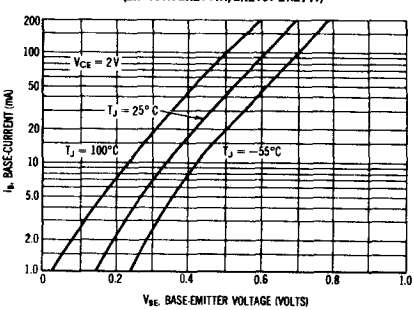


FIGURE 4 — INPUT ADMITTANCE (2N2137A-2N2141A, 2N2137-2N2141)



2N2137 thru 2N2146 (continued)

FIGURE 5 — INPUT ADMITTANCE
(2N2142A-2N2146A, 2N2142-2N2146)

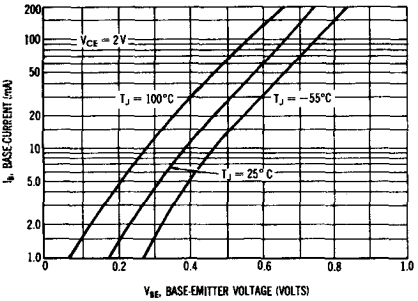


FIGURE 6 — NORMALIZED DC CURRENT GAIN
(ALL TYPES)

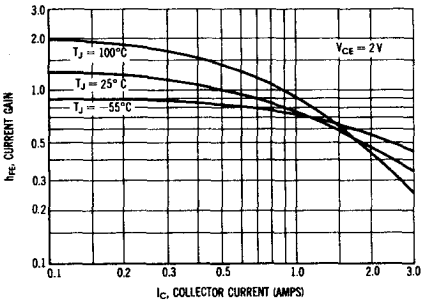


FIGURE 7 — SATURATION REGION
(2N2137A-2N2141A, 2N2137-2N2141)

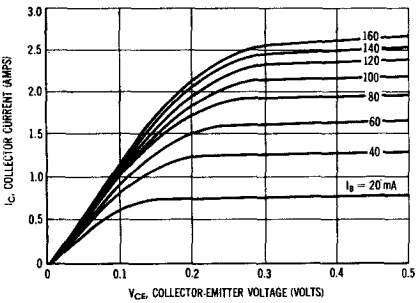
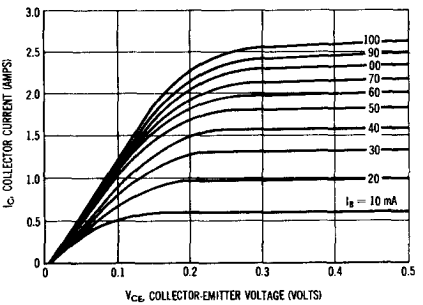


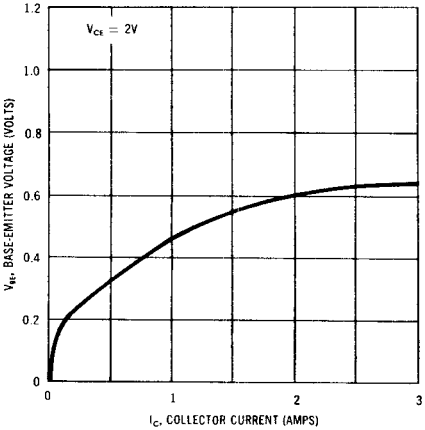
FIGURE 8 — SATURATION REGION
(2N2142A-2N2146A, 2N2142-2N2146)



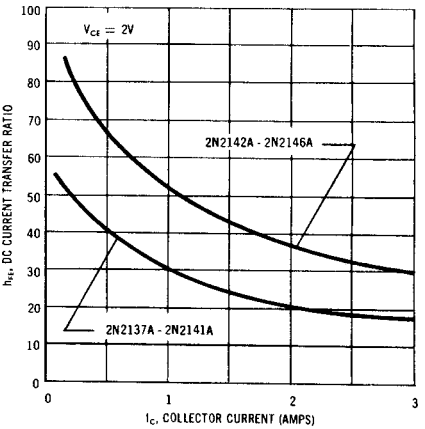
2N2137 thru 2N2146 (continued)

INPUT & TRANSFER CHARACTERISTICS

BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT
All Types



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N2152 thru 2N2154 (GERMANIUM)
2N2156 thru 2N2158
2N2152A thru 2N2154A, 2N2156A thru 2N2158A, HI-REL

P_D = 170W
I_C = 30 A
V_{CBO} = 45-75 V

CASE 5
(TO-36)



PNP germanium power transistors for high-power, high-gain applications in high-reliability industrial equipment.

MAXIMUM RATINGS

Characteristic	Symbol	2N2152 2N2156	2N2153 2N2157	2N2154 2N2158	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current	I_C	30			Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	170			Watts
Derate above 25^oC		0.5			$W/^oC$
Operating Junction Temperature Range	T_J	-65 to +110			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

2N2152 thru 2N2154 2N2156 thru 2N2158 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1.0 Adc, I_B = 0)	2N2152, 2N2156	BV_{CEO}*	30	-	-	Vdc
	2N2153, 2N2157		45	-	-	
	2N2154, 2N2158		60	-	-	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc, V_{BE} = 0)	2N2152, 2N2156	BV_{CES}*	45	-	-	Vdc
	2N2153, 2N2157		60	-	-	
	2N2154, 2N2158		75	-	-	
Floating Potential (V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156	V_{EBF}	-	-	1.0	Vdc
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	-	1.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	-	1.0	
Collector Cutoff Current (V_{CB} = 2V, I_E = 0)	All Types	I_{CBO}	-	.08	0.2	mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N2152, 2N2156		-	0.9	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N2153, 2N2157		-	0.9	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N2154, 2N2158		-	0.9	4.0	
(V_{CB} = $V_{CB(max)}$, I_E = 0, T_C = 71°C)	All Types		-	4.0	15	
Emitter Cutoff Current (V_{BE} = 25 Vdc, I_C = 0)		I_{EBO}	-	0.2	4.0	mAdc
(V_{BE} = 30 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = 40 Vdc, I_C = 0)			-	0.2	4.0	
(V_{BE} = $V_{EB(max)}$, I_C = 0, T_C = 71°C)	All Types		-	2.7	15	
ON CHARACTERISTICS						
DC Current Gain (I_C = 5.0 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154	h_{FE}	50	75	100	-
	2N2156, 2N2157, 2N2158		80	105	160	
(I_C = 15 Adc, V_{CB} = 2 Vdc)	2N2152, 2N2153, 2N2154		25	47	-	
	2N2156, 2N2157, 2N2158		40	63	-	
(I_C = 25 Adc, V_{CB} = 2 Vdc)	All Types		15	38	-	
Collector-Emitter Saturation Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)	All Types	$V_{CE(sat)}$	-	0.06	0.1	Vdc
(I_C = 25 Adc, I_B = 2 Adc)	All Types		-	0.2	0.3	
Base-Emitter On Voltage (I_C = 5.0 Adc, I_B = 500 mAdc)	All Types	$V_{BE(on)}$	-	0.65	1.0	Vdc
(I_C = 25 Adc, I_B = 2 Adc)	All Types		-	1.0	2.0	
SMALL SIGNAL CHARACTERISTICS						
Common-Emitter Cutoff Frequency (I_C = 5.0 Adc, V_{CE} = 6.0 Vdc)		$f_{\alpha e}$	2	2.7	-	kHz

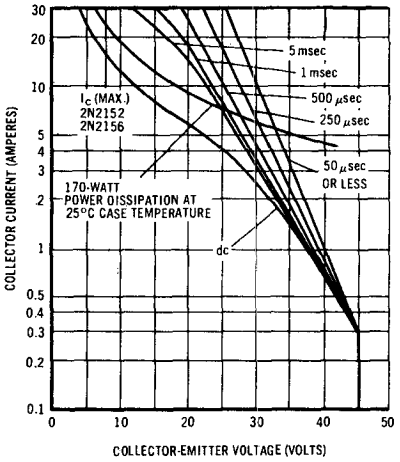
*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

2N2152 thru 2N2154, 2N2156 thru 2N2158 (continued)

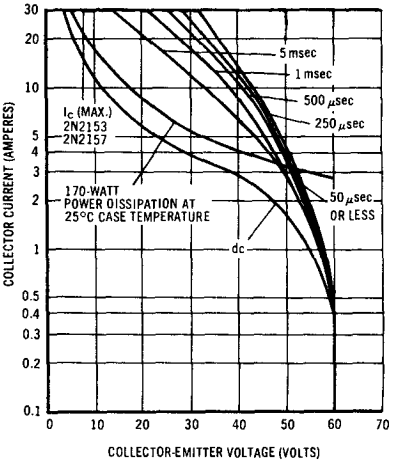
SAFE OPERATING AREAS

The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

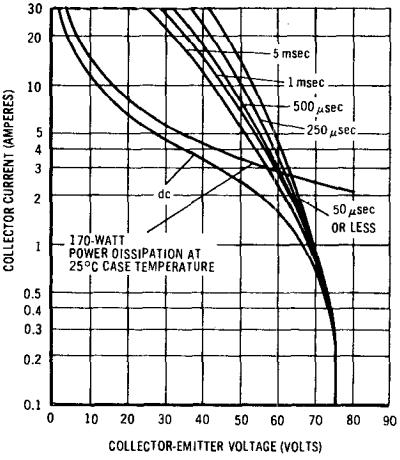
2N2152, 2N2156



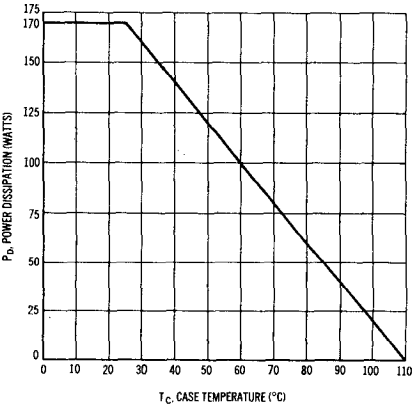
2N2153. 2N2157



2N2154, 2N2158



POWER-TEMPERATURE DERATING CURVE



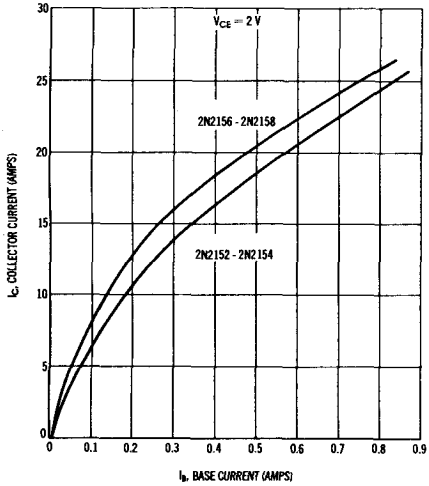
The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^\circ - T_C}{0.5}$$

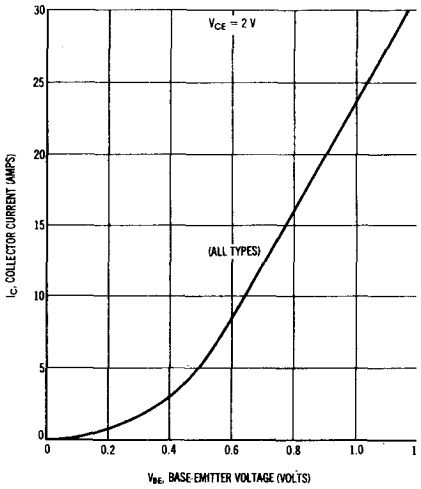
2N2152 thru 2N2154 2N2156 thru 2N2158 (continued)

TYPICAL INPUT AND TRANSFER CHARACTERISTICS

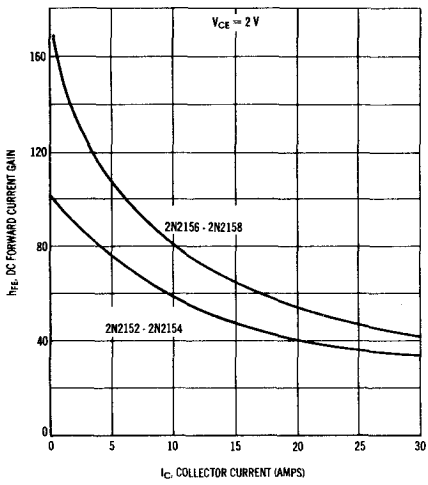
COLLECTOR CURRENT versus BASE CURRENT



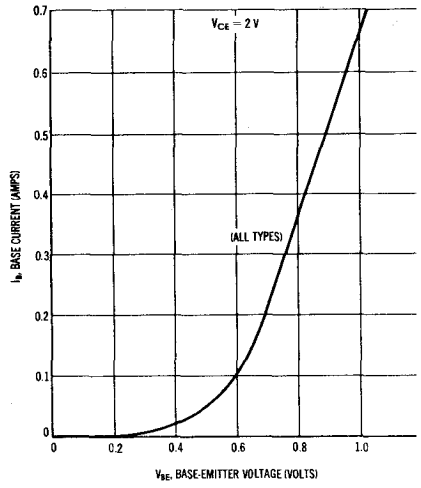
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT

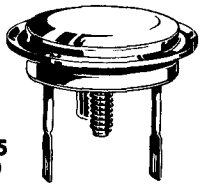


BASE CURRENT versus BASE-EMITTER VOLTAGE



2N2490 thru 2N2493 (GERMANIUM)

$P_D = 170W$
$I_C = 15 A$
$V_{CBO} = 60\text{-}100 V$



CASE 5
(TO-36)

PNP germanium power transistors for general purpose power and switching applications.

MAXIMUM RATINGS

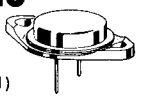
Characteristic	Symbol	2N2490	2N2491	2N2492	2N2493	Unit
Collector-Base Voltage	V_{CBO}	70	60	80	100	Volts
Collector-Emitter Voltage	V_{CES}	60	50	70	85	Volts
Emitter-Base Voltage	V_{EBO}	40	30	60	80	Volts
Collector Current	I_C	15	15	15	15	Amps
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	170	Watts
Junction Temperature Range	T_J	← -65 to +110 →				^oC

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = -2 Vdc)	All Types	I_{CBO}	—	0.2	mAdc
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = -40 Vdc)	2N2490		—	3	
(V_{EB} = -30 Vdc)	2N2491		—	3	
(V_{EB} = -60 Vdc)	2N2492		—	2	
(V_{EB} = -80 Vdc)	2N2493		—	3	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = -70 Vdc, V_{BE} = 1.5 Vdc)	2N2490		—	3	
(V_{CE} = -60 Vdc, V_{BE} = 1.5 Vdc)	2N2491		—	3	
(V_{CE} = -80 Vdc, V_{BE} = 1.5 Vdc)	2N2492		—	2	
(V_{CE} = -100 Vdc, V_{BE} = 1.5 Vdc)	2N2493		—	3	
(V_{CE} = -35 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2490, 2N2491		—	35	
(V_{CE} = -40 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2492		—	35	
(V_{CE} = -50 Vdc, V_{BE} = 1.5 Vdc, T_C = +100°C)	2N2493		—	35	
Collector-Emitter Breakdown Voltage		V_{CEO}			Volts
(I_C = 1 A, I_B = 0)	2N2490		-50	—	
	2N2491		-40	—	
	2N2492		-65	—	
	2N2493		-75	—	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490, 2N2491		—	-0.9	
	2N2492, 2N2493		—	-0.8	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	All Types		—	-1.5	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 12 Adc, I_B = 2 Adc)	2N2490, 2N2491		—	-0.7	
	2N2492, 2N2493		—	-0.5	
DC Current Gain		h_{FE}			—
(I_C = 1 Adc, V_{CE} = -2 Vdc)	2N2490		45	—	
	2N2491		65	—	
	2N2492, 2N2493		50	—	
(I_C = 5 Adc, V_{CE} = -2 Vdc)	2N2490		20	40	
	2N2491		35	70	
	2N2492, 2N2493		25	50	
(I_C = 5 Adc, V_{CE} = -2 Vdc, T_A = -65°C)	2N2490		15	—	
	2N2491		25	—	
	2N2492, 2N2493		20	—	
(I_C = 12 Adc, V_{CE} = -2 Vdc)	2N2490		8	—	
	2N2491		12	—	
	2N2492, 2N2493		10		
Common Emitter Cutoff Frequency (I_C = 5A, V_{CE} = -6 V)		f_{ae}	5	—	kc
Turn-On Time (I_C = 5 A, $I_{B1} = I_{B2}$ = 0.5 A)		t_{on}	—	25	μsec
Turn-Off Time (I_C = 5 A, $I_{B1} = I_{B2}$ = 0.5 A)		t_{off}	—	15	μsec

2N2526 (GERMANIUM)
2N2527
2N2528

$P_D = 85$ W
$I_C = 10$ A
$V_{CBO} = 80$-160 V



CASE 3,4
(TO-3,TO-41)

PNIP germanium power transistors for high-voltage power switching applications.

For units with solder lugs attached, specify devices MP2526 etc. (TO-41 package)

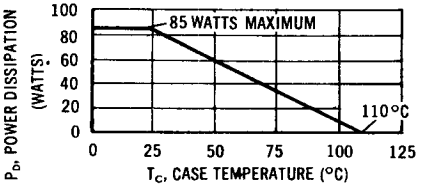
MAXIMUM RATINGS

Characteristic	Symbol	2N2526	2N2527	2N2528	Unit
Collector-Emitter Voltage	V_{CE}	80	120	160	Vdc
Collector-Base Voltage	V_{CB}	80	120	160	Vdc
Emitter-Base Voltage	V_{EB}	5	5	5	Vdc
Collector Current (Cont)	I_C	10	10	10	Amps
Base Current (Cont)	I_B	5	5	5	Amps
Emitter Reverse Current (Surge 60 cps Recurrent)	I_E	1.5	1.5	1.5	Amps
Storage and Operating Temperatures	T_{stg} T_J	-65 to +110			°C
Total Device Dissipation (25°C Mtg. Case Temp.)	P_D	85	85	85	Watts
Thermal Resistance	θ_{JC}	1.0			°C/W

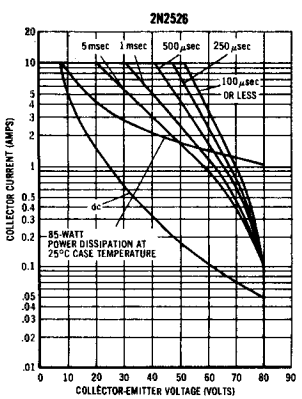
POWER-TEMPERATURE DERATING CURVE

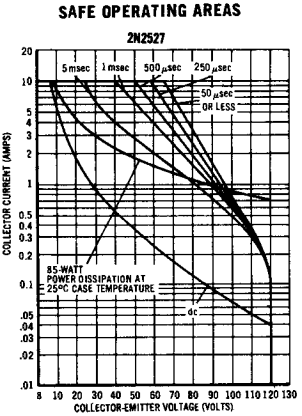
The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 85 watts at a case temperature of 25°C and is 0 watts at 110°C with a linear relation between the two temperatures such that:

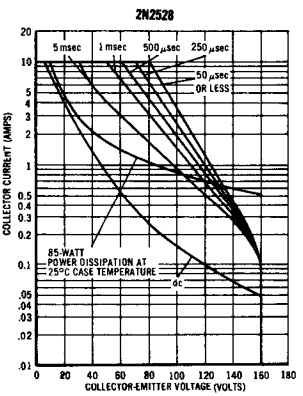
$$\text{Allowable } P_D = \frac{110° - T_C}{1.0} \text{ Watts}$$



SAFE OPERATING AREAS







The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N2526 thru 2N2528 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

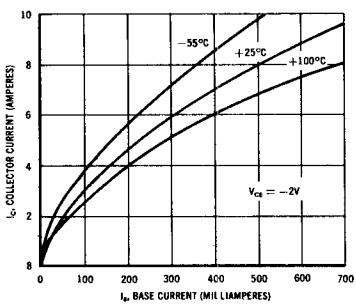
Characteristic	Types	Symbol	Min.	Typ.	Max.	Unit
Collector-Emitter Cutoff Current*		I_{CEX}				mA
(V_{CE} = -80 V, V_{BE} = 0.2 Vdc, T_C = 100°C)	2N2526		–	–	35	
(V_{CE} = -120 V, V_{BE} = 0.2 Vdc, T_C = 100°C)	2N2527		–	–	35	
(V_{CE} = -160 V, V_{BE} = 0.2 Vdc, T_C = 100°C)	2N2528		–	–	35	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = -80 Vdc, I_E = 0)	2N2526		–	–	3	
(V_{CB} = -120 Vdc, I_E = 0)	2N2527		–	–	3	
(V_{CB} = -160 Vdc, I_E = 0)	2N2528		–	–	3	
(V_{CB} = -2.0 Vdc, I_E = 0)	All Types		–	–	150	μAdc
Collector-Emitter Cutoff Current		I_{CER}				mAdc
(V_{CE} = -80 Vdc, R_{BE} = 100 Ω)	2N2526		–	–	25	
(V_{CE} = -120 Vdc, R_{BE} = 100 Ω)	2N2527		–	–	25	
(V_{CE} = -160 Vdc, R_{BE} = 100 Ω)	2N2528		–	–	25	
Emitter-Base Breakdown Voltage (I_E = 50 mAdc)	All Types	BV_{EBO}	5	–	–	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 100 mA, I_B = 0)	2N2526	$BV_{CEO(sus)}$	-80	–	–	Volts
	2N2527		-120	–	–	
	2N2528		-160	–	–	
DC Current Gain (I_C = 3 Adc, V_{CE} = -2.0 Vdc)	All Types	h_{FE}	20	–	50	–
Small Signal Current Gain (V_{CE} = -12 Vdc, I_C = 0.5 Adc, f = 30 kc)	All Types	h_{fe}	10	15	–	–
Transconductance (V_{CE} = -2.0 Vdc, I_C = 3 Adc)	All Types	g_{FE}	4	6	–	Mhos
Collector-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	All Types	$V_{CE(sat)}$	–	-0.5	-0.8	Vdc
Base-Emitter Saturation Voltage (I_C = 10 Adc, I_B = 1.0 Adc)	All Types	$V_{BE(sat)}$	–	0.8	1.2	Vdc
Rise Time	All Types	t_r	–	5.5	–	μsec
Storage Time	All Types	t_s	–	1.2	–	μsec
Fall Time	All Types	t_f	–	2.0	–	μsec

*To avoid excessive heating of collector junction, perform this test with a sweep method.

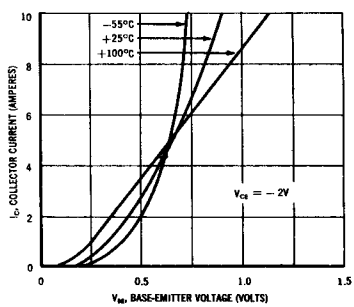
TYPICAL INPUT CHARACTERISTICS

ALL TYPES

COLLECTOR CURRENT versus BASE CURRENT



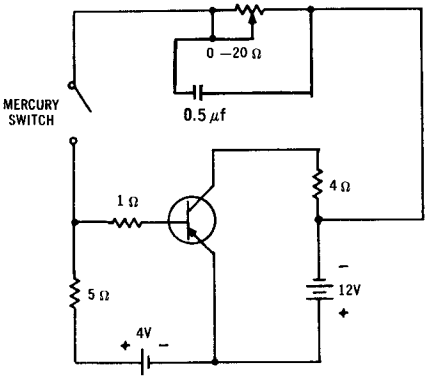
COLLECTOR CURRENT versus DRIVE VOLTAGE



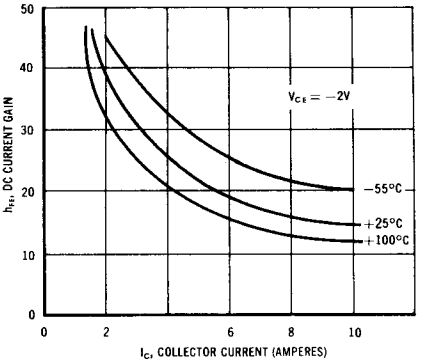
2N2526 thru 2N2528 (continued)

SWITCHING TEST CIRCUIT

PULSE CONDITIONS ; $I_C = 3$ Adc, $I_B = 300$ mAdc

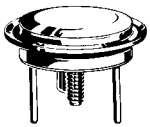


DC CURRENT GAIN versus COLLECTOR CURRENT



2N2728 (GERMANIUM)

$P_D = 170$W
$I_C = 50$ A
$V_{CBO} = 15$ V



CASE 7
(TO-36)

PNP germanium high-current power transistors especially designed for switching and power converter circuit operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells, and 1.5-volt batteries.

MAXIMUM RATINGS

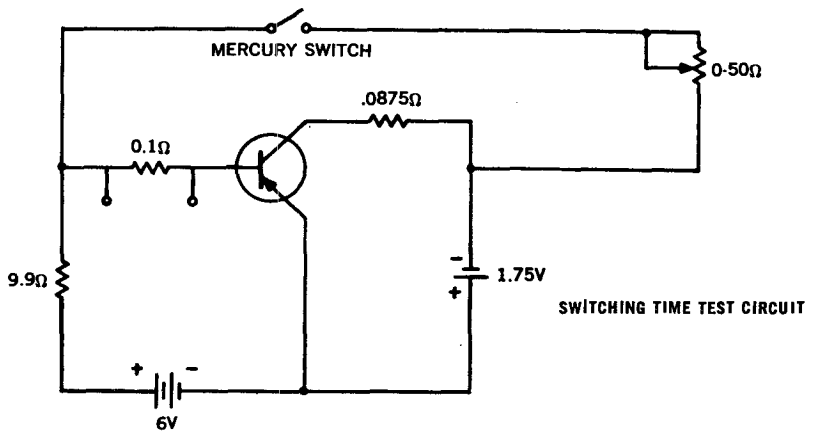
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	5	Vdc
Emitter-Base Voltage	V_{EBO}	15	Vdc
Collector Current (continuous)	I_C	50	Adc
Base Current (continuous)	I_B	10	Adc
Total Device Dissipation @ 25°C Case Temperature	P_D	170	Watts
Operating Temperature	T_J	+110	°C
Storage Temperature	T_{stg}	-65 to +110	°C
Thermal Resistance (Junction to Case)	θ_{JC}	0.5	°C/W

2N2728 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CE} = 15 V, V_{BE} = 1 V V_{CE} = 10 V, V_{BE} = 1 V, T_C = 100°C	I_{CEX}	- -	- -	10 35	mAdc
Emitter-Base Cutoff Current V_{EB} = 15 V	I_{EBO}	-	-	10	mAdc
Emitter Floating Potential V_{CB} = 15 V, I_E = 0	V_{EBF}	-	-	0.5	Vdc
Collector-Emitter Breakdown Voltage* I_C = 500 mA, I_B = 0	BV_{CEO}	5	10	-	V
DC Current Transfer Ratio I_C = 20 A, V_{CE} = 2 V	h_{FE}	40	-	130	-
Collector-Emitter Saturation Voltage I_C = 50 A, I_B = 5 A	$V_{CE(sat)}$	-	.075	0.1	Vdc
Base-Emitter Voltage I_C = 50 A, I_B = 5 A	$V_{BE(sat)}$	-	0.85	1.0	Vdc
Common Emitter Cutoff Frequency I_C = 20 A, V_{CE} = 2 V	f_{ae}	3	4.5	-	kc
Rise Time I_C = 20 A, V_{CC} = 1.75 V, $I_{B(on)}$ = 2 A	t_r	-	18	25	μsec
Storage Time V_{BE} = 6 V, R_{be} = 10 Ω	t_s	-	15	20	μsec
Fall Time V_{BE} = 6 V, R_{be} = 10 Ω	t_f	-	10	15	μsec

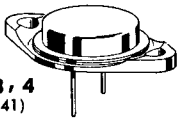
* To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.



SWITCHING TIME TEST CIRCUIT

2N2832 (GERMANIUM)
2N2833
2N2834

$P_D = 85\,W$
$I_C = 20\,A$
$V_{CBO} = 80\text{-}140\,V$



CASE 3, 4
(TO-3, 41)

PNP germanium high-speed, high-frequency, power transistors for output stages of CRT deflection circuits, high-efficiency power inverters, and similar applications.

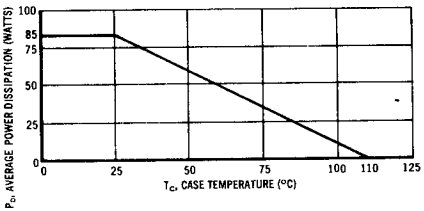
For units with solder lugs attached, specify devices MP2832 etc. (TO-41 package)

MAXIMUM RATINGS

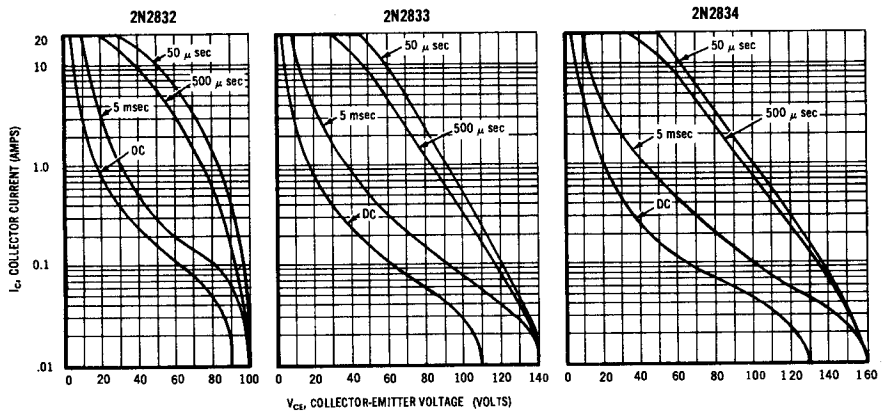
Characteristic	Symbol	2N2832	2N2833	2N2834	Unit
Collector-Base Voltage	V_{CBO}	80	120	140	Volts
Collector-Emitter Voltage	V_{CEO}	50	75	100	Volts
Emitter-Base Voltage	V_{EBO}	2	2	2	Volts
Collector Current (Continuous)	I_C	20	20	20	Amps
Base Current (Continuous)	I_B	5	5	5	Amps
Power Dissipation	P_D	85	85	85	Watts
Junction and Storage Temperature Range	T_J & T_{stg}	-65 to +110°			°C

POWER-TEMPERATURE DERATING CURVE

THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED



SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the Ic - V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

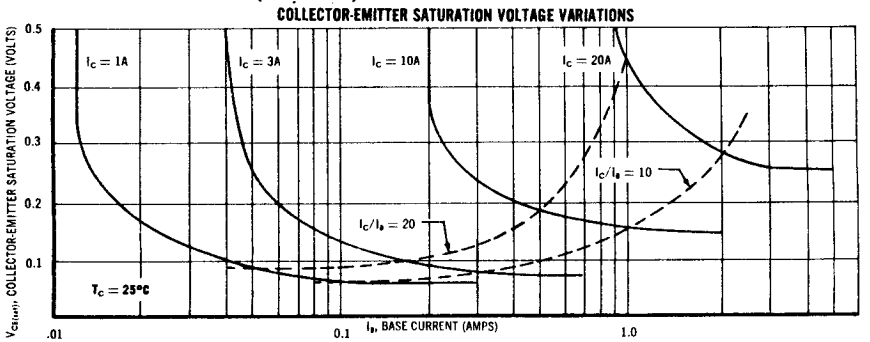
2N2832 thru 2N2834 (continued)

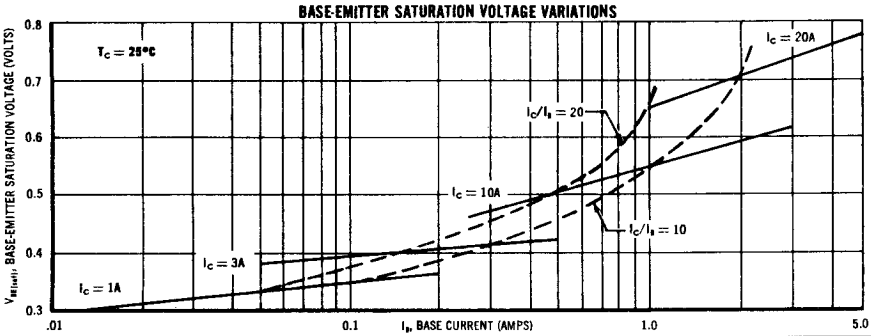
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current*		I_{CBO}*				mA
(V_{CB} = 2V, I_E = 0)	All Types		---	---	0.3	
(V_{CB} = 80V, I_E = 0)	2N2832		---	---	10	
(V_{CB} = 120V, I_E = 0)	2N2833		---	---	10	
(V_{CB} = 140V, I_E = 0)	2N2834		---	---	10	
Collector-Emitter Current*		I_{CES}*				mA
(V_{CE} = 100V, V_{BE} = 0)	2N2832		---	---	20	
(V_{CE} = 140V, V_{BE} = 0)	2N2833		---	---	20	
(V_{CE} = 180V, V_{BE} = 0)	2N2834		---	---	20	
Collector-Emitter Cutoff Current**		I_{CEX}**				mA
(V_{CE} = 50V, V_{BE} = 0.2V, T_C = +85°C)	2N2832		---	---	40	
(V_{CE} = 75V, V_{BE} = 0.2V, T_C = +85°C)	2N2833		---	---	40	
(V_{CE} = 100V, V_{BE} = 0.2V, T_C = +85°C)	2N2834		---	---	40	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 50 mAdc, I_C = 0)			2	---	---	
Collector-Emitter Breakdown Voltage**		$BV_{CEO(sus)}$**				Volts
(I_E = 100 mA, I_B = 0)	2N2832		50	---	---	
	2N2833		75	---	---	
	2N2834		100	---	---	
Emitter Floating Potential*		V_{EBF}*				Volts
(V_{CB} = 80V, I_E = 0)	2N2832		---	---	0.5	
(V_{CB} = 120V, I_E = 0)	2N2833		---	---	0.5	
(V_{CB} = 140V, I_E = 0)	2N2834		---	---	0.5	
DC Current Transfer Ratio		h_{FE}				---
(I_C = 1.0 A, V_{CE} = 2V)			50	75	---	
(I_C = 10A, V_{CE} = 2V)			25	---	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			---	---	0.15	
(I_C = 10 Adc, I_B = 1.0 Adc)			---	---	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			---	---	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 1 A, I_B = 100 mAdc)			---	---	0.6	
(I_C = 10 A, I_B = 1Adc)			---	---	0.75	
(I_C = 20 A, I_B = 2 Adc)			---	---	1.0	
Small Signal Current Gain		h_{fe}				---
(I_C = 1.0 A, V_{CE} = 10 V, f = 5 mc)			2	3.5	---	
Rise Time		t_r	---	2	4	μsec
Storage Time		t_s	---	3	6	μsec
Fall Time		t_f	---	1	2.5	μsec

* SWEEP TEST: 1/2 Sine Wave, 60 cps min
** PULSE TEST: PW = 1 msec, 2% Duty Cycle

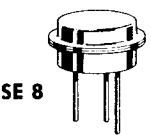
2N2832 thru 2N2834 (continued)





2N2912 (GERMANIUM)

$P_D = 75W$
$I_C = 25 A$
$V_{CBO} = 15 V$



CASE 8

PNP germanium, epitaxial-base, high-speed, power transistors for switching and power converter circuits operating from low-voltage power sources such as solar cells, thermo-electric generators, sea cells, fuel cells, and 1.5-volt batteries.

MAXIMUM RATINGS

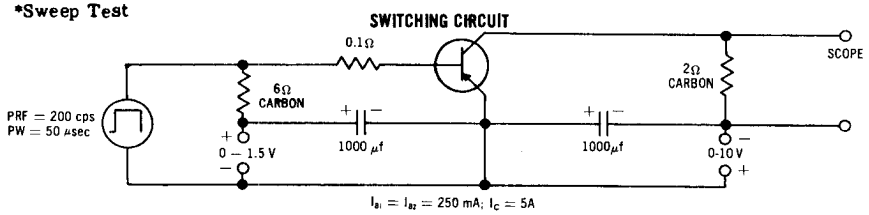
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Volts
Collector-Emitter Voltage	V_{CEO}	6	Volts
Emitter-Base Voltage	V_{EBO}	1.5	Volts
Collector Current (Continuous)	I_C	25	Amps
Base Current (Continuous)	I_B	3	Amps
Power Dissipation	P_D	75	Watts
Operating Case Temperature Range	T_C	-65 to +110	°C
Storage Temperature Range	T_{stg}	-65 to +110	°C
Thermal Resistance	θ_{JC} θ_{CA}	1 30	°C/W °C/W

2N2912 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

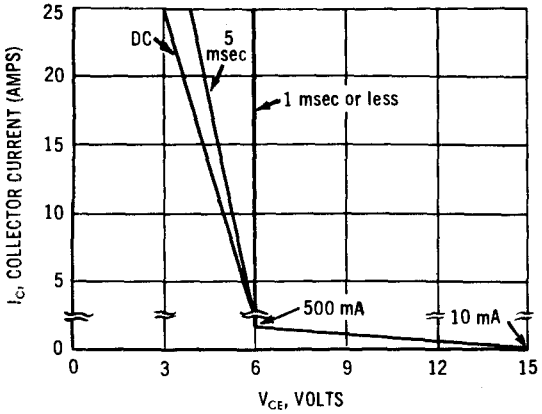
Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0.2 Vdc) (V_{CE} = 6 Vdc, V_{BE} = 0.2 Vdc, T_C = 85°C)	I_{CEX}	--- ---	10 15	mAdc
Collector-Base Cutoff Current (V_{CB} = 2 Vdc, I_E = 0)	I_{CBO}	---	0.2	mAdc
Emitter Floating Potential (V_{CB} = 15 Vdc, I_E = 0)	V_{EBF}	---	0.2	Vdc
Emitter Cutoff Current (V_{EB} = 1.5 Vdc)	I_{EBO}	---	50	mAdc
Collector-Emitter Voltage* (I_C = 500 mAdc, I_B = 0)	V_{CEO}*	6	---	Vdc
DC Forward Current Transfer Ratio (V_{CE} = 2 Vdc, I_C = 10 Adc)	h_{FE}	75	---	---
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 0.5 Adc) (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{CE\ (sat)}$	--- ---	0.12 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = 25 Adc, I_B = 2.5 Adc)	$V_{BE(sat)}$	---	1.2	Vdc
Base-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 0.5 Adc)	$V_{BE\ (sat)}$	---	0.5	Vdc
Rise Time (I_C = 5A, V_{CE} = 10 V, $I_{B\ (on)}$ = 250 mA)	t_r	---	2	μsec
Storage Time (I_C = 5 A, V_{CE} = 10 V, $I_{B\ (on)}$ = 250 mA)	t_s	---	2.5	μsec
Fall Time (I_C = 5 A, V_{CE} = 10 V, V_{EB} = 1.5 V, R_{be} = 6 Ohms)	t_f	---	2	μsec
Common Emitter Small-Signal Forward Current Transfer Ratio Cutoff Frequency (V_{CE} = 2 V, I_C = 5 A, f = 1 mc)	$\lvert h_{fe} \rvert$	20	---	---

*Sweep Test

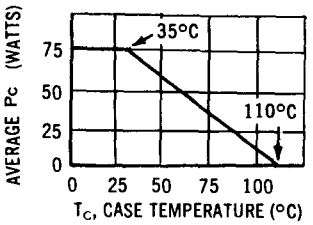


2N2912 (continued)

SAFE AREA OF OPERATION



The safe operating area curve is applicable for all case temperatures. The thermal derating curve must also be observed to insure operation below maximum T_J.

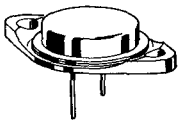


POWER-TEMPERATURE DERATING CURVE

2N3021 thru 2N3026 (SILICON)

P_D = 25 W
I_C = 3 A
V_{CBO} = 30-60 V

CASE 1
(TO-3)



PNP silicon power transistors for Class C power amplifiers, high-current core switching and high-speed switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N3021 2N3024	2N3022 2N3025	2N3023 2N3026	Unit
Collector-Base Voltage	V_{CB}	30	45	60	Volts
Collector-Emitter Voltage	V_{CE}	30	45	60	Volts
Emitter-Base Voltage	V_{EB}	4	4	4	Volts
Collector Current	I_C	3	3	3	Amps
Base Current	I_B	0.5	0.5	0.5	Amp
Power Dissipation	P_D	25	25	25	Watts
Junction Operating Temperature Range	T_J	← -65 to +175 →			°C

2N3021 thru 2N3026 (continued)

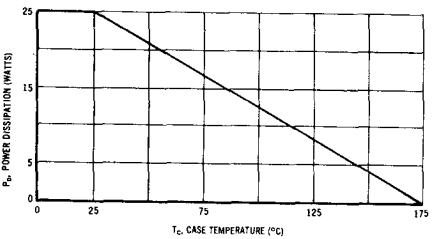
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

Characteristics		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{BE} = 4 Vdc)	All Types	I_{EBO}	—	1	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 25 Vdc, V_{BE} = 2 Vdc)	2N3021, 2N3024		—	0.2	
(V_{CE} = 40 Vdc, V_{BE} = 2 Vdc)	2N3022, 2N3025		—	0.2	
(V_{CE} = 54 Vdc, V_{BE} = 2 Vdc)	2N3023, 2N3026		—	0.2	
(V_{CE} = 15 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3021, 2N3024		—	2	
(V_{CE} = 25 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3022, 2N3025		—	2	
(V_{CE} = 35 Vdc, V_{BE} = 2 Vdc, T_C = 150°C)	2N3023, 2N3026		—	2	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3021, 2N3024		30	—	
(I_C = 50 mAdc, I_B = 0)	2N3022, 2N3025		45	—	
(I_C = 20 mAdc, I_B = 0)	2N3023, 2N3026		60	—	
DC Current Gain		h_{FE}			—
(I_C = 1.0 Adc, V_{CE} = 2 Vdc)	2N3021, 2N3022, 2N3023		20	60	
	2N3024, 2N3025, 2N3026		50	180	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3021, 2N3022, 2N3023		—	1.5	
	2N3024, 2N3025, 2N3026		—	1.0	
Base-Emitter Saturation Voltage		$V_{BE\ (sat)}$			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	All Types		—	1.5	
Small Signal Current Gain		h_{fe}			—
(I_C = 0.5 Adc, V_{CE} = 15 Vdc, f = 30 mc)	All Types		2	—	
Switching Times (Figures 17 and 18)		$t_d + t_r$	—	100	nsec
(I_C = 1 Adc, I_{B1} = I_{B2} = 100 mAdc)	All Types	t_s	—	100	
		t_f	—	75	

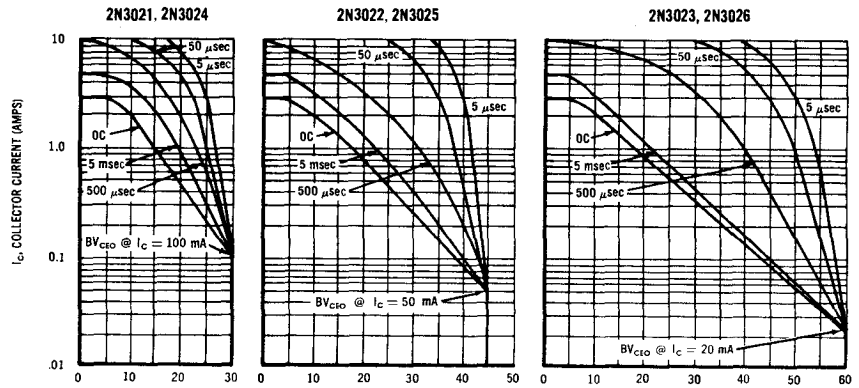
*Perform tests using sweep method to prevent heating.

POWER-TEMPERATURE DERATING CURVE

THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED. BOTH LIMITS ARE APPLICABLE AND MUST BE OBSERVED



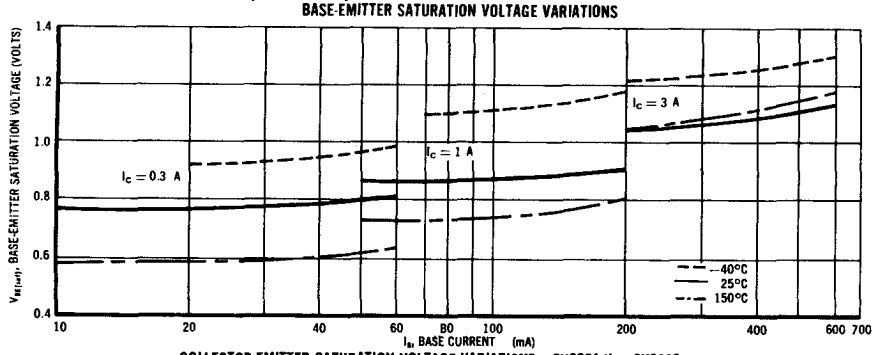
SAFE OPERATING AREAS



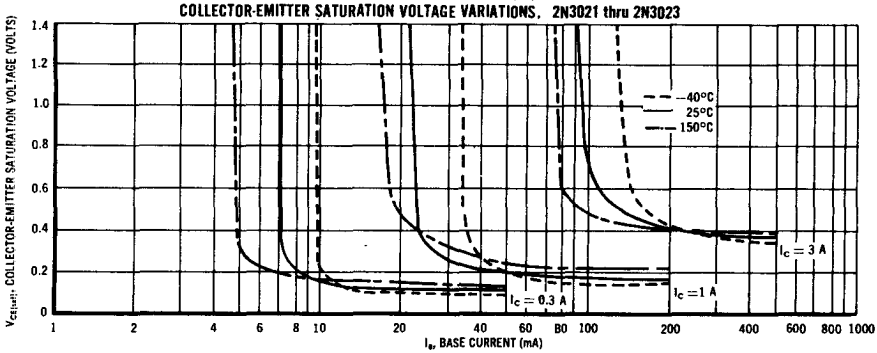
The Safe Operating Area Curves indicate Ic - Vce limits below which the devices will not go intn secondary breakdown. As the safe operating areas shown are independent nf temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure nperation below the maximum junction temperature.

2N3021 thru 2N3026 (continued)

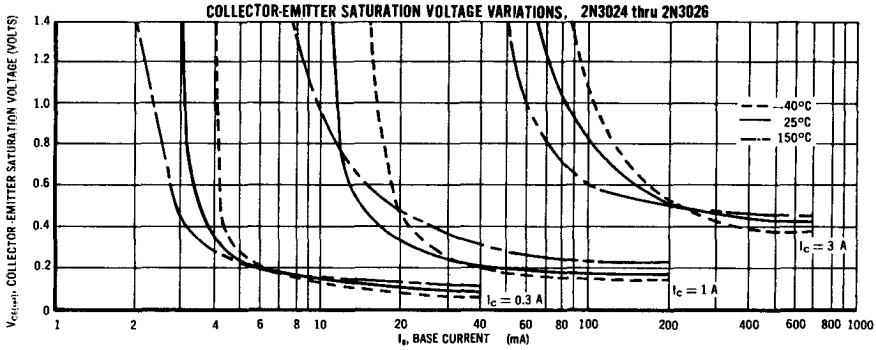
BASE-EMITTER SATURATION VOLTAGE VARIATIONS



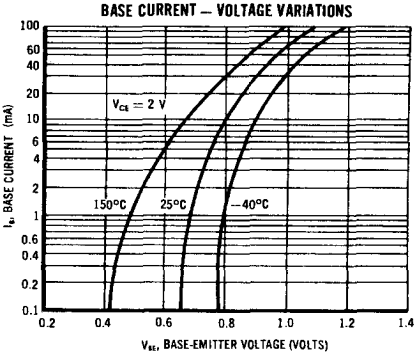
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS, 2N3021 thru 2N3023



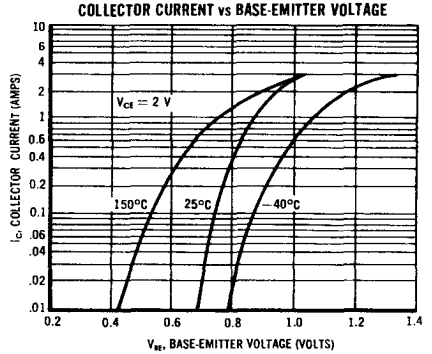
COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS, 2N3024 thru 2N3026



BASE CURRENT — VOLTAGE VARIATIONS

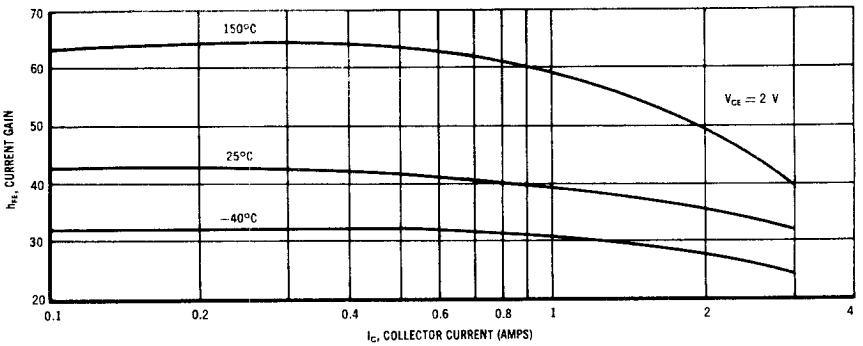


COLLECTOR CURRENT vs BASE-EMITTER VOLTAGE

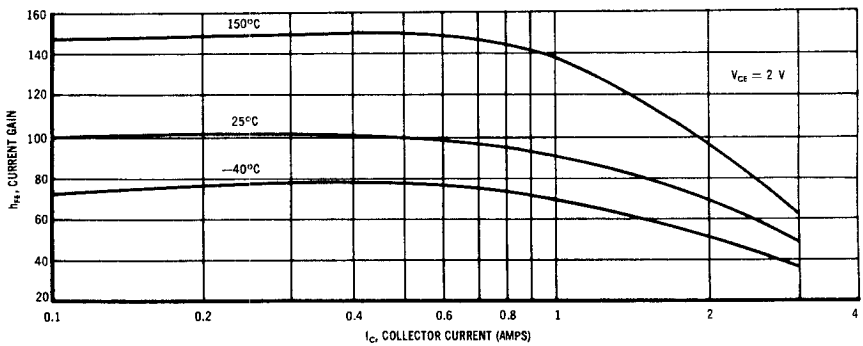


2N3021 thru 2N3026 (continued)

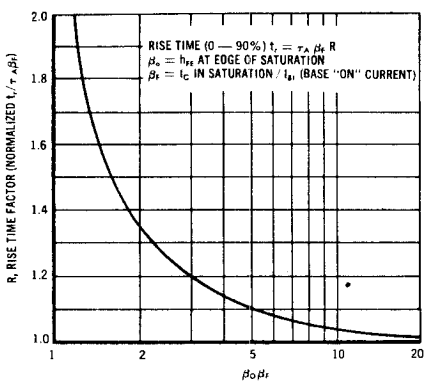
CURRENT GAIN VARIATIONS. 2N3021 thru 2N3023



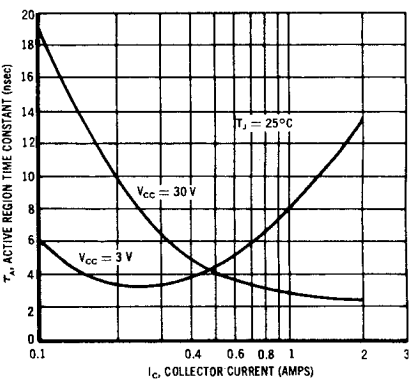
CURRENT GAIN VARIATIONS. 2N3024 thru 2N3026



RISE TIME FACTOR



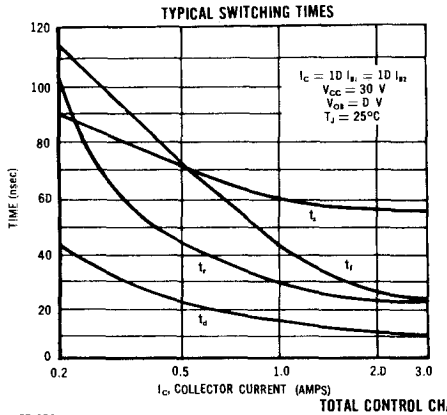
ACTIVE REGION TIME CONSTANT

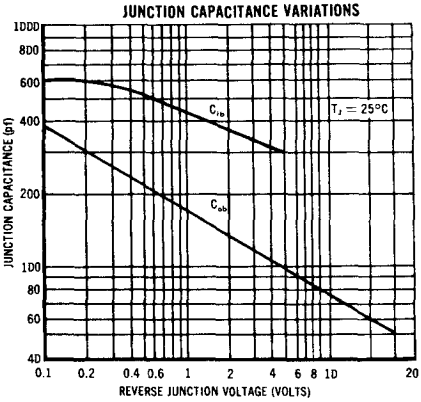


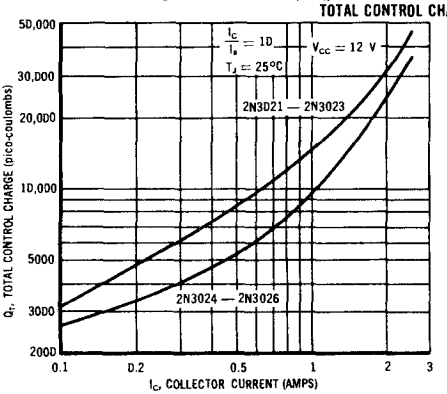
SWITCHING TIME EQUATIONS

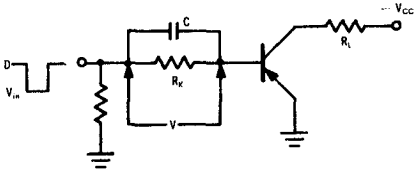
Using charge control theory and data given with this transistor, switching times for a wide variety of conditions can be readily computed.

2N3021 thru 2N3026 (continued)



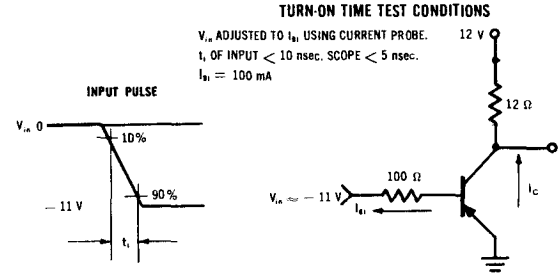






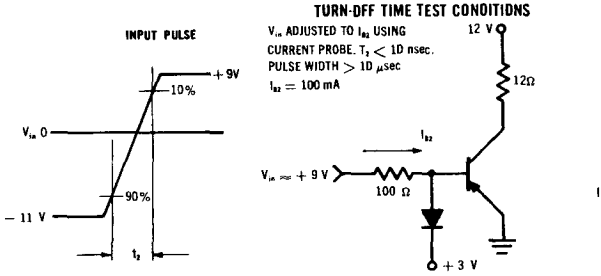
Total Control Charge. When a transistor is held in a conductive state by a current, I_{B1}, a charge, Q_S, is developed in the active region. A charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Given Q_T from Figure 16A, the external C for minimum turn-off in any circuit is: $C = Q_T/V$, where V is shown in the circuit above and is $I_{B1}\ R_K$.

TURN-ON TIME TEST CONDITIONS



t_d IS MEASURED FROM 10% POINT OF V_{in}

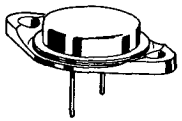
TURN-OFF TIME TEST CONDITIONS



t_s IS MEASURED FROM 90% POINT OF V_{in}

2N3055 (SILICON)

$V_{CB} = 100$ V
$I_C = 15$ A
$P_D = 117$ W



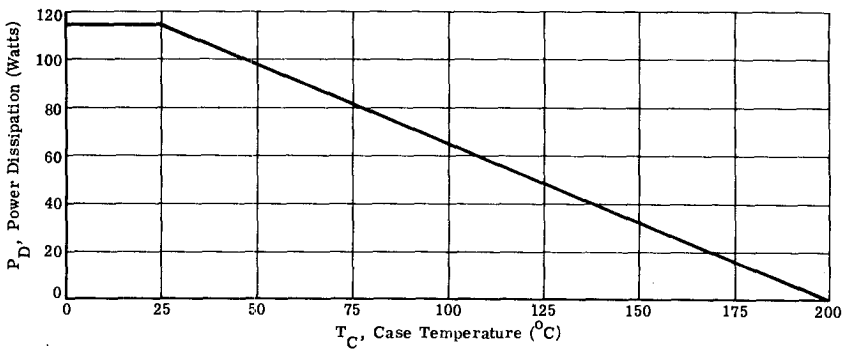
NPN silicon power transistors designed for switching and amplifier applications.

CASE 1
(TO-3)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	100	Vdc
Collector-Emitter Voltage	V_{CE}	60	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current (Continuous)	I_C	15	Adc
Base Current (Continuous)	I_B	7	Adc
Power Dissipation	P_D	115	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	$^oC/W$
Junction Operating Temperature Range	T_J	-65^oC to $+200^oC$	^oC

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



2N3055 (continued)

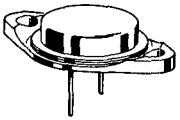
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)	I_{EBO}	-	5.0	mAdc
Collector Cutoff Current (V_{CB} = 100 Vdc, V_{BE} = 1.5 Vdc)	I_{CEX}	-	5.0	mAdc
(V_{CE} = 100 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)		-	30.0	
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	$V_{CEO(sus)}$	60	-	Vdc
DC Current Gain (I_C = 4.0 Adc, V_{CE} = 4 Vdc)	h_{FE}	20	70.0	-
(I_C = 10.0 Adc, V_{CE} = 4 Vdc)		5.0	-	
Collector-Emitter Saturation Voltage (I_C = 4.0 Adc, I_B = 0.4 Adc)	$V_{CE(sat)}$	-	1.1	Vdc
(I_C = 10.0 Adc, I_B = 3.3 Adc)		-	8.0	
Collector-Emitter Voltage* (I_C = 200 mAdc, R_{BE} = 100)	V_{CER}	70	-	Vdc
Base-Emitter Voltage (I_C = 4.0 Adc, V_{CE} = 4 Adc)	V_{BE}	-	1.8	Vdc
Small Signal Current Gain (V_{CE} = 4.0 Vdc, I_C = 1.0 Adc, f = 1 kHz)	h_{fe}	15	-	kHz
(V_{CE} = 4.0 Vdc, I_C = 1.0 Adc)	f_{hfe}	20	-	
Collector-Emitter Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	0.7	mAdc

*Use sweep test to prevent overheating.

2N3232 (SILICON)
2N3235

V_{CB} = 55-60 V
I_C = 7.5-10 A
P_D = 117 W



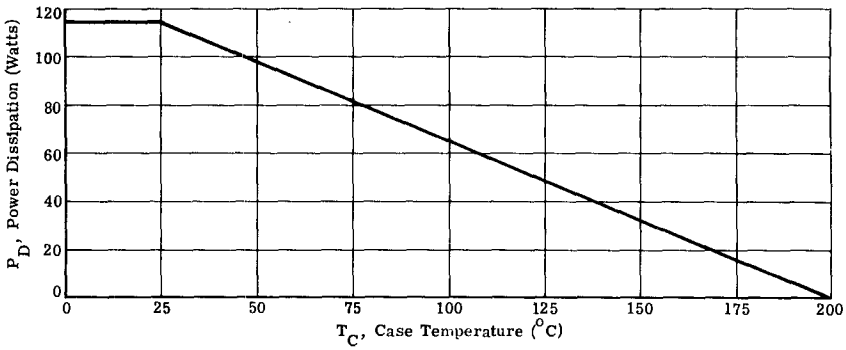
CASE 1
(TO-3)

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N3232	2N3235	Unit
Collector-Base Voltage	V_{CB}	60	55	Vdc
Collector-Emitter Voltage	V_{CE}	60	55	Vdc
Emitter-Base Voltage	V_{EB}	6	7	Vdc
Collector Current (Continuous)	I_C	7.5	10	Adc
Base Current (Continuous)	I_B	3	7	Adc
Power Dissipation	P_D	115	115	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	1.5	°C/W
Junction Operating Temperature Range	T_J	-65°C to +200°C		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



2N3232, 2N3235 (continued)

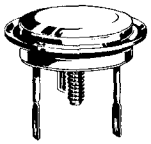
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{EB} = 6.0 Vdc)	2N3232		-	1.0	
(V_{EB} = 7.0 Vdc)	2N3235		-	5.0	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc)	2N3232		-	1.0	
	2N3235		-	5.0	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3232		-	1.0	
	2N3235		-	5.0	
Collector-Emitter Sustaining Voltage*		$V_{CEO(sus)}$*			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3232		60	-	
	2N3235		55	-	
Collector Current		I_{CEO}			mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3232		-	10	
(V_{CE} = 55 Vdc, I_B = 0)	2N3235		-	10	
DC Current Gain*		h_{FE}			-
(I_C = 1.5 Adc, V_{CE} = 10 Vdc)	2N3232		15	-	
(I_C = 3.0 Adc, V_{CE} = 10 Vdc)	2N3235		15	75	
(I_C = 2 Adc, V_{CE} = 4 Vdc)	2N3232		20	-	
(I_C = 4 Adc, V_{CE} = 4 Vdc)	2N3235		20	70	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3.0 Adc, I_B = 0.2 Adc)	2N3232		-	2.5	
(I_C = 4.0 Adc, I_B = 0.4 Adc)	2N3235		-	1.1	
Base-Emitter Voltage*		V_{BE}			Vdc
(I_C = 3.0 Adc, V_{CE} = 10 Vdc)	2N3232		-	3.5	
(I_C = 4.0 Adc, V_{CE} = 4 Vdc)	2N3235		-	1.8	
Small Signal Current Gain		h_{fe}			-
(V_{CE} = 10 Vdc, I_C = 3.0 Adc, f = 1.0 MHz)	2N3232		1.0	-	
(V_{CE} = 4 Vdc, I_C = 4.0 Adc, f = 1.0 MHz)	2N3235		1.0	-	

*Use sweep test to prevent overheating.

2N3311 thru 2N3316 (GERMANIUM)

$P_D = 170W$
$I_C = 5\ A$
$V_{CBO} = 30\text{-}60\ V$



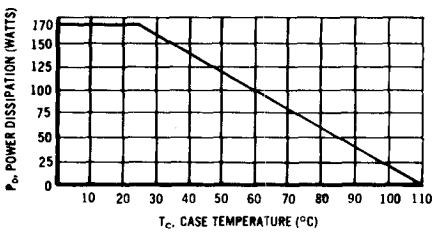
PNP germanium power transistors for high-power applications.

CASE 5
(TO-36)

MAXIMUM RATINGS

Characteristic	Symbol	2N3311 2N3314	2N3312 2N3315	2N3313 2N3316	Unit
Collector-Base Voltage	V_{CBO}	30	45	60	Volts
Collector-Emitter Voltage	V_{CES}	30	45	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	30	40	Volts
Emitter-Base Voltage	V_{EBO}	20	25	30	Volts
Collector Current (Continuous)	I_C	5	5	5	Amps
Power Dissipation at $T_C = 25^oC$	P_D	170	170	170	Watts
Junction Temperature Range	T_J	-65 to +110			^oC
Thermal Resistance	θ_{JC}	0.5			°C/W

POWER-TEMPERATURE DERATING CURVE



The maximum continuous power is related to maximum junction temperature by the thermal resistance factor. This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110^o - Tc}{0.5}$$

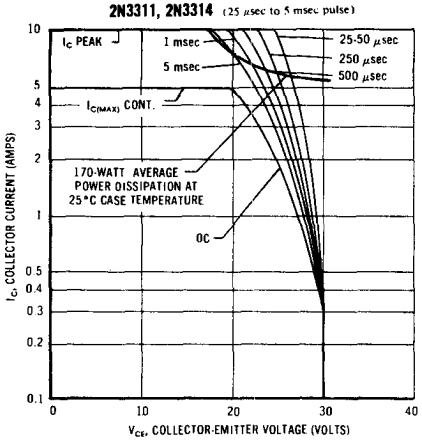
2N3311 thru 2N3316 (continued)

ELECTRICAL CHARACTERISTICS (At $T_C = 25°C$ unless otherwise specified.)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mAdc
($V_{CB} = V_{CB\ max}$)			—	5.0	
(V_{CB} = -2 Vdc, I_E = 0)			—	0.3	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 10 Vdc, I_B = 0)	2N3311, 2N3314		—	200	
(V_{CE} = 15 Vdc, I_B = 0)	2N3312, 2N3315		—	200	
(V_{CE} = 20 Vdc, I_B = 0)	2N3313, 2N3316		—	200	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 25 Vdc, V_{BE} = 1 Vdc,					
T_C = 100°C)	2N3311, 2N3314		—	35	
(V_{CE} = 40 Vdc, V_{BE} = 1 Vdc,					
T_C = 100°C)	2N3312, 2N3315		—	35	
(V_{CE} = 55 Vdc, V_{BE} = 1 Vdc,					
T_C = 100°C)	2N3313, 2N3316		—	35	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
($V_{EB} = V_{EB\ max}$, I_C = 0)			—	4	
Collector-Emitter Breakdown Voltage*		BV_{CES}*			Vdc
(I_C = 300 mAdc, V_{EB} = 0)	2N3311, 2N3314		30	—	
	2N3312, 2N3315		45	—	
	2N3313, 2N3316		60	—	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 500 mAdc, I_B = 0)	2N3311, 2N3314		-20	—	
	2N3312, 2N3315		-30	—	
	2N3313, 2N3316		-40	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 300 mAdc)			—	0.1	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3311 thru 2N3313		—	0.6	
	2N3314 thru 2N3316		—	0.5	
DC Current Gain		h_{FE}			—
(I_C = 3 Adc, V_{CB} = 2 Vdc)	2N3311 thru 2N3313		60	120	
	2N3314 thru 2N3316		100	200	
(I_C = 500 mAdc, V_{CB} = 2 Vdc)	2N3311 thru 2N3313		—	150	
	2N3314 thru 2N3316		—	250	
Small Signal Current Gain		h_{fe}			—
(I_C = 3 Adc, V_{CE} = 2 Vdc,					
f = 0.5 kc)	2N3311 thru 2N3313		30	90	
	2N3314 thru 2N3316		40	120	
Common Emitter Cutoff Frequency		f_{ae}			kc
(I_C = 3 Adc, V_{CE} = 2 Vdc)			1.0	—	

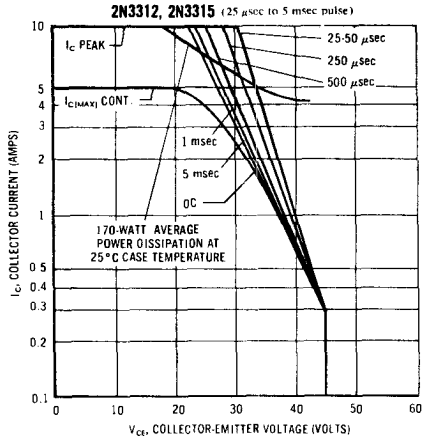
*To avoid excessive heating of the collector junction, perform these tests with an oscilloscope.

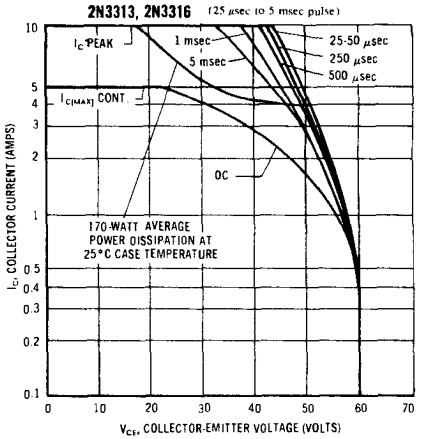
2N3311 thru 2N3316 (continued)



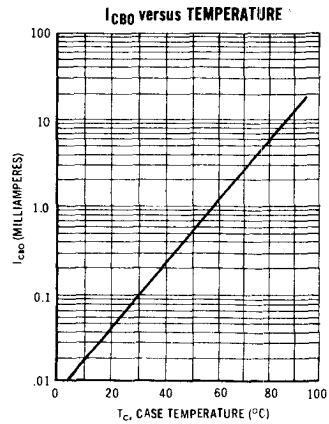
SAFE OPERATING AREA

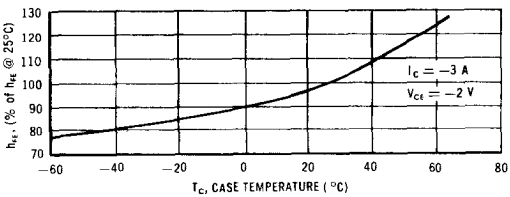
The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

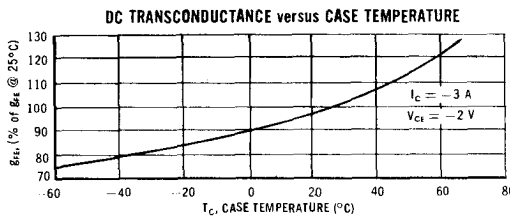




TEMPERATURE CHARACTERISTICS

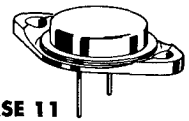






2N3445 thru 2N3448 (SILICON)

$P_D = 115$ W
$I_C = 7.5$ A
$V_{CBO} = 80\text{-}100$ V



CASE 11
(TO-3)

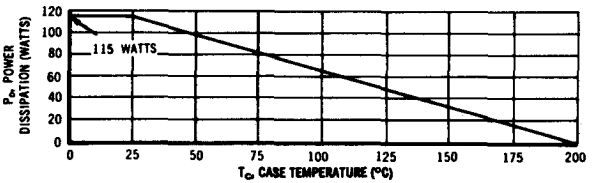
NPN silicon power transistors for switching and amplifier applications requiring fast response, wide band and good Beta linearity.

MAXIMUM RATINGS

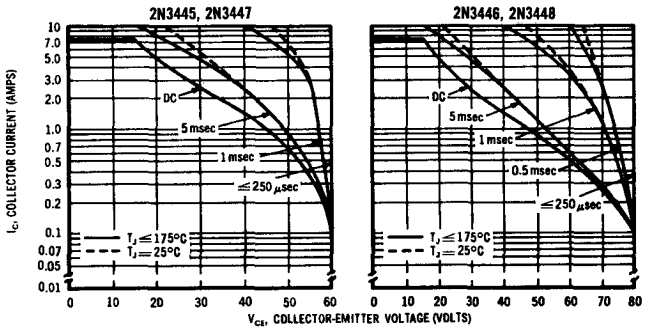
Characteristic	Symbol	2N3445 2N3447	2N3446 2N3448	Unit
Collector-Base Voltage	V_{CB}	80	100	Volts
Collector-Emitter Voltage	V_{CE}	60	80	Volts
Emitter-Base Voltage	V_{EB}	6	10	Volts
Collector Current	I_C	7.5	7.5	Amps
Base Current	I_B	4.0	4.0	Amps
Power Dissipation	P_D	115	115	Watts
Junction Operating Temperature Range	T_J	-85 to +200		°C

POWER-TEMPERATURE DERATING CURVE

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.



SAFE OPERATING AREAS



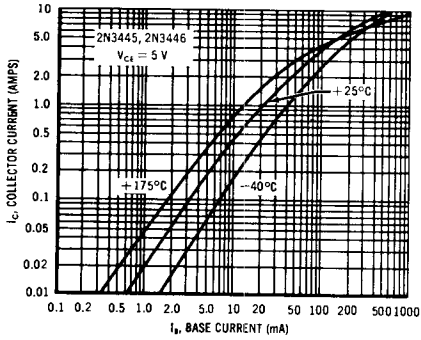
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

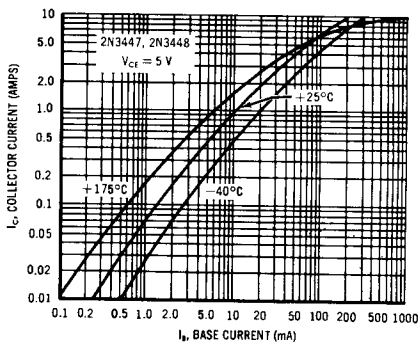
2N3445 thru 2N3448 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

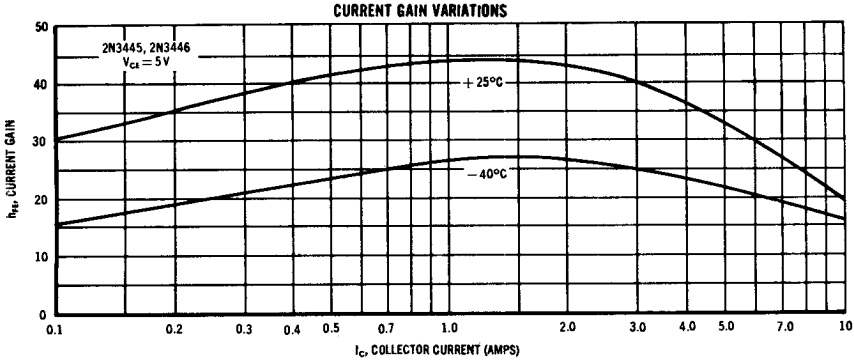
Characteristic		Symbol	Min	Typ	Max	Unit
Emitter-Base Cutoff Current						mAdc
(V_{EB} = 6 Vdc)	2N3445, 2N3447	I_{EBO}	—	—	0.25	
(V_{EB} = 10 Vdc)	2N3446, 2N3448		—	—	0.25	
Collector-Emitter Cutoff Current						mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3445, 2N3447	I_{CEX}	—	—	0.1	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3445, 2N3447		—	—	1.0	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3448, 2N3448		—	—	0.1	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3448, 2N3448		—	—	1.0	
Collector-Emitter Cutoff Current						mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3445, 2N3447	I_{CEO}	—	—	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N3446, 2N3448		—	—	1.0	
Collector-Base Breakdown Voltage						Vdc
(I_C = 1 mAdc, I_E = 0)	2N3445, 2N3447	BV_{CBO}	60	—	—	
	2N3446, 2N3448		100	—	—	
Collector-Emitter Sustaining Voltage						Vdc
(I_C = 100 mAdc, I_B = 0)	2N3445, 2N3447	$V_{CEO(sus)}$	60	—	—	
	2N3448, 2N3448		60	—	—	
DC Current Gain						—
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446	h_{FE}	20	45	—	
	2N3447, 2N3446		40	85	—	
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446		20	40	80	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		40	75	120	
Collector-Emitter Saturation Voltage						Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446	$V_{CE(sat)}$	—	0.6	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	0.8	1.5	
Base-Emitter Saturation Voltage						Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3445, 2N3446	$V_{BE(sat)}$	—	1.0	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3447, 2N3448		—	1.0	1.5	
Base-Emitter Voltage						Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3445, 2N3446	V_{BE}	—	1.0	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3447, 2N3448		—	1.0	1.4	
Small Signal Current Gain						—
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kc)	2N3445, 2N3446	h_{fe}	20	—	100	
	2N3447, 2N3448		40	—	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 mc)	All Types		1.0	1.6	—	
Common Base Output Capacitance						pf
(V_{CB} = 10 Vdc, f = 0.1 mc)	All Types	C_{ob}	—	260	400	
Switching Times						μsec
(V_{CC} ≈ 25 Vdc, R_L = 5 ohms, I_C = 5 A, I_{B1} = I_{B2} = 0.5 A)						
Delay Time plus Rise Time		$t_d + t_r$	—	0.15	0.35	
Storage Time		t_s	—	0.9	2.0	
Fall Time		t_f	—	0.15	0.35	

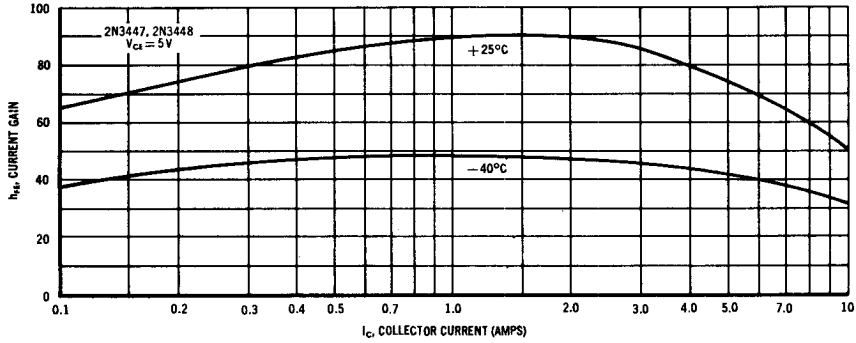
COLLECTOR CURRENT versus BASE CURRENT

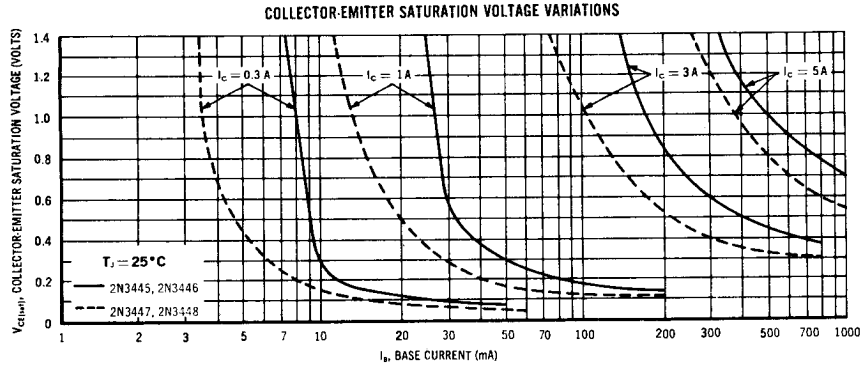




2N3445 thru 2N3448 (continued)

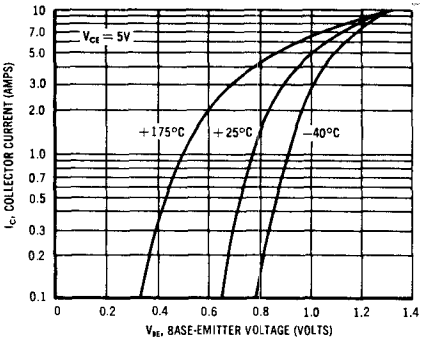




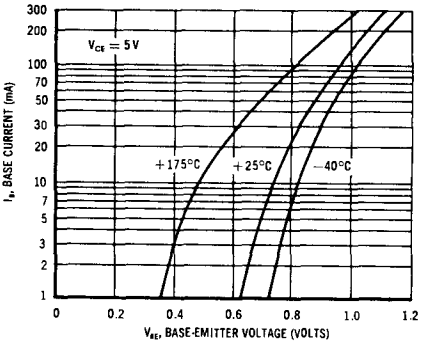


2N3445 thru 2N3448 (continued)

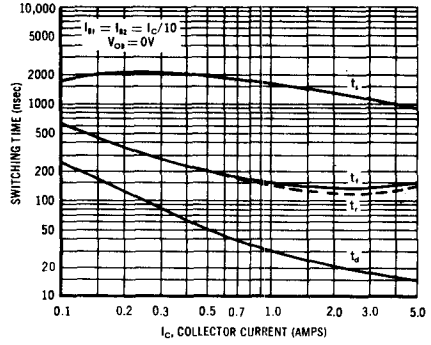
COLLECTOR CURRENT-VOLTAGE VARIATIONS



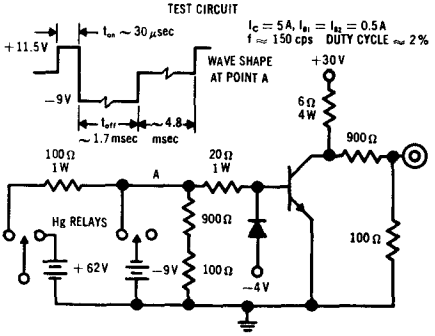
BASE CURRENT-VOLTAGE VARIATIONS



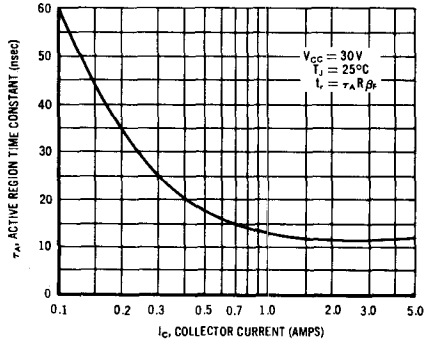
TYPICAL SWITCHING TIMES



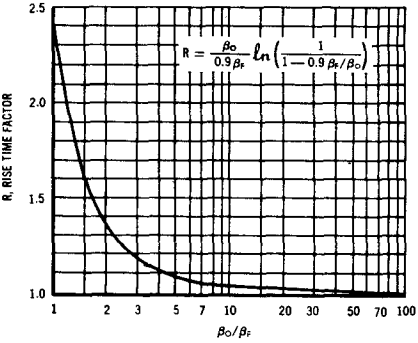
TEST CIRCUIT



ACTIVE REGION TIME CONSTANT

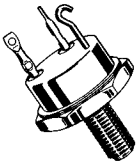


RISE TIME FACTOR



2N3487 thru 3492 (SILICON)

V_{CB} = 80-120 V
I_C = 7.5 A
P_D = 117 W



CASE 9
(TO-61)

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N3487 2N3490	2N3488 2N3491	2N3489 2N3492	Unit
Collector-Base Voltage	V_{CB}	80	100	120	Vdc
Collector-Emitter Voltage	V_{CE}	60	80	100	Vdc
Emitter-Base Voltage	V_{EB}	10	10	10	Vdc
Collector Current (Continuous)	I_C	7.5	7.5	7.5	Adc
Base Current (Continuous)	I_B	4.0	4.0	4.0	Adc
Power Dissipation	P_D	115	115	115	Watts
Thermal Resistance, Junction to Case	θ_{JC}	1.5	1.5	1.5	°C/W
Junction Operating Temperature Range	T_J	-65°C to +200°C			°C

2N3487 thru 2N3492 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 10 Vdc)	All Types	I_{EBO}	-	0.10	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc)	2N3487, 2N3490		-	25	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc)	2N3488, 2N3491		-	25	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc)	2N3489, 2N3492		-	25	
(V_{CE} = 60 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3487, 2N3490		-	250	
(V_{CE} = 80 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3488, 2N3491		-	250	
(V_{CE} = 100 Vdc, V_{BE} = -1 Vdc, T_C = 150°C)	2N3489, 2N3492		-	250	
Collector-Emitter Cutoff Current		I_{CEO}			μAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3487, 2N3490		-	250	
(V_{CE} = 60 Vdc, I_B = 0)	2N3488, 2N3491		-	250	
(V_{CE} = 80 Vdc, I_B = 0)	2N3489, 2N3492		-	250	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 100 μAdc, I_E = 0)	2N3487, 2N3490		80	-	
	2N3488, 2N3491		100	-	
	2N3489, 2N3492		120	-	
Collector-Emitter Sustaining Voltage		$V_{CEO(sus)}$			Vdc
(I_C = 100 mAdc, I_B = 0)	2N3487, 2N3490		60	-	
	2N3488, 2N3491		80	-	
	2N3489, 2N3490		100	-	
DC Current Gain		h_{FE}			-
(I_C = 0.5 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		20	-	
	2N3490, 2N3491, 2N3492		40	-	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488		20	60	
	2N3489		15	45	
(I_C = 5.0 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491		40	120	
	2N3492		30	90	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1 Adc, I_B = 0.1 Adc)	All Types		-	0.3	
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.2	
	2N3490, 2N3491, 2N3492		-	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 0.3 Adc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3490, 2N3491, 2N3492		-	1.5	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 3 Adc, V_{CE} = 5 Vdc)	2N3487, 2N3488, 2N3489		-	1.5	
(I_C = 5 Adc, V_{CE} = 5 Vdc)	2N3490, 2N3491, 2N3492		-	1.4	
Small Signal Current Gain		h_{fe}			-
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 kHz)	2N3487, 2N3488, 2N3489		20	100	
	2N3490, 2N3491, 2N3492		40	200	
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 10 MHz)	All Types		1.0	-	
Common Base Output Capacitance (V_{CB} = 10 Vdc, f = 0.1 MHz)	All Types	C_{ob}	-	400	pF
Switching Times (V_{CC} = 25 Vdc, R_L = 5Ω, I_C = 5 Adc, I_{B_1} = -I_{B_2} = 0.5 Adc)			-	-	μs
Delay Time plus Rise Time		t_d+t_r	-	0.35	μs
Storage Time		t_s	-	2.0	
Fall Time		t_f	-	0.35	

2N3487 thru 2N3492 (continued)

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE

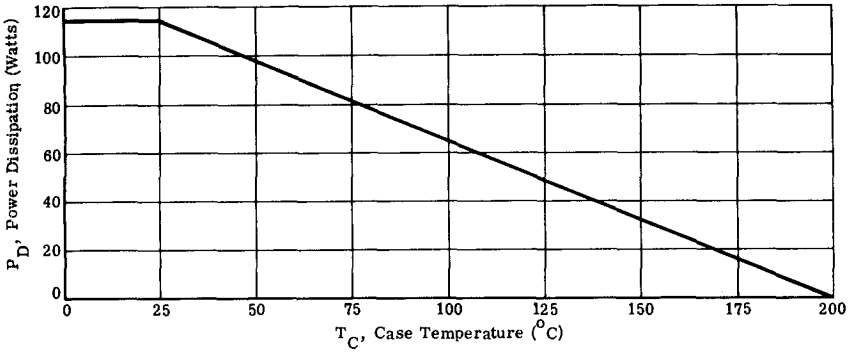
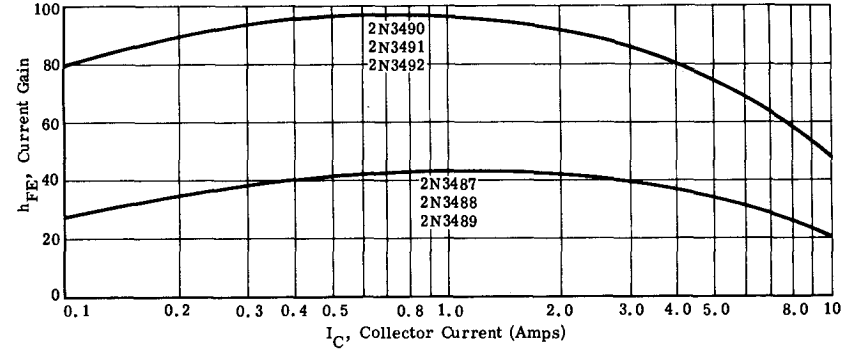


FIGURE 2 — DC CURRENT GAIN versus COLLECTOR CURRENT

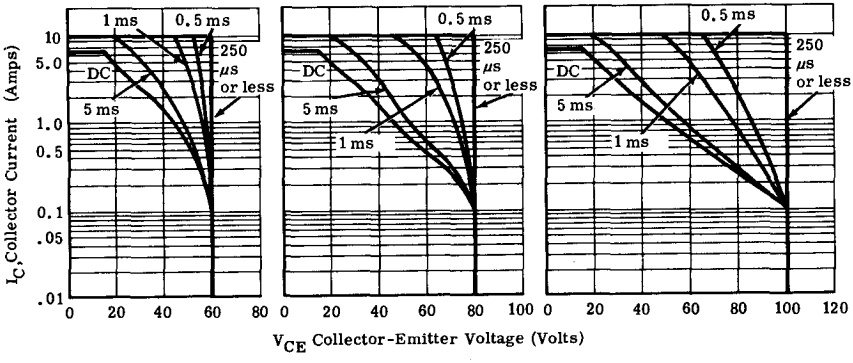


ACTIVE - REGION SAFE OPERATING AREAS

FIGURE 3 — 2N3487, 2N3490

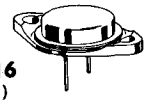
FIGURE 4 — 2N3489, 2N3492

FIGURE 5 — 2N3488, 2N3491



2N3611 thru 2N3614 (GERMANIUM)

$P_D = 85$ W
$I_C = 7$ A
$V_{CBO} = 40$-60 V



CASE 11,16
(TO-3, 41)

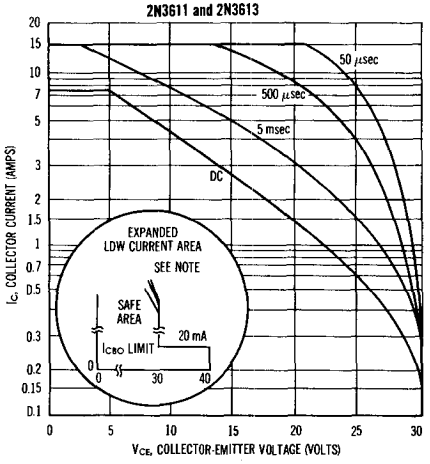
PNP germanium power transistors for switching and amplifier applications.

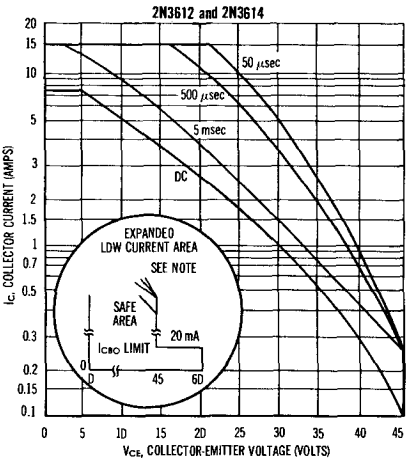
For units with solder lugs attached, specify devices MP3611 etc. (TO-41 package)

MAXIMUM RATINGS

Characteristics	Symbol	2N3611 2N3613	2N3612 2N3614	Unit
Collector-Emitter Voltage	V_{CES}	30	45	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	Vdc
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	20	30	Vdc
Collector Current (Continuous)	I_C	7		Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2		Adc
Storage Temperature Range	T_{stg}	-65 to +110		°C
Operating Case Temperature Range	T_C	-65 to +110		°C
Total Device Dissipation @ T_C = 25°C Derate above T_C = 25°C	P_D	85 1		Watts W/°C
Thermal Resistance, Junction to Case	θJC	1.0		°C/W
Thermal Resistance, Case to Ambient	θCA	32.7		°C/W

SAFE OPERATING AREAS





The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3611 thru 2N3614 (continued)

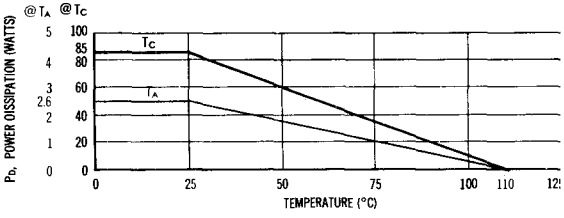
ELECTRICAL CHARACTERISTICS

Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3611, 2N3613	BV_{CES}*	30	–	Vdc
	2N3612, 2N3614		45	–	
Collector-Emitter Breakdown Voltage* (I_C = 500 mAdc)	2N3611, 2N3613	BV_{CEO}*	25	–	Vdc
	2N3612, 2N3614		35	–	
Floating Potential (V_{CB} = V_{CB} max)	All Types	V_{EBF}	–	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)	All Types	I_{CEO}	–	30	mAdc
Collector-Emitter Leakage Current (V_{CE} = V_{CE} max, V_{BE} = 1.0 Vdc, T_C = +100°C)	All Types	I_{CEX}	–	10	mAdc
Collector-Base Cutoff Current (V_{CB} = 2 Vdc)	All Types	I_{CBO}	–	.040	mAdc
(V_{CB} = 25 Vdc)	2N3611, 2N3613		–	0.5	
(V_{CB} = 40 Vdc)	2N3612, 2N3614		–	0.5	
(V_{CB} = V_{CB} max)	All Types		–	5.0	
Emitter-Base Cutoff Current (V_{EB} = V_{EB} max)	All Types	I_{EBO}	–	500	μAdc
(V_{EB} = 12 Vdc)	All Types		–	100	
Collector-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 300 mAdc)	All Types	$V_{CE(sat)}$	–	0.25	Vdc
(I_C = 7 Adc, I_B = 700 mAdc)	All Types		–	0.35	
Base-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 300 mAdc)	2N3611, 2N3612	$V_{BE(sat)}$	–	0.7	Vdc
	2N3613, 2N3614		–	0.6	
(I_C = 7 Adc, I_B = 700 mAdc)	2N3611, 2N3612		–	1.1	
	2N3613, 2N3614		–	0.9	
Transconductance (I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612	g_{FE}	3.0	–	mhos
	2N3613, 2N3614		3.5	–	
Small Signal Current Gain (I_C = 0.5 A, V_{CE} = 12 V, f = 20 kc)	All Types	h_{fe}	15	–	–
(I_C = 0.5 A, V_{CE} = 2 V, f = 1 kc)	2N3611, 2N3612		40	100	
	2N3613, 2N3614		60	150	
DC Current Gain (I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612	h_{FE}	35	70	–
	2N3613, 2N3614		60	120	
(I_C = 7 Adc, V_{CE} = 2 Vdc)	2N3611, 2N3612		20	–	
	2N3613, 2N3614		30	–	

*Sweep Test: 1/2 sine wave, 60 cps

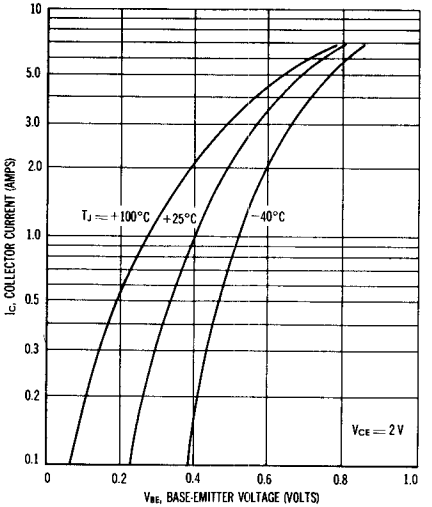
POWER-TEMPERATURE DERATING CURVE

These transistors are also subject to safe area curves. Both limits are applicable and must be observed.

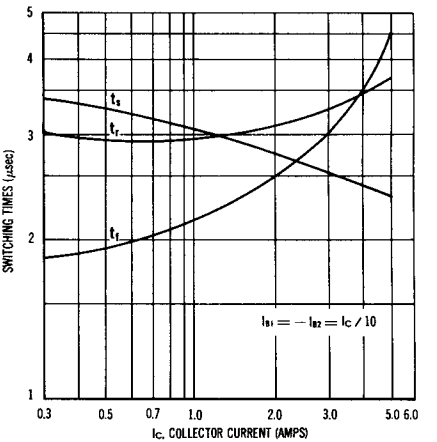


2N3611 thru 2N3614 (continued)

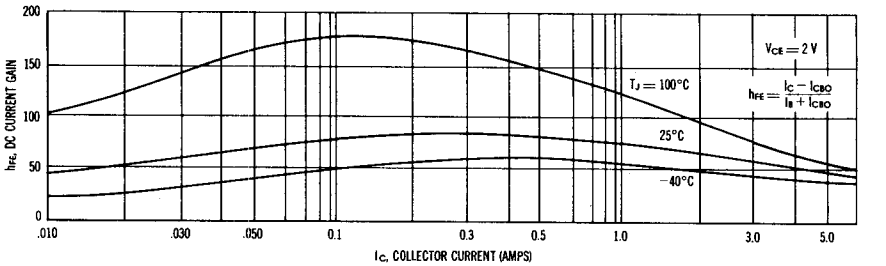
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



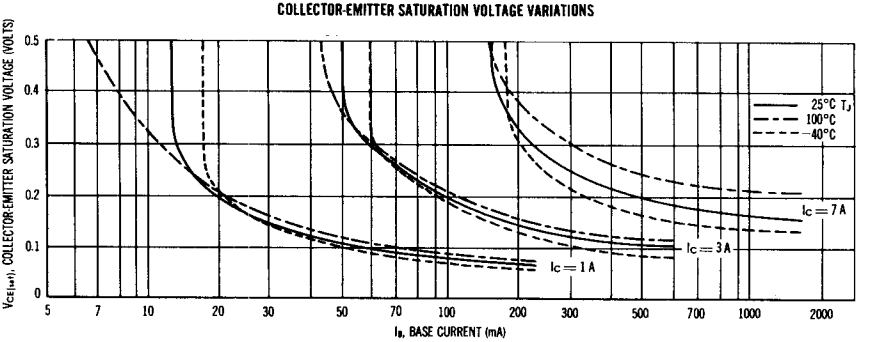
TYPICAL SWITCHING TIMES



DC CURRENT GAIN versus COLLECTOR CURRENT

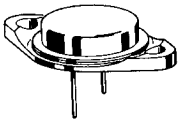


COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS



2N3615 thru 2N3618 (GERMANIUM)

$P_D = 85$ W
$I_C = 7$ A
$V_{CBO} = 80$-100 V



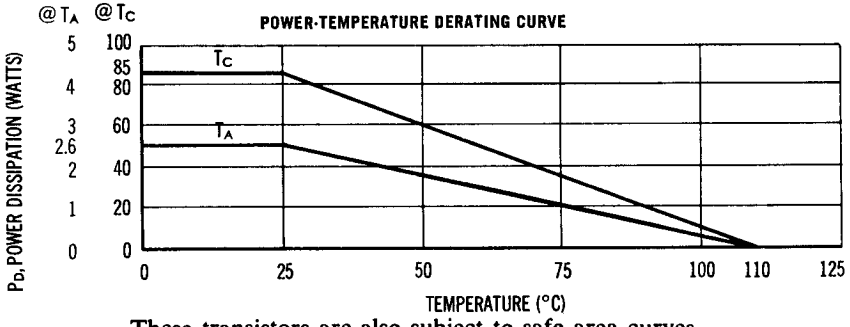
PNP germanium power transistors for switching and amplifier applications.

CASE 11,16
(TO-3,41)

For units with solder lugs attached, specify devices MP3615 etc. (TO-4 package)

MAXIMUM RATINGS

Characteristics	Symbol	2N3615 2N3617	2N3616 2N3618	Unit
Collector-Emitter Voltage	V_{CES}	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	50	60	Vdc
Collector-Base Voltage	V_{CBO}	80	100	Vdc
Emitter-Base Voltage	V_{EBO}	40	50	Vdc
Collector Current (Continuous)	I_C	7		Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	15		Adc
Base Current (Continuous)	I_B	2		Adc
Storage Temperature	T_{stg}	-65 to +110		°C
Operating Case Temperature	T_C	-65 to +110		°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	85 1		Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	1.0		°C/W
Thermal Resistance, Case to Ambient	θ_{CA}	32.7		°C/W



These transistors are also subject to safe area curves. Both limits are applicable and must be observed.

2N3615 thru 2N3618 (continued)

ELECTRICAL CHARACTERISTICS (at T_C = 25°C unless otherwise specified)

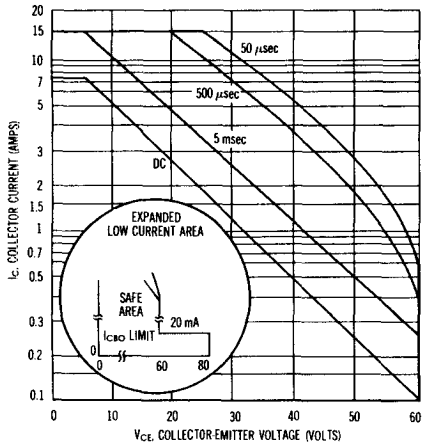
Characteristics		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	2N3615, 2N3617	BV_{CES}*	60	–	Vdc
	2N3616, 2N3618		75	–	
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc)	2N3615, 2N3617	BV_{CEO}*	50	–	Vdc
	2N3618, 2N3618		60	–	
Floating Potential (V_{CB} = V_{CB} max)	All Types	V_{EBF}	–	1.0	Vdc
Collector-Emitter Leakage Current (V_{CE} = 1/2 V_{CEO} max)	All Types	I_{CEO}	–	30	mAdc
Collector-Emitter Leakage Current (V_{CE} = V_{CE} max, V_{BE} = 1.0 Vdc, T_C = +100°C)	All Types	I_{CEX}	–	10	mAdc
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 2 Vdc)	All Types		–	.060	
(V_{CB} = 55 Vdc)	2N3615, 2N3617		–	1.0	
(V_{CB} = 65 Vdc)	2N3616, 2N3618		–	1.0	
(V_{CB} = V_{CB} max)	All Types		–	5.0	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = V_{EB} max)	All Types		–	500	
(V_{EB} = 12 Vdc)	All Types		–	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 300 mAdc)	All Types		–	0.25	
(I_C = 7 Adc, I_B = 700 mAdc)	All Types		–	0.35	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 3 Adc, I_B = 300 mAdc)	2N3615, 2N3616		–	0.7	
	2N3617, 2N3618		–	0.6	
(I_C = 7 Adc, I_B = 700 mAdc)	2N3615, 2N3616		–	1.1	
	2N3617, 2N3618		–	0.9	
Transconductance		g_{FE}			mhos
(I_C = 3 A, V_{CE} = 2 V)	2N3615, 2N3616		3.0	–	
	2N3617, 2N3618		3.5	–	
Small Signal Current Gain		h_{fe}			–
(I_C = 0.5 A, V_{CE} = 12 V, f = 20 kc)	All Types		15	–	
(I_C = 0.5 A, V_{CE} = 2 V, f = 1 kc)	2N3615, 2N3616		40	100	
	2N3617, 2N3618		60	150	
DC Current Gain		h_{FE}			–
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3615, 2N3616		30	60	
	2N3617, 2N3618		45	90	
(I_C = 7 Adc, V_{CE} = 2 Vdc)	2N3615, 2N3616		20	–	
	2N3617, 2N3618		30	–	
Current-Gain — Bandwidth Product		f_T	Typ		kc
(I_C = .5 Adc, V_{CE} = 2 Vdc)	All Types		600		

*Sweep Test: 1/2 sine wave, 60 cps

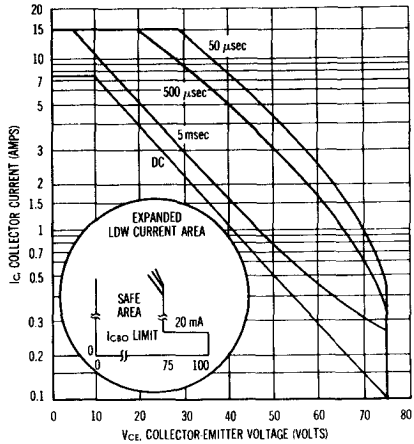
2N3615 thru 2N3618 (continued)

SAFE OPERATING AREAS

2N3615 and 2N3617

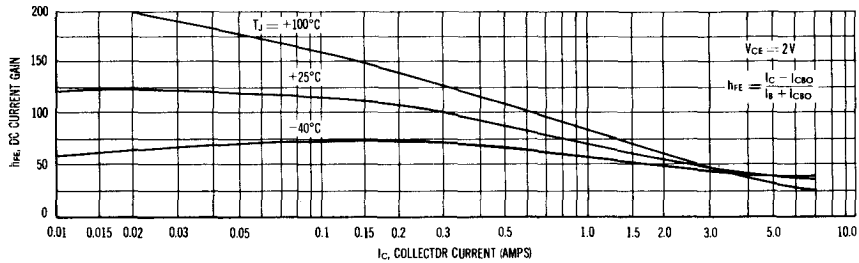


2N3616 and 2N3618

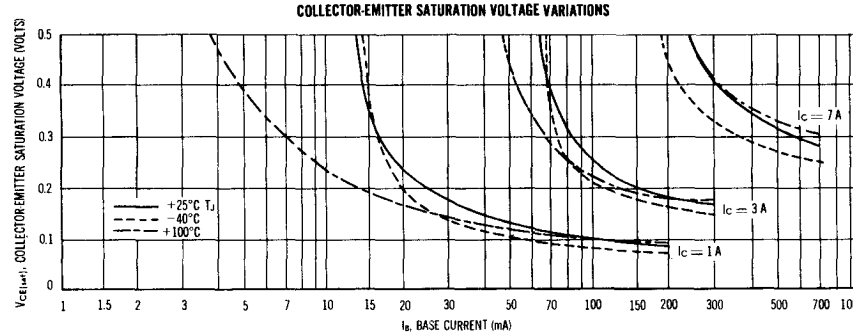


NOTE The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

DC CURRENT GAIN versus COLLECTOR CURRENT

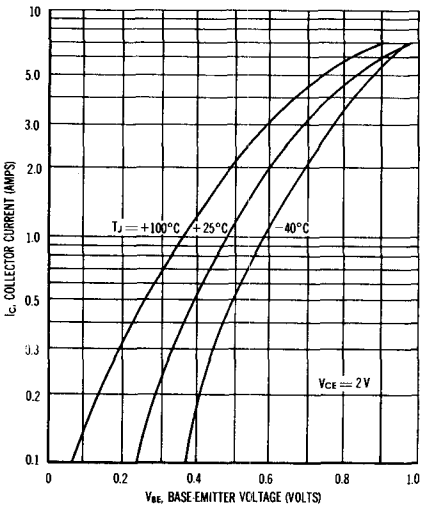


COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

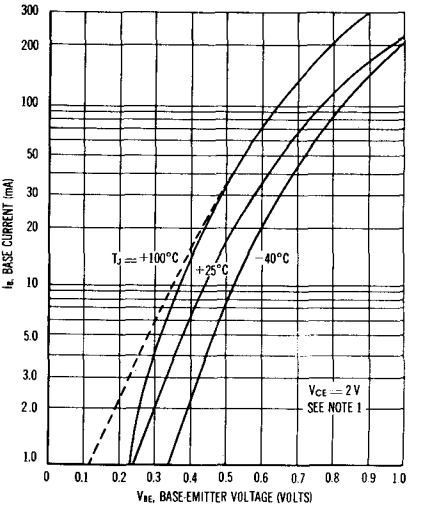


2N3615 thru 2N3618 (continued)

COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

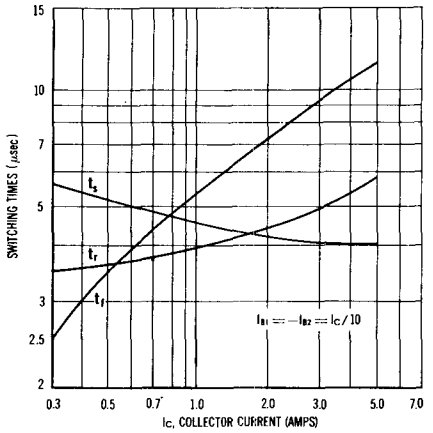


BASE CURRENT versus BASE-EMITTER VOLTAGE

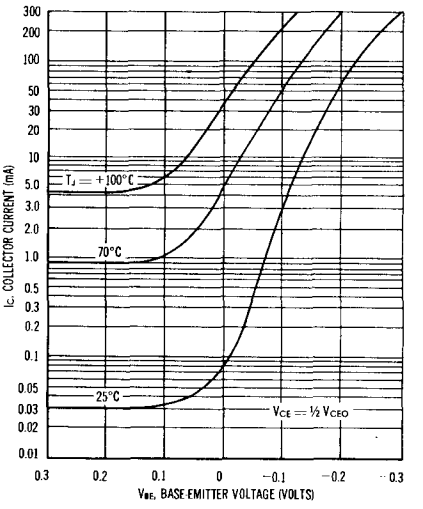


NOTE 1 — Dotted line indicates Metered Base Current plus the I_{CBO} of the transistor at 100°C.

TYPICAL SWITCHING TIMES

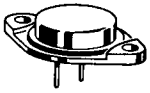


COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



2N3713 thru 2N3716 (SILICON)

$P_D = 150W$
$I_C = 10A$
$V_{CBO} = 80\text{-}100V$

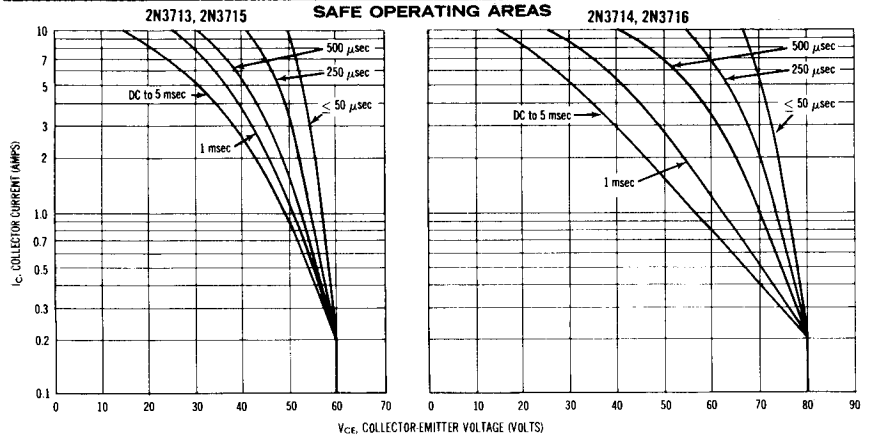


NPN silicon power transistors for medium-speed switching and amplifier applications. Complementary to PNP types 2N3789 thru 2N3792.

CASE 11
(TO-3)

MAXIMUM RATINGS

Characteristic	Symbol	2N3713 2N3715	2N3714 2N3716	Unit
Collector-Base Voltage	V_{CBO}	80	100	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EBO}	7	7	Volts
Collector Current	I_C	10	10	Amps
Base Current	I_B	4.0	4.0	Amps
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	Θ_{JC}	1.2	1.2	°C/W
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		°C



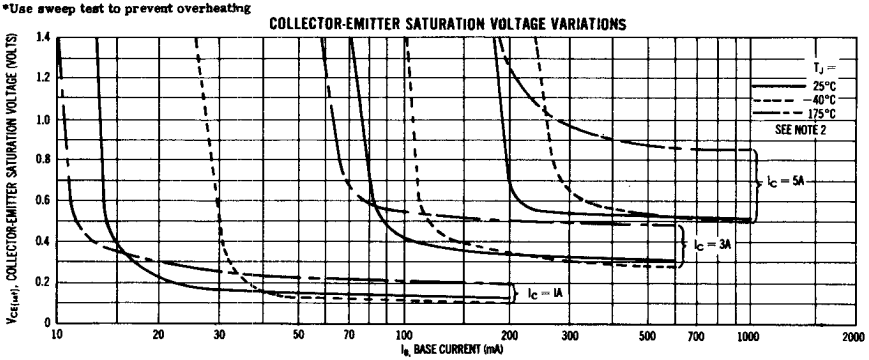
The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

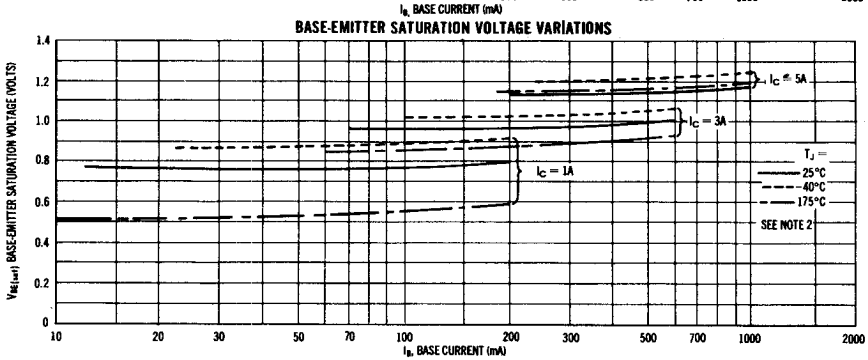
2N3713 thru 2N3716 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Types	Symbol	Min	Max	Unit
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)	All Types	I_{EBO}	—	5	mAdc
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3713, 2N3715		—	1	
(V_{CE} = 100 Vdc, V_{BE} = -1.5 Vdc)	2N3714, 2N3716		—	1	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3713, 2N3715		—	10	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3714, 2N3716		—	10	
Collector-Emitter Sustaining Voltage*		$V_{CEO(sus)}$*			Vdc
(I_C = 200 mAdc, I_B = 0)	2N3713, 2N3715		60	—	
	2N3714, 2N3716		80	—	
DC Current Gain*		h_{FE}*			—
(I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		25	90	
	2N3715, 2N3716		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3713, 2N3714		15	—	
	2N3715, 2N3716		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714		—	1.0	
	2N3715, 2N3716		—	0.6	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3713, 2N3714		—	2.0	
	2N3715, 2N3716		—	1.5	
Base-Emitter Voltage*		V_{BE}*			Vdc
(I_C = 3 Adc, V_{CE} = 2 Vdc)	All Types		—	1.5	
Small Signal Current Gain		h_{fe}			—
(V_{CE} = 10 Vdc, I_C = 0.5 Adc, f = 1 mc)	All Types		4	—	
Switching Times			Typ		μsec
(I_C = 5A, I_{B1} = I_{B2} = 0.5 A)					
Rise Time		t_r	0.45		
Storage Time		t_s	0.3		
Fall Time		t_f	0.4		

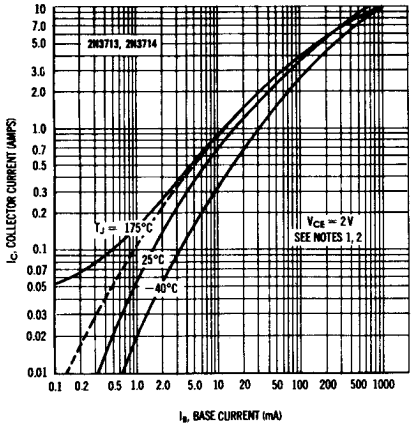
*Use sweep test to prevent overheating

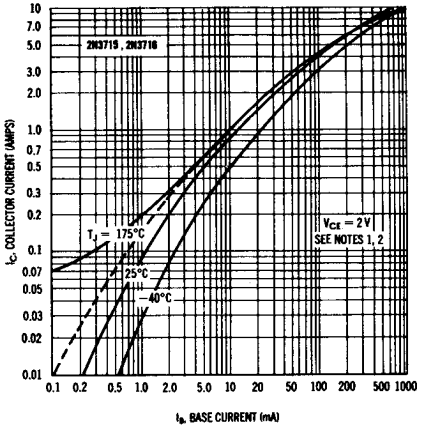




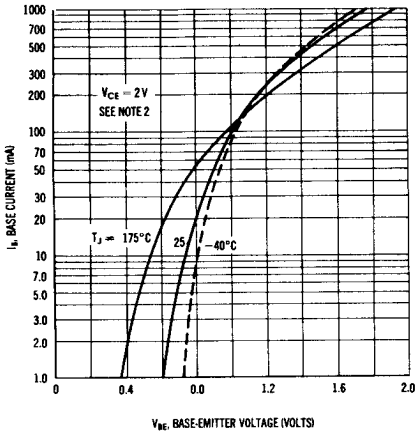
2N3713 thru 2N3716 (continued)

COLLECTOR CURRENT versus BASE CURRENT

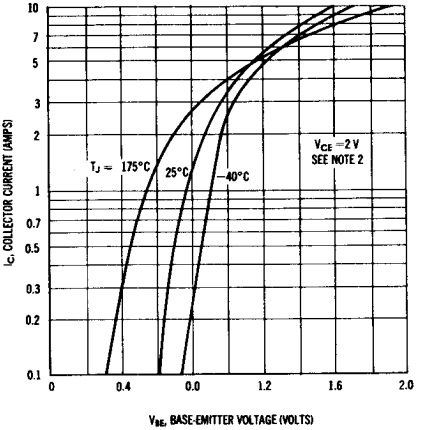




BASE CURRENT-VOLTAGE VARIATIONS

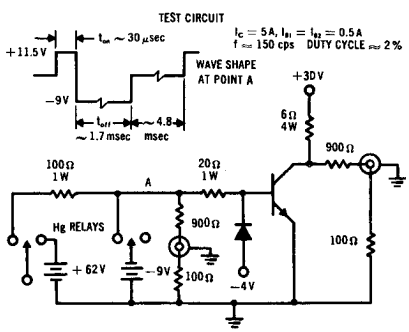


COLLECTOR CURRENT-VOLTAGE VARIATIONS

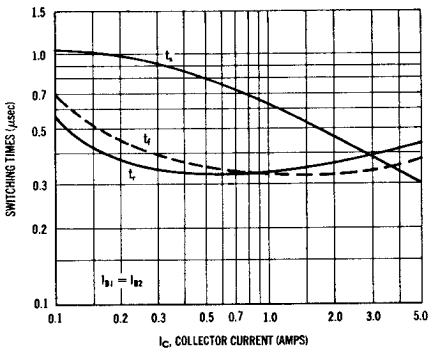


NOTE 1. Dotted line indicates metered base current plus the I_{CBO} of the transistor at 175°C.

NOTE 2. Pulse test: pulse width ≈ 200 μsec, duty cycle ≈ 1.5%

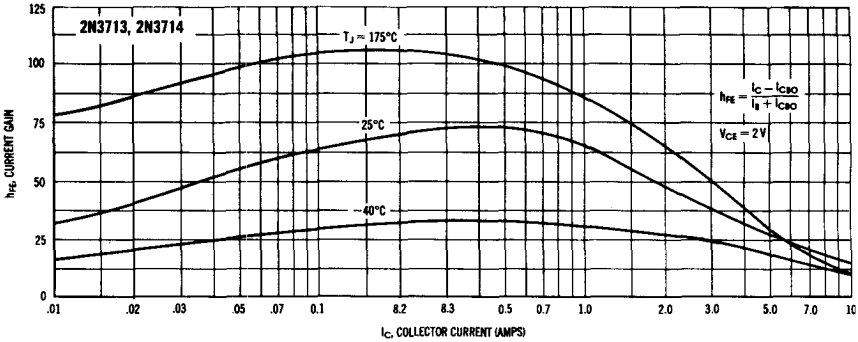


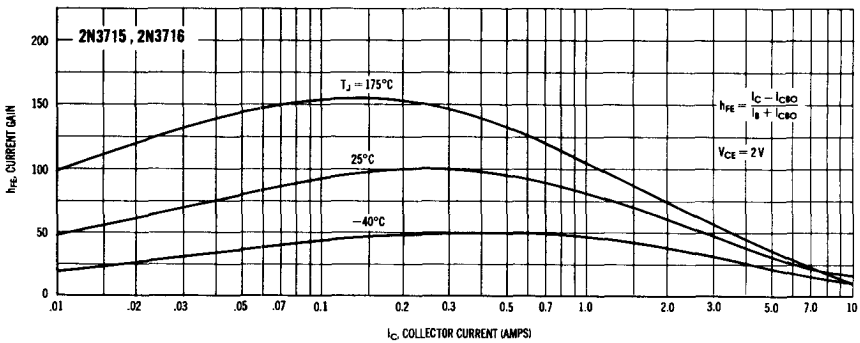
TYPICAL SWITCHING TIMES



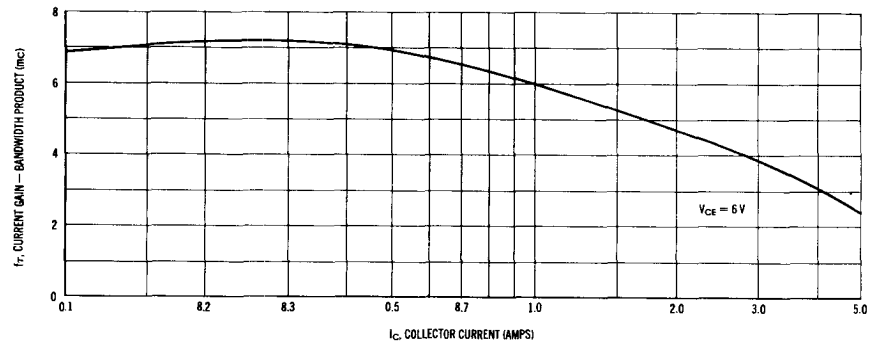
2N3713 thru 2N3716 (continued)

CURRENT GAIN VARIATIONS





CURRENT-GAIN—BANDWIDTH PRODUCT versus COLLECTOR CURRENT



2N3719 (SILICON)
2N3720

$P_D = 1$ W
$I_C = 3$ A
$V_{CBO} = 40\text{-}60$ V



CASE 31
(TO-5)

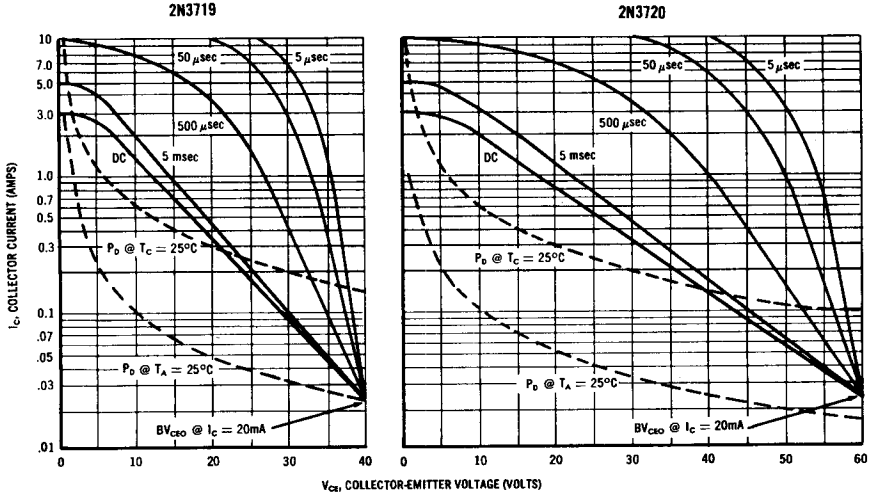
PNP silicon annular power transistors for high-speed, high-current switching in core, driver and Class C power applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N3719	2N3720	Unit
Collector-Base Voltage	V_{CBO}	40	60	Volts
Collector-Emitter Voltage	V_{CEO}	40	60	Volts
Emitter-Base Voltage	V_{EBO}	4	4	Volts
Collector Current—Continuous Collector Current—Peak	I_C	3 10	3 10	Amps Amps
Base Current	I_B	0.5	0.5	Amp
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1.0 5.72		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	6 34.3		Watts $mW/^oC$
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		^oC

SAFE OPERATING AREAS



2N3719 and 2N3720 (continued)

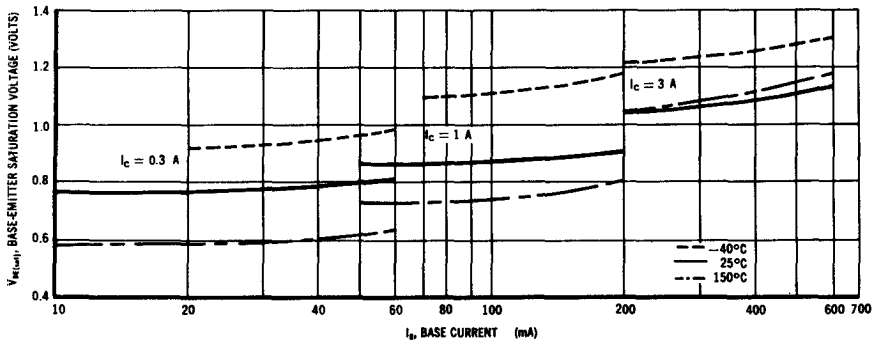
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Leakage Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, V_{BE} = 2 Vdc)	2N3719		—	10	
(V_{CE} = 60 Vdc, V_{BE} = 2 Vdc)	2N3720		—	10	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 25°C)	2N3719		—	.010	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	2N3719		—	1	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 25°C)	2N3720		—	.010	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N3720		—	1	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 4 Vdc, I_C = 0)			—	1	
DC Current Gain*		h_{FE}*			—
(I_C = 500 mA, V_{CE} = 1.5 V, T_A = 25°C)			20	—	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = 25°C)			25	180	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = -40°C)			15	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA, T_A = -40 to +100°C			—	0.75	
(I_C = 3 A, I_B = 300 mA, T_A = 25°C)			—	1.5	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA)			—	1.5	
(I_C = 3 A, I_B = 300 mA)			—	2.3	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Volts
(I_C = 20 mA, I_B = 0)	2N3719		40	—	
	2N3720		60	—	
Collector Output Capacitance		C_{ob}			pf
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)			—	120	
Input Capacitance		C_{ib}			pf
(V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kc)			—	1000	
Current-Gain — Bandwidth Product		f_T			mc
(V_{CE} = 10 Vdc, I_C = 500 mAdc, f = 30 mc)			60	—	
Delay Plus Rise Time		t_{on}			nsec
(I_C = 1 Adc, I_{B1} = 100 mA)			—	75	
Storage Time		t_s			nsec
(I_C = 1 Adc, I_{B1} = I_{B2} = 100 mA)			—	150	
Fall Time		t_f			nsec
(I_C = 1 Adc, I_{B1} = I_{B2} = 100 mA)			—	75	

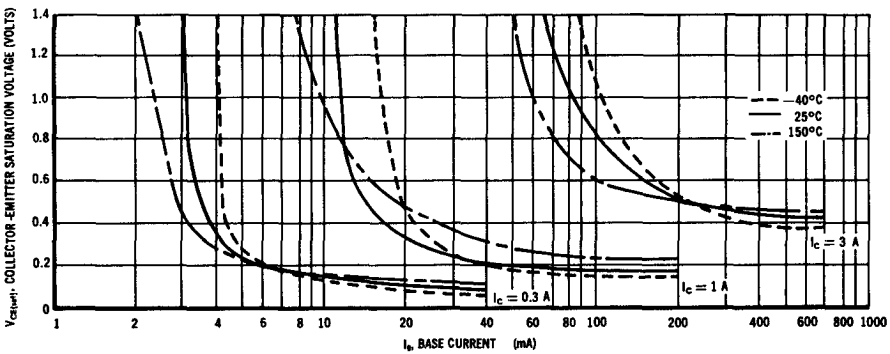
*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N3719, 2N3720 (continued)

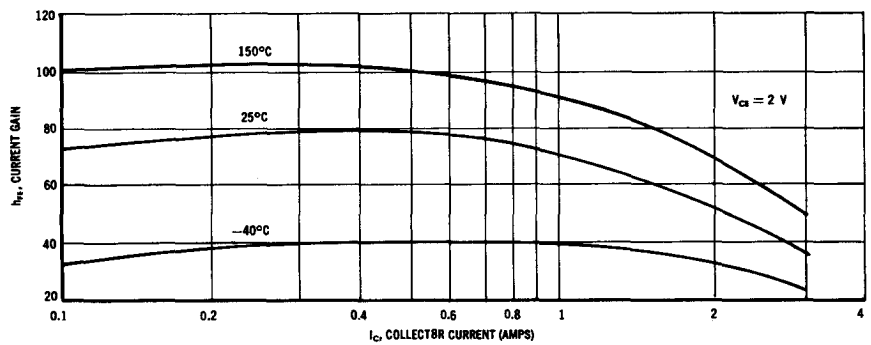
BASE EMITTER SATURATION VOLTAGE VARIATIONS



COLLECTOR-EMITTER SATURATION VOLTAGE VARIATIONS

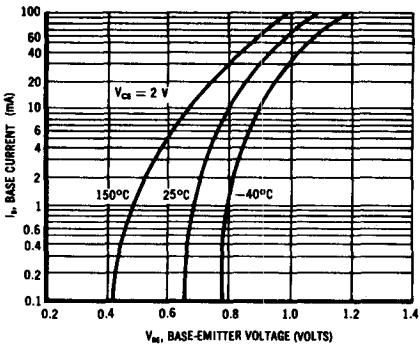


CURRENT GAIN VARIATIONS

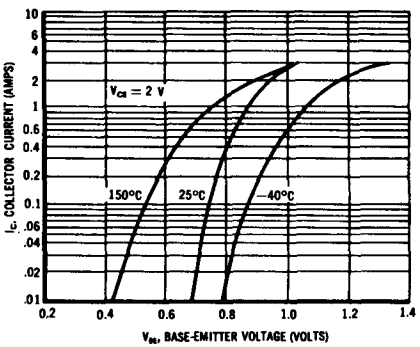


2N3719 and 2N3720 (continued)

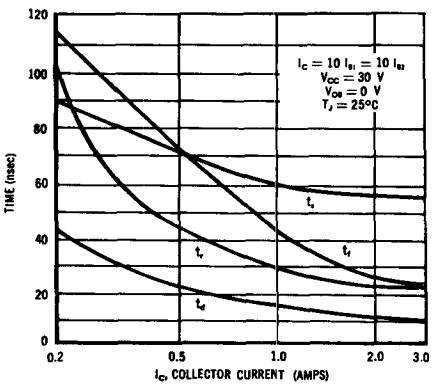
BASE CURRENT — VOLTAGE VARIATIONS



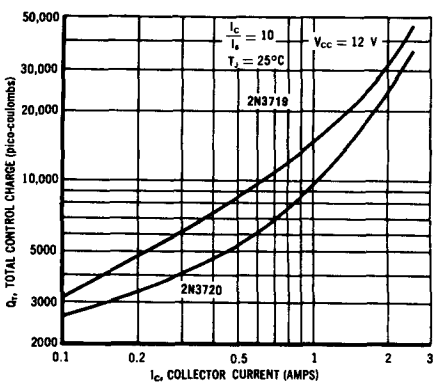
COLLECTOR CURRENT vs BASE-EMITTER VOLTAGE



TYPICAL SWITCHING TIMES



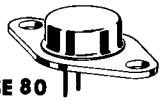
TOTAL CONTROL CHARGE VARIATION



2N3738 (SILICON)
2N3739



$P_D = 20W$
$I_C = 3A$
$V_{CEO} = 225\text{-}300V$



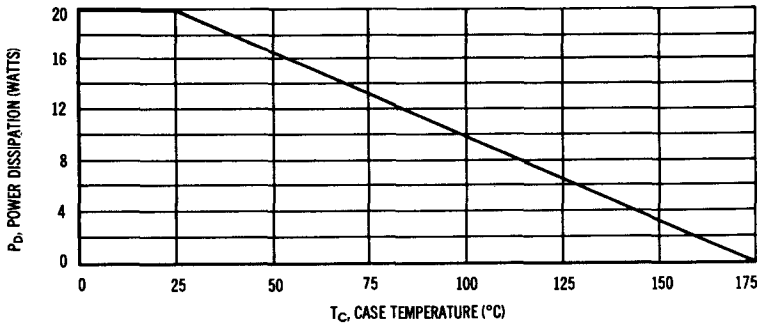
CASE 80
(TO-66)

High-voltage NPN silicon power transistors, designed for use in line operated equipment such as audio output amplifiers; low-current, high-voltage converters; and AC line relays, feature excellent dc gain.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	2N3738	2N3739	Unit
Collector-Base Voltage	V_{CB}	250	325	Vdc
Emitter-Base Voltage	V_{EB}	6	6	Vdc
Collector-Emitter Voltage	V_{CEO}	225	300	Vdc
Collector Current (Continuous)	I_C	3		Adc
Collector Current (Peak)	I_C	3		Amps
Base Current	I_B	250		mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	20 0.133		Watts $W/^oC$
Thermal Resistance	θ_{JC}	7.5		$^oC/W$
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +175		^oC

POWER-TEMPERATURE DERATING CURVE



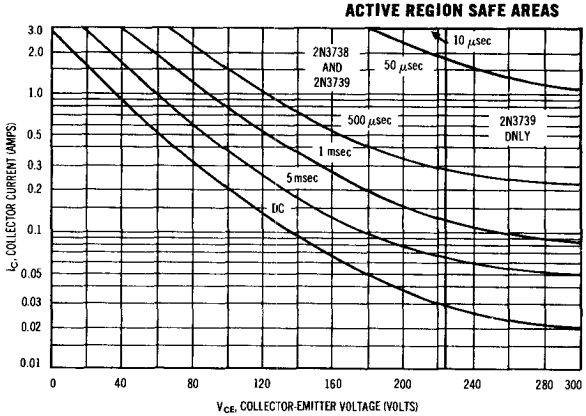
2N3738, 2N3739 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 5 mAdc, I_B = 0)	2N3738	$V_{CEO(sus)}$*	225	—	Vdc
	2N3739		300	—	
Emitter-Base Cutoff Current (V_{EB} = 6 Vdc)	Both Types	I_{EBO}	—	0.1	mAdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 250 Vdc, V_{BE} = 1.5 Vdc)	2N3738		—	0.5	
(V_{CE} = 300 Vdc, V_{BE} = 1.5 Vdc)	2N3739		—	0.5	
(V_{CE} = 125 Vdc, V_{BE} = 1.5 Vdc, T_C = 100°C)	2N3738		—	1.0	
(V_{CE} = 200 Vdc, V_{BE} = 1.5 Vdc, T_C = 100°C)	2N3739		—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 125 Vdc, I_B = 0)	2N3738		—	0.25	
(V_{CE} = 200 Vdc, I_B = 0)	2N3739		—	0.25	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 250 Vdc, I_E = 0)	2N3738		—	0.1	
(V_{CB} = 325 Vdc, I_E = 0)	2N3739		—	0.1	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	Both Types		30	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	Both Types		40	200	
(I_C = 250 mAdc, V_{CE} = 10 Vdc)	Both Types		25	—	
Collector-Emitter Saturation Voltage* (I_C = 250 mAdc, I_B = 25 mAdc)	Both Types	$V_{CE(sat)}$*	—	2.5	Vdc
Base-Emitter Voltage* (I_C = 100 mAdc, V_{CE} = 10 Vdc)	Both Types	V_{BE}*	—	1.0	Vdc
TRANSIENT CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 mc)	Both Types	f_T	15	—	mc
Common Base Output Capacitance (V_{CB} = 100 Vdc, I_C = 0, f = 100 kc)	Both Types	C_{ob}	—	20	pf
Small Signal Current Gain (I_C = 100 mAdc, V_{CE} = 20 Vdc, f = 1 kc)	Both Types	h_{fe}	35	—	—

*PULSE TEST: PW ≤ 300 μsec, Duty Cycle ≤ 2%

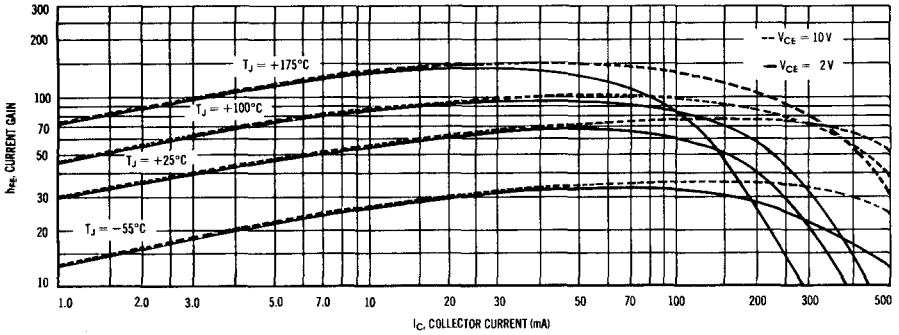
ACTIVE REGION SAFE AREAS



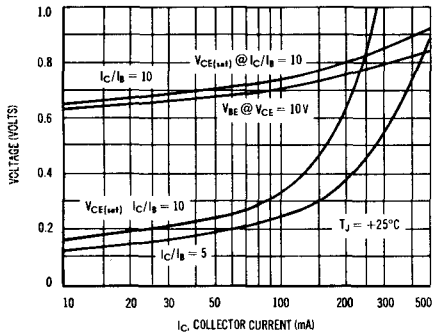
The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CEO} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3738, 2N3739 (continued)

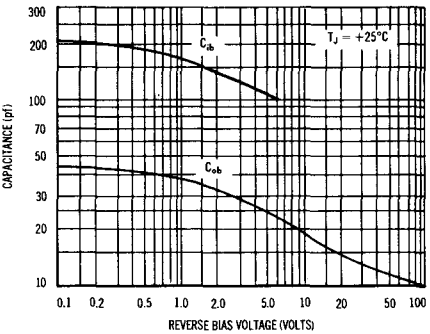
CURRENT GAIN



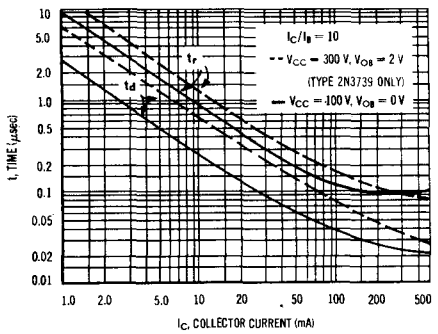
"ON" VOLTAGES



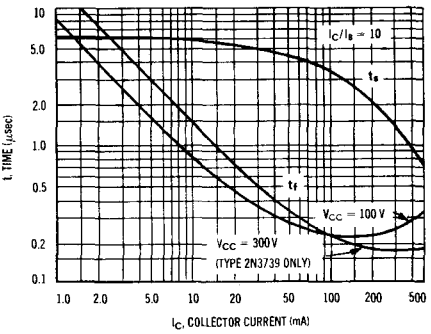
CAPACITANCE



TURN-ON TIME



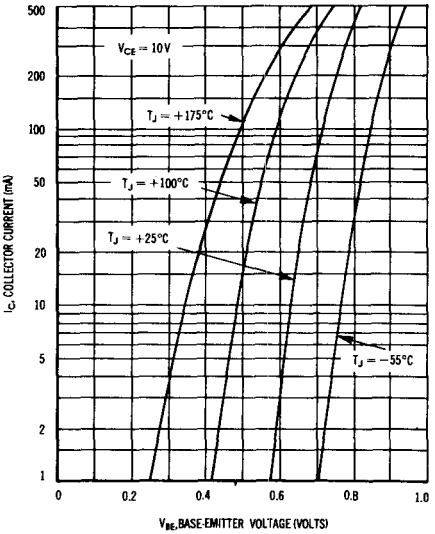
TURN-OFF TIME



2N3738, 2N3739 (continued)

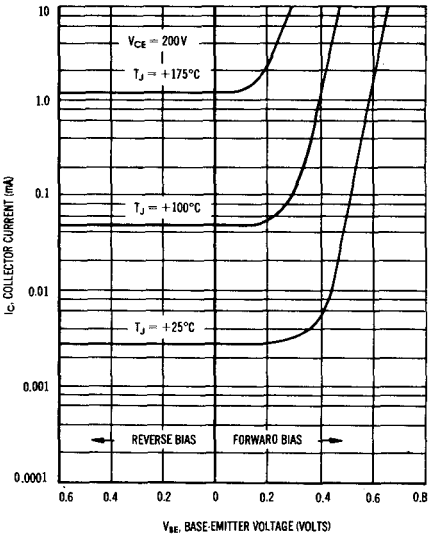
LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

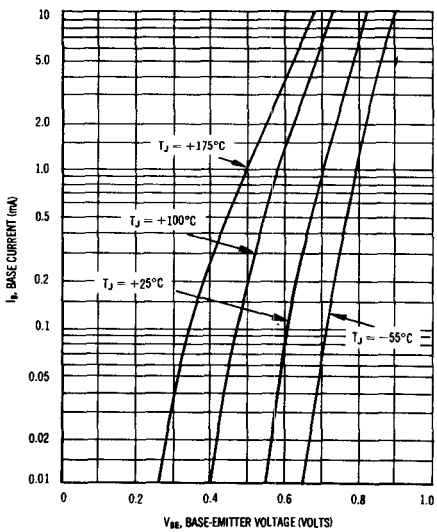


CUT-OFF CHARACTERISTICS

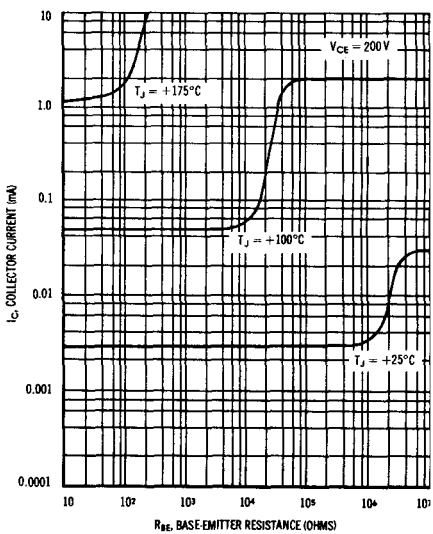
TRANSCONDUCTANCE



INPUT ADMITTANCE

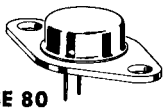


EFFECT OF BASE-EMITTER RESISTANCE



2N3740 (SILICON)
2N3741

V_{CB} = 60-80V
I_C = 4A
P_D = 25W



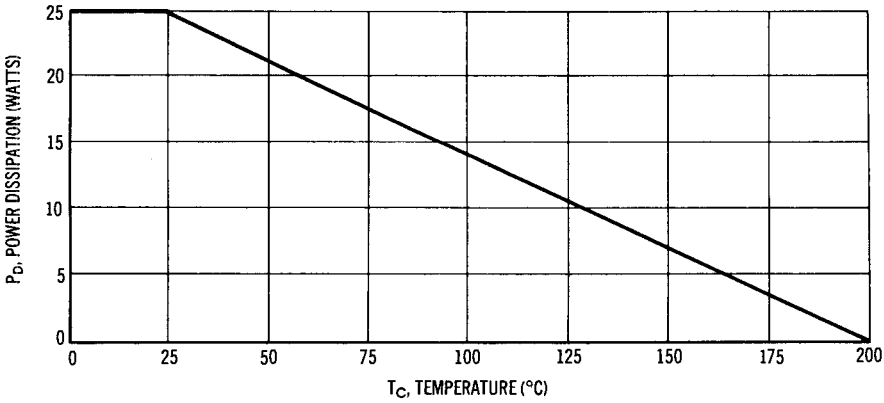
CASE 80
(TO-66)

Medium-power PNP transistors, ideal for use as drivers, switches and direct replacement of germanium medium-power devices, feature low saturation voltage and excellent safe area limits.

MAXIMUM RATINGS

Characteristics	Symbol	2N3740	2N3741	Unit
Collector-Base Voltage	V_{CB}	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7	7	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector Current (Continuous) See Figure 2	I_C	4		Adc
Collector Current (Peak) See Figure 2	I_C	4		Adc
Base Current (Continuous)	I_B	2		Adc
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	25 0.143		Watts W/°C
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2.
Both limits are applicable and must be observed.

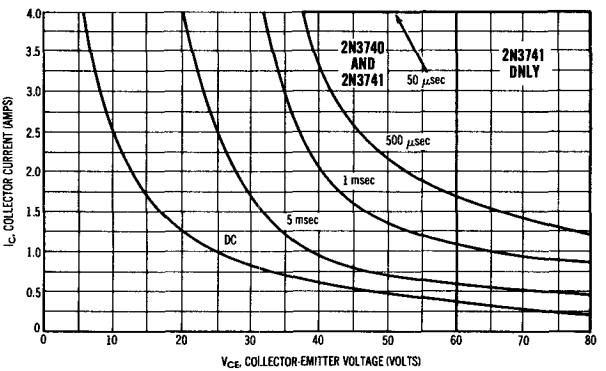
2N3740, 2N3741 (continued)

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)

Characteristics		Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N3740	2	$V_{CEO(sus)}$*	60	—	Vdc
	2N3741			80	—	
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)	Both Types		I_{EBO}	—	0.5	mAdc
Collector Cutoff Current		5, 6	I_{CEX}			mAdc
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	2N3740			—	0.1	
(V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc)	2N3741			—	0.1	
(V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc, T_C = 150 °C)	2N3740			—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc, T_C = 150 °C)	2N3741			—	1.0	
Collector-Emitter Cutoff Current		5, 6	I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N3740			—	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N3741			—	1.0	
Collector-Base Cutoff Current		—	I_{CBO}			mAdc
(V_{CB} = 60 Vdc, I_E = 0)	2N3740			—	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N3741			—	0.1	
ON CHARACTERISTICS						
DC Current Gain		7	h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	Both Types			40	—	
(I_C = 250 mAdc, V_{CE} = 1 Vdc)	Both Types			30	100	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	Both Types			20	—	
(I_C = 1 Adc, V_{CE} = 1 Vdc)	Both Types			10	—	
Collector-Emitter Saturation Voltage (I_C = 1 Adc, I_B = 125 mAdc)	Both Types	8, 9, 10	$V_{CE(sat)}$	—	0.6	Vdc
Base-Emitter Voltage (I_C = 250 mAdc, V_{CE} = 1 Vdc)	Both Types	3, 4, 9, 10	V_{BE}	—	1.0	Vdc
TRANSIENT CHARACTERISTICS						
Current-Gain Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1 mc)	Both Types	—	f_T	4	—	mc
Common-Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0, f = 100 kc)	Both Types	13	C_{ob}	—	100	pf
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	Both Types	—	h_{fe}	25	—	—

*PULSE TEST: PW ≤ 300 μsec, Duty Cycle ≤ 2%

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating curve (figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

2N3740, 2N3741 (continued)

LARGE SIGNAL CHARACTERISTICS

FIGURE 3 – TRANSCONDUCTANCE

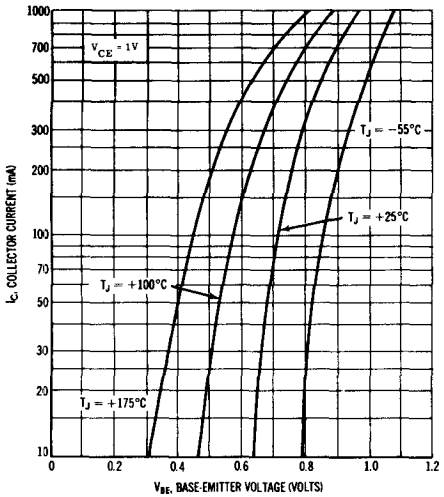
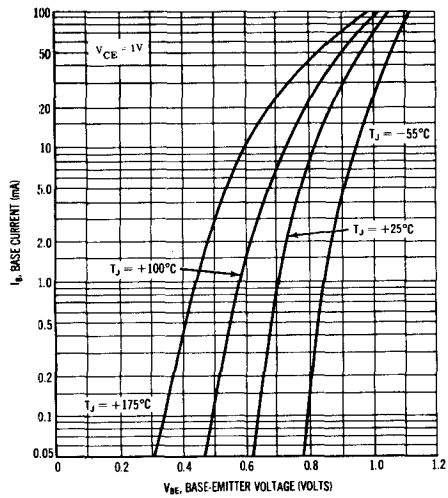


FIGURE 4 – INPUT ADMITTANCE



"OFF" REGION CHARACTERISTICS

FIGURE 5 – TRANSCONDUCTANCE

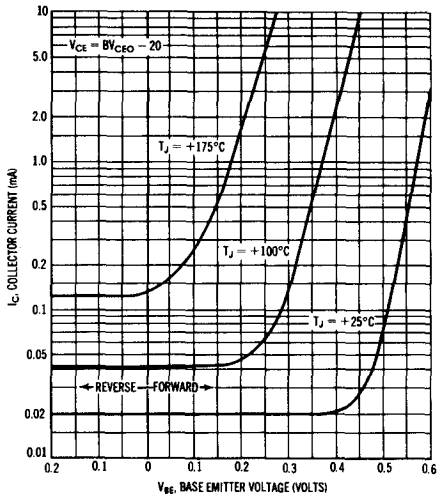
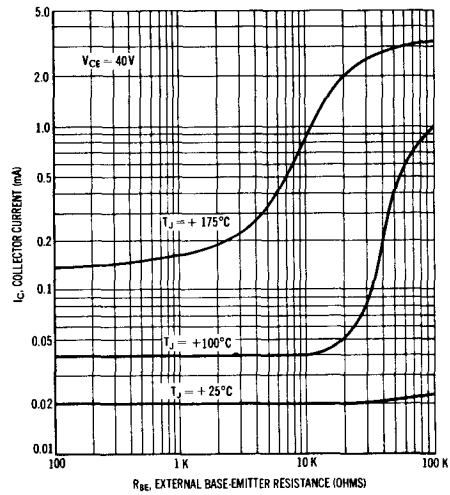
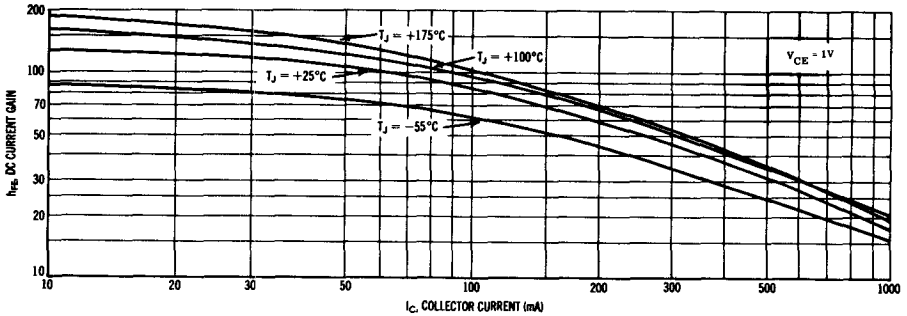


FIGURE 6 – EFFECTS OF BASE-EMITTER RESISTANCE



2N3740, 2N3741 (continued)

FIGURE 7 — CURRENT GAIN



SATURATION REGION CHARACTERISTICS

FIGURE 8 — COLLECTOR SATURATION REGION

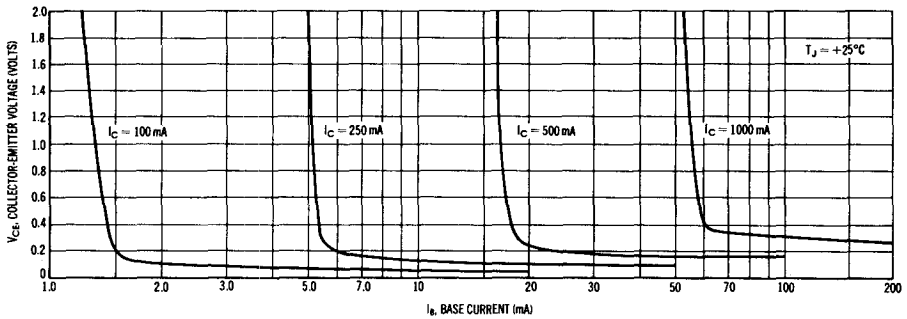


FIGURE 9 — "ON" VOLTAGES

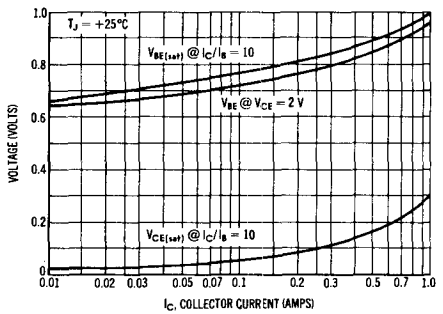
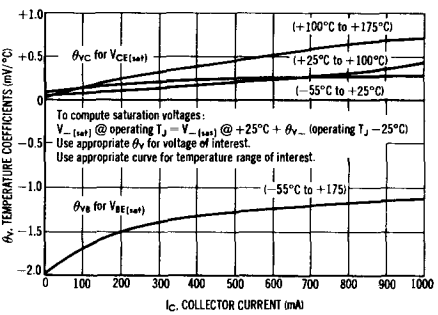


FIGURE 10 — TEMPERATURE COEFFICIENTS



2N3740, 2N3741 (continued)

DYNAMIC CHARACTERISTICS

FIGURE 11 — TURN-ON TIME

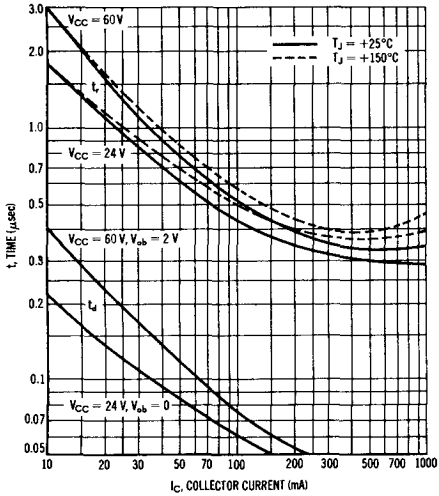


FIGURE 13 — CAPACITANCE

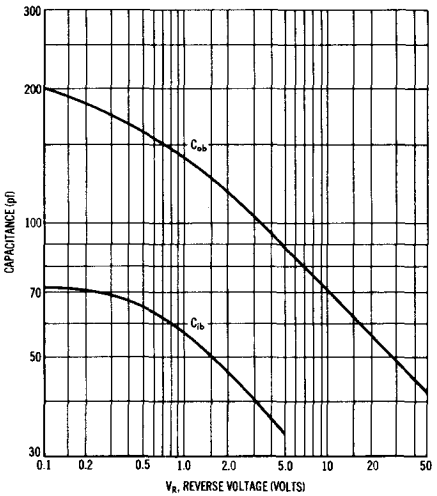


FIGURE 12 — STORAGE TIME

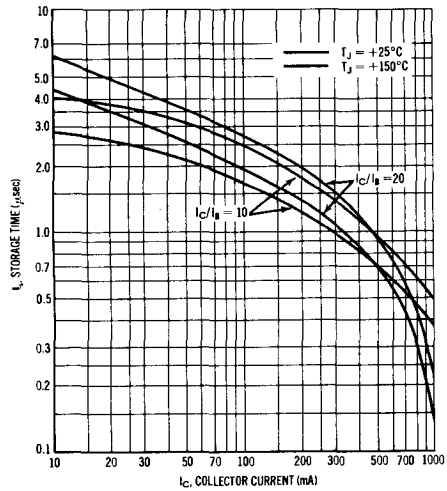
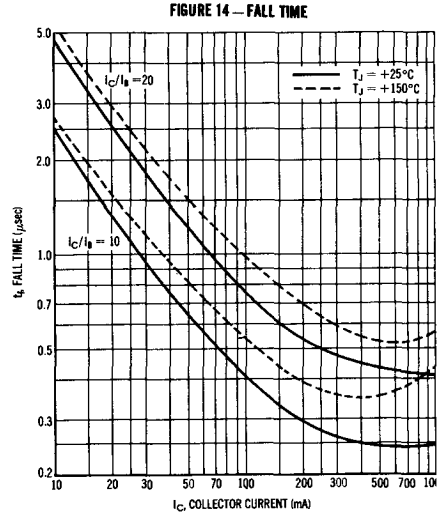
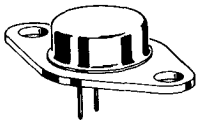


FIGURE 14 — FALL TIME



2N3766 (SILICON)
2N3767

V_{CB} = 80-100V
I_C = 4A
P_D = 20W



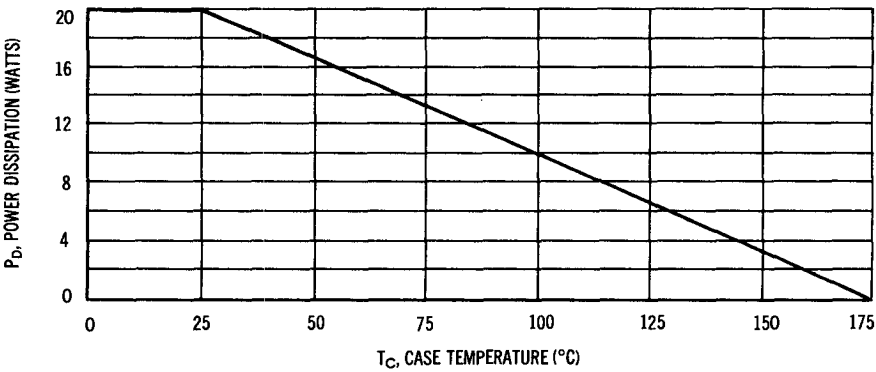
CASE 80
(TO-66)

Medium-power NPN silicon transistors, for use in switching, and medium-power-amplifier applications.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	2N3766	2N3767	Unit
Collector-Base Voltage	V_{CB}	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6	6	Vdc
Collector-Emitter Voltage	V_{CEO}	60	80	Vdc
Collector Current (Continuous)	I_C	4		Adc
Collector Current (Peak)	I_C	4		Adc
Base Current	I_B	2		Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	20 0.133		Watts W/°C
Thermal Resistance	θ_{JC}	7.5		°C/W
Junction Operating and Storage Temperature Range	T_J,T_{stg}	-65 to +175		°C

POWER-TEMPERATURE DERATING CURVE

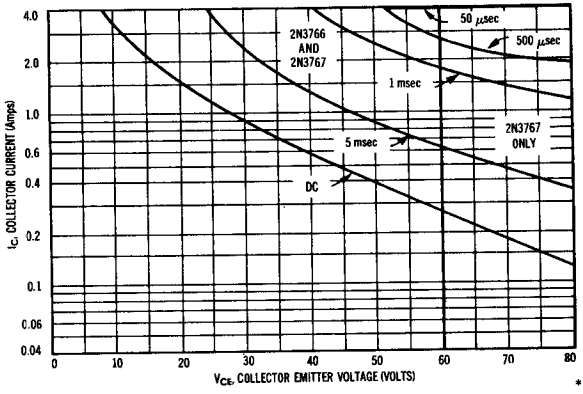


Safe area curves are indicated. Both limits are applicable and must be observed.

2N3766, 2N3767 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage* (I_C = 100 mAdc, I_B = 0)	2N3766	BV_{CEO}*	60	—	Vdc
	2N3787		80	—	
Emitter-Base Cutoff Current (V_{EB} = 6 Vdc)	Both Types	I_{EBO}	—	0.75	mAdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 80 Vdc, V_{BE} = 1.5 Vdc)	2N3766		—	0.1	
(V_{CE} = 100 Vdc, V_{BE} = 1.5 Vdc)	2N3767		—	0.1	
(V_{CE} = 50 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3766		—	1.0	
(V_{CE} = 70 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	2N3767		—	1.0	
Collector-Emitter Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 60 Vdc, I_B = 0)	2N3766		—	0.7	
(V_{CE} = 80 Vdc, I_B = 0)	2N3767		—	0.7	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 80 Vdc, I_E = 0)	2N3766		—	0.1	
(V_{CB} = 100 Vdc, I_E = 0)	2N3767		—	0.1	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 50 mAdc, V_{CE} = 5 Vdc)	Both Types		30	—	
(I_C = 500 mAdc, V_{CE} = 5 Vdc)	Both Types		40	160	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	Both Types		20	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 1 Adc, I_B = 0.1 Adc)	Both Types		—	2.5	
(I_C = 500 mAdc, I_B = 50 mAdc)	Both Types		—	1.0	
Base-Emitter Voltage		V_{BE}			Vdc
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	Both Types		—	1.5	
TRANSIENT CHARACTERISTICS					
Current-Gain - Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc, f = 10 mc)	Both Types	f_T	15	—	mc
Common-Base Output Capacitance (V_{CB} = 10 Vdc, I_C = 0 Adc, f = 100 kc)	Both Types	C_{obo}	—	50	pf
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	Both Types	h_{fe}	40	—	—



ACTIVE REGION SAFE AREAS

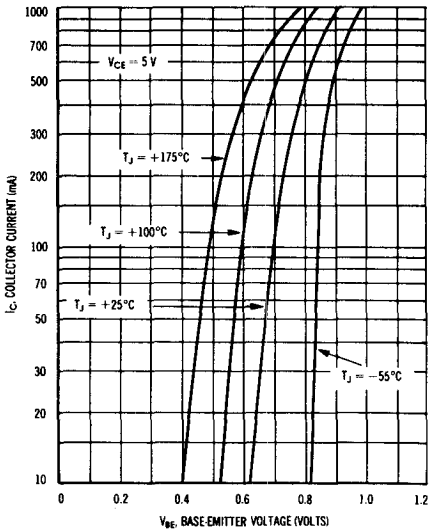
The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CEO} voltage limit only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; then and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

*Pulse Test: PW ≤ 300 μsec, duty cycle ≤ 2%

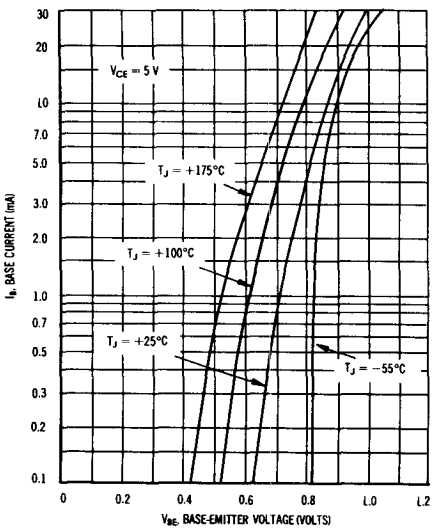
2N3766, 2N3767 (continued)

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

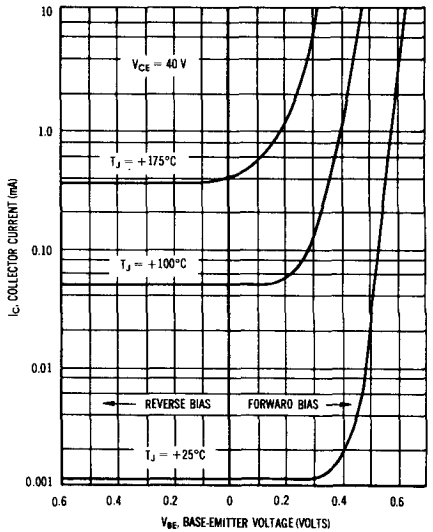


INPUT ADMITTANCE

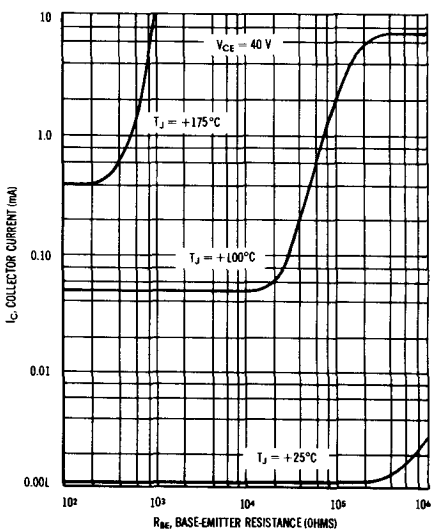


CUT-OFF CHARACTERISTICS

TRANSCONDUCTANCE

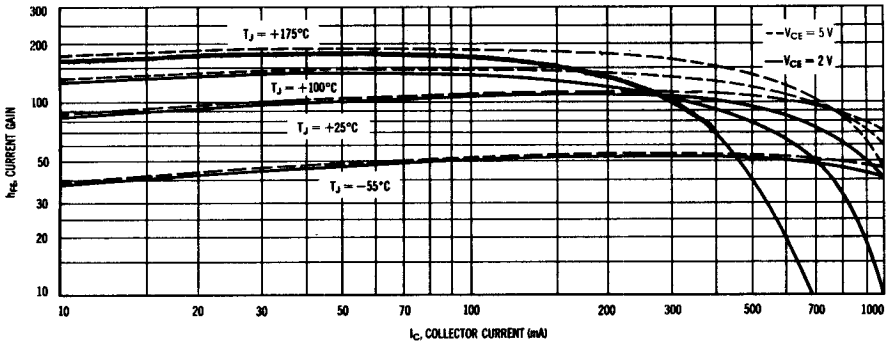


EFFECT OF BASE-EMITTER RESISTANCE

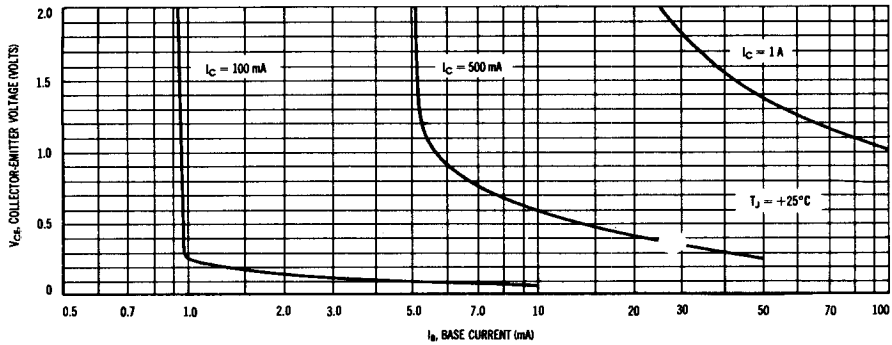


2N3766, 2N3767 (continued)

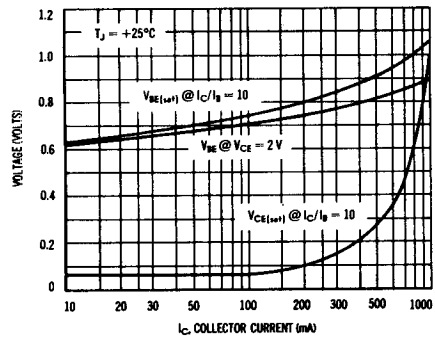
CURRENT GAIN



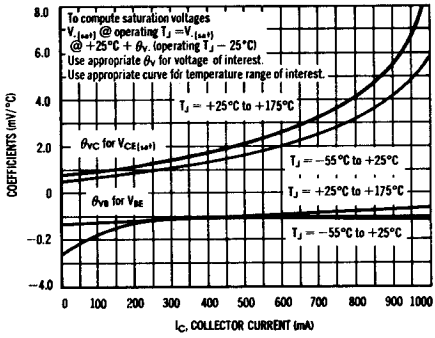
COLLECTOR SATURATION REGION



"ON" VOLTAGES



TEMPERATURE CO-EFFICIENTS

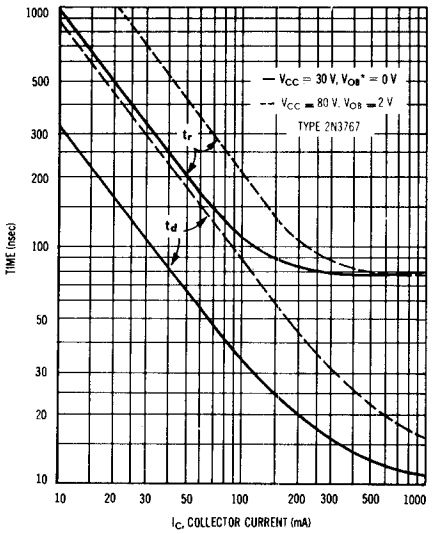


2N3766, 2N3767 (continued)

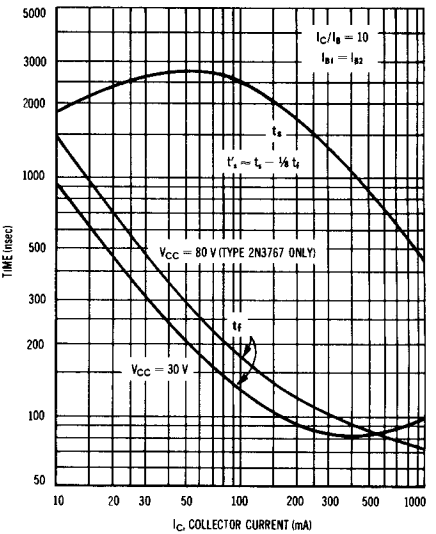
TRANSIENT CHARACTERISTICS

($T_J = 25°C$)

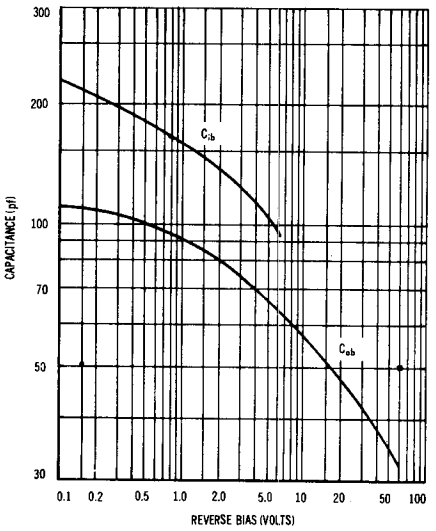
TURN-ON TIME



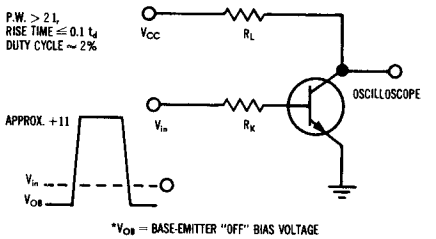
TURN-OFF TIME



CAPACITANCE

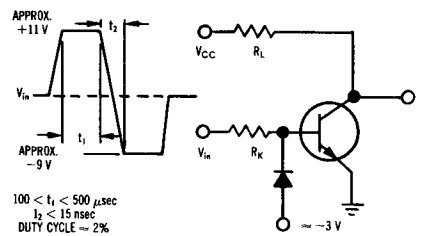


EQUIVALENT CIRCUIT FOR MEASURING DELAY AND RISE TIME



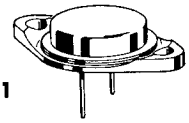
*V_{OB} = BASE-EMITTER "OFF" BIAS VOLTAGE

EQUIVALENT CIRCUIT FOR MEASURING STORAGE AND FALL TIMES



2N3789 thru 2N3792 (SILICON)

P_D = 150W
I_C = 10A
V_{CEO} = 60-80V



CASE 11
(TO-3)

PNP silicon power transistors for medium-speed switching and amplifier applications. Complementary to NPN type 2N3713 thru 2N3716.

MAXIMUM RATINGS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	2N3789 2N3791	2N3790 2N3792	Unit
Collector-Base Voltage	V_{CB}	60	80	Volts
Collector-Emitter Voltage	V_{CEO}	60	80	Volts
Emitter-Base Voltage	V_{EB}	7	7	Volts
Collector Current (Continuous)	I_C	10	10	Amps
Collector Current (Peak)	I_C	10	10	Amps
Base Current (Continuous)	I_B	4.0	4.0	Amps
Power Dissipation	P_D	150	150	Watts
Thermal Resistance	θ_{JC}	1.17	1.17	°C/W
Junction Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

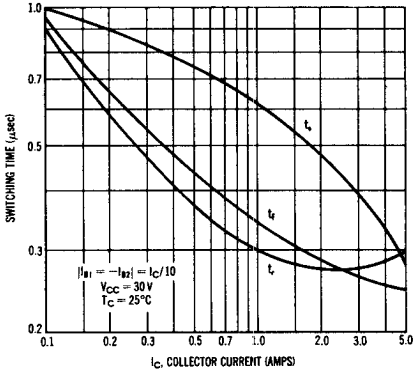
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

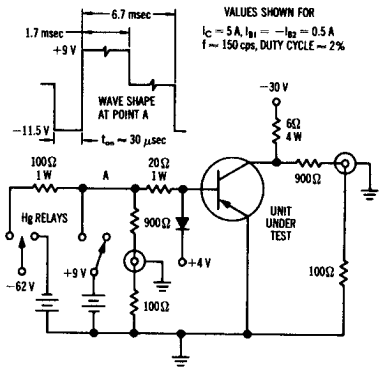
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	2N3789, 2N3791	$V_{CEO(sus)}$*	60	—	Vdc
	2N3790, 2N3792		80	—	
Collector-Emitter Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc)	2N3789, 2N3791		—	1	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc)	2N3790, 2N3792		—	1	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3789, 2N3791		—	5	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	2N3790, 2N3792		—	5	
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc)	All Types	I_{EBO}	—	5	mAdc
DC Current Gain*		h_{FE}*			—
(I_C = 1 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790		25	90	
	2N3791, 2N3792		50	150	
(I_C = 3 Adc, V_{CE} = 2 Vdc)	2N3789, 2N3790		15	—	
	2N3791, 2N3792		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790		—	1.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.0	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 4 Adc, I_B = 0.4 Adc)	2N3789, 2N3790		—	2.0	
(I_C = 5 Adc, I_B = 0.5 Adc)	2N3791, 2N3792		—	1.5	
Current Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 0.5 Adc)	All Types	f_T	4	—	mc

*Sweep Test: 1/2 sine wave cycle @ 60 cps.

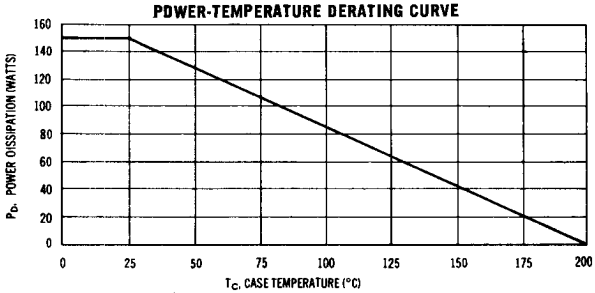
2N3789 thru 2N3792 (continued)

TYPICAL SWITCHING TIMES AND TEST CIRCUIT





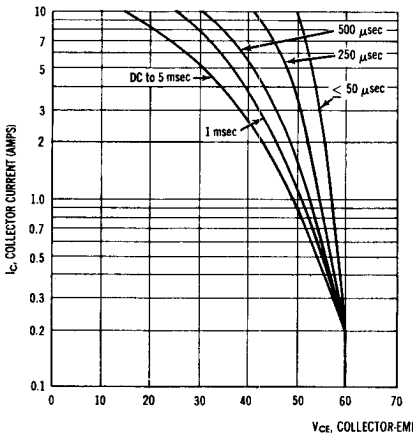
POWER-TEMPERATURE DERATING CURVE



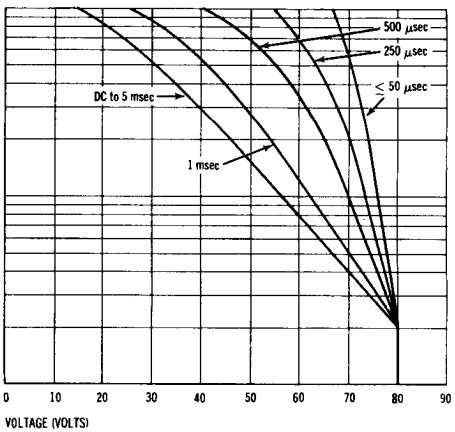
Safe area curves are indicated. Both limits are applicable and must be observed.

ACTIVE-REGION SAFE OPERATING AREAS

2N3789, 2N3791



2N3790, 2N3792



V_{CE}, COLLECTOR-EMITTER VOLTAGE (VOLTS)

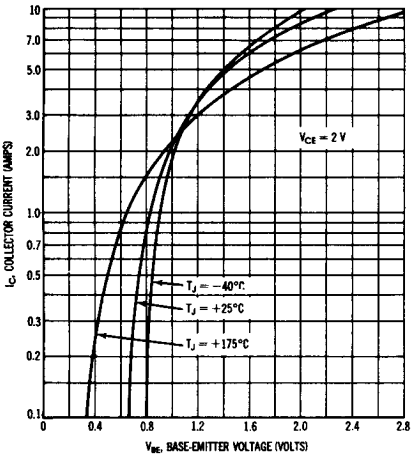
The Safe Operating Area Curves indicate I_C - V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursion make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

2N3789 thru 2N3792 (continued)

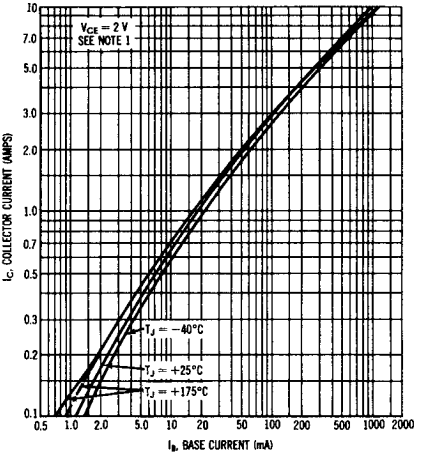
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3789, 2N3790

(PULSE TEST: pulse width ~ 200 μsec, duty cycle ~ 1%)

TRANSCONDUCTANCE

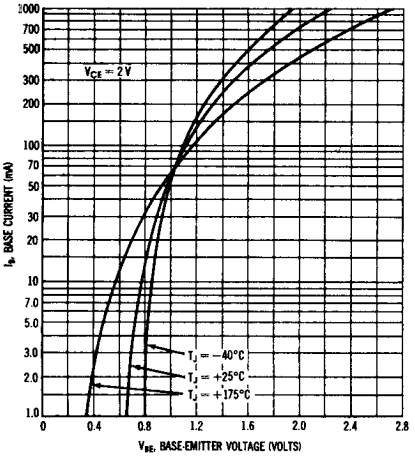


CURRENT GAIN

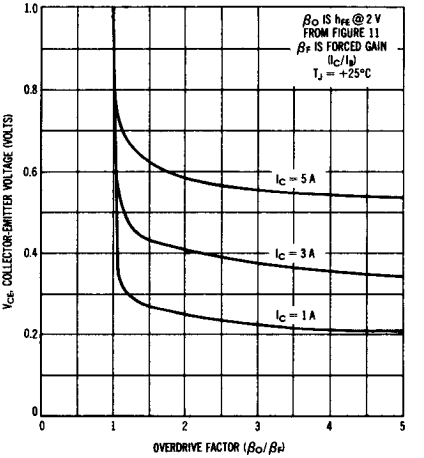


Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

INPUT ADMITTANCE



SATURATION REGION

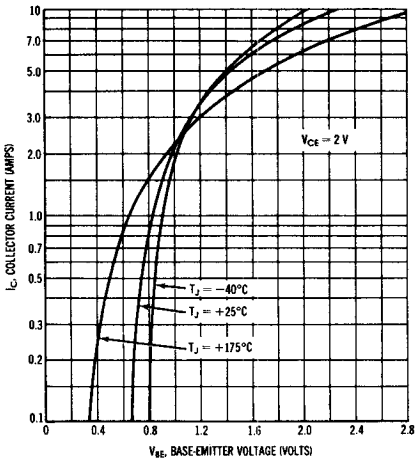


2N3789 thru 2N3792 (continued)

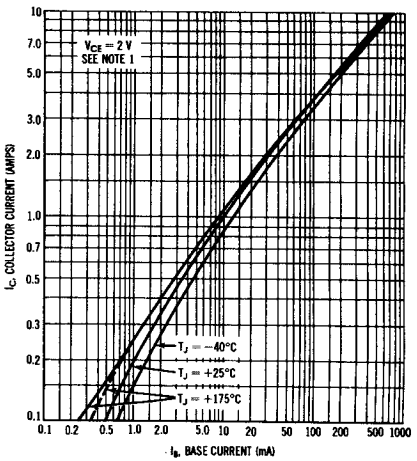
LARGE SIGNAL CHARACTERISTICS – TYPE 2N3791, 2N3792

(PULSE TEST: pulse width ~ 200 μsec, duty cycle ~ 1%)

TRANSCONDUCTANCE

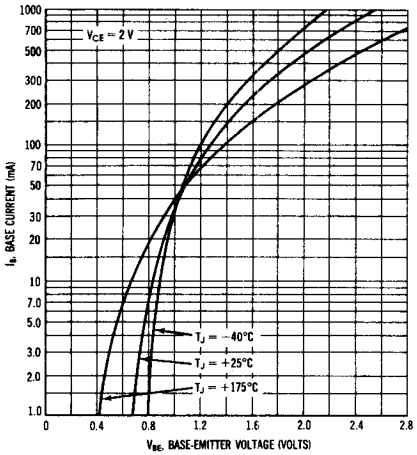


CURRENT GAIN

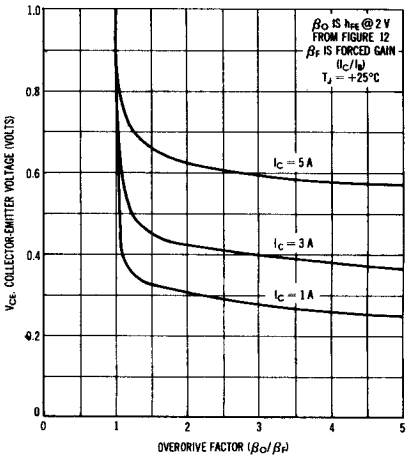


Dashed line indicates metered base current minus I_{CBO} of the transistor at 175°C.

INPUT ADMITTANCE

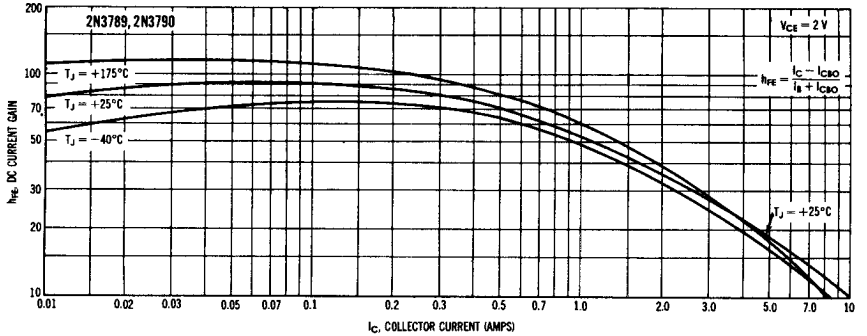


SATURATION REGION

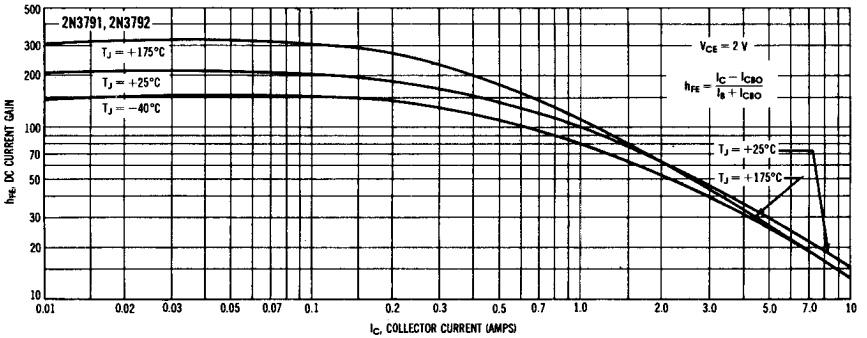


2N3789 thru 2N3792 (continued)

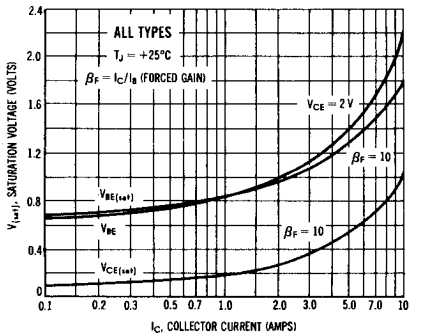
CURRENT GAIN VARIATIONS



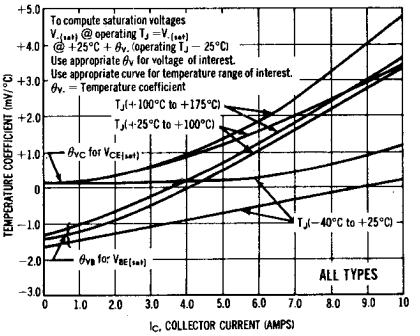
CURRENT GAIN VARIATIONS



SATURATION VOLTAGES

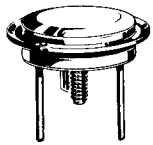


TEMPERATURE COEFFICIENTS



2N4048 thru 2N4053 (GERMANIUM)

$P_D = 170$ W
$I_C = 60$ A
$V_{CB} = 45\text{-}75$ V



CASE 7
(TO-36)

Collector connected to case

PNP germanium power transistor designed for high current applications requiring high gain and extremely low saturation voltage.

MAXIMUM RATINGS

Characteristic	Symbol	2N4048 2N4051	2N4049 2N4052	2N4050 2N4053	Unit
Collector-Emitter Voltage	V_{CEO}	30	45	60	Vdc
Collector-Emitter Voltage	V_{CES}	45	60	75	Vdc
Collector-Base Voltage	V_{CB}	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	25	30	40	Vdc
Collector Current	I_C	60			Adc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	170 0.294			Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +110			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

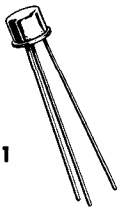
2N4048 thru 2N4053 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise specified.)

Characteristic		Symbol	Min	Typ	Max	Unit
DC Current Gain		h_{FE}				-
(I_C = 15 Adc, V_{CE} = 2 Vdc)	2N4048 thru 2N4050		60	85	120	
	2N4051 thru 2N4053		80	110	180	
(I_C = 60 Adc, V_{CE} = 2 Vdc)	All Types		15	25	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 15 Adc, I_B = 1 Adc)	All Types		-	0.09	0.15	
(I_C = 60 Adc, I_B = 6 Adc)	All Types		-	0.15	0.30	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 15 Adc, I_B = 1 Adc)	All Types		-	0.30	0.60	
(I_C = 60 Adc, I_B = 6 Adc)	All Types		-	0.60	1.00	
Safe Operating Area Test		SOA				Vdc
(I_C = 60 A)	2N4048, 2N4051		35	-	-	
	2N4049, 2N4052		40	-	-	
	2N4050, 2N4053		45	-	-	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 300 mAdc, V_{BE} = 0)	2N4048, 2N4051		45	-	-	
	2N4049, 2N4052		60	-	-	
	2N4050, 2N4053		75	-	-	
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 1.0 Adc, I_E = 0)	2N4048, 2N4051		30	-	-	
	2N4049, 2N4052		45	-	-	
	2N4050, 2N4053		60	-	-	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	-	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	-	0.5	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 45 Vdc, I_E = 0)	2N4048, 2N4051		-	0.9	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4049, 2N4052		-	0.9	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4050, 2N4053		-	0.9	4.0	
Collector-Base Cutoff Current		I_{CEX}				mAdc
(V_{CE} = V_{CEO}, V_{BE} = 2V, T_C = +70°C)	All Types		-	4.0	15	
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 2 Vdc, I_E = 0)	All Types		-	80	200	
Emitter Cutoff Current		I_{EBO}				mAdc
(V_{BE} = 25 Vdc, I_C = 0)	2N4048, 2N4051		-	0.2	4.0	
(V_{BE} = 30 Vdc, I_C = 0)	2N4049, 2N4052		-	0.2	4.0	
(V_{BE} = 40 Vdc, I_C = 0)	2N4050, 2N4053		-	0.2	4.0	
(V_{BE} = V_{EBO}, I_C = 0, T_C = +71°C)	All Types		-	2.7	15	
Common-Emitter Cutoff Frequency		$f_{\alpha e}$				kHz
(I_C = 15 Adc, V_{CE} = 2 Vdc)	All Types		2	3.6	-	

2N4234 (SILICON)
2N4235
2N4236

$P_D = 6$ W
$I_C = 1$ A
$V_{CB} = 40\text{-}80$ V



CASE 31
(TO-5)

PNP silicon power transistors ideal for use as drivers, switches, and direct replacement of germanium medium-power devices.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N4234	2N4235	2N4236	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7	7	7	Vdc
Collector Current	I_C	1			Adc
Base Current	I_B	0.2			Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	1 5.7			Watts $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	6 34			Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, (Junction to Case)	θ_{JC}	29	°C/W

2N4234, 2N4235, 2N4236 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	2N4234	$BV_{CEO(sus)}$*	40	-	Vdc
	2N4235		60	-	
	2N4236		80	-	
Emitter-Cutoff Current (V_{BE} = 7 Vdc, I_C = 0)	All Types	I_{EBO}	-	0.5	mAdc
Collector-Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4234		-	0.1	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4235		-	0.1	
(V_{CE} = 80 Vdc, $V_{BE(off)}$ = 1.5 Vdc)	2N4236		-	0.1	
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4234		-	1.0	
(V_{CE} = 40 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4235		-	1.0	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1.5 Vdc, T_C = 150°C)	2N4236		-	1.0	
Collector-Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 30 Vdc, I_B = 0)	2N4234		-	1.0	
(V_{CE} = 40 Vdc, I_B = 0)	2N4235		-	1.0	
(V_{CE} = 60 Vdc, I_B = 0)	2N4236		-	1.0	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N4234		-	0.1	
(V_{CB} = 60 Vdc, I_E = 0)	2N4235		-	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N4236		-	0.1	
DC Current Gain		h_{FE}			-
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	All Types		40	-	
(I_C = 250 mAdc, V_{CE} = 1 Vdc)	All Types		30	150	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	All Types		20	-	
(I_C = 1 Adc, V_{CE} = 1 Vdc)	All Types		10	-	
Collector-Emitter Saturation Voltage (I_C = 1 Adc, I_B = 125 mAdc)	All Types	$V_{CE(sat)}$	-	0.6	Vdc
Base-Emitter Voltage (I_C = 250 mAdc, V_{CE} = 1 Vdc)	All Types	$V_{BE(off)}$	-	1.0	Vdc
Current-Gain -- Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1 MHz)	All Types	f_T	3	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	All Types	C_{ob}	-	100	pF
Small-Signal Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	All Types	h_{fe}	25	-	-

*PULSE TEST: PW ≤ 300 μsec, Duty Cycle ≤ 2%

NOTE: See 2N3740 data sheet for electrical characteristic curves.

2N4237 (SILICON)
2N4238
2N4239

$P_D = 5$ W
$I_C = 1$ A
$V_{CB} = 50\text{-}100$ V



CASE 31
(TO-5)

NPN silicon power transistor designed for use in driver circuits, switching, and medium-power amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N4237	2N4238	2N4239	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	80	100	Vdc
Emitter-Base Voltage	V_{EB}	6	6	6	Vdc
Collector Current	I_C	1			Adc
Base Current	I_B	0.2			Adc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.8 5.3			Watts $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5 33			Watts $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175			^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance (Junction to Case)	θ_{JC}	30	°C/W

2N4237, 2N4238, 2N4239 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

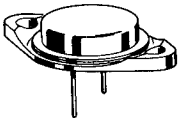
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Voltage* (I_C = 100 mAdc, I_B = 0)	2N4237	BV_{CEO*}	40	-	Vdc
	2N4238		60	-	
	2N4239		80	-	
Emitter Cutoff Current (V_{BE} = 6 Vdc, I_C = 0)	All Types	I_{EBO}	-	0.75	mAdc
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, $V_{BE(on)}$ = 1.5 Vdc)	2N4237		-	0.1	
(V_{CE} = 80 Vdc, $V_{BE(on)}$ = 1.5 Vdc)	2N4238		-	0.1	
(V_{CE} = 100 Vdc, $V_{BE(on)}$ = 1.5 Vdc)	2N4239		-	0.1	
(V_{CE} = 30 Vdc, $V_{BE(on)}$ = 1.5 Vdc, T_C = 150°C)	2N4237		-	1.0	
(V_{CE} = 50 Vdc, $V_{BE(on)}$ = 1.5 Vdc, T_C = 150°C)	2N4238		-	1.0	
(V_{CE} = 70 Vdc, $V_{BE(on)}$ = 1.5 Vdc, T_C = 150°C)	2N4239		-	1.0	
Collector Cutoff Current		I_{CEO}			mAdc
(V_{CE} = 40 Vdc, I_B = 0)	2N4237		-	0.7	
(V_{CE} = 60 Vdc, I_B = 0)	2N4238		-	0.7	
(V_{CE} = 80 Vdc, I_B = 0)	2N4239		-	0.7	
Collector Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)	2N4237		-	0.1	
(V_{CB} = 80 Vdc, I_E = 0)	2N4238		-	0.1	
(V_{CB} = 100 Vdc, I_E = 0)	2N4239		-	0.1	
DC Current Gain		h_{FE}			-
(I_C = 50 mAdc, V_{CE} = 4 Vdc)	All Types		30	-	
(I_C = 500 mAdc, V_{CE} = 4 Vdc)	All Types		40	160	
(I_C = 1.0 Adc, V_{CE} = 4 Vdc)	All Types		20	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		-	1.0	
(I_C = 1 Adc, I_B = 0.1 Adc)	All Types		-	2.5	
Base-Emitter On Voltage (I_C = 1.0 Adc, V_{CE} = 4 Vdc)	All Types	$V_{BE(on)}$	-	1.5	Vdc
Current-Gain — Bandwidth Product (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 10 MHz)	All Types	f_T	1.0	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)	All Types	C_{ob}	-	75	pF
Small-Signal Current Gain (I_C = 100 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	All Types	h_{fe}	40	-	-

*PULSE TEST: PW ≤ 300 μsec, Duty Cycle ≤ 2%

NOTE: See 2N3766 data sheet for electrical characteristic curves.

2N4276 thru 2N4283 (GERMANIUM)

$P_D = 170$ W
$I_C = 60$ A
$V_{CB} = 30\text{-}75$ V



CASE 3A
(TO-3)

PNP germanium power transistors designed for high current applications requiring high-gain and low saturation voltages.

MAXIMUM RATINGS

Characteristic	Symbol	2N4276 2N4277	2N4278 2N4279	2N4280 2N4281	2N4282 2N4283	Unit
Collector-Emitter Voltage	V_{CEO}	20	30	45	60	Vdc
Collector-Base Voltage	V_{CB}	30	45	60	75	Vdc
Emitter-Base Voltage	V_{EB}	20	25	30	40	Vdc
Collector Current	I_C	60				Adc
Total Device Dissipation @ $T_C = 25^oC$	P_D	170				Watts
Operating Junction Temperature Range	T_J	-65 to +110				^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.5	$^oC/W$

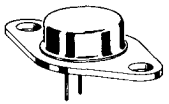
2N4276 thru 2N4283 (Continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
DC Current Gain		h_{FE}				-
(I_C = 15 Adc, V_{CE} = 2 Vdc)	2N4276, 2N4278, 2N4280, 2N4282		60	85	120	
(I_C = 50 Adc, V_{CE} = 2 Vdc)	2N4277, 2N4279, 2N4281, 2N4283		80	110	180	
	All Types		15	25	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 15 Adc, I_B = 1 Adc)	All Types		-	0.09	0.15	
(I_C = 50 Adc, I_B - 5 Adc)	All Types		-	0.15	0.30	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 15 Adc, I_B = 1 Adc)	All Types		-	0.30	0.60	
(I_C = 50 Adc, I_B = 5 Adc)	All Types		-	0.60	1.00	
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 1.0 Adc, I_B = 0)	2N4276, 2N4277		20	-	-	
	2N4278, 2N4279		30	-	-	
	2N4280, 2N4281		45	-	-	
	2N4282, 2N4283		60	-	-	
Floating Potential		V_{EBF}				Vdc
(V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277		-	-	0.5	
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	-	0.5	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	-	0.5	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	-	0.5	
Collector Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2 Vdc, I_E = 0)	All Types		-	80	0.2	
(V_{CB} = 30 Vdc, I_E = 0)	2N4276, 2N4277		-	-	4.0	
(V_{CB} = 45 Vdc, I_E = 0)	2N4278, 2N4279		-	-	4.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N4280, 2N4281		-	-	4.0	
(V_{CB} = 75 Vdc, I_E = 0)	2N4282, 2N4283		-	-	4.0	
(V_{CE} = $V_{CEO(max)}$, V_{BE} = 2 Vdc, T_C = +70°C)	All Types		-	-	15	
Emitter Cutoff Current		I_{EBO}				mAdc
(V_{BE} = 20 Vdc, I_C = 0)	2N4276, 2N4277		-	-	4.0	
(V_{BE} = 25 Vdc, I_C = 0)	2N4278, 2N4279		-	-	4.0	
(V_{BE} = 30 Vdc, I_C = 0)	2N4280, 2N4281		-	-	4.0	
(V_{BE} = 40 Vdc, I_C = 0)	2N4282, 2N4283		-	-	4.0	
(V_{BE} = $V_{BE(max)}$, I_C = 0, T_C = +71°C)	All Types		-	2.7	15	
Common Emitter Cutoff Frequency		$f_{\alpha e}$				kHz
(I_C = 15 Adc, V_{CE} = 2 Vdc)	All Types		2	3.6	-	

MJ2249 (SILICON)
MJ2250
MJ3101

V_{CB} = 60-80 V
I_C = 1 A
P_D = 17.5 W



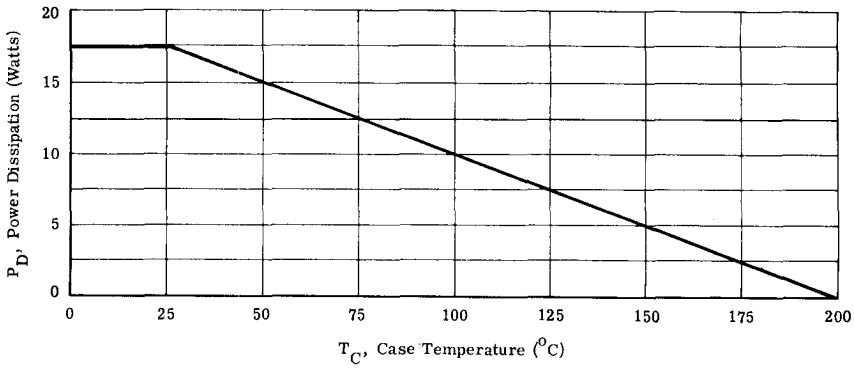
NPN silicon transistors designed for switching and amplifier applications and driving higher power devices.

CASE 80
(TO-66)

MAXIMUM RATINGS

Characteristic	Symbol	MJ3101	MJ2249	MJ2250	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	60	80	Vdc
Emitter-Base Voltage	V_{EB}	6	6	6	Vdc
Collector Current - Continuous Peak	I_C	2.0 3.0			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	17.5 0.133			Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175			°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MJ2249, MJ2250 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

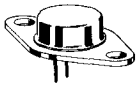
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Voltage* (I_C = 100 mAdc, I_B = 0)	MJ3101	BV_{CEO}*	40	—	Vdc
	MJ2249		60	—	
	MJ2250		80	—	
Collector-Base Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	MJ3101	I_{CBO}		1.0	mAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 60 Vdc, I_E = 0)	MJ2249		—	1.0	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
(V_{CB} = 80 Vdc, I_E = 0)	MJ2250		—	1.0	
(V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)			—	2.0	
Emitter-Base Cutoff Current (V_{EB} = 6 Vdc, I_C = 0)	All Types	I_{EBO}	—	1.0	mAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 50 mAdc, V_{CE} = 4 Vdc)	All Types	h_{FE}	25	—	—
(I_C = 100 mAdc, V_{CE} = 4 Vdc)†	All Types		25	200	
(I_C = 500 mAdc, V_{CE} = 4 Vdc)*	All Types		25	200	
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{CE(sat)}$	—	1.0	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	2.5	
(I_C = 1 Adc, I_B = 0.1 Adc)*	MJ2249, MJ2250		—	2.5	
Base-Emitter Voltage (I_C = 500 mAdc, I_B = 50 mAdc)	All Types	$V_{BE(sat)}$	—	1.2	Vdc
(I_C = 750 mAdc, I_B = 75 mAdc)	MJ3101		—	1.5	
(I_C = 1.0 Adc, I_B = 0.1 Adc)	MJ2249, MJ2250		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 500 mAdc, V_{CE} = 10 Vdc)	All Types	f_T	10	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2%

†Color coded h_{FE} groups available at 100 mAdc

MJ2251 (SILICON)
MJ2252

$P_D = 10W$
$I_C = 500mA$
$V_{CEO} = 225\text{-}300V$



CASE 80
(TO-66)

High-voltage NPN silicon power transistors, particularly well suited for power output stages in television, radio, phonograph and other consumer product applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage MJ2251 MJ2252	V_{CEO}	 225 300	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ T_C = 70°C Derate above 70°C	P_D	 10 0.125	 Watts W/°C
Operating and Storage Temperature Range	T_J, T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0) MJ2251 MJ2252	BV_{CEO}	 225 300	 — —	 — —	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_E = 0)	I_{CBO}	—	—	100	μAdc
Emitter-Base Leakage Current (V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	—	100	μAdc
DC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	200	—
Small Signal Current Gain (I_C = 20 mAdc, V_{CE} = 50 Vdc, f = 10 mc)	h_{fe}	1.0	—	—	—
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kc) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kc)	h_{fe}	 — —	 40 65	 — —	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kc) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kc)	h_{re}	 — —	 2.5 4.0	 — —	X10^{-5}
Input Impedance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kc) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kc)	h_{ie}	 — —	 150 75	 — —	ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 125 Vdc, f = 1 kc) (I_C = 30 mAdc, V_{CE} = 125 Vdc, f = 1 kc)	h_{oe}	 — —	 5 20	 — —	μmhos

MJ2251, MJ2252 (continued)

COLLECTOR CHARACTERISTICS

FIGURE 1 — MJ2251

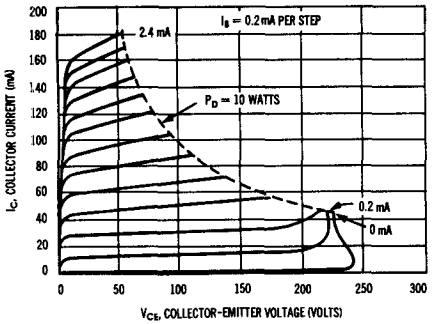


FIGURE 2 — MJ2252

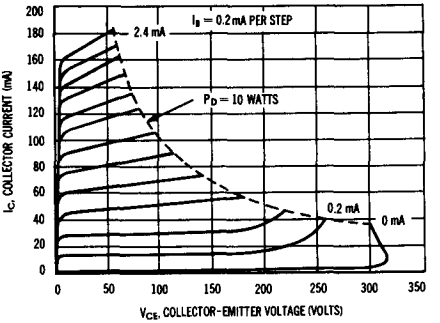


FIGURE 3 — COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

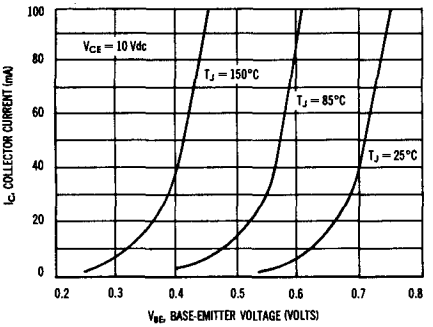


FIGURE 4 — TYPICAL LINE-OPERATED 1.5-WATT AUDIO AMPLIFIER

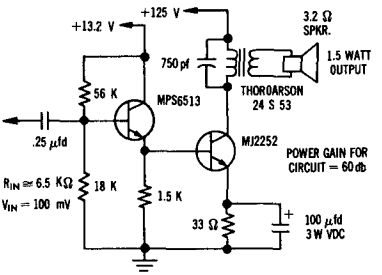


FIGURE 5 — TYPICAL TOTAL HARMONIC DISTORTION versus P_{out}

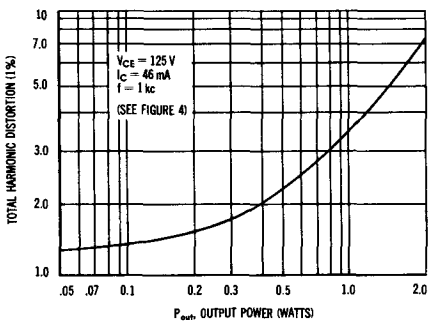
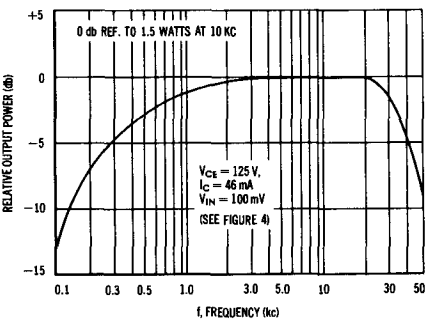
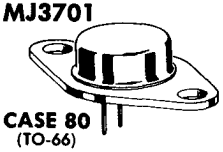


FIGURE 6 — TYPICAL FREQUENCY RESPONSE OF LINE OPERATED AUDIO AMPLIFIER



MJ2253 (SILICON)
MJ2254
MJ3701



CASE 80
(TO-66)



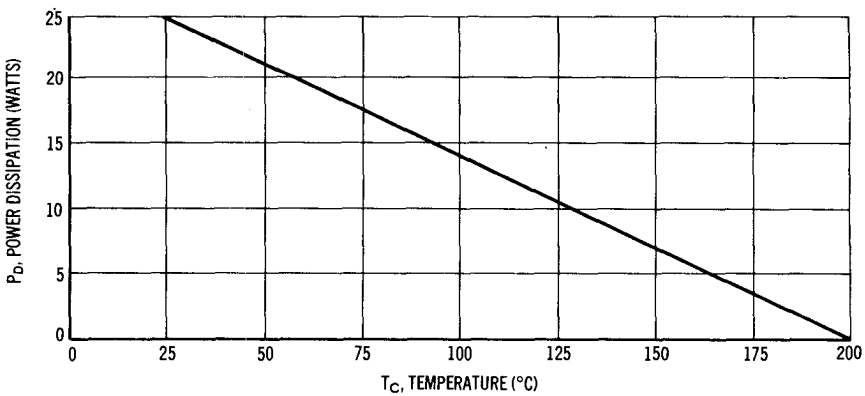
$P_D = 25W$
$I_C = 3A$
$V_{CEO} = 40\text{-}80V$

Medium-power silicon PNP power transistor, ideal for use as drivers, switches, amplifiers, and direct replacement of germanium medium-power devices.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristics	Symbol	MJ3701	MJ2253	MJ2254	Unit
Collector-Emitter Voltage	V_{CEO}	40	60	80	Vdc
Collector-Base Voltage	V_{CB}	50	70	90	Vdc
Emitter-Base Voltage	V_{EB}	5	7	7	Vdc
Collector Current - Continuous Peak	I_C	3.0 4.0			Adc
Base Current	I_B	0.5			Adc
Total Device Dissipation @ $T_C = 25°C$ Derate above $25°C$	P_D	25 0.143			Watts $W/°C$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200			°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Curves are indicated by Figure 2. Both limits are applicable and must be observed.

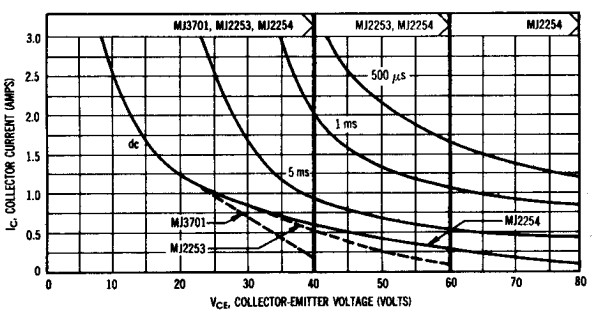
MJ2253, MJ2254, MJ3701 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 100 mAdc, I_B = 0)	MJ3701	$BV_{CEO(sus)}$*	40	—	Vdc
	MJ2253		60	—	
	MJ2254		80	—	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 50 Vdc, I_E = 0)	MJ3701		—	1.0	
(V_{CB} = 70 Vdc, I_E = 0)	MJ2253		—	1.0	
(V_{CB} = 90 Vdc, I_E = 0)	MJ2254		—	1.0	
(V_{CB} = 40 Vdc, I_E = 0, T_C = 150°C)	MJ3701		—	2.0	
(V_{CB} = 60 Vdc, I_E = 0, T_C = 150°C)	MJ2253		—	2.0	
(V_{CB} = 80 Vdc, I_E = 0, T_C = 150°C)	MJ2254		—	2.0	
Emitter-Base Cutoff Current		I_{EBO}			mAdc
(V_{BE} = 5 Vdc, I_C = 0)	MJ3701		—	2.0	
(V_{BE} = 7 Vdc, I_C = 0)	MJ2253, MJ2254		—	1.0	
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 100 mAdc, V_{CE} = 4 Vdc)†	All Types		20	—	
(I_C = 250 mAdc, V_{CE} = 4 Vdc)	All Types		20	100	
(I_C = 500 mAdc, V_{CE} = 4 Vdc)*	All Types		15	—	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	0.3	
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	0.8	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	1.2	
(I_C = 1.0 Adc, I_B = 125 mAdc)	All Types		—	1.5	
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)	All Types	f_T	3.0	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2% †Color coded h_{FE} groups available at 100 mAdc

FIGURE 2 — ACTIVE REGION SAFE OPERATING AREAS

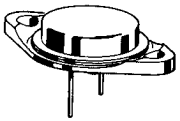


The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. These curves can be used as long as the average power derating curve (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

NOTE: For additional design curves, please refer to Type 2N3740

MJ2255
MJ2256
MJ2257

V_{CE} = 40-80 V
I_C = 8A
P_D = 120W



CASE 11
(TO-3)

NPN silicon power transistors designed for switching and amplifier applications.

MAXIMUM RATINGS

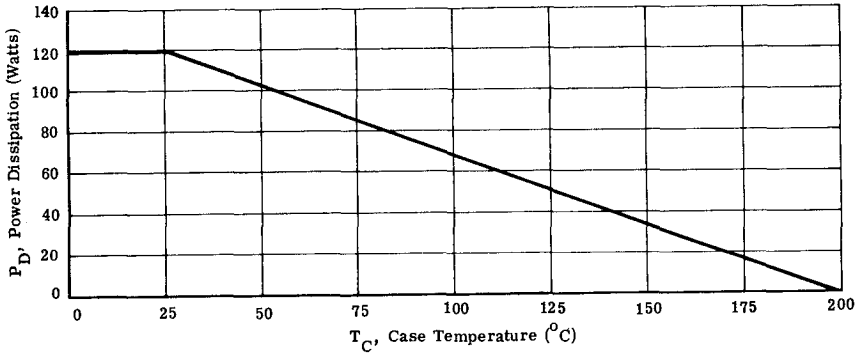
Characteristic	Symbol	MJ2255	MJ2256	MJ2257	Unit
Collector-Emitter Voltage	V_{CE}	40	60	80	Vdc
Emitter-Base Voltage	V_{EB}	7	7	7	Vdc
Collector Current (Continuous)	I_C	8	8	8	Adc
Base Current (Continuous)	I_B	3	3	3	Adc
Power Dissipation	P_D	120	120	120	Watts
Thermal Resistance	θ_{JC}	1.46	1.46	1.46	$^oC/W$
Junction Operating Temperature Range	T_J	-65^oC to $+200^oC$			^oC

MJ2255, MJ2256, MJ2257 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	MJ2255		-	20	
(V_{CE} = 60 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	MJ2256		-	-	
(V_{CE} = 80 Vdc, V_{BE} = -1.5 Vdc, T_C = 150°C)	MJ2257		-	-	
Emitter Cutoff Current (V_{EB} = 7 Vdc)	All types	I_{EBO}	-	5	mAdc
DC Current Gain (I_C = 5 Adc, V_{CE} = 4 Vdc)	All types	h_{FE}	15	-	-
Collector-Emitter Saturation Voltage (I_C = 5 Adc, I_B = 0.5 Adc)	All types	$V_{CE(sat)}$	-	1.0	Vdc
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 0.4 Adc, f = 1 MHz)	All types	h_{fe}	1.0	-	-

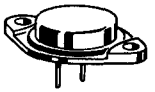
FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MJ2267 (SILICON)
MJ2268



$P_D = 150W$
$I_C = 5A$
$V_{CEO} = 40\text{-}55V$



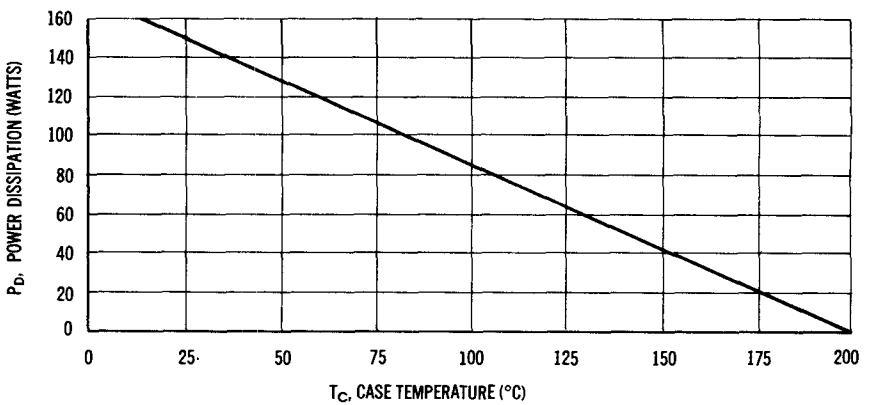
CASE 11
(TO-3)

Silicon PNP power transistors, designed for medium-speed switching and high-power amplifier applications. These devices can be directly substituted for germanium types.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	MJ2267	MJ2268	Unit
Collector-Emitter Voltage	V_{CEO}	40	55	Vdc
Collector-Base Voltage	V_{CB}	40	55	Vdc
Emitter-Base Voltage	V_{EB}	7	7	Vdc
Collector Current - Continuous Peak	I_C	5.0 10		Adc
Base Current	I_B	3		Adc
Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	150 0.86		Watts W/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



Safe Area Limits are indicated by Figures 2, 3. Both limits are applicable and must be observed.

MJ2267, MJ2268 (continued)

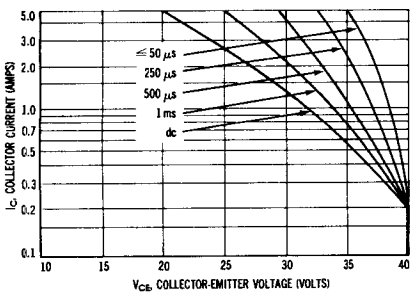
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 200 mAdc, I_B = 0)	MJ2267	$BV_{CEO(sus)}$*	40	—	Vdc
	MJ2268		55	—	
Collector Cutoff Current		I_{CEX}			mAdc
(V_{CE} = 40 Vdc, V_{BE} = 1.5 Vdc)	MJ2287		—	1.0	
(V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	MJ2268		—	1.0	
(V_{CE} = 20 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2267		—	5.0	
(V_{CE} = 30 Vdc, V_{BE} = 1.5 Vdc, T_C = 150°C)	MJ2268		—	5.0	
Emitter-Base Cutoff Current (V_{EB} = 7 Vdc, I_C = 0)	Both Types	I_{EBO}	—	5.0	mAdc
ON CHARACTERISTICS					
DC Current Gain		h_{FE}			—
(I_C = 1.0 Adc, V_{CE} = 2.0 Vdc)	Both Types		20	—	
(I_C = 3.0 Adc, V_{CE} = 2.0 Vdc)*	Both Types		15	70	
Collector-Emitter Saturation Voltage* (I_C = 3.0 Adc, I_B = 0.3 Adc)	Both Types	$V_{CE(sat)}$*	—	1.0	Vdc
Base-Emitter Saturation Voltage* (I_C = 3.0 Adc, I_B = 0.3 Adc)	Both Types	$V_{BE(sat)}$*	—	1.5	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 10 Vdc)		f_T	3.0	—	MHz

*PULSE TEST: PW ≤ 300 μs, Duty Cycle ≤ 2%.

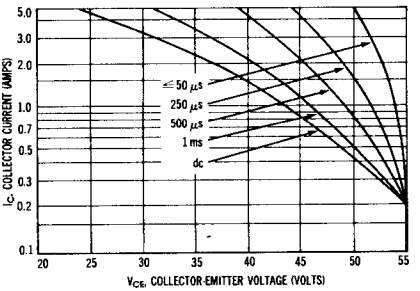
ACTIVE REGION SAFE OPERATING AREAS

FIGURE 2 — MJ2267



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short.

FIGURE 3 — MJ2268

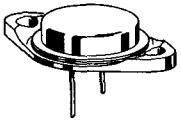


(Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

NOTE: For additional design curves, please refer to Type 2N3789

MJ2801 (SILICON)
MJ2802

V_{CB} = 50-70 V
I_C = 10 A
P_D = 120 W



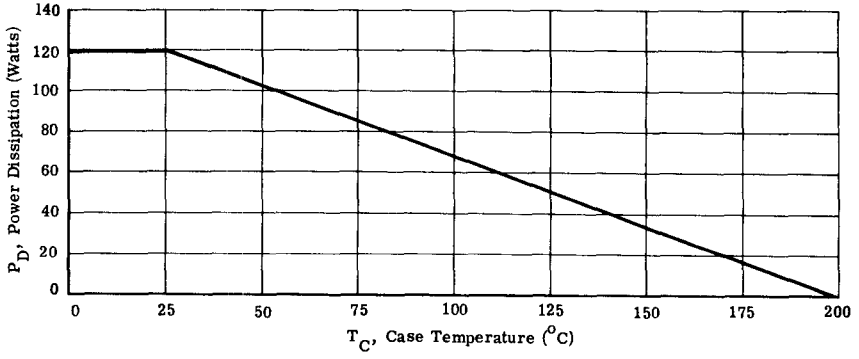
NPN silicon power transistors designed for switching and amplifier applications.

CASE 11
(TO-3)

MAXIMUM RATINGS

Characteristic	Symbol	MJ2801	MJ2802	Unit
Collector-Base Voltage	V_{CB}	50	70	Vdc
Collector-Emitter Voltage	V_{CE}	40	60	Vdc
Emitter-Base Voltage	V_{EB}	7		Vdc
Collector Current (Continuous)	I_C	10		Adc
Base Current (Continuous)	I_B	3		Adc
Power Dissipation	P_D	120	120	Watts
Junction Operating Temperature Range	T_J	-65°C to +200°C		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



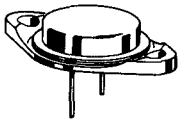
MJ2801, MJ2802 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Emitter Breakdown Voltage (I_C = 200 mAdc)	MJ2801 MJ2802	BV_{CEO}	40 60	- -	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{BE} = -1.5 Vdc) (V_{CE} = 70 Vdc, V_{BE} = -1.5 Vdc)	MJ2801 MJ2802	I_{CEX}	- -	10 -	mAdc
Collector Cutoff Current (V_{CB} = 50 Vdc) (V_{CB} = 70 Vdc) (V_{CB} = 30 Vdc, T_A = 150°C) (V_{CB} = 50 Vdc, T_A = 150°C)	MJ2801 MJ2802 MJ2801 MJ2802	I_{CBO}	- - - -	5.0 5.0 10 10	mAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc)	Both types	I_{EBO}	-	10	mAdc
DC Current Gain (I_C = 8 Adc, V_{CE} = 4 Vdc)	Both types	h_{FE}	15	60	-
Collector-Emitter Saturation Voltage (I_C = 8 Adc, I_B = 0.8 Adc)	Both types	$V_{CE(sat)}$	-	1.5	Vdc

MJ3010 (SILICON)
MJ3011

V_{CEO} = 200-325 V
I_C = 3.5 A
P_D = 100 W



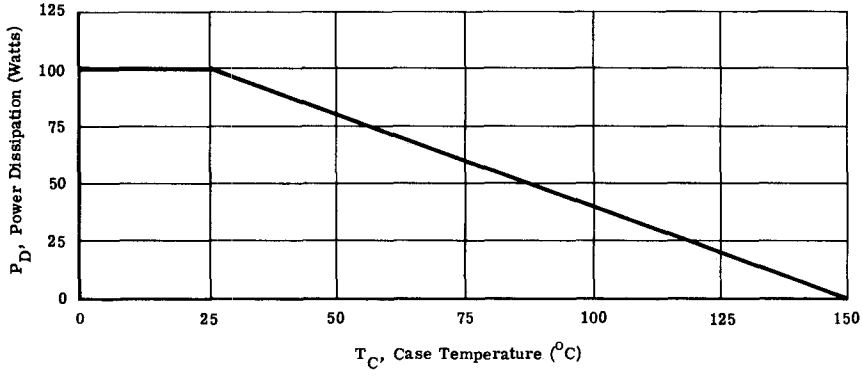
NPN power transistors designed for horizontal and vertical deflection amplifier circuits for TV. Also for high power line-operated audio outputs for radio, TV, phonographs and P.A. systems.

CASE 11
(TO-3)

MAXIMUM RATINGS

Characteristic	Symbol	MJ3010	MJ3011	Unit
Collector-Emitter Voltage	V_{CEO}	200	325	Vdc
Collector-Emitter Voltage	V_{CEX}	275	700	Vdc
Emitter-Base Voltage	V_{EB}	5	5	Vdc
Collector Current (Continuous)	I_C	3.5	3.5	Adc
Base Current (Continuous)	I_B	1.0	1.0	Adc
Power Dissipation @ T_C = 25°C	P_D	100	100	Watts
Junction Operating Temperature Range	T_J	-65°C to +150°C		°C

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MJ3010, MJ3011 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

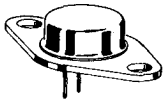
Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc)	MJ3010 MJ3011	BV_{CEO}	200 325	- -	Vdc
Collector Cutoff Current (V_{CE} = 250 Vdc, V_{EB} = 0) (V_{CE} = 700 Vdc, V_{EB} = 0)	 MJ3010 MJ3011	I_{CES}	 - -	 5 5	mAdc
Collector Cutoff Current (V_{CE} = 250 Vdc, V_{EB} = 1.5 Vdc, T_J = 100°C) (V_{CE} = 700 Vdc, V_{EB} = 1.5 Vdc, T_J = 100°C)	 MJ3010 MJ3011	I_{CEX}	 - -	 10 10	mAdc
Collector Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	Both types	I_{EBO}	-	5	mAdc
DC Current Gain (I_C = 0.5 Adc, V_{CE} = 5 Vdc) (I_C = 2.0 Adc, V_{CE} = 5 Vdc) (I_C = 2.5 Adc, V_{CE} = 5 Vdc)	 MJ3010 MJ3011 MJ3011	h_{FE}	 20 10 4	 180 - -	-

MJ3101 (SILICON)

For Specifications, See MJ2249 Data Sheet

MJ3201 (SILICON)
MJ3202

V_{CB} = 225-300 V
I_C = 100 mA
P_D = 4 W



CASE 80
(TO-66)

NPN power transistors designed for line-operated audio outputs for radio, TV, phonographs and P.A. systems.

MAXIMUM RATINGS

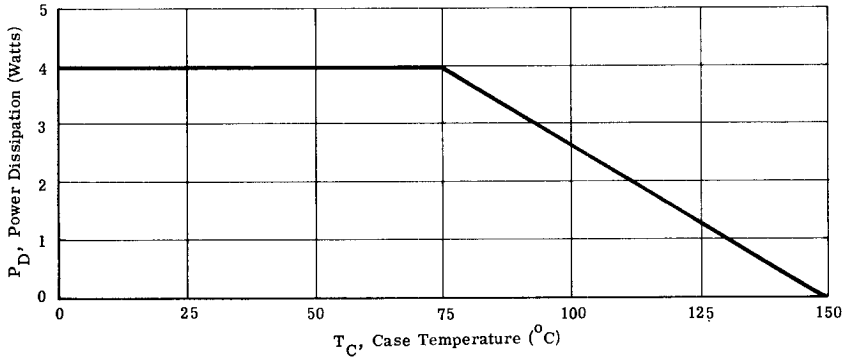
Characteristic	Symbol	MJ3201	MJ3202	Unit
Collector-Base Voltage	V_{CB}	225	300	Vdc
Collector-Emitter Voltage	V_{CE}	225	300	Vdc
Emitter-Base Voltage	V_{EB}	3	3	Vdc
Collector Current (Continuous)	I_C	100	100	Adc
Base Current (Continuous)	I_B	50	50	Adc
Power Dissipation	P_D	4	4	Watts
Junction Operating Temperature Range	T_J	-65^oC to $+150^oC$		^oC

MJ3201, MJ3202 (continued)

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	MJ3201 MJ3202	BV_{CEO}	225 300	- -	Vdc
Collector Cutoff Current (V_{CB} = 300 Vdc, I_C = 0) (V_{CB} = 225 Vdc, I_C = 0)		I_{CBO}	- -	100 100	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc)		I_{EBO}	-	100	μAdc
DC Current Gain (V_{CE} = 10 Vdc, I_C = 50 mAdc)		h_{FE}	30	150	-

FIGURE 1 — POWER-TEMPERATURE DERATING CURVE



MP500 thru MP502 (GERMANIUM)
MP500A thru MP502A, HI-REL
MP504 thru MP506
MP504A thru MP506A, HI-REL

$P_D = 170W$
$I_C = 60A$
$V_{CBO} = 45\text{-}75V$

CASE 7
(TO-36)



PNP germanium power transistors for high-gain, high-power amplifier and switching applications in high reliability industrial equipment.

MAXIMUM RATINGS

Characteristic	Symbol	MP500 MP504	MP501 MP505	MP502 MP506	Unit
Collector-Base Voltage	BV_{CBO}	45	60	75	Volts
Collector-Emitter Voltage	BV_{CES}	45	60	75	Volts
Collector-Emitter Voltage	BV_{CEO}	30	45	60	Volts
Emitter-Base Voltage	BV_{EBO}	25	30	40	Volts
Collector Current	I_C	60	60	60	Amps
Power Dissipation at T_C = 25°C	P_D	170	170	170	Watts
Junction Temperature Range	T_J	← -65 to +110 →			°C

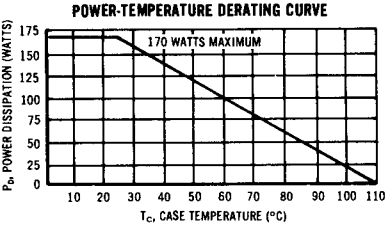
POWER DERATING

The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

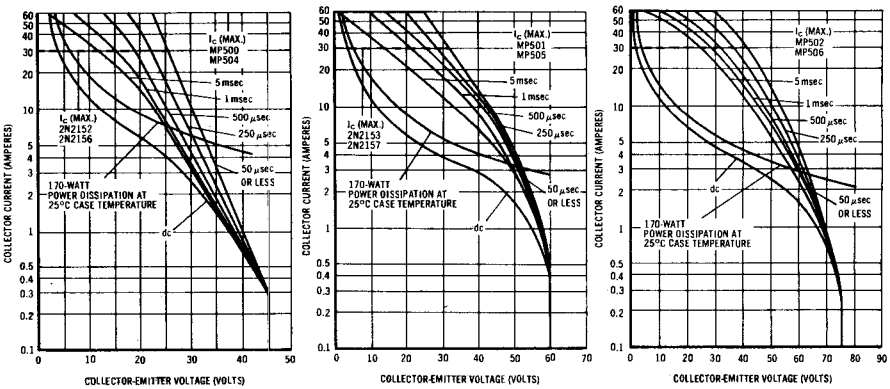
This curve has a value of 170 Watts at case temperatures of 25°C and is 0 Watts at 110°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{110° - T_C}{0.5}$$

POWER-TEMPERATURE DERATING CURVE



SAFE OPERATING AREA



The Safe Operating Area Curves indicate I_C — V_{CE} limits below which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Duty cycle of the excursions make no significant change in these safe areas.) To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

MP500 thru MP502, MP504 thru MP506 (continued)

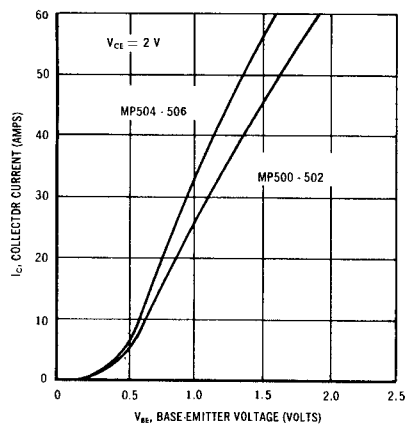
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics apply to corresponding "A" type numbers also.

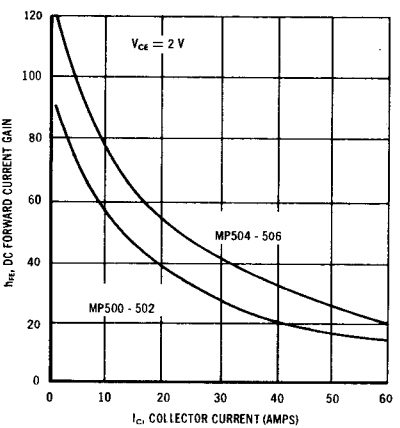
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current						mAdc
(V_{CB} = -45 V, I_E = 0)	MP500, MP504	I_{CBO1}	—	0.9	4.0	
(V_{CB} = -60 V, I_E = 0)	MP501, MP505		—	0.9	4.0	
(V_{CB} = -75 V, I_E = 0)	MP502, MP506		—	0.9	4.0	
Collector-Base Cutoff Current						mAdc
(V_{CB} = V_{CBmax}, I_E = 0, T_C = +71°C)	All Types	I_{CBO}	—	4.0	15	
Collector-Base Cutoff Current						μAdc
(V_{CB} = -2 V, I_E = 0)	All Types	I_{CBO}	—	80	200	
Emitter-Base Cutoff Current						mAdc
(V_{EB} = -25 V, I_C = 0)	MP500, MP504	I_{EBO}	—	0.2	4.0	
(V_{EB} = -30 V, I_C = 0)	MP501, MP505		—	0.2	4.0	
(V_{EB} = -40 V, I_C = 0)	MP502, MP506		—	0.2	4.0	
Emitter-Base Cutoff Current						mAdc
(V_{EB} = $V_{EB\,max}$, I_C = 0, T_C = +71°C)	All Types	I_{EBO}	—	2.7	15	
Collector-Emitter Breakdown Voltage						Vdc
(I_C = 300 mA, V_{EB} = 0)	MP500, MP504	BV_{CES}	-45	—	—	
	MP501, MP505		-60	—	—	
	MP502, MP506		-75	—	—	
Collector-Emitter Breakdown Voltage						Vdc
(I_C = 1.0 A, I_B = 0)	MP500, MP504	BV_{CEO}	-30	—	—	
	MP501, MP505		-45	—	—	
	MP502, MP506		-60	—	—	
Floating Potential						Vdc
(V_{CB} = 45 V, I_E = 0)	MP500, MP504	V_{EBF}	—	—	1.0	
(V_{CB} = 60 V, I_E = 0)	MP501, MP505		—	—	1.0	
(V_{CB} = 75 V, I_E = 0)	MP502, MP506		—	—	1.0	
DC Current Transfer Ratio						—
(I_C = 15 A, V_{CE} = 2 V)	MP500 through MP502	h_{FE1}	30	47	60	
	MP504 through MP506		50	63	100	
(I_C = 50 A, V_{CE} = 2 V)	All Types	h_{FE}	12	20	—	
Collector-Emitter Saturation Voltage						Vdc
(I_C = 15 A, I_B = 1 A)	All Types	$V_{CE(sat)}$	—	0.11	0.2	
(I_C = 50 A, I_B = 5 A)	All Types		—	0.2	0.45	
Base-Emitter Saturation Voltage						Vdc
(I_C = 15 A, I_B = 1 A)	All Types	$V_{BE(sat)}$	—	0.7	1.5	
(I_C = 50 A, I_B = 5 A)	All Types		—	2.0	2.5	
Common Emitter Cutoff Frequency						kc
(I_C = 15 A, V_{CE} = 2 V)	All Types	f_{ae}	2	3.6	—	

INPUT AND TRANSFER CHARACTERISTICS

COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

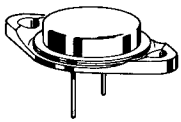


DC CURRENT GAIN versus COLLECTOR CURRENT



MP525 (GERMANIUM)

$P_D = 106W$
$I_C = 10A$
$V_{CE} = 60V$



CASE 3
(TO-3)

Germanium PNP power transistor designed for audio amplifier applications requiring gains of 30 – 150 at I_C = 3 amps.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

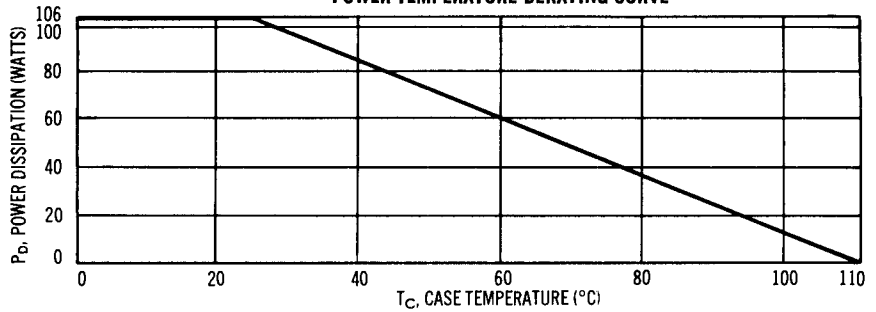
Characteristics	Symbol	MP525	Unit
Collector-Emitter Voltage	V_{CE}	60	Vdc
Collector Current (Continuous)	I_C	10	Adc
Junction Temperature Range	T_J	-65 to +110	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	 106 1.25	 Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	0.8	°C/W

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

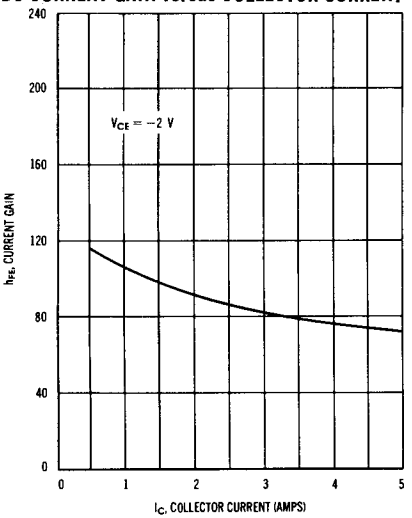
Characteristics	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 2 Vdc)	I_{CBO}	—	200	μA
Collector-Emitter Cutoff Current (V_{CE} = 30 Vdc, V_{EB} = 0) (V_{CE} = 60 Vdc, V_{BE} = 1.5 Vdc)	 I_{CES} I_{CEX}	 — —	 15 15	mA
Collector-Emitter Breakdown Voltage (I_C = 300 mA, R = 10 ohms)	BV_{CER}	35	—	Vdc
DC Current Gain (I_C = 3 Adc, V_{CE} = 2 Vdc) (See Note)	h_{FE}	30	150	—

MP525 (continued)

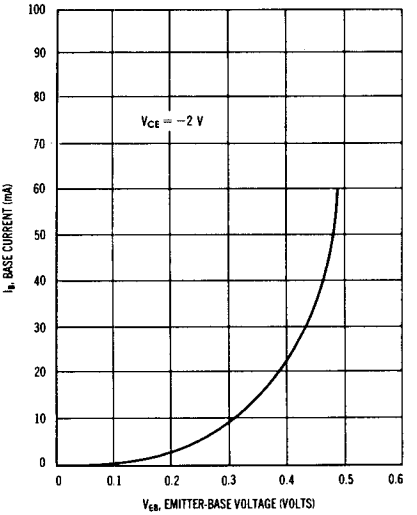
POWER-TEMPERATURE DERATING CURVE



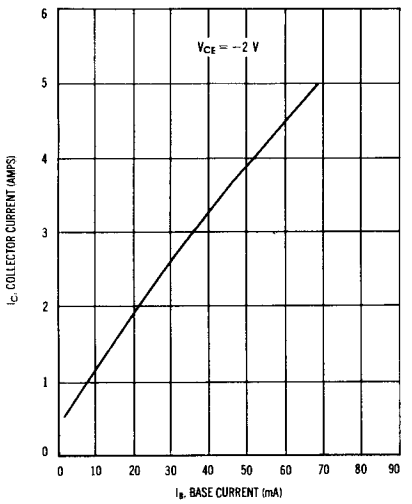
DC CURRENT GAIN versus COLLECTOR CURRENT



BASE CURRENT versus EMITTER BASE VOLTAGE



COLLECTOR CURRENT versus BASE CURRENT



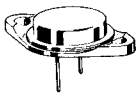
NOTE: upon customer's request the transistors will be numerically coded to identify matched pairs. The dc current transfer ratios are sorted into approximately 1:1.5 ranges. Any two devices within a bracket constitute a matched pair. No guarantee is made of gain distribution.

I_C = 3 Adc, V_{CE} = 2 Vdc

	h_{FE}	
Bracket	Min	Max
-1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150

MP1612, A, B (GERMANIUM)

$P_D = 85$ W
$I_C = 20$ A
$V_{CB} = 100\text{-}160$ V



CASE 3
(TO-3)

High-current, germanium PNP power transistor developed specially for high-speed, high-frequency, applications such as television horizontal deflection circuits.

MAXIMUM RATINGS

Characteristic	Symbol	MP1612	MP1612A	MP1612B	Unit
Collector-Base Voltage	V_{CB}	100	140	160	Volts
Collector-Emitter Voltage	V_{CEO}	50	75	100	Volts
Emitter-Base Voltage	V_{EB}	2.5	2.5	2.5	Volts
Collector Current (Continuous)	I_C	20	20	20	Amps
Base Current (Continuous)	I_B	5	5	5	Amps
Power Dissipation	P_D	85	85	85	Watts
Operating Junction Temperature Range	T_J	-65 to +110			^oC

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			mA
(V_{CB} = 80 V, I_E = 0)	MP1612		—	10	
(V_{CB} = 120 V, I_E = 0)	MP1612A		—	10	
(V_{CB} = 140 V, I_E = 0)	MP1612B		—	10	
Collector-Emitter Current		I_{CES}			mA
(V_{CE} = 100 V, V_{BE} = 0)	MP1612		—	20	
(V_{CE} = 140 V, V_{BE} = 0)	MP1612A		—	20	
(V_{CE} = 160 V, V_{BE} = 0)	MP1612B		—	20	
Collector-Emitter Cutoff Current		I_{CEX}			mA
(V_{CE} = 50 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612		—	40	
(V_{CE} = 75 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612A		—	40	
(V_{CE} = 100 V, V_{BE} = 0.2 V, T_C = +85°C)	MP1612B		—	40	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 50 mAdc, I_C = 0)			2.5	—	
Collector-Emitter Sustaining Voltage		$BV_{CEO(sus)}$			Volts
(I_E = 100 mA, I_B = 0)	MP1612		50	—	
	MP1612A		75	—	
	MP1612B		100	—	
DC Current Gain		h_{FE}			—
(I_C = 5.0 A, V_{CB} = 2 V)			40	—	
(I_C = 10 A, V_{CB} = 2 V)			25	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$			Vdc
(I_C = 10 Adc, I_B = 1.0 Adc)			—	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			—	0.5	
Fall Time (Figure 5)		t_f			μsec
(I_C = 5 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.25	
(I_C = 10 Adc, I_{B1} = 0.5 Adc, I_{B2} = 1.0 Adc)			—	1.5	

MP1612, A, B (continued)

SAFE OPERATING AREAS

FIGURE 1 — MP1612

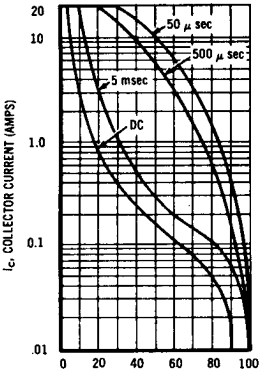


FIGURE 2 — MP1612A

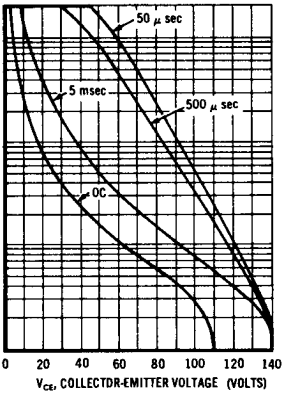
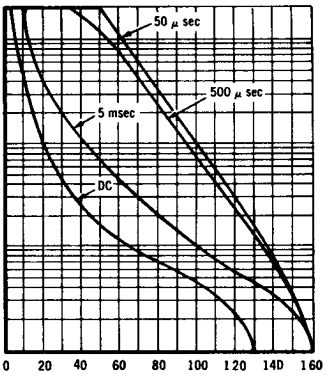
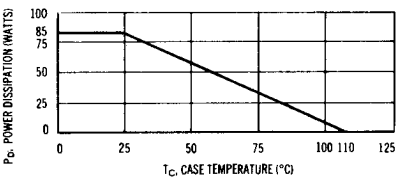


FIGURE 3 — MP1612B



The Safe Operating Area Curves indicate the I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As secondary breakdown is independent of temperature and duty cycle, these curves can be used as long as the average power derating durve (Figure 4) is also taken into consideration to insure operation below the maximum junction temperature.

FIGURE 4 — POWER — TEMPERATURE DERATING CURVE



THESE TRANSISTORS ARE ALSO SUBJECT TO SAFE AREA CURVES AS INDICATED BY FIGURES 1, 2, 3.

FIGURE 5 — FALL TIME TEST CIRCUIT

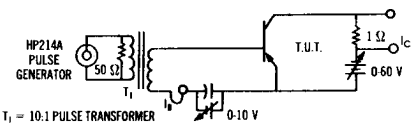
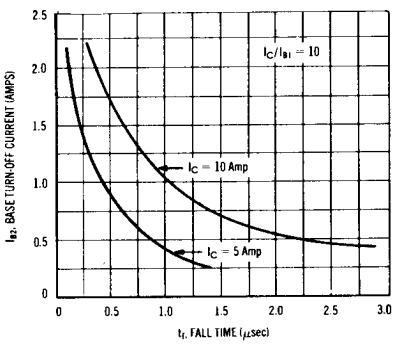
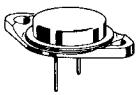


FIGURE 6 — BASE TURN-OFF CURRENT versus FALL TIME



MP1613 (GERMANIUM)

$P_D = 85$ W
$I_C = 7$ A
$V_{CEO} = 75$ V



CASE 3
(TO-3)

Medium-current germanium PNP power transistor, designed for use in 12 Volt vertical deflection circuits in television receivers; features: high-breakdown voltage, low leakage current, and low saturation voltage.

MAXIMUM RATINGS

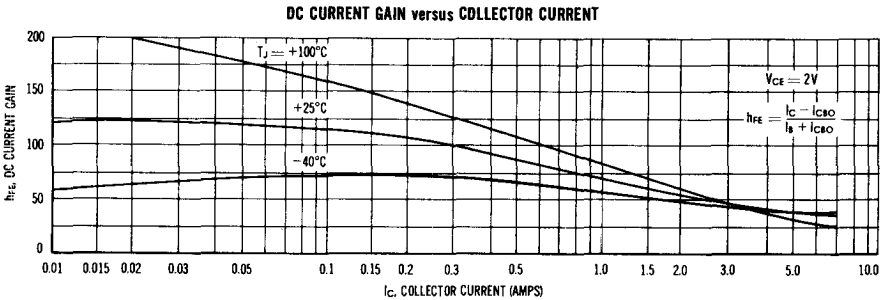
Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CES}	90	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	75	Vdc
Collector-Base Voltage	V_{CB}	100	Vdc
Emitter-Base Voltage	V_{EB}	50	Vdc
Collector Current (Continuous)	I_C	7	Adc
Peak Collector Current (PW ≤ 5 msec)	I_C	15	Adc
Base Current (Continuous)	I_B	2	Adc
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +110	°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	85 1	Watts W/°C
Thermal Resistance, Junction to Case	θ_{JC}	1.0	°C/W

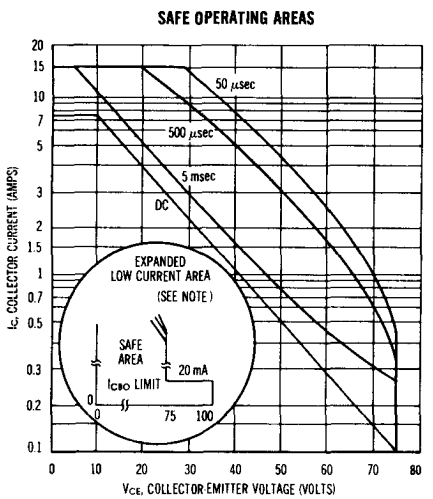
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

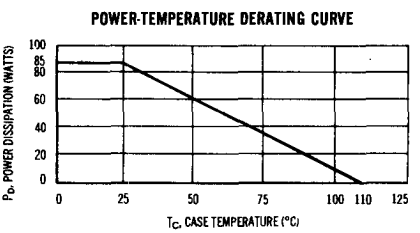
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	BV_{CES}*	90	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 300 mAdc)	BV_{CEO}*	75	—	—	Vdc
Collector-Emitter Leakage Current (V_{CE} = 37.5 V)	I_{CEO}	—	—	30	mAdc
Collector-Emitter Leakage Current (V_{CE} = 90 V, V_{BE} = 1.0 Vdc, T_C = +100°C)	I_{CEX}	—	—	10	mAdc
Collector-Base Cutoff Current (V_{CB} = 2 Vdc) (V_{CB} = V_{CB} max)	I_{CBO}	— —	— —	.060 5.0	mAdc
Emitter-Base Cutoff Current (V_{EB} = 12 Vdc)	I_{EBO}	—	—	100	μAdc
Collector-Emitter Saturation Voltage (I_C = 3 Adc, I_B = 300 mAdc)	$V_{CE(sat)}$	—	—	0.25	Vdc
DC Current Gain (I_C = 50 mAdc, V_{CE} = 2 Vdc) (I_C = 1 Adc, V_{CE} = 2 Vdc)	h_{FE}	— 40	120 70	200 —	—

*Sweep Test: 1/2 sine wave, 60 cps

MP1613 (continued)



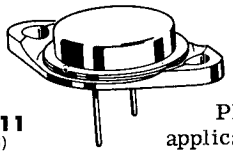




NOTE: The Safe Operating Area Curves indicate I_C - V_{CE} limits which the device will not go into secondary breakdown. Collector load lines for specific circuits must fall within the applicable Safe Area to avoid causing a collector-emitter short. (Case temperature and duty cycle of the excursions make no significant change in these safe areas.) The load line may exceed the BV_{CES} voltage only if the collector current has been reduced to 20 mA or less before or at the BV_{CES} limit; than and only then may the load line be extended to the absolute maximum voltage rating of BV_{CBO}. To insure operation below the maximum T_J, the power-temperature derating curve must be observed for both steady state and pulse power conditions.

MP2060 thru MP2063 (GERMANIUM)

$P_D = 85$ W
$I_C = 7$ A
$V_{CBO} = 40$-90 V

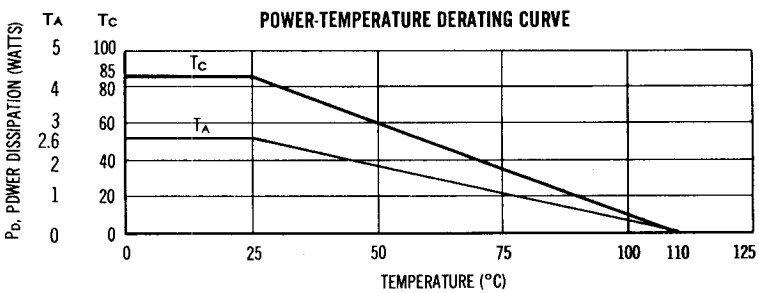


CASE 11
(TO-3)

PNP germanium power transistors for audio amplifier applications.

MAXIMUM RATINGS

Characteristics	Symbol	MP2060	MP2061	MP2062	MP2063	Unit
Collector-Emitter Voltage	V_{CES}	30	45	60	75	Vdc
Collector-Emitter Voltage (Open Base)	V_{CEO}	25	35	50	60	Vdc
Collector-Base Voltage	V_{CBO}	40	60	75	90	Vdc
Emitter-Base Voltage	V_{EBO}	← 20 →				Vdc
Collector Current (Continuous)	I_C	← 7 →				Adc
Peak Collector Current (PW ≦ 5 msec)	I_C	← 15 →				Adc
Base Current (Continuous)	I_B	← 2 →				Adc
Storage Temperature	T_{stg}	← -65 to +110 →				°C
Operating Case Temperature	T_C	← - 65 to +110 →				°C
Total Device Dissipation @T_C = 25°C Derate above 25°C	P_D	← 85 → ← 1 →				Watts W/°C
Thermal Resistance Junction to Case	θ_{JC}	1.0				°C/W
Thermal Resistance Case to Ambient	θ_{CA}	32.7				°C/W



MP2060 thru MP2063 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
DC Forward Current Gain (Note 1) (I_C = 3 Adc, V_{CE} = 2 Vdc)	All Types	h_{FE}	30	—	200	—
Current Gain-Bandwidth Product (I_C = 0.5 Adc, V_{CE} = 12 Vdc)	All Types	f_T	—	600	—	kc
Collector-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)	All Types	$V_{CE(sat)}$	—	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 3.0 Adc, I_B = 0.3 Adc)	All Types	$V_{BE(sat)}$	—	—	0.70	Vdc
DC Transconductance (I_C = 3.0 Adc, V_{CE} = 2 Vdc)	All Types	g_{FE}	3.0	—	—	mhos
Collector-Emitter Breakdown Voltage* (I_C = 250 mAdc)	MP2060	BV_{CES}*	30	—	—	Vdc
	MP2061		45	—	—	
	MP2062		60	—	—	
	MP2063		75	—	—	
Collector-Emitter Sustaining Voltage* (I_C = 500 mAdc)	MP2060	$BV_{CEO(sus)}$*	25	—	—	Vdc
	MP2061		35	—	—	
	MP2062		40	—	—	
	MP2063		60	—	—	
Collector-Base Breakdown Voltage (I_C = 20 mAdc)	MP2060	BV_{CBO}	40	—	—	Vdc
	MP2061		60	—	—	
	MP2062		75	—	—	
	MP2063		90	—	—	
Collector-Base Cutoff Current		I_{CBO}				mAdc
(V_{CB} = 2 Vdc)	All Types		—	—	0.060	
(V_{CB} = 25 Vdc)	MP2060		—	—	1.0	
(V_{CB} = 35 Vdc)	MP2061		—	—	1.0	
(V_{CB} = 40 Vdc)	MP2062		—	—	1.0	
(V_{CB} = 60 Vdc)	MP2063		—	—	1.0	
Collector-Emitter Cutoff Current		I_{CEX}				mAdc
(V_{CE} = 30 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2060		—	—	10	
(V_{CE} = 45 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2061		—	—	10	
(V_{CE} = 60 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2062		—	—	10	
(V_{CE} = 75 Vdc, $V_{BE(off)}$ = 1 Vdc, T_C = 100°C)	MP2063		—	—	10	
Emitter-Base Cutoff Current (V_{BE} = 20 Vdc)	All Types	I_{EBO}	—	—	1.0	mAdc
Input Impedance (I_C = -500 mAdc, V_{CE} = -12 Vdc, i_b = 1 mAdc, f = 1 kc)		h_{ie}	—	25	—	ohms
Distortion (I_C = -500 mAdc, V_{CE} = -12 Vdc, R_S = 30 ohms, R_L = 25 ohms, R_E (unbypassed) = 0.33 ohm, P_{out} = 2 watts)		η	—	3	—	%

*Sweep Test: 1/2 sine wave, 60 cps

Note 1:

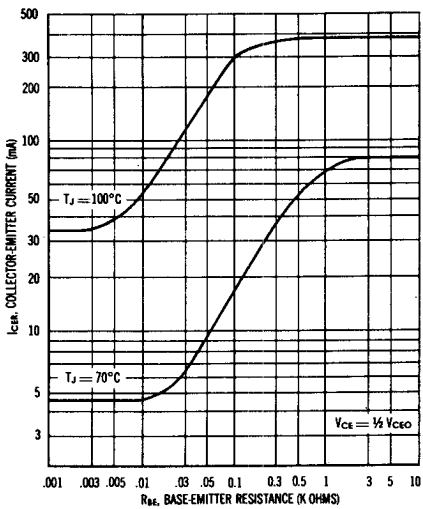
Upon customer's request the transistors will be numerically coded to identify matched pairs. The DC current transfer ratios are sorted into approximately 1:1.5 ranges. Any two devices within a bracket constitute a matched pair. No guarantee is made of gain distribution.

I_C = 3 Adc, V_{CE} = 2 Vdc

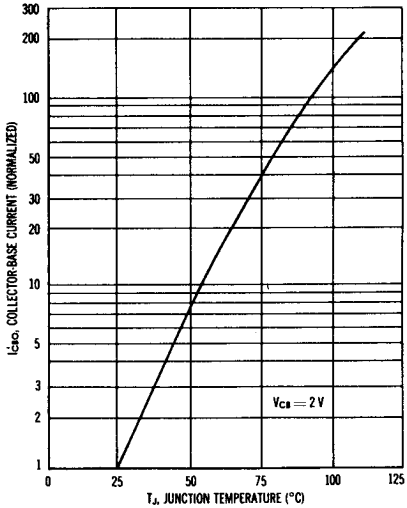
	h_{FE} Min.	h_{FE} Max.
Appropriate MP# -1	30	45
-2	40	60
-3	50	75
-4	60	90
-5	80	120
-6	100	150
-7	130	200

MP2060 thru MP2063 (continued)

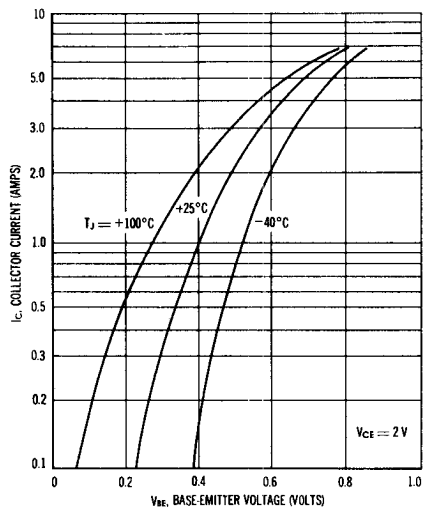
COLLECTOR-EMITTER CURRENT versus BASE-EMITTER RESISTANCE



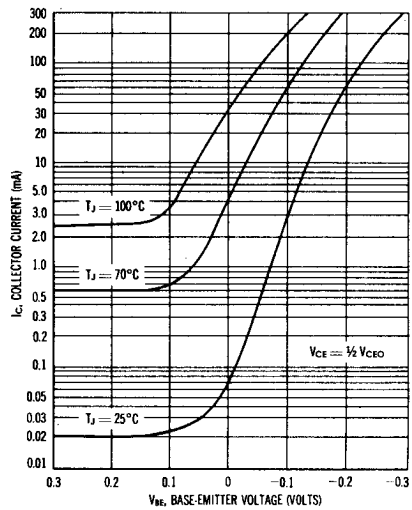
NORMALIZED COLLECTOR-BASE CURRENT



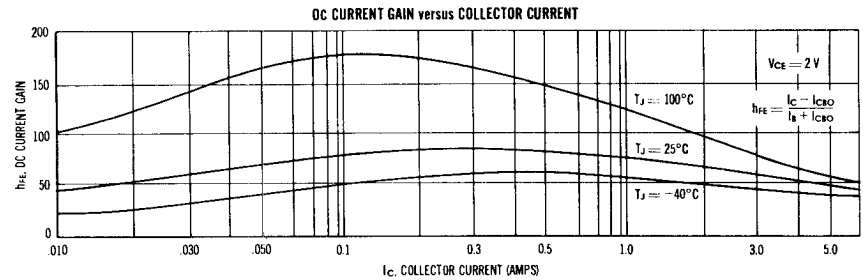
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE



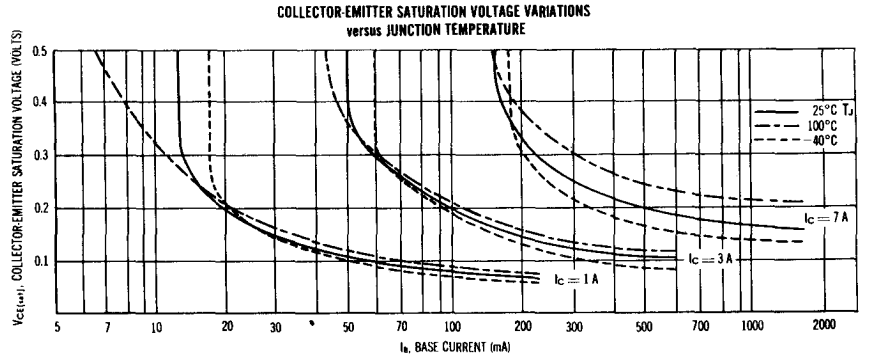
COLLECTOR CURRENT versus BASE-EMITTER VOLTAGE

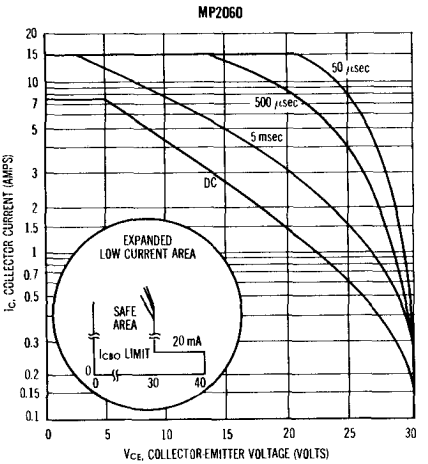


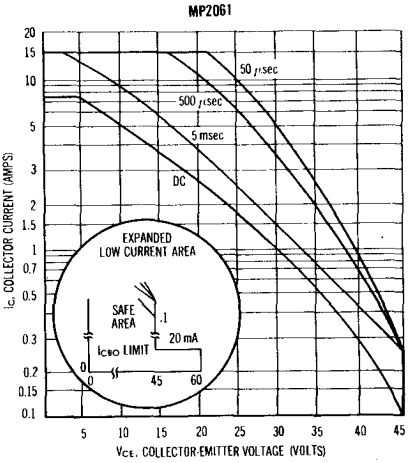
DC CURRENT GAIN versus COLLECTOR CURRENT

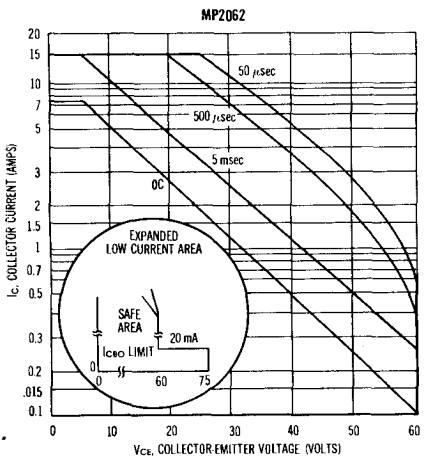


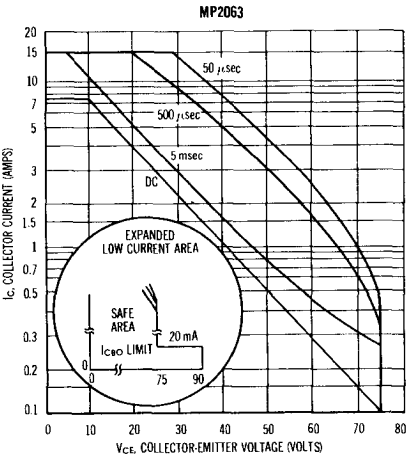
MP2060 thru MP2063 (continued)











ADDITIONS AND MODIFICATIONS

GERMANIUM MILLIWATT TRANSISTORS

The following table lists a number of semiconductor devices that comply with the terms of military specifications, the applicable military specifications and the appropriate page in the data sections of this manual. For additional information, military-type data sheets are available.

MILLIWATT TRANSISTORS

JAN 2N331	MIL-S-19500/4C	7-8
JAN 2N398	MIL-S-19500/174A	7-12
USAF 2N461	MIL-T-19500/45	7-14
USA 2N465	MIL-T-19500/50A	7-15
JAN 2N466	MIL-S-19500/51D	7-15
USA 2N467	MIL-T-19500/52B	7-15
JAN 2N526	MIL-S-19500/60D	7-17
USN 2N650A thru USN 652A	MIL-S-19500/175B	7-20
USA 2N1008B	MIL-S-19500/196A	7-24

For case outline dimensions, see page 1-186.

GERMANIUM MILLIWATT TRANSISTORS

This line of low-frequency, low-power transistors consists of a wide selection of highly reliable germanium PNP devices designed for general purpose switching, amplifier, and control applications.

The line is generally characterized by devices having a power rating to 225 mW, a maximum operating temperature range from -65°C to +100°C, and a typical cutoff frequency ($f_{\alpha b}$) to 8 Mc.

QUICK SELECTION GUIDE — FOR AMPLIFIER / OSCILLATOR AND SWITCHING APPLICATIONS TO 20 KILOCYCLES

The following transistors merit first consideration within the specified gain-voltage groups. All of the specified devices have collector power dissipation ratings (P_C) of 150-225 mW, and a maximum operating junction temperature of 100°C.

MINIMUM DC CURRENT GAIN (h_{FE})	TRANSISTOR VOLTAGE RATING; V_{CER} (R = 10K)			
	12-24	25-39	40-49	50-60
20	—	2N524	MA910 ③	2N2042
30	2N322	2N525 2N1191 ①	2N1924 2N1186	—
40	2N323 2N1008 ① ②	2N526 2N1192 ①	2N1008A ① ② 2N1925	2N1008B ① ② 2N2043
60	2N324 2N1705	2N527 2N1175	2N1926	—
90	2N467 2N508 MA1706	2N1193 ① 2N2171 2N3427	2N1188	—
130	MA1707	2N3428	—	—
180	MA1708	2N1194 ① MA1702		—

① Small Signal Current Gain h_{fe} ② V_{CEO} ③ V_{CES}

COMPLETE NUMERICAL-ALPHABETICAL LISTING

Type	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS					MILITARY and Hi-Rel Type
						h_{FE} @ V_{CE} & Ic				f_{ab}	
	P_C mW	T_J °C	V_{CBO} volts	V_{CER} (R = 10 K) volts	Ic mA	min	max	volts	mA	typ mc	
2N319	225	100	—	20	500	25	42	1	20	1.0 ⑤	
2N320	225	100	—	20	500	34	65	1	20	1.5 ⑤	
2N321	225	100	—	20	500	53	121	1	20	2.0 ⑤	
2N322	225	100	—	18	500	34	65	1	20	1.0 ⑤	
2N323	225	100	—	18	500	53	121	1	20	1.5 ⑤	
2N324	225	100	—	18	500	72	198	1	20	2.0 ⑤	
2N331	200	100	30	V_{EB} = 12	200	30	70	6	1	1.5	JAN 2N331
2N381	225	100	50	25	400	35	65	1	20	3	
2N382	225	100	50	25	400	60	95	1	20	4	
2N383	225	100	50	25	400	75	120	1	20	5	
2N398	50	85	105	V_{pt} = 105	100	20	—	0.35	5	1.0	USN 2N398
2N398A	150	100	105	V_{pt} = 105	200	20		0.35	5	1.0	
2N460	225	100	45	35 ⑦	400	31	200	6	1 ②	4	
2N461	225	100	45	35 ⑦	400	0.94 h_{fb}	0.972	6	1 ②	1.2	USAF 2N461
2N464	200	100	45	40	100	14	—	6	1	1.0	
2N465	200	100	45	30	100	27	—	6	1	1.5	USA 2N465
2N466	200	100	35	20	100	56	—	6	1	2.0	JAN 2N466
2N467	200	100	35	15	100	112	—	6	1	2.5	USA 2N467
2N508	225	100	—	18	500	99	198	1	20	2.5 ⑤	
2N524	225	100	—	30	500	25	42	1	20	0.8 ⑤	2N524A ①
2N525	225	100	—	30	500	34	65	1	20	1.0 ⑤	2N525A ①
2N526	225	100	—	30	500	53	90	1	20	1.3 ⑤	JAN 2N526 2N526A ①
2N527	225	100	—	30	500	72	121	1	20	1.5 ⑤	2N527A ①
2N650	200	100	45	30	500	30	70	6	1	1.5	2N650A ① USN 2N650A
2N651	200	100	45	30	500	50	120	6	1	2.0	2N651A ① USN 2N651A
2N652	200	100	45	30	500	100	225	6	1	2.5	2N652A ① USN 2N652A
2N653	200	100	30	25	250	30	70	6	1	1.5	
2N654	200	100	30	25	250	50	125	6	1	2.0	
2N655	200	100	30	25	250	100	250	6	1	2.5	
2N1008	200	100	20	20 ⑥	300	40 h_{fe}	150	5	10	—	
2N1008A	200	100	40	40 ⑥	300	40 h_{fe}	150	5	10	—	
2N1008B	200	100	60	60 ⑥	300	40 h_{fe}	150	5	10	—	
2N1175	225	100	—	25	500	70	140	1	20	1.5 ⑤	
2N1185	200	100	45	30	500	190	400	6	1	3.0	
2N1186	200	100	60	45	500	30	70	6	1	1.5	
2N1187	200	100	60	45	500	50	120	6	1	2.0	
2N1188	200	100	60	45	500	100	225	6	1	2.5	
2N1189	200	100	45	30	500	60	—	1	10 ②	3.5	
2N1190	200	100	45	30	500	100	—	1	10 ②	4.5	
2N1191	200	100	40	25	200	30	70	6	1	1.5	
2N1192	200	100	40	25	200	50	125	6	1	2.0	

NUMERICAL-ALPHABETICAL LISTING (continued)

Type	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS					MILITARY and Hi-Rel Type
						h_{FE} @ V_{CE} & I_C				f_{ab}	
	P_C mW	T_J °C	V_{CBO} volts	V_{CER} (R = 10K) volts	I_C mA	min	max	volts	mA	typ mc	
2N1193	200	100	40	25	200	100	250	6	1	2.5	
2N1194	200	100	40	25	200	190	500	6	1	3.0	
2N1408	150	100	50	50 ④	200	10	—	1	1③	—	
2N1413	225	100	35	25	500	23	65	1	20	0.8 ⑤	
2N1415	225	100	—	25	500	53	—	1	20	1.3 ⑤	
2N1705	200	100	18	12	400	70 h_{fe}	150	6	1	4 5	
2N1706	200	100	25	18	400	50 h_{fe}	150	5	10	3 5	
2N1707	200	100	30	25	400	30 h_{fe}	150	5	10	3 5	
2N1924	225	100	—	40	500	34	65	1	20	1.0 ⑤	
2N1925	225	100	—	40	500	53	90	1	20	1.3 ⑤	
2N1926	225	100	—	40	500	72	121	1	20	1.5 ⑤	
2N2042	200	100	105	55	200	20	50	0.35	5	0.5 ⑤	2N2042A ①
2N2043	200	100	105	55	200	40	100	0.35	5	0.75 ⑤	2N2043A ①
2N2171	225	100	50	25	400	110	250	1.0	20	7.5	
2N3427	200	100	45	30	500	100	350	1	100	6.0	
2N3428	200	100	45	30	500	150	400	1	100	8.0	
MA112	175	85	15	—	200	30 h_{fe}	70	6	1	—	
MA113	175	85	15	—	200	50 h_{fe}	125	6	1	—	
MA114	175	85	15	—	200	100 h_{fe}	250	6	1	—	
MA115	175	85	15	—	200	30 h_{fe}	125	6	1	—	
MA116	175	85	15	—	200	50 h_{fe}	250	6	1	—	
MA117	175	85	15	—	200	30 h_{fe}	250	6	1	—	
MA286	175	85	10	—	200	14 h_{fe}	40	6	1	—	
MA287	175	85	10	—	200	30 h_{fe}	250	6	1	—	
MA288	175	85	10	—	200	180 h_{fe}	—	6	1	—	
MA881	200	100	60	60 ④	500	30	—	1	10	0.75⑤	
MA882	200	100	60	60 ④	500	40	—	1	10	1.0 ⑤	
MA883	200	100	60	60 ④	500	75	—	1	10	1.25⑤	
MA884	200	100	60	60 ④	500	125	—	1	10	1.75⑤	
MA885	200	100	50	50 ④	500	15 h_{fe}	40	6	1	0.75⑤	
MA886	200	100	50	50 ④	500	30 h_{fe}	70	6	1	0.75⑤	
MA887	200	100	50	50 ④	500	50 h_{fe}	120	6	1	1.25⑤	
MA888	200	100	50	50 ④	500	100 h_{fe}	225	6	1	0.5 ⑤	
MA889	200	100	50	50 ④	500	190 h_{fe}	400	6	1	—	
MA909	150	100	75	35 ④	200	20	—	0.35	5	—	
MA910	150	100	90	45 ④	200	20	—	0.35	5	—	
MA1702	200	100	45	30	500	200	—	1	100	7.0 min	
MA1703	200	100	25	25	500	100	350	1	100	3.0 min	
MA1704	200	100	25	25	500	150	400	1	100	5.0 min	
MA1705	200	100	25	25	500	200	—	1	100	6.0 min	
MA1706	200	100	15	15	500	100	350	1	100	3.0 min	
MA1707	200	100	15	15	500	150	400	1	100	4.0 min	
MA1708	200	100	15	15	500	200	—	1	100	5.0 min	

① Hi-Rel ② I_E ③ I_B ④ BV_{CES} ⑤ Minimum ⑥ V_{CEO} ⑦ R_{BE} = 1K

2N319 thru 2N321

V_{CBO} = 25 V
h_{FE} — to 53-121 (min-max)
$f\alpha_b$ — to 2.0 MC

CASE 31
(TO-5)



Base connected to case

PNP germanium transistor for audio amplifier and low-frequency switching applications.

MAXIMUM RATINGS

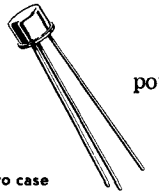
Characteristic	Symbol	Maximum	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Free Air	P_D	225	mW

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector Cutoff Current V_{CB} = -25 Vdc, I_E = 0	I_{CBO}	-	16	μAdc
Emitter Cutoff Current V_{EB} = -15 Vdc, I_C = 0	I_{EBO}	-	10	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	20	-	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N319		25	42	-
2N320		34	65	-
2N321		53	121	-
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N319		23	-	-
2N320		30	-	-
2N321		47	-	-
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 Mc	C_{ob}	-	35	pf
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc	$f_{\alpha b}$			
2N319		1.0	-	Mc
2N320		1.5	-	Mc
2N321		2.0	-	Mc

2N322 thru 2N324
2N508

V_{CBO} = 18 V
h_{FE} -to 99-198 (min-max)
$f\alpha_b$ - to 2.5 MC



CASE 31
(TO-5)
Base connected to case

PNP germanium transistors for audio driver and low-power output service in entertainment equipment.

MAXIMUM RATINGS

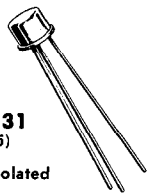
Characteristic	Symbol	Maximum	Unit
Collector-Base Voltage	V_{CBO}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to + 100	°C
Power Dissipation at 25°C Free Air	P_D	225	mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector Cutoff Current V_{CB} = -16 Vdc, I_E = 0	I_{CBO}	—	16	μAdc
Emitter Cutoff Current V_{EB} = -3 Vdc, I_C = 0	I_{EBO}	—	16	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 5 K	BV_{CER}	18	—	Vdc
DC Current Gain V_{CE} = -1 Vdc, I_C = 20 mAdc	h_{FE}			
2N322		34	65	—
2N323		53	121	—
2N324		72	198	—
2N508		99	198	—
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}	180	320	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 Mc	C_{ob}	—	35	pf
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc	f_{ab}			
2N322		1.0	—	Mc
2N323		1.5	—	Mc
2N324		2.0	—	Mc
2N508		2.5	—	Mc

2N331
2N331 JAN

V_{CBO} = 30 V
h_{fe} = 30-70 (min-max)
$f_{\alpha b}$ - to 1.5 MC



CASE 31
(TO-5)
All leads isolated

PNP germanium transistor for audio range amplifier and switching service in military equipment. Have collector dissipation and storage temperature ratings significantly higher than those of the military specification (see maximum ratings table below).

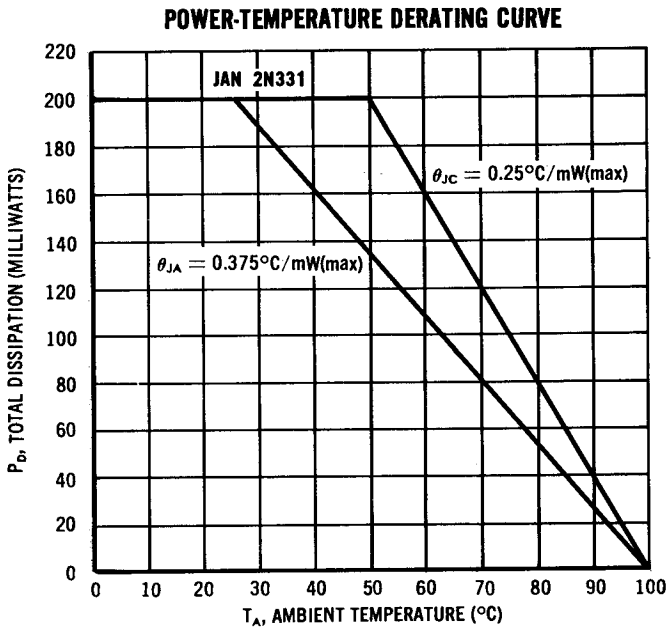
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-30	Volts
Emitter-Base Voltage	V_{EBO}	-12	Volts
Storage Temperature (MIL-S-19500/4C)	T_{stg}	-65 to + 85	°C
Storage Temperature (JAN 2N331)	T_{stg}	-65 to + 100	°C
Collector Dissipation at T_A = 25°C (MIL-S-19500/4C (Derate 1.25 mW/°C above 25°C)	P_D	75	mW
Collector Dissipation at T_A = 25°C (JAN 2N331) (Derate 2.67 mW/°C above 25°C)	P_D	200	mW

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Emitter Cutoff Current (V_{EB} = -12 Vdc, I_C = 0)	I_{EBO}	—	-10	μAdc
Collector Cutoff Current (V_{CB} = -30 Vdc, I_E = 0)	I_{CBO}	—	-10	μAdc
Small-Signal Open-Circuit Output Admittance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 ke)	h_{ob}	—	1	μmho
Small-Signal Short-Circuit Input Impedance (V_{CB} = -6 Vdc, I_E = 1.0 mAdc, f = 1 kc)	h_{ib}	—	50	Ohms
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = -6 Vdc, I_C = 1.0 mAdc, f = 1 kc)	h_{fe}	30	70	—
Small-Signal Short-Circuit Forward-Current Transfer Ratio Cutoff Frequency (V_{CB} = -6 Vdc, I_E = 1 mAdc)	f_{hfb}	0.4	—	mc
Output Capacitance (V_{CB} = -6 Vdc, I_E = 1 mAdc)	C_{ob}	—	50	pf
Noise Figure (V_{CB} = -6 Vdc, I_E = 1 mAdc, R_S = 1000, ohms, f = 1 kc, f=Δ1 cps)	NF	—	20	db

2N331 (continued)



2N381 thru 2N383
2N2171

V_{CBO} = 50 V
h_{FE} — to 110-250 (min-max)
$f\alpha_b$ — to 7.5 MC



CASE 31
(TO-5)

Base connected to case

PNP germanium transistors for small-signal audio amplifiers, Class B push-pull output stages and medium-speed switching circuits.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	50	Volts
Collector-Emitter Voltage (R_{BE} = 10K)	V_{CER}	25	Volts
Emitter-Base Voltage	V_{EBO}	20	Volts
Collector Current	I_C	400	mA
Junction Temperature	T_J	-65 to +100	°C
Collector Dissipation	P_D		
T_A = 25°C		225	mW
derate		3	mW/°C
T_C = 25°C		500	mW
derate		6.7	mW/°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current (V_{CB} = -25 Vdc)		I_{CBO}	- - -	6	10	μ Adc
Emitter-Base cutoff Current (V_{EB} = -20 Vdc)		I_{EBO}	- - -	5	10	μ Adc
Collector-Emitter Voltage (I_C = 500 μAdc, R_{BE} = 10K)		BV_{CER}	25	- - -	- - -	Vdc
Collector-Emitter Voltage (I_C = 50 μAdc, V_{BE} = 1.0 Vdc)	2N381	BV_{CER}	- - -	50	- - -	Vdc
	2N382, 2N383, 2N2171		- - -	45	- - -	
DC Current Gain		h_{FE}				- - -
(I_C = 20 mAdc, V_{CE} = -1.0 Vdc)	2N381		35	- - -	65	
	2N382		60	- - -	95	
	2N383		75	- - -	120	
	2N2171		110	- - -	250	
(I_C = 100 mAdc, V_{CE} = -1.0 Vdc)	2N381		30	- - -	- - -	
	2N382		50	- - -	- - -	
	2N383		65	- - -	- - -	
	2N2171		90	- - -	- - -	

2N381 thru 2N383
2N2171 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Small Signal Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kc)		h_{fe}				- - -
	2N381		35	60	85	
	2N382		70	90	135	
	2N383		90	115	155	
	2N2171		120	210	310	
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = -5 V, f = 1 kc)		h_{re}				$X10^{-3}$
	2N381		- - -	0.66	- - -	
	2N382		- - -	0.69	- - -	
	2N383		- - -	0.72	- - -	
	2N2171		- - -	0.75	- - -	
Input Impedance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kc)		h_{ie}				ohms
	2N381		- - -	300	- - -	
	2N382		- - -	450	- - -	
	2N382		- - -	550	- - -	
	2N2171		- - -	850	- - -	
Output Admittance (I_C = 10 mA, V_{CE} = -5.0 V, f = 1 kc)		h_{oe}				μmhos
	2N381		- - -	420	- - -	
	2N382		- - -	400	- - -	
	2N383		- - -	380	- - -	
	2N2171		- - -	500	- - -	
Transducer Gain		G_T				db
(R_g = 300 Ω , R_L = 500 Ω)	2N381		- - -	36	- - -	
(R_g = 450 Ω , R_L = 500 Ω)	2N382		- - -	38	- - -	
(R_g = 550 Ω , R_L = 500 Ω)	2N383		- - -	39.5	- - -	
(R_g = 785 Ω , R_L = 500 Ω)	2N2171		- - -	42.5	- - -	
Output Capacitance (I_C = 1 mA, V_{CB} = -6V)		C_{ob}	- - -	20	- - -	pf
Noise Figure		NF				db
(I_C = 1 mA, V_{CE} = -6V, R_g = 1 kc, f = 1 kc)						
	2N381		- - -	6	- - -	
	2N382		- - -	5.5	- - -	
	2N383		- - -	5.0	- - -	
	2N2171		- - -	3.5	- - -	
Cutoff Frequency (I_C = 1 mA, V_{CB} = -6V)		f_{hfb}				mc
	2N381		- - -	3	- - -	
	2N382		- - -	4	- - -	
	2N383		- - -	5	- - -	
	2N2171		- - -	7.5	- - -	

2N398, 2N398 A

2N398 USN/JAN

V_{CBO} = 105 V
h_{FE} = 20 (min)
f_{α_b} - to 1.0 MC (typ)

CASE 31
(TO-5)

All leads isolated



PNP germanium transistor for high-voltage, audio-frequency applications.

MAXIMUM RATINGS

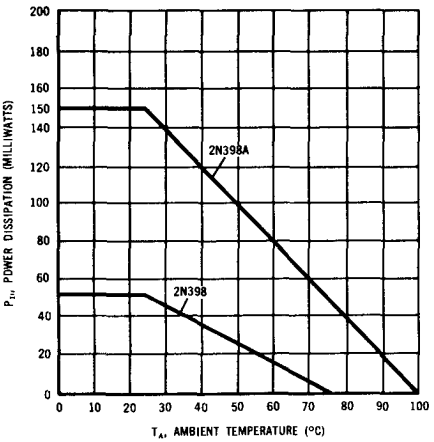
Characteristic	Symbol	2N398A	2N398	Unit
Collector-Base Voltage	V_{CBO}	105	105	Vdc
Collector-Emitter Voltage	V_{CEO}	105	105	Vdc
Emitter-Base Voltage	V_{EBO}	50	50	Vdc
DC Collector Current	I_C	200	100	mA
Emitter Current	I_E	200	100	mA
Junction Temperature	T_J	-65 to +100	-65 to +85	°C
Storage Temperature	T_{stg}	-65 to +100	-65 to +85	°C
Collector Dissipation @ 25°C	P_D	150	50	mW
Thermal Resistance, Junction to Air	$\theta_{JA\ max}$	0.5	1.2	°C/mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

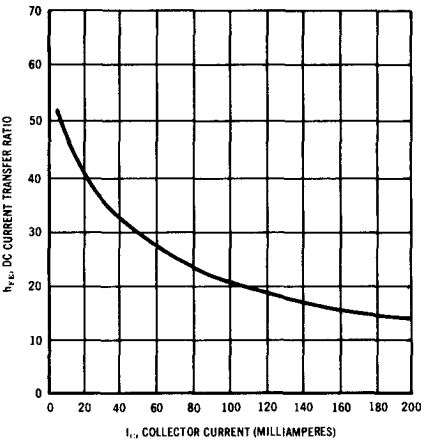
Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current (V_{CB} = 105 V, I_B = 0)	I_{CBO}	-	12.0	50	μA
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_B = 0)	I_{CBO}	-	5.0	14	μA
Emitter-Base Cutoff Current (V_{EB} = 50 V, I_C = 0)	I_{EBO}	-	3.0	50	μA
Collector-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{CE\ (SAT)}$	-	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc; I_B = 0.25 mAdc)	$V_{BE\ (SAT)}$	-	0.22	0.40	Vdc
DC Current Transfor Ratio (I_C = 5 mAdc; V_{CE} = 0.35 Vdc)	h_{FE}	20	65	-	-
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})	V_{PT}	105	160	-	Vdc
Small-Signal Short-Circuit, Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc; I_E = 1 mAdc)	f_{ab}	-	1.0	-	mc

2N398 (continued)

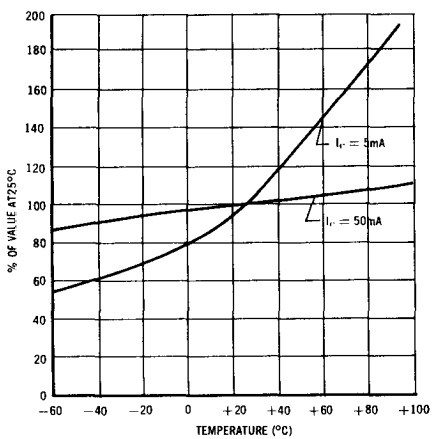
POWER — TEMPERATURE DERATING CURVE



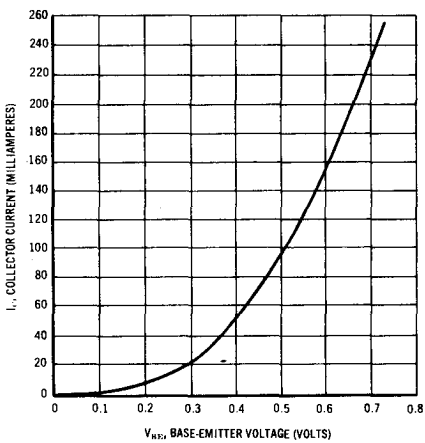
DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT
$V_{CE} = 0.35V$



LARGE SIGNAL CURRENT GAIN (H_{FE}) versus TEMPERATURE
(Normalized to 25°C Value; $V_{CE} = 0.35V$)



OUTPUT CURRENT versus BASE-DRIVE VOLTAGE
($V_{CE} = -1$ V)



2N460, 2N461
2N461 USAF/JAN

V_{CBO} = 45 V
h_{fe} = 31-200 (min-max)
$f\alpha_b$ - to 4 MC (typ)



CASE 31
(TO-5)
Base connected to case

PNP germanium transistor for general purpose industrial applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	45	Volts
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	35	Volts
Emitter-Base Voltage	V_{EBO}	10	Volts
Collector Current	I_C	400	mA
Collector Dissipation at 25° C Case Temperature Derate above 25° C at 25° C Ambient Temperature Derate above 25° C	P_D	 500 6.7 225 3	 mW mW/° C mW mW/° C
Junction Temperature Range	T_J	-65 to +100	° C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current (V_{CB} = 45 Vdc)		I_{CBO}	---	---	15	μAdc
Emitter-Base Cutoff Current (V_{EB} = -10 Vdc)		I_{EBO}	---	---	10	μAdc
Collector-Emitter Voltage (I_C = 1 mAdc, R_{BE} = 1 K)		BV_{CER}	35	---	---	Vdc
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N460 2N461	h_{fb}	0.94 0.955	0.96 0.968	0.972 0.988	---
Small-Signal Current Gain (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N461	h_{fe}	31	---	200	---
Reverse Voltage Ratio (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N460 2N461	h_{rb}	--- ---	2 3	15 15	$X10^{-4}$
Input Resistance (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N460 2N461	h_{ib}	25 25	30 ---	40 40	Ohms
Output Admittance (V_{CB} = -6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N460 2N461	h_{ob}	--- ---	0.8 0.5	1.5 1.5	μohms
Frequency Cutoff (V_{CE} = -5 Vdc, I_E = 1 mAdc)	2N460 2N461	f_{hfb}	--- ---	1.2 4	--- ---	mc
Output Capacitance (V_{CB} = -10 Vdc, I_E = 1 mAdc, f = 1 mc)		C_{ob}	---	20	---	pf
Noise Figure (V_{CE} = -4.5 Vdc, I_E = 0.5 mAdc, R_g = 1 K, f = 1 kc)	2N460 2N461	NF	--- ---	5 4	--- ---	db

2N464 thru 2N467
2N465 USA/JAN
2N466 JAN
2N467 USA/JAN

V_{CBO} = 45 V
h_{fe} - to 112 (min)
$f\alpha_b$ - to 1.2 MC (typ)



CASE 31
(TO-5)
All leads isolated

PNP germanium transistor for general purpose applications in the audio-frequency range.

MAXIMUM RATINGS

Characteristic	Symbol	2N464	2N465	2N466	2N467	Unit
Collector-Base Voltage	V_{CBO}	45	45	35	35	Volts
Collector-Emitter Voltage	V_{CE}	40	30	20	15	Volts
Emitter-Base Voltage	V_{EBO}	12				Volts
DC Collector Current	I_C	500				mA
Max. Junction & Storage Temperature	T_J and T_{stg}	100				°C
Collector Dissipation in Free Air	P_D	200				mW
Derate above 25°C		2.67				mW/°C
Thermal Resistance, Junction to Air	θ_{JA}	0.375				°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

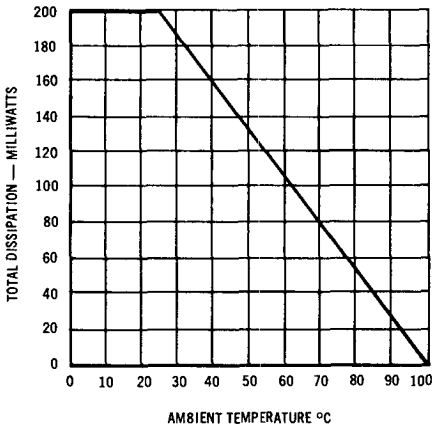
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10 K ohms)	2N464	BV_{CER}	40	–	–	Vdc
	2N465		30	–	–	
	2N466		20	–	–	
	2N467		15	–	–	
Collector-Base Cutoff Current (V_{CB} = 20 Vdc)		I_{CBO}	–	6	15	μAdc
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N464	f_{ab}	–	0.7	–	mc
	2N465		–	0.8	–	
	2N466		–	1.0	–	
	2N467		–	1.2	–	
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kc)	2N464	h_{fe}	14	26	–	–
	2N465		27	45	–	
	2N466		56	90	–	
	2N467		112	180	–	

2N464 thru 2N467 (continued)

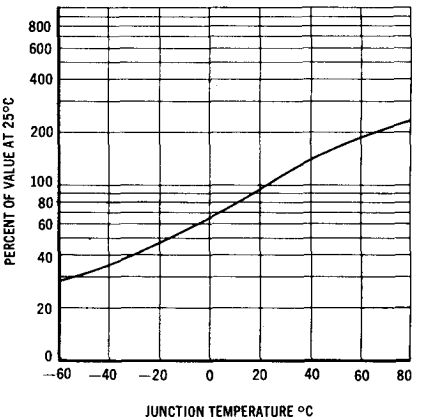
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Small Signal Input Impedance (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kc)	2N464	h_{ie}	–	900	–	Ohms
	2N465		–	1400	–	
	2N466		–	3000	–	
	2N467		–	5500	–	
Small Signal Power Gain (V_{CE} = 6 Vdc, I_E = 1.0 mAdc, f = 1 kc, matched)	2N464	G_e	–	40	–	db
	2N465		–	42	–	
	2N466		–	44	–	
	2N467		–	45	–	
Noise Figure (V_{CE} = 2.5 Vdc, I_E = 0.5 mAdc, f = 1 kc, R_g = 10 Kohms, Δf = 1 cps)		NF	–	–	22	db

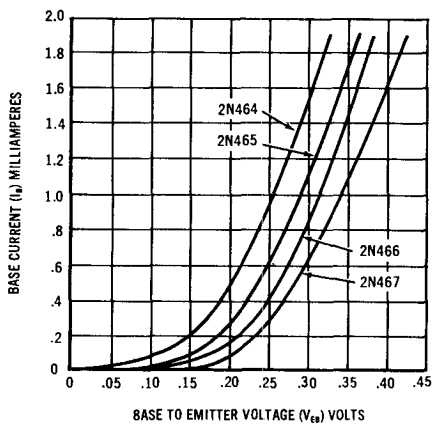
POWER-TEMPERATURE DERATING CURVE



SMALL SIGNAL CURRENT GAIN versus TEMPERATURE

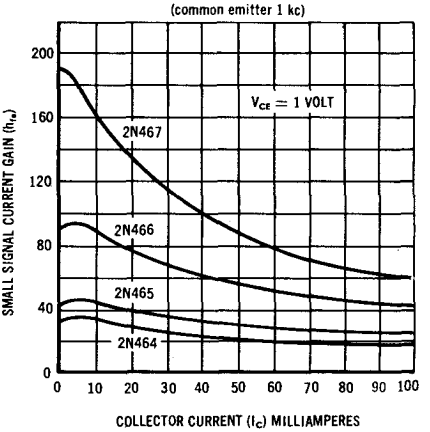


Input Current versus Emitter-Drive Voltage



Small Signal Current Gain versus Collector Current

(common emitter 1 kc)

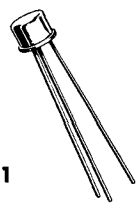


2N508

FOR SPECIFICATIONS, SEE 2N322 DATA SHEET

2N524 thru 2N527
2N524A thru 2N527A, Hi-Rel
2N526 JAN

V_{CBO} = 45 V
h_{FE} - to 72-121 (min-max)
$f_{\alpha b}$ - to 7.0 MC (max)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	15	Vdc
Collector Current	I_C	500	mAdc
Storage and Operating Temperature	T_{stg}, T_j	-65 to +100	°C
Collector Dissipation in Free Air @ 25°C Ambient	P_D	225	mW
Thermal Resistance (Junction to Air)	θ_{JA}	0.333	°C/mW
Thermal Resistance (infinite heat sink)	θ_{JC}	0.15	°C/mW

2N524 THRU 2N527 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

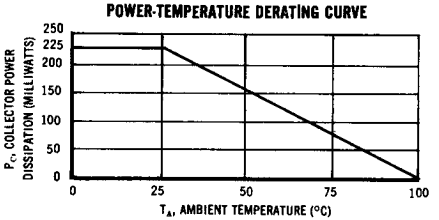
Characteristic		Symbol	Minimum	Maximum	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	All Types	I_{CBO}	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	All Types	I_{EBO}	-	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 0.6 mAdc, R_{BE} = 10K)	All Types	BV_{CER}	30	-	μVdc
Collector-Emitter Reach Through (Punch-Thru) Voltage (V_{EB} = 1 Vdc, VTVM Z ≥ I Megohm)	All Types	V_{RT}	30	-	μVdc
Static Forward-Current Transfer Ratio (V_{CE} = 1 Vdc, I_C = 20 mAdc)	2N524	h_{FE}	25	42	-
	2N525		34	65	-
	2N526		53	90	-
	2N527		72	121	-
Small-Signal Short-Circuit Forward Current Transfer Ratio Frequency Cutoff (V_{CB} = 5 Vdc, I_E = 1 mAdc)	2N524	f_{ab}	0.8	5.0	Mc
	2N525		1.0	5.5	Mc
	2N526		1.3	6.5	Mc
	2N527		1.5	7.0	Mc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Mc)	All Types	C_{ob}	5	40	pf
Small-Signal Open Circuit Output Admittance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc)	2N524	h_{ob}	0.10	1.3	μmho
	2N525		0.10	1.2	μmho
	2N526		0.10	1.0	μmho
	2N527		0.10	0.9	μmho
Small-Signal Open Circuit Reverse Transfer Voltage Ratio (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc)	2N524	h_{rb}	1.0	10	$X10^{-4}$
	2N525		1.0	11	$X10^{-4}$
	2N526		1.0	12	$X10^{-4}$
	2N527		1.0	14	$X10^{-4}$
Small-Signal Short Circuit Input Impedance (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc)	2N524	h_{ib}	26	36	ohms
	2N525		26	35	ohms
	2N526		26	33	ohms
	2N527		26	31	ohms
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$			
(I_B = 2 mAdc, I_C = 20 mAdc)	2N524				
(I_B = 1.33 mAdc, I_C = 20 mAdc)	2N525		-	130	mVdc
(I_B = 1.0 mAdc, I_C = 20 mAdc)	2N526		-	130	mVdc
(I_B = 0.67 mAdc, I_C = 20 mAdc)	2N527		-	130	mVdc
			-	130	mVdc
Base Input Voltage (V_{CE} = 1 Vdc, I_C = 20 mAdc)	2N524	V_{BE}	220	320	mVdc
	2N525		200	300	mVdc
	2N526		190	280	mVdc
	2N527		180	260	mVdc

2N524 thru 2N527 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Minimum	Maximum	Unit
Noise Figure (V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc, BW = 1 Cycle)	All Types	NF	-	15	db
Small-Signal Short-Circuit Forward-Current Transfer Ratio (V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc)	2N524	h_{fe}	18	41	-
	2N525		30	64	-
	2N526		44	88	-
	2N527		60	120	-

POWER-TEMPERATURE DERATING CURVE

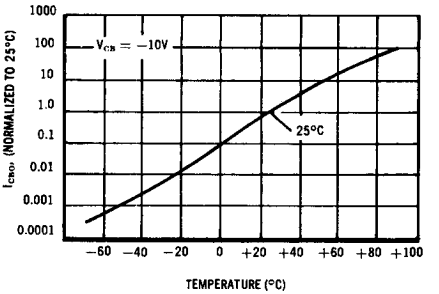


The maximum continuous power is related to maximum junction temperature by the thermal resistance factor.

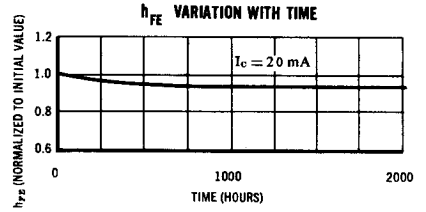
This curve has a value of 225mW at case temperatures of 25°C and is 0 mW at 100°C with a linear relation between the two temperatures such that:

$$\text{allowable } P_D = \frac{100° - T_A}{0.333}$$

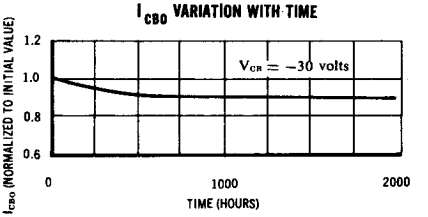
COLLECTOR CUTOFF CURRENT versus TEMPERATURE



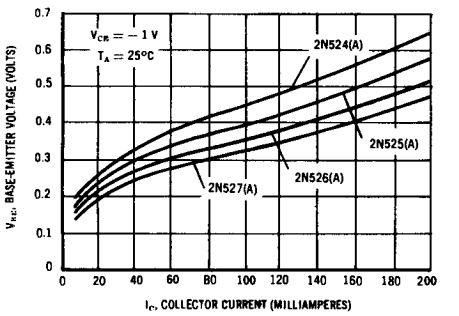
h_{FE} VARIATION WITH TIME



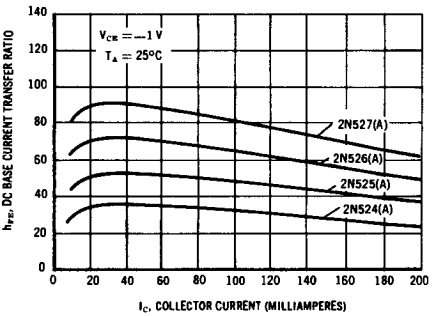
I_{CBO} VARIATION WITH TIME



COMMON EMITTER INPUT VOLTAGE versus COLLECTOR CURRENT



D-C BASE CURRENT GAIN versus COLLECTOR CURRENT



2N650, A thru 2N652, A

2N650A thru 2N652A, Hi-Rel

2N650A thru 2N652A JAN

V_{CBO} = 45 V
h_{FE} - to 80 (min)
$f_{\alpha b}$ - to 2.5 MC (typ)

CASE 31
(TO-5)

All leads isolated



PNP germanium transistor for switching and amplifier applications in the audio-frequency range. Available for military and high-reliability industrial purposes.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EBO}	30	Vdc
Collector Current * (Continuous)	I_C	500*	mAdc
Junction Temperature Range	$T_{J\ (max)}$	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation in Free Air (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Air)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation.

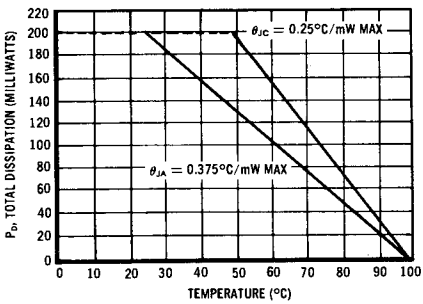
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 V, I_E = 0)	All Types		–	3.0	10	
(V_{CB} = 45 V, I_E = 0)			–	—	50	
(V_{CB} = 10 V, I_E = 0, T_A = +71°C)			–	55	100	
Emitter-Base Cutoff Current (V_{EB} = 30 V, I_C = 0)		I_{EBO}	–	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 V, R_{BE} = 10 K)	All Types	I_{CER}	–	–	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_F = 1.0 V)	All Types	V_{pt}	45	–	–	Vdc
Output Capacitance (V_{CB} = 6 V, I_E = 0)	All Types	C_{ob}	–	10	25	pf
Noise Figure (V_{CE} = 4.5 V, I_E = 0.5 mA, R_g = 1 K, f = 1 kc, Δf = 1 cps)	All Types	NF	–	5	15	db
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 V, I_E = 1 mA)		f_{ab}				mc
	2N650		0.75	1.5	–	
	2N651		1.0	2.0	–	
	2N652		1.25	2.5	–	

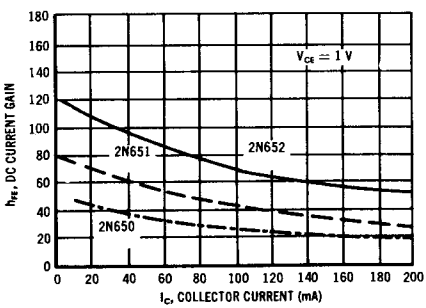
2N650 thru 2N652 (continued)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Input Impedance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)	2N650	h_{ib}	27	31	37	Ohms
	2N651		27	34	37	
	2N652		27	35	37	
Output Admittance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)	2N650	h_{ob}	0.2	0.65	1.0	μmho
	2N651		0.2	0.60	0.9	
	2N652		0.2	0.55	0.8	
Small Signal Current Gain (V_{CE} = 6 V, I_E = 1 mA, f = 1 kc)	2N650	h_{fe}	30	49	70	–
	2N651		50	80	120	
	2N652		100	130	225	
DC Current Transfer Ratio (V_{CE} = 1.0 V, I_C = 10 mA)	2N650	h_{FE}	33	44	–	–
	2N651		45	75	–	
	2N652		80	115	–	
Base-Emitter Drive Voltage (V_{CE} = 1.0 V, I_C = 10 mA)	2N650	V_{EB}	–	0.245	0.270	Vdc
	2N651		–	0.235	0.260	
	2N652		–	0.225	0.250	
Collector-Emitter Saturation Voltage (I_C = 50 mA, I_B = 2.5 mA)	2N650	V_{CE} (sat)	–	0.175	0.250	Vdc
(I_C = 50 mA, I_B = 1.67 mA)	2N651		–	0.175	0.250	
(I_C = 50 mA, I_B = 1.25 mA)	2N652		–	0.175	0.250	
Collector-Emitter Saturation Voltage (I_C = 100 mA, I_B = 5.0 mA)	2N650	V_{CE} (sat)	–	0.250	0.500	Vdc
(I_C = 100 mA, I_B = 3.33 mA)	2N651		–	0.250	0.500	
(I_C = 100 mA, I_B = 2.5 mA)	2N652		–	0.250	0.500	

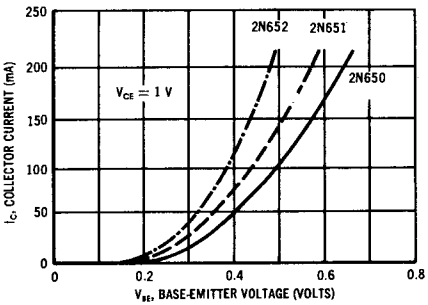
POWER-TEMPERATURE DERATING CURVE



h_{FE} versus COLLECTOR CURRENT



COLLECTOR OUTPUT CURRENT versus BASE DRIVE VOLTAGE



2N653 thru 2N655

V_{CBO} = 30 V
h_{fe} - to 100-250 (min-max)
f_{α_b} - to 2.5 MC (typ)

CASE 31
(TO-5)



All leads isolated

PNP germanium transistor, for high-gain amplifier and switching service in the audio frequency range.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector to Base Voltage	V_{CBO}	30	Volts
Collector to Emitter Voltage	V_{CER}	25	Volts
Emitter to Base Voltage	V_{EBO}	25	Volts
Collector D. C. Current *	I_C	250*	mA
Junction Temperature Limits	T_J	-65 to +100	°C
Storage Temperature Limits	T_{stg}	-65 to +100	°C
Collector Dissipation in Free Air Derate 2.67 mW/° C above 25° C	P_D	200	mW
Thermal Resistance, Junction to Air	θ_{JA}	0.375	°C/mW

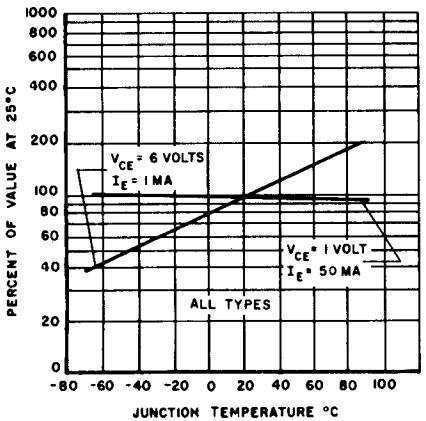
*Limited by power dissipation.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

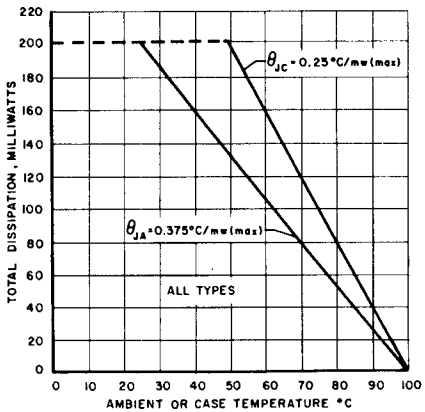
Characteristic	Symbol	2N653			2N654			2N655			Unit
		Min	Max	Typ	Min	Max	Typ	Min	Max	Typ	
Small Signal Current Gain V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kC	h_{fe}	30	49	70	50	80	125	100	130	250	-
Small Signal Input Impedance V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kC	h_{ie}	750	-	2900	1500	-	4700	3000	-	8500	ohms
Small Signal Current Gain Cutoff Frequency V_{CB} = 6 V, I_E = 1.0 mA	f_{ab}		1.5			2.0			2.5		mc
Output Capacity V_{CB} = 6 V, I_E = 0 mA, f = 1 mc	C_{ob}		10			10			10		pf
Noise Figure V_{CE} = 4.5 V, I_E = 0.5 mA, Rg = 1, f = 1 kC Δf = 1 cps	NF		10			10			10		db
Collector Reverse Current V_{CB} = 25 V, I_E = 0	I_{CBO}		5	15		5	15		5	15	μa
Emitter Reverse Current V_{EB} = 25 V, I_C = 0	I_{EBO}		5	15		5	15		5	15	μa
Collector-Emitter Reverse Current V_{CE} = 25 V, R_{BE} = 10 k	I_{CER}			600			600			600	μa
Base-Emitter Input Voltage V_{CE} = 6 V, I_C = 1.0 mA	V_{BE}			0.3			0.3			0.3	Vdc

2N653 thru 2N655 (continued)

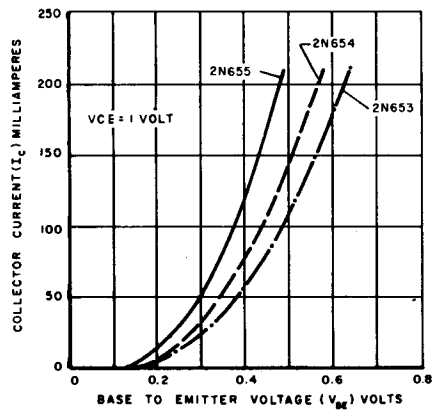
SMALL SIGNAL CURRENT GAIN (h_{fe}) versus TEMPERATURE



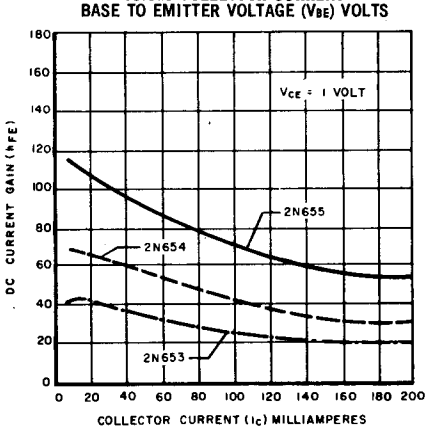
POWER-TEMPERATURE DERATING CURVE



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



LARGE SIGNAL CURRENT GAIN versus COLLECTOR CURRENT
BASE TO EMITTER VOLTAGE (V_{BE}) VOLTS



2N1008, A, B
2N1008B USA/JAN

V_{CBO} = 60 V
h_{fe} = 40-150 (min-max)



CASE 31
(TO-5)
All leads isolated

PNP germanium transistor for audio driver and medium speed switching applications.

MAXIMUM RATINGS

Characteristics	Symbol	2N1008	2N1008A	2N1008B	Unit
Collector-Base Voltage	V_{CBO}	20	40	60	Volts
Collector-Emitter Voltage	V_{CEO}	20	40	60	Volts
Emitter-Base Voltage	V_{EBO}	15			Volts
Collector Current	I_C	300			mAdc
Base Current	I_B	30			mAdc
Collector Dissipation	P_D				
T_A = 25°C		200			mW
derate		2.78			mW/°C
T_C = 25°C		300			mW
derate		4.0			mW/°C
Junction and Storage Temperature Range	T_J	-65 to +100			°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

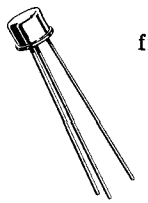
Characteristics	Symbol	Min	Typ	Max	UNIT
Collector Leakage Current	I_{CBO}				μAdc
(V_{CB} = 10 Vdc) 2N1008		---	5	10	
(V_{CB} = 10 Vdc, T_A = 85°C) 2N1008		---	---	500	
(V_{CB} = 25 Vdc) 2N1008A		---	5	10	
(V_{CB} = 25 Vdc, T_A = 85°C) 2N1008A		---	---	500	
(V_{CB} = 45 Vdc) 2N1008B		---	7	15	
(V_{CB} = 45 Vdc, T_A = 85°C) 2N1008B		---	---	750	
Emitter Leakage Current	I_{EBO}				μAdc
(V_{EB} = 10 Vdc) 2N1008		---	5	10	
2N1008A		---	---	10	
2N1008B		---	---	10	
Collector-Emitter Breakdown Voltage	BV_{CER}				Vdc
(I_C = 1.0 mAdc, R_{BE} = 10 K)					
2N1008		15	---	---	
2N1008A		35	---	---	
2N1008B		55	---	---	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	V_{CE} (sat)	---	---	0.25	Vdc
Small Signal Current Gain (I_C = -10 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	h_{fe}	40	---	150	---
Input Resistance (V_{CB} = 6 V, I_E = 1 mA)	h_{ie}	200	---	1000	ohms

2N1175

FOR SPECIFICATIONS, SEE 2N1413-2N1415 DATA SHEET

2N1185 thru 2N1188

V_{CBO} = 60 V
h_{FE} - to 130-170 (min-max)
$f\alpha_b$ - to 3.0 MC



PNP germanium transistors for high-gain audio amplifier and switching applications.

CASE 31
(TO-5)

All leads isolated from case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage 2N1185 2N1186-2N1188	V_{CBO}	 45 60	Vdc
Collector-Emitter Voltage 2N1185 2N1186-2N1188	V_{CER}	 30 45	Vdc
Emitter-Base Voltage	V_{EBO}	30	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in Free Air (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Air)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation

2N1185 thru 2N1188 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

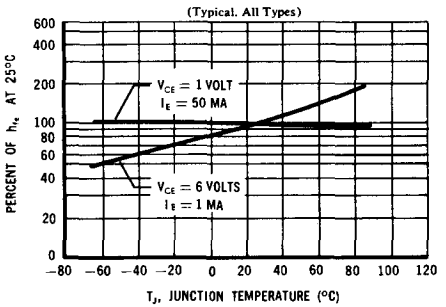
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 V, I_E = 0)	2N1185		-	3.0	10	
(V_{CB} = 45 V, I_E = 0)	2N1186 thru 2N1188		-	5.0	10	
(V_{CB} = 60 V, I_E = 0)	2N1186 thru 2N1188		-	-	50	
(V_{CB} = 10 V, I_E = 0, T_A = +71° C)	All Types		-	55	100	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 30 V, I_C = 0)	All Types		-	3.0	10	
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 30 V, R_{BE} = 10 K)	2N1185		-	-	600	
(V_{CE} = 45 V, R_{BE} = 10 K)	2N1186 thru 2N1188		-	-	600	
Collector-Emitter Punch-Thru Voltage		V_{pt}				Vdc
(V_F = 1.0 V, VTVM Impedance ≥ 1 M ohm)	2N1185		45	-	-	
	2N1186 thru 2N1188		60	-	-	
Output Capacitance		C_{ob}				pf
(V_{CB} = 6 V, I_E = 0)	All Types		-	10	25	
Noise Figure		NF				db
(V_{CE} = 4.5 V, I_E = 0.5 mA, R_g = 1 K, f = 1 kc, Δf = 1 cps	All Types		-	5	15	
Small Signal Current Gain Cutoff Frequency		f_{ab}				mc
(V_{CB} = 6 V, I_E = 1 mA)	2N1185		1.75	3.0	-	
	2N1186		0.75	1.5	-	
	2N1187		1.0	2.0	-	
	2N1188		1.25	2.5	-	
Input Impedance		h_{ib}				Ohms
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)	2N1185		27	35	37	
	2N1186		27	31	37	
	2N1187		27	34	37	
	2N1188		27	35	37	
Output Admittance		h_{ob}				μmho
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)	2N1185		0.2	0.50	0.7	
	2N1186		0.2	0.65	1.0	
	2N1187		0.2	0.60	0.9	
	2N1188		0.2	0.55	0.8	
Small Signal Current Gain		h_{fe}				-
(V_{CE} = 6 V, I_E = 1 mA, f = 1 kc)	2N1185		190	260	400	
	2N1186		30	49	70	
	2N1187		50	80	120	
	2N1188		100	130	225	
DC Current Transfer Ratio		h_{FE}				-
(V_{CE} = 1.0 V, I_C = 10 mA)	2N1185		130	170	-	
	2N1186		33	44	-	
	2N1187		45	75	-	
	2N1188		80	115	-	

2N1185 thru 2N1188 (continued)

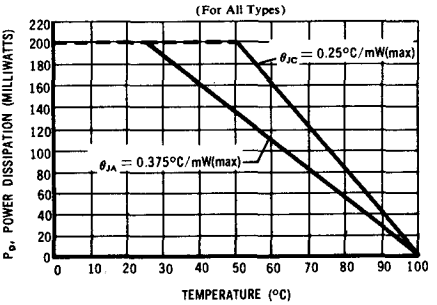
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Base-Emitter Input Voltage (V_{CE} = 1.0 V, I_C = 10 mA)	2N1185	V_{BE}	-	0.215	0.240	Vdc
	2N1186		-	0.245	0.270	
	2N1187		-	0.235	0.260	
	2N1188		-	0.225	0.250	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$				Vdc
(I_C = 50 mA, I_B = 1.0 mA)	2N1185		-	0.175	0.250	
(I_C = 50 mA, I_B = 2.5 mA)	2N1186		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.67 mA)	2N1187		-	0.175	0.250	
(I_C = 50 mA, I_B = 1.25 mA)	2N1188		-	0.175	0.250	
Collector-Emitter Saturation Voltage		$V_{CE\ (sat)}$				Vdc
(I_C = 100 mA, I_B = 2.0 mA)	2N1185		-	0.250	0.500	
(I_C = 100 mA, I_B = 5.0 mA)	2N1186		-	0.250	0.500	
(I_C = 100 mA, I_B = 3.33 mA)	2N1187		-	0.250	0.500	
(I_C = 100 mA, I_B = 2.5 mA)	2N1188		-	0.250	0.500	

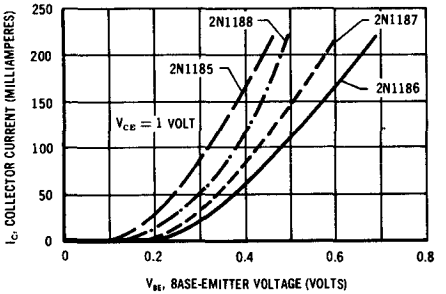
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE



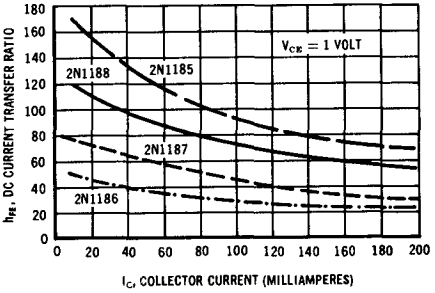
POWER-TEMPERATURE DERATING CURVE



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N1189, 2N1190

V_{CBO} = 45 V
h_{FE} = to 100 (MIN)
$f_{\alpha b}$ - to 4.5 MC (typ)



CASE 31
(TO-5)
All leads isolated

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EBO}	15	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Junction, Storage Temperature	T_J, T_{stg}	-65 to +100	°C
Collector Dissipation in Free Air (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Air)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

*Limited by power dissipation.

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

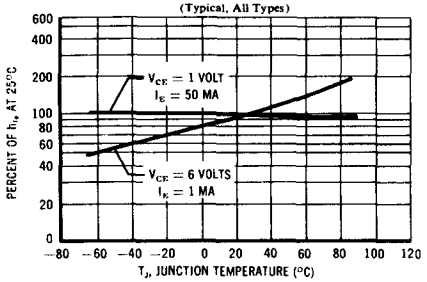
Characteristic	Types	Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	3.0	10	
(V_{CB} = 45 Vdc, I_E = 0)			—	—	50	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C)			—	55	100	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 15 Vdc, I_C = 0)			—	3.0	10	
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 30 Vdc, R_{BE} = 10K)			—	—	600	
Collector-Emitter Punch-Thru Voltage		V_{pt}				Vdc
(V_{EB} = 1 Vdc, VTVM Impedance ≥1 M ohm			45	—	—	
Output Capacitance		C_{ob}				pf
(V_{CB} = 6 Vdc, I_E = 0, f = 1 mc)			—	12.0	25	
Noise Figure		NF				db
(V_{CE} = 4.5 V_{dc}, I_E = 0.5 mAdc			—	5	15	
R_g = 1 K, f = 1 kc, Δf = 1 cps)						
Small-Signal Current-Gain Cutoff Frequency		f_{hfb}				mc
(V_{CB} = 6 Vdc, I_E = 1 mAdc)						
	2N1189		1.75	3.5	—	
	2N1190		2.25	4.5	—	

2N1189, 2N1190 (continued)

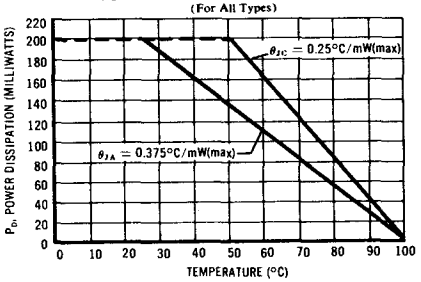
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)		h_{ib}	27	31	37	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)		h_{ob}	0.1	—	0.9	μmho
Small Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)		h_{fe}				—
	2N1189		75	120	175	
	2N1190		125	190	300	
DC Current Transfer Ratio (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)		h_{FE}				—
	2N1189		60	115	—	
	2N1190		100	170	—	
Base-Emitter Drive Voltage (V_{CE} = 1.0 Vdc, I_E = 10 mAdc)		V_{BE}				Vdc
	2N1189		—	0.24	0.26	
	2N1190		—	0.22	0.25	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 50 mAdc, I_B = 1.5 mA)	2N1189		—	0.14	0.22	
(I_C = 50 mAdc, I_B = 1.0 mA)	2N1190		—	0.15	0.22	
(I_C = 100 mAdc, I_B = 3.0 mA)	2N1189		—	0.17	0.3	
(I_C = 100 mAdc, I_B = 2.0 mA)	2N1190		—	0.19	0.3	

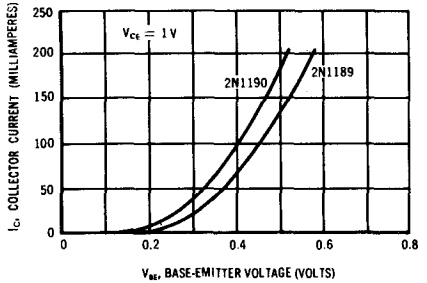
SMALL SIGNAL CURRENT GAIN(h_{fe}) versus TEMPERATURE
(Typical, All Types)



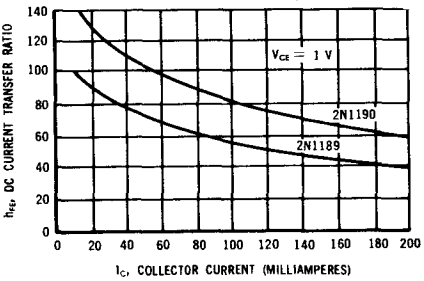
POWER-TEMPERATURE DERATING CURVE
(For All Types)



OUTPUT CURRENT versus BASE DRIVE VOLTAGE

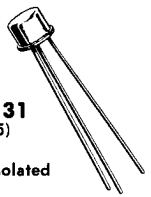


DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



2N1191 thru 2N1194

V_{CBO} = 40 V
h_{FE} - to 125-600 (min-max)
$f_{\alpha b}$ - to 3.0 MC (typ)



CASE 31
(TO-5)

All leads isolated

PNP germanium transistors for high-gain audio amplifier and switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	BV_{CBO}	40	Vdc
Collector-Emitter Voltage	BV_{CER}	25	Vdc
Emitter-Base Voltage	BV_{EBO}	25	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Storage and Operating Temperature	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in Free Air (Derate 2.67 mW/°C above 25°C)	P_D	200	mW
Thermal Resistance (Junction to Air)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

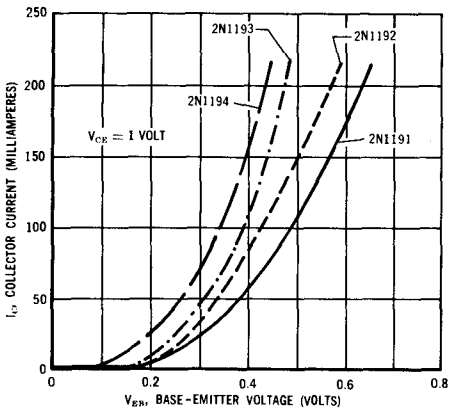
Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 25 V, I_E = 0)	All Types	I_{CBO}	–	–	15	μAdc
(V_{CB} = 1.0 V, I_E = 0)			–	2.0	–	μAdc
Emitter-Base Cutoff Current (V_{EB} = 25 V, I_C = 0)	All Types	I_{EBO}	–	–	15	μAdc
Collector-Emitter Leakage Current (V_{CE} = 25 V, R_{BE} = 10 K)	All Types	I_{CER}	–	–	600	μAdc
Output Capacitance (V_{CE} = 6 V, I_E = 1.0 mA)	All Types	C_{ob}	–	20	–	pf
Noise Figure (V_{CE} = 4.5 V, I_E = 0.5 mA, f = 1 kc, R_s = 100 ohms)	All Types	NF	–	10	–	db
Small Signal Current Gain Cutoff Frequency (V_{CB} = 6 V, I_E = 1.0 mA)	2N1191	f_{ab}	–	1.5	–	mc
	2N1192		–	2.0	–	mc
	2N1193		–	2.5	–	mc
	2N1194		–	3.0	–	mc

2N1191 thru 2N1194 (continued)

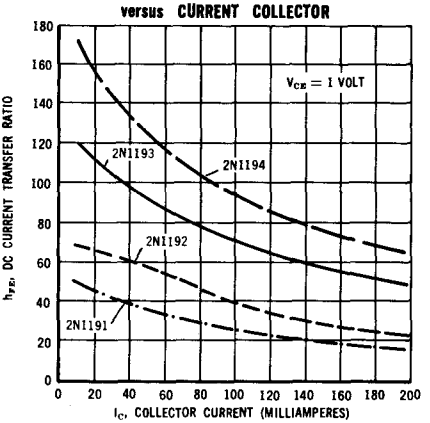
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typical	Max	Unit
Small Signal Current Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kc)	2N1191	h_{fe}	30	40	70	–
	2N1192		50	75	125	–
	2N1193		100	160	250	–
	2N1194		190	280	500	–
DC Current Gain (V_{CE} = 1 V, I_C = 10 mA)	2N1191	h_{FE}	20	–	80	–
	2N1192		40	–	135	–
	2N1193		70	–	300	–
	2N1194		125	–	600	–
Small Signal Power Gain (V_{CE} = 6 V, I_E = 1.0 mA, f = 1 kc, matched)	2N1191	G_e	–	42	–	db
	2N1192		–	44	–	db
	2N1193		–	46	–	db
	2N1194		–	48	–	db
Base-Emitter Input Voltage (V_{CE} = 6 V, I_C = 1.0 mA)	All Types	V_{BE}	–	–	0.3	Vdc

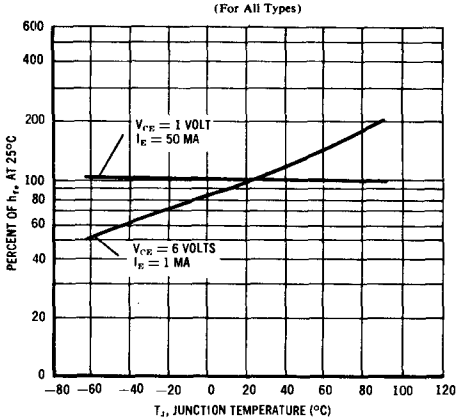
OUTPUT CURRENT versus BASE DRIVE VOLTAGE



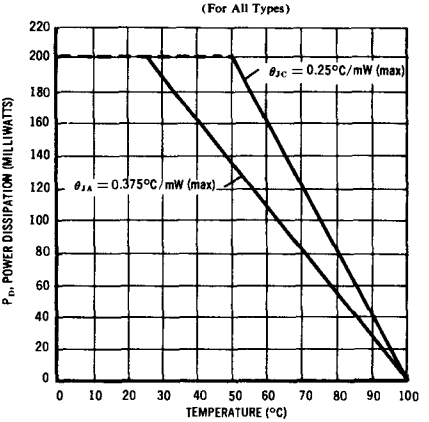
DC CURRENT TRANSFER RATIO versus CURRENT COLLECTOR



SMALL SIGNAL CURRENT GAIN (h_{fe}) versus TEMPERATURE
(For All Types)

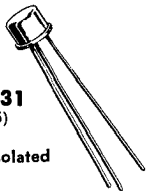


POWER-TEMPERATURE DERATING CURVE
(For All Types)



2N1408

V_{CBO} = 50 V
h_{FE} = 10 (min)



CASE 31
(TO-5)

All leads isolated

PNP germanium transistor for high voltage neon driver, solenoid and relay driver circuits.

MAXIMUM RATINGS

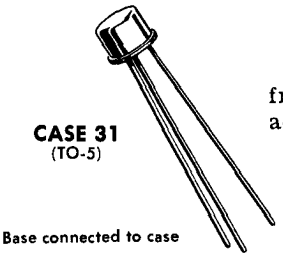
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	50	Volts
Collector-Emitter Voltage	V_{CES}	50	Volts
Emitter-Base Voltage	V_{EBO}	10	Volts
Collector Current	I_C	200	mA
Collector Dissipation at T_A = 25°C	P_D	150	mW
derating factor		2.0	mW/°C
Junction Temperature Range	T_J	-65 to +100	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	---	7	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	---	7	μAdc
Collector-Emitter Leakage Current (V_{CB} = 50 Vdc, R_{BE} = 0)	I_{CES}	---	150	μAdc
Collector-Base Breakdown Voltage (I_C = 25 μAdc, I_E = 0)	BV_{CBO}	50	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 25 μAdc, I_C = 0)	BV_{EBO}	10	---	Vdc
Collector-Emitter Punch-Thru Voltage (I_E = 25 μAdc)	V_{pt}	50	---	Vdc
Base-Emitter Input Voltage (I_B = 1.0 mAdc, V_{CE} = 1.0 Vdc)	V_{BE}	---	0.6	Vdc
DC Current Gain (V_{CE} = 1 Vdc, I_B = 1 mAdc)	h_{FE}	10	---	---
Small Signal Current Gain (V_{CE} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kc)	h_{fe}	10	---	---
Output Admittance (V_{CB} = 5.0 Vdc, I_E = 1.0 mA, f = 1 kc)	h_{ob}	---	2.0	μmhos

2N1413 thru 2N1415
2N1175

BV_{CBO} = 35 V
h_{FE} - to 62 (min)
$f\alpha_b$ - to 1.5 MC (min)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistor for general purpose low-frequency amplifier and switching applications. Characteristic curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Characteristic	Symbol	Maximum	Unit
Collector-Base Voltage	V_{CBO}	35	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	10	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Free Air	P_D	225	mW

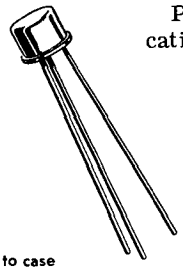
2N1413 thru 2N1415, 2N1175 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector Cutoff Current V_{CB} = 30 Vdc, I_E = 0	I_{CBO}	–	12	μAdc
Emitter Cutoff Current V_{EB} = 10 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	BV_{CER}	25	–	Vdc
Punch-Thru Voltage	V_{pt}	25	–	Vdc
DC Current Gain I_C = 20 mAdc, V_{CE} = 1 Vdc	h_{FE}			
2N1413		25	42	–
2N1414		34	65	–
2N1415		53	90	–
2N1175		70	140	–
DC Current Gain I_C = 100 mAdc, V_{CE} = 1 Vdc	h_{FE}			
2N1413		23	–	–
2N1414		30	–	–
2N1415		47	–	–
2N1175		62	–	–
Base Input Voltage V_{CE} = 1 Vdc, I_C = 20 mAdc	V_{BE}			
2N1175		–	260	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Mc	C_{ob}	–	40	μμf
Frequency Cutoff V_{CE} = 5 Vdc, I_E = 1 mAdc	f_{ab}			
2N1413		0.8	–	Mc
2N1414		1.0	–	Mc
2N1415		1.3	–	Mc
2N1175		1.5	–	Mc
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{fe}			
2N1413		20	41	–
2N1414		30	64	–
2N1415		44	88	–
2N1175		60	120	–
Small-Signal Open Circuit Output Admittance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{ob}			
2N1413		0.10	1.3	μmoh
2N1414		0.10	1.2	μmho
2N1415		0.10	1.0	μmho
2N1175		0.10	0.9	μmho
Small-Signal Open-Circuit Reverse-Transfer Voltate Ratio V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{rb}			
2N1413		1.0	10	$X10^{-4}$
2N1414		1.0	11	$X10^{-4}$
2N1415		1.0	12	$X10^{-4}$
2N1175		1.0	14	$X10^{-4}$
Small-Signal Short-Circuit Input Impedance V_{CB} = 5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{ib}			
2N1413		26	36	ohms
2N1414		26	35	ohms
2N1415		26	33	ohms
2N1175		26	31	ohms

2N1705 thru 2N1707

V_{CBO} - to 30 V
h_{FE} - to 60-120 (min-max)
$f_{\alpha b}$ - to 4 MC (typ)



CASE 31
(TO-5)

Base connected to case

PNP germanium transistors for audio driver applications in transistorized radio receivers.

MAXIMUM RATINGS

Characteristic	Symbol	2N1705	2N1706	2N1707	Unit
Collector-Base Voltage	V_{CBO}	18	25	30	Volts
Collector-Emitter Voltage (R_{BE} = 1 K)	V_{CER}	12	18	25	Volts
Emitter-Base Voltage	V_{EBO}	5	5	10	Volts
Collector Current	I_C	400			mA
Collector Dissipation at T_C = 25°C	P_D	200			mW
Junction Temperature Range	T_J	-65 to +100			°C

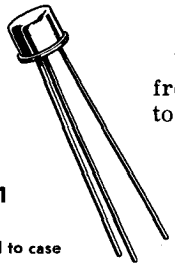
2N1705 thru 2N1707 (continued)

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = -10 Vdc)	2N1705		---	5	10	
	2N1706		---	---	10	
(V_{CV} = -25 Vdc)	2N1707		---	---	15	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = -5 Vdc)	2N1705		---	4	20	
	2N1706		---	---	20	
(V_{EB} = -10 Vdc)	2N1707		---	---	10	
Collector-Emitter Voltage		BV_{CER}				Vdc
(I_C = 1 mAdc, R_{BE} = 1 K)	2N1705		12	---	---	
	2N1706		18	---	---	
	2N1707		25	---	---	
Base-Emitter Voltage		V_{BE}				V
(I_C = 10 mA, V_{CE} = 5 V)	2N1706		0.15	---	0.35	
(I_C = 20 mA, V_{CE} = 1 V)	2N1705		0.2	---	0.4	
DC Current Gain		h_{FE}				---
(I_C = 10 mAdc, V_{CE} = -5 V)	2N1707		40	90	150	
(I_C = 20 mAdc, V_{CE} = -1 V)	2N1706		60	---	120	
Small Signal Current Gain		h_{fe}				---
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kc)	2N1705		70	110	150	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kc)	2N1706		50	90	150	
	2N1707		30	---	150	
Output Admittance Conductance		h_{ob}				μmhos
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kc)	2N1705		---	0.5	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kc)	2N1706, 2N1707		---	3.0	---	
Input Impedance		h_{ib}				ohms
(I_C = 1 mA, V_{CE} = -6 V, f = 1 kc)	2N1705		---	30	---	
(I_C = 10 mA, V_{CE} = -5 V, f = 1 kc)	2N1706, 2N1707		---	4	---	
Voltage Feedback Ratio						
(I_C = 1 mA, V_{CB} = -6 V, f = 1 kc)	2N1705	h_{rb}	---	3	---	$X10^{-4}$
(I_C = 10 mA, V_C = -5 V, f = 1 kc)	2N1706	h_{re}	---	0.69	---	$X10^{-3}$
	2N1707	h_{rb}	---	4.5	---	$X10^{-4}$
Frequency Cutoff		f_{ab}				mc
(I_C = 1 mA, V_C = -6 V)	2N1706, 2N1707		---	3	---	
	2N1705		---	4	---	
Output Capacitance		C_{ob}				pf
(I_C = 1 mA, V_{CB} = -6 V, f = 1 mc)			---	20	---	
Noise Figure		NF				db
(I_C = 1 mA, V_{CB} = -6 V, R_g = 1 K, f = 1 kc)	2N1705		---	6	---	

2N1924 thru 2N1926

BV_{CBO} = 60 V
h_{FE} - to 72 (min)
$f\alpha_b$ - to 1.5 MC (min)



CASE 31
(TO-5)
Base connected to case

PNP germanium transistors for general purpose, low-frequency applications. Characteristics curves similar to 2N524-2N527 series.

MAXIMUM RATINGS

Characteristic	Symbol	Maximum	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	25	Vdc
Collector Current	I_C	500	mAdc
Junction and Storage Temperature	T_j & T_{stg}	-65 to +100	°C
Power Dissipation at 25°C Free Air	P_D	225	mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector Cutoff Current V_{CB} = -45 Vdc, I_E = 0	I_{CBO}	–	10	μAdc
Emitter Cutoff Current V_{EB} = -25 Vdc, I_C = 0	I_{EBO}	–	10	μAdc
Collector-Base Voltage I_C = 200 μAdc, I_E = 0	V_{CBO}	60	–	Vdc
Collector-Emitter Voltage I_C = 50 μAdc, V_{BE} = +1.5 Vdc, R_{BE} = 10 K	V_{CEX}	50	–	Vdc
Collector-Emitter Voltage I_C = 0.6 mAdc, R_{BE} = 10 K	V_{CER}	40	–	Vdc
Punch-Thru Voltage (V_{EB} = 1 Vdc, VTVM Z ≥ 1 Megohm)	V_{pt}	50	–	Vdc

2N1924 thru 2N1926 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
DC Current Gain I_C = 20 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N1924		34	65	–
2N1925		53	90	–
2N1926		72	121	–
DC Current Gain I_C = 100 mAdc, V_{CE} = -1 Vdc	h_{FE}			
2N1924		30	–	–
2N1925		47	–	–
2N1926		65	–	–
Collector-Emitter Saturation Voltage	$V_{CE(SAT)}$			
I_B = 1.33 mAdc, I_C = 20 mAdc 2N1924		50	110	mVdc
I_B = 1.0 mAdc, I_C = 20 mAdc 2N1925		55	110	mVdc
I_B = 0.67 mAdc, I_C = 20 mAdc 2N1926		60	110	mVdc
Base Input Voltage V_{CE} = -1 Vdc, I_C = 20 mAdc	V_{BE}			
2N1924		200	300	mVdc
2N1925		190	290	mVdc
2N1926		180	280	mVdc
Output Capacitance; Input AC Open Circuit V_{CB} = -5 Vdc, I_E = 1 mAdc, f = 1 Mc	C_{ob}	–	30	pf
Frequency Cutoff V_{CB} = -5 Vdc, I_E = 1 mAdc	f_{ab}			
2N1924		1.0	–	Mc
2N1925		1.3	–	Mc
2N1926		1.5	–	Mc
Small-Signal Short-Circuit Forward-Transfer Current Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{fe}			
2N1924		30	64	–
2N1925		44	88	–
2N1926		60	120	–
Small-Signal Open Circuit Output Admittance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{oe}			
2N1924		15	60	μmho
2N1925		20	65	μmho
2N1926		25	70	μmho
Small-Signal Open-Circuit Reverse-Transfer Voltage Ratio V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{re}			
2N1924		2	8	$X10^{-4}$
2N1925		3	9	$X10^{-4}$
2N1926		4	10	$X10^{-4}$
Small-Signal Short-Circuit Input Impedance V_{CE} = -5 Vdc, I_E = 1 mAdc, f = 1 Kc	h_{ie}			
2N1924		700	2200	ohms
2N1925		1200	3200	ohms
2N1926		1500	4200	ohms

2N2042, 2N2043
2N2042A thru 2N2043A, Hi-Rel

V_{CBO} = 105 V
h_{FE} — to 40-100 (min-max)
$f\alpha_b$ — to 0.75 MC



CASE 31
(TO-5)

PNP germanium transistor suitable for high-voltage audio switching and amplifier applications. Suitable for high-reliability projects.

All leads isolated from case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	105	Vdc
Collector-Emitter Voltage	V_{CES}	105	Vdc
Emitter-Base Voltage	V_{EBO}	75	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Operating Junction Temperature Range	T_J	-65 to +100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation in Free Air Derate above 25°C	P_D	200 2.67	mW mW/°C
Thermal Resistance (Junction to Air)	θ_{JA}	0.375	°C/mW
Thermal Resistance (Junction to Case)	θ_{JC}	0.250	°C/mW

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

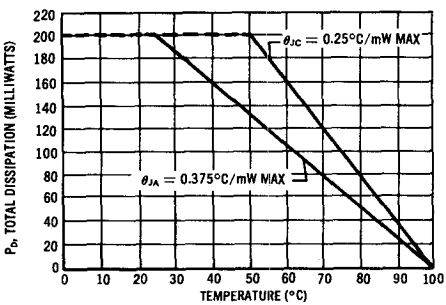
Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 105 V, I_E = 0)			–	25	
(V_{CB} = 2.5 V, I_E = 0)			–	10	
(V_{CB} = 105 V, I_E = 0, T_A = +71°C)			–	500	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 75 V, I_C = 0)			–	50	
(V_{EB} = 2.5 V, I_C = 0)			–	10	
Collector-Emitter Cutoff Current		I_{CER}			μAdc
(V_{CE} = 55 V, R_{BE} = 10 K)			–	600	
Collector-Emitter Cutoff Current		I_{CES}			mAdc
(V_{CE} = 105 V, V_{BE} = 0)			–	1.0	
DC Collector-Emitter Punch-Through Voltage		V_{pt}			Vdc
(V_{fl} = 1.0 V, VTVM R_{in} 10-12 megohm)			105	–	
DC Current Gain		h_{FE}			–
(I_C = 5 mA, V_{CE} = 0.35 V)	2N2042		20	50	
	2N2043		40	100	
Common Base, Small-Signal Input Impedance		h_{ib}			Ohms
(V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)			30	50	

2N2042 , 2N2043 (continued)

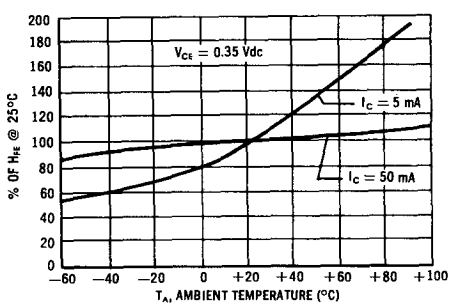
ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Minimum	Maximum	Unit
Common Base, Small-Signal Output Admittance (V_{CB} = 6 V, I_E = 1 mA, f = 1 kc)		h_{ob}	0.1	1.0	μmho
Common Emitter, Small-Signal Current Transfer Ratio (V_{CE} = 6 V, I_C = 1 mA, f = 1 kc)	2N2042 2N2043	h_{fe}	20 45	80 180	–
Base-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA)		$V_{BE(sat)}$	–	0.30	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 mA, I_B = 0.25 mA) (I_C = 100 mA, I_B = 10 mA)		$V_{CE(sat)}$	– –	0.25 0.75	Vdc
Collector Output Capacitance (V_{CB} = 6 V, I_E = 0)		C_{ob}	–	25	pf
Common-Base, Small-Signal Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 V, I_E = 1 mA)	2N2042 2N2043	f_{hfb}	0.50 0.75	– –	mc

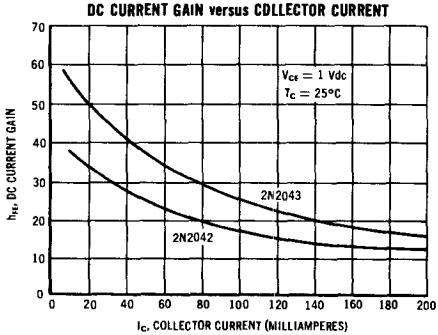
POWER-TEMPERATURE DERATING CURVE



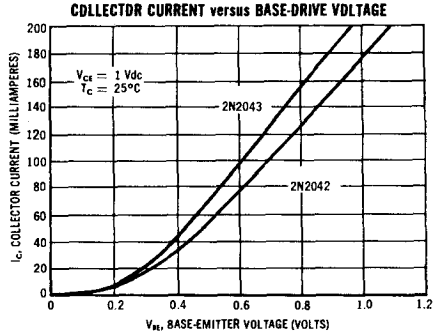
LARGE SIGNAL CURRENT GAIN versus TEMPERATURE



DC CURRENT GAIN versus COLLECTOR CURRENT



COLLECTOR CURRENT versus BASE-DRIVE VOLTAGE

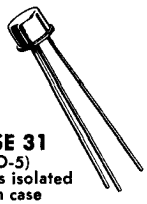


2N2171

FOR SPECIFICATIONS, SEE 2N381 DATA SHEET

2N3427, 2N3428

V_{CBO} = 45 V
h_{FE} = 150-400 (min-max)
$f\alpha_b$ = to 8.0 MC (typ)



CASE 31
(TO-5)
All leads isolated from case

PNP germanium transistors for audio amplifier and medium-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Collector-Emitter Voltage	V_{CER}	30	Vdc
Emitter-Base Voltage	V_{EBO}	30	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Base Current (Continuous)	I_B	50*	mAdc
Storage and Operating Temperature Range	T_{stg}, T_J	-65 to +100	°C
Collector Dissipation in Free Air Derate Above 25°C	P_D	200 2.67	mW mW/°C

*Limited by power dissipation

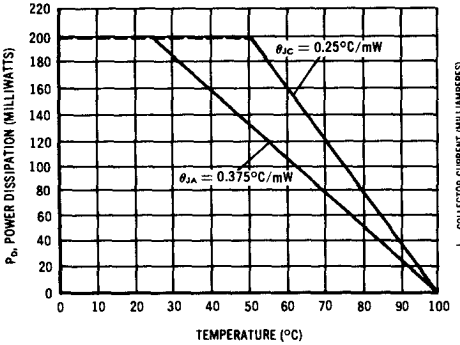
2N3427, 2N3428 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

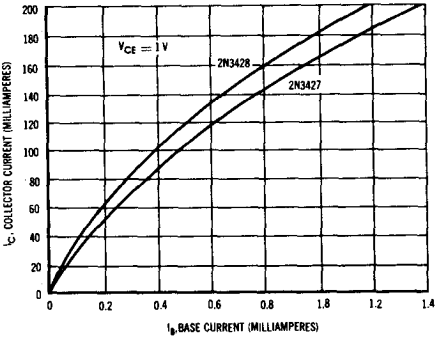
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 1.5 Vdc, I_E = 0)			–	3.0	5	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71°C)			–	–	100	
(V_{CB} = 30 Vdc, I_E = 0)			–	–	10	
(V_{CB} = 45 Vdc, I_E = 0)			–	–	50	
Emitter-Base Cutoff Current (V_{EB} = 30 Vdc, I_C = 0)		I_{EBO}	–	3.0	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 30 Vdc, R_{BE} = 10K ohms)		I_{CER}	–	–	600	μAdc
Collector-Emitter Punch-Thru Voltage (V_{fl} = 1.0 Vdc, VTVM impedance ≥ 1 megohm)		V_{pt}	30	–	–	Vdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 mc)		C_{ob}	–	10	20	pf
Noise Figure (V_{CE} = 4.5 Vdc, I_E = 0.5 mAdc, R_g = 1 K ohms, f = 1 kc, Δf = 1 cps)		NF	–	5	10	db
Small-Signal Current-Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	2N3427 2N3428	f_{hfb}	4.0 5.0	6.0 8.0	– –	mc
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)		h_{ib}	25	–	35	Ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)		h_{ob}	0.05	–	0.50	μmho
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	2N3427 2N3428	h_{fe}	200 350	325 475	500 800	–
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 2 mc)	2N3427 2N3428	$\lvert h_{fe} \rvert$	2.0 2.5	– –	7 8	–
DC Current Gain		h_{FE}				–
(I_C = 20 mAdc, V_{CE} = 1 Vdc)	2N3427 2N3428		150 250	275 375	– –	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3427 2N3428		100 150	210 260	350 400	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N3427 2N3428		75 125	– –	– –	
Base-Emitter Input Voltage (V_{CE} = 1 Vdc, I_C = 100 mAdc)		V_{BE}	–	–	–	Vdc
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 100 mAdc, I_B = 2 mAdc)	2N3427 2N3428		– –	0.155 0.150	0.200 0.190	
(I_C = 200 mAdc, I_B = 4 mAdc)	2N3427 2N3428		– –	0.220 0.200	0.300 0.280	

2N3427, 2N3428 (continued)

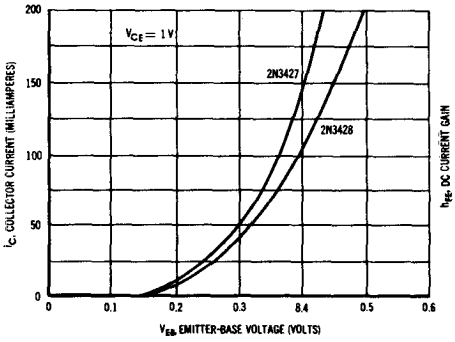
POWER-TEMPERATURE DERATING CURVE



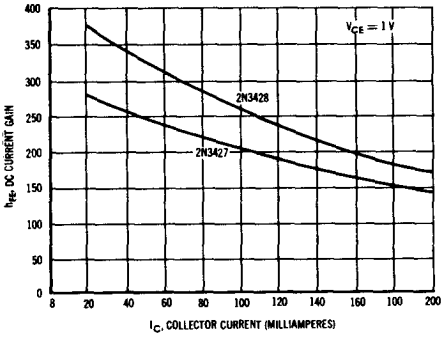
COLLECTOR CURRENT versus BASE CURRENT



OUTPUT CURRENT versus BASE DRIVE VOLTAGE



DC CURRENT GAIN versus COLLECTOR CURRENT



MA100

$V_{CB} = 60$ V
$h_{FE} = 30$ min
$f\alpha_b = 1.0$ Mc (min)



Low noise germanium transistor, designed for audio amplifier applications, feature stabilization bake for greater gain stability, and rugged quad-mount construction.

CASE 31
(TO-5)

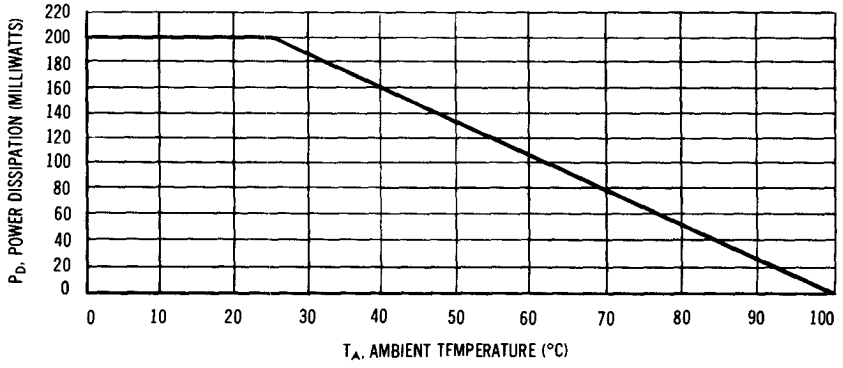
All leads isolated from case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	15	Vdc
Collector Current (Continuous)*	I_C*	500	mAdc
Collector Dissipation at $T_A = 25^oC$ Derate above 25^oC	P_C	200 2.67	mW mW/^oC
Junction Temperature Range	T_J	-65 to +100	^oC
Storage Temperature Range	T_{stg}	-65 to +100	^oC

*Limited by power dissipation.

POWER-TEMPERATURE DERATING CURVE

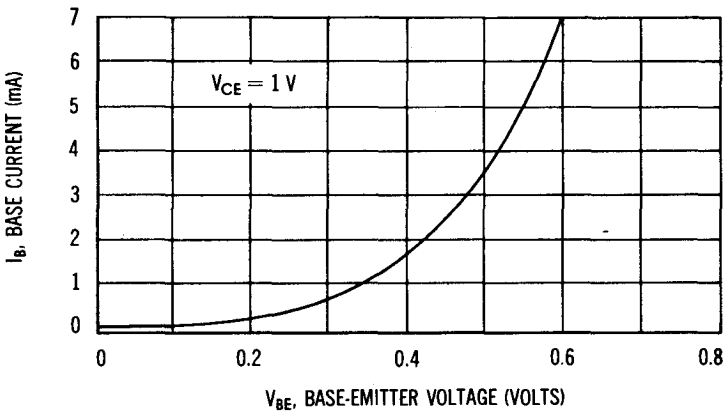


MA100 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

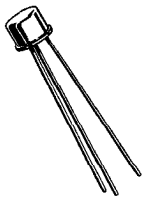
Characteristic	Symbol	Min	Max	Unit
Collector-Base Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0)	I_{CBO}	— —	100 10	μAdc
Emitter-Base Cutoff Current (V_{EB} = 15 Vdc, I_C = 0)	I_{EBO}	—	10	μAdc
Collector-Emitter Leakage Current (V_{CE} = 60 Vdc, R_{BE} = 0)	I_{CES}	—	100	μAdc
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 1 mc)	C_{ob}	—	25	pf
Input Impedance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	h_{ib}	26	40	ohms
Output Admittance (V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	h_{ob}	0.1	1.0	μmhos
DC Current Gain (V_{CE} = 1 Vdc, I_C = 10 mAdc)	h_{FE}	30	—	—
Small-Signal Current Gain (V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	h_{fe}	50	190	—
Small-Signal Current Gain Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)	f_{ab}	1.0	—	mc
Noise Figure (V_{CE} = 5 Vdc, I_C = 100 μAdc, R_S = 1 K ohms, f = 100 cps)	NF	—	8	db

BASE INPUT CURRENT versus BASE DRIVE VOLTAGE



MA112 thru MA117

V_{CBO} = 15 V
h_{fe} — to 100-250 (min-max)



CASE 31
(TO-5)

All leads isolated from case

PNP Germanium transistors for economical circuit applications. Available with a wide variety of gain ranges.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	15	V
Collector-Base Voltage	V_{CBO}	15	V
Emitter-Base Voltage	V_{EBO}	15	V
Collector Current	I_C	200	mA
Storage Temperature Limits	T_{stg}	-55 to +85	°C
Power Dissipation @ T_A = +25°C	P_D	175	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Current (V_{CE} = 15 V, R_{BE} = 10 KΩ)	All Types	I_{CER}	-	600	μA
Collector-Base Current (V_{CB} = 15 V, I_E = 0)	All Types	I_{CBO}	-	15	μA
Small Signal Current Gain (V_{CE} = 6 V, I_C = 1 mA)	MA112	h_{fe}	30	70	
	MA113		50	125	
	MA114		100	250	
	MA115		30	125	
	MA116		50	250	
	MA117		30	250	

MA200 thru MA206

V_{CB} — to 105 V
h_{FE} = 20-40 min
P_C = 150 mW



CASE 34
(TO-5)

Germanium PNP transistor designed for high-voltage applications in the audio frequency range, such as neon driver, solenoid or relay driver applications.

All leads isolated from case

MAXIMUM RATINGS (T_A = 25°C)

Characteristic	Symbol	MA200 MA202	MA201 MA203	MA204	MA205	MA206	Unit
Collector-Base Voltage	V_{CB}	105	105	90	75	60	Vdc
Collector-Emitter Voltage	V_{CE}	105	105	90	75	60	Vdc
Emitter-Base Voltage	V_{EB}	10	20	20	20	10	Vdc
Collector Current	I_C	← 200 →					mAdc
Emitter Current	I_E	← 200 →					mAdc
Junction and Storage Temperature Range	T_J, T_{stg}	← -65 to +100 →					°C
Thermal Resistance	θ_{JA} max	← 0.5 →					°C/mW
Collector Dissipation at T_A = 25°C Derate above 25°C	P_C	← 150 → ← 2 →					mW mW/°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

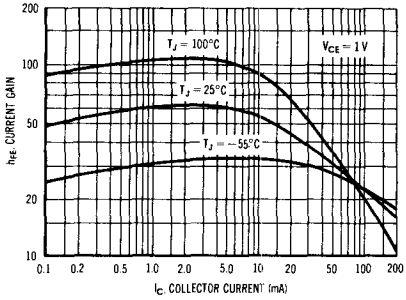
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μA
(V_{CB} = 105 V, I_E = 0)	MA 200 thru MA203					
(V_{CB} = 90 V, I_E = 0)	MA204		—	12.0	50	
(V_{CB} = 75 V, I_E = 0)	MA205					
(V_{CB} = 60 V, I_E = 0)	MA206					
Collector-Base Cutoff Current (V_{CB} = 2.5 V, I_E = 0)		I_{CBO}	—	5.0	14	μA
Emitter-Base Cutoff Current		I_{EBO}				μA
(V_{EB} = 10 V, I_C = 0)	MA200, MA202, MA206		—	3.0	50	
(V_{EB} = 20 V, I_C = 0)	MA201, MA203, MA204, MA205		—	3.0	50	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	—	0.11	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	—	0.22	0.40	Vdc
DC Current Gain		h_{FE}				—
(I_C = 5 mAdc, V_{CE} = 0.35 Vdc)	MA200, MA201, MA204, MA205, MA206		20	—	—	
	MA202, MA203		40	—	—	
DC Collector-Emitter Punch-Through Voltage (V_{CB} necessary to obtain V_{EB} of -1 V max, using instrument with Z_{in} > 11 megohm to measure V_{BE})		V_{PT}				Vdc
	MA200, MA201, MA202, MA203		105	—	—	
	MA204		90	—	—	
	MA205		75	—	—	
	MA206		60	—	—	
Small-Signal Short-Circuit Forward Current Transfer Ratio Cutoff Frequency (V_{CB} = 6 Vdc, I_E = 1 mAdc)		f_{ab}	—	1.0	—	mc

MA200 thru MA206 (continued)

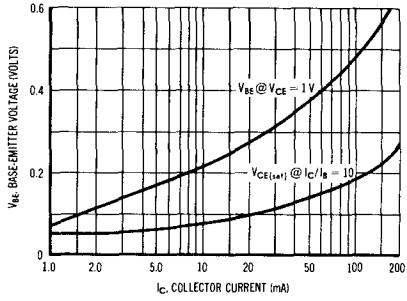
DC CHARACTERISTICS

(T_J = 25°C unless otherwise noted)

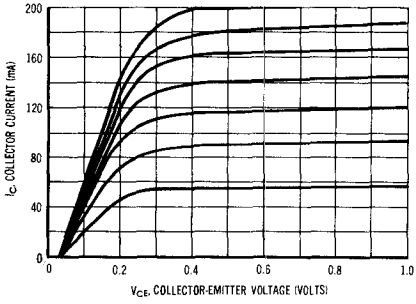
CURRENT GAIN



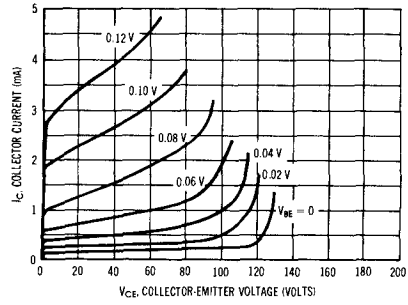
"ON" VOLTAGES



COLLECTOR SATURATION REGION

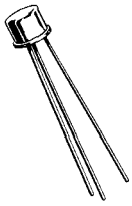


COLLECTOR HIGH VOLTAGE REGION



MA286 thru MA288

V_{CBO} = 10 V
h_{fe} — to 180 (min)



CASE 31
(TO-5)

All leads isolated from case

PNP germanium transistors for very economical circuit applications. Available with wide variety of gain ranges.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	10	V
Collector-Base Voltage	V_{CBO}	10	V
Emitter-Base Voltage	V_{EBO}	10	V
Collector Current	I_C	200	mA
Storage Temperature Limits	T_{stg}	-55 to +85	°C
Power Dissipation @ T_A = +25°C	P_D	175	mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Current (V_{CE} = 10 V, R_{BE} = 10 KΩ)	All Types	I_{CER}	-	600	μA
Small Signal Current Gain (V_{CE} = 6 V, I_C = 1 mA)	MA286	h_{fe}	14	40	-
	MA287		30	250	
	MA288		180	-	

MA881 thru MA889

V_{CBO} = 60 V
h_{FE} — to 125(min)
$f\alpha_b$ — to 1.75 MC(min)



CASE 31
(TO-5)

All leads isolated from case

PNP germanium transistors for audio amplifier and medium-speed switching applications. Recommended as driver transistors for 50-60 Volt power transistors.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage MA881 thru MA884 MA885 thru MA889	V_{CBO}	 60 50	Vdc
Collector-Emitter Voltage MA881 thru MA884 MA885 thru MA889	V_{CES}	 60 50	Vdc
Emitter-Base Voltage	V_{EBO}	15	Vdc
Collector Current (Continuous)*	I_{C*}	500	mAdc
Collector Dissipation at T_A = 25°C Derate above 25°C	P_D	200 2.67	mW mW/°C
Storage and Operating Temperature Range	T_{stg}, T_J	-50 to +100	°C

*Limited by power dissipation

MA881 thru MA889 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)	MA881 thru MA884		---	10	
(V_{CB} = 60 Vdc, I_E = 0)	MA881 thru MA884		---	100	
(V_{CB} = 25 Vdc, I_E = 0)	MA885 thru MA889		---	15	
(V_{CB} = 50 Vdc, I_E = 0)	MA885 thru MA889		---	100	
Emitter-Base Cutoff Current		I_{EBO}			μAdc
(V_{EB} = 15 Vdc, I_C = 0)	MA881 thru MA884		---	10	
	MA885 thru MA889		---	15	
Collector-Emitter Leakage Current		I_{CES}			μAdc
(V_{CE} = 60 Vdc, R_{BE} = 0)	MA881 thru MA884		---	100	
(V_{CE} = 50 Vdc, R_{BE} = 0)	MA885 thru MA889		---	100	
Output Capacitance		C_{ob}			pf
(V_{CB} = 6 Vdc, I_E = 0, f = 1 mc)	All types		---	25	
Input Impedance		h_{ib}			ohms
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	All types		26	40	
Output Admittance		h_{ob}			μmhos
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	All types		0.1	1.0	
DC Current Gain		h_{FE}			----
(V_{CE} = 1 Vdc, I_C = 10 mAdc)	MA881		30	---	
	MA882		40	---	
	MA883		75	---	
	MA884		125	---	
Small-Signal Current Gain		h_{fe}			----
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	MA881, MA886		30	70	
	MA882, MA887		50	120	
	MA883, MA888		100	225	
	MA884, MA889		190	400	
	MA885		15	40	
Small-Signal Current Gain Cutoff Frequency		f_{ab}			mc
(V_{CB} = 6 Vdc, I_E = 1 mAdc)	MA881, MA886		0.75	---	
	MA882, MA887		1.0	---	
	MA883, MA888		1.25	---	
	MA884, MA889		1.75	---	
	MA885		0.5	---	

MA909, MA910

V_{CB} = to 90 V
h_{FE} = 20 (min)



CASE 31
(TO-5)

All leads isolated from case

PNP Germanium transistors for high-voltage neon driver, solenoid and relay driver circuits.

MAXIMUM RATINGS

Characteristic	Symbol	MA909	MA910	Unit
Collector-Base Voltage	V_{CB}	75	90	Volts
Collector-Emitter Voltage	V_{CE}	75	90	Volts
Emitter-Base Voltage	V_{EB}	35	45	Volts
Collector Current	I_C	200		mA
Collector Dissipation at $T_C = 25°C$	P_C	150		mW
Junction and Storage Temperature	$T_{J(max)}$	100		°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Cutoff Current		I_{CBO}			Adc
(V_{CB} = 2.5 Vdc, I_E = 0)	Both Types		-	14	
(V_{CB} = 75 Vdc, I_E = 0)	MA909		-	50	
(V_{CB} = 90 Vdc, I_E = 0)	MA910		-	50	
Emitter-Base Cutoff Current		I_{EBO}			Adc
(V_{EB} = 35 Vdc, I_C = 0)	MA909		-	50	
(V_{EB} = 45 Vdc, I_C = 0)	MA910		-	50	
Collector-Emitter Leakage Current		I_{CES}			Adc
(V_{CE} = 75 Vdc, R_{BE} = 0)	MA909		-	100	
(V_{CE} = 90 Vdc, R_{BE} = 0)	MA910		-	100	
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{CE(sat)}$	-	0.35	Vdc
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 0.25 mAdc)		$V_{BE(sat)}$	-	0.40	Vdc
DC Current Gain (I_C = 5 mAdc, V_{CE} = 0.35 Vdc)		h_{FE}	20	-	-
Collector-Emitter Punch-Thru Voltage		V_{pt}			Vdc
(V_{fl} = 1.0 Vdc, R_{in} of VTVM - 10 to 12 Megohms)	MA909		75	-	
	MA910		90	-	

MA1702 thru MA1708

V_{CBO} — to 45 V
h_{FE} — to 150-400 (min-max)
$f\alpha_b$ — to 7.0 MC (min)



CASE 31
(TO-5)

All leads isolated from case

PNP germanium transistors for audio amplifier and medium speed switching applications requiring high ac gain at low collector current or high dc gain at high collector current.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage MA1702 MA1703 thru MA1705 MA1706 thru MA1708	V_{CBO}	 45 25 15	Vdc
Collector-Emitter Voltage MA1702 MA1703 thru MA1705 MA1706 thru MA1708	V_{CER}	 30 25 15	Vdc
Emitter-Base Voltage MA1702 MA1703 thru MA1705 MA1706 thru MA1708	V_{EBO}	 30 25 4.5	Vdc
Collector Current (Continuous)	I_C	500*	mAdc
Base Current (Continuous)	I_B	50*	mAdc
Maximum Junction Temperature	$T_{J(max)}$	100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C
Collector Dissipation in Free Air Derate Above 25° C	P_D	200 2.67	mW mW/° C

*Limited by power dissipation

MA1702 thru MA1708 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 1.5 Vdc, I_E = 0)	MA1702 thru MA1705		-	3.0	5	
(V_{CB} = 10 Vdc, I_E = 0, T_A = +71° C)	MA1702		-	-	100	
(V_{CB} = 15 Vdc, I_E = 0)	MA1706 thru MA1708		-	-	15	
(V_{CB} = 25 Vdc, I_E = 0)	MA1703 thru MA1705		-	-	15	
(V_{CB} = 30 Vdc, I_E = 0)	MA1702		-	-	10	
(V_{CB} = 45 Vdc, I_E = 0)	MA1702		-	-	50	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 4.5 Vdc, I_C = 0)	MA1706 thru MA1708		-	-	15	
(V_{EB} = 25 Vdc, I_C = 0)	MA1703 thru MA1705		-	-	15	
(V_{EB} = 30 Vdc, I_C = 0)	MA1702		-	3.0	10	
Collector-Emitter Leakage Current		I_{CER}				μAdc
(V_{CE} = 15 Vdc, R_{BE} = 10 K ohms)	MA1706 thru MA1708		-	-	600	
(V_{CE} = 25 Vdc, R_{BE} = 10 K ohms)	MA1703 thru MA1705		-	-	600	
(V_{CE} = 30 Vdc, R_{BE} = 10 K ohms)	MA1702		-	-	600	
Collector-Emitter Punch-Thru Voltage		V_{pt}				Vdc
(V_{fl} = 1.0 Vdc, VTVM impedance ≥ 1 megohm)	MA1702		30	-	-	
Output Capacitance		C_{ob}				pf
(V_{CB} = 6 Vdc, I_E - 0, f = 1 mc)	All Types		-	10	20	
Noise Figure		NF				db
(V_{CE} = 4.5 Vdc, I_E = 0.5 mA, R_g = 1 K, f = 1 kc, Δf = 1 cps)	MA1702		-	5	10	
Small-Signal Current Gain Cutoff Frequency		f_{hfb}				mc
(V_{CB} = 6 Vdc, I_E = 1 mAdc)	MA1702		7.0	-	-	
	MA1703		3.0	-	-	
	MA1704		5.0	-	-	
	MA1705		6.0	-	-	
	MA1706		3.0			
	MA1707		4.0			
	MA1708		5.0			
Input Impedance		h_{ib}				Ohms
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	MA1702 thru MA1705		25	-	35	
	MA1706 thru MA1708		25	-	37	
Output Admittance		h_{ob}				μmho
(V_{CB} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	MA1702		0.05	-	0.50	
Small Signal Current Gain		h_{fe}				-
(V_{CE} = 6 Vdc, I_E = 1 mAdc, f = 1 kc)	MA1702, MA1705, MA1708		500	-	-	
	MA1703, MA1706		200	-	500	
	MA1704, MA1707		350	-	800	
DC Current Gain		h_{FE}				-
(I_C = 20 mAdc, V_{CE} = 1 Vdc)	MA1702		350	-	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MA1702, MA1705, MA1708		200	-	-	
	MA1703, MA1706		100	-	350	
	MA1704, MA1707		150	-	400	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	MA1702		135	-	-	
	MA1703		70	-	-	
	MA1704		110	-	-	
	MA1705		125	-	-	
Collector-Emitter Saturation Voltage		V_{CE} (sat)				Vdc
(I_C = 200 mAdc, I_B = 4.0 mAdc)	MA1702		-	-	0.260	

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

SWITCHING AND GENERAL PURPOSE TRANSISTORS

SWITCHING AND GENERAL PURPOSE TRANSISTORS

This section contains both silicon and germanium transistors intended primarily for high-speed switching and for high-frequency amplifier applications below the VHF/UHF bands. (See next section for RF transistors intended for VHF/UHF operation.)

Many of these devices may be used for either switching or amplifier purposes, while others are intended principally for high-speed switching applications. To aid in the selection of transistors for special applications, a number of selection guides are provided. The devices listed in these guides are preferred devices which merit first consideration for new designs and for redesign of older equipment.

The following table lists a number of semiconductor devices that comply with the terms of military specifications, the applicable military specifications and the appropriate page in the data sections of this manual. For additional information, military-type data sheets are available.

USN 2N705	MIL-S-19500/86A	8-13
JAN 2N706	MIL-S-19500/120B	8-15
JAN 2N929	MIL-S-19500/253A	8-46
JAN 2N930	MIL-S-19500/253A	8-46
USN 2N962	MIL-S-19500/258A	8-48
USN 2N964	MIL-S-19500/258A	8-48
USN 2N1131	MIL-S-19500/177B	8-64
USN 2N1132	MIL-S-19500/177B	8-24
JAN 2N2218	MIL-S-19500/251D	8-74
JAN 2N2218A	MIL-S-19500/251D	8-80
JAN 2N2219	MIL-S-19500/251D	8-74
JAN 2N2219A	MIL-S-19500/251D	8-80
JAN 2N2221	MIL-S-19500/255D	8-74
JAN 2N2221A	MIL-S-19500/255D	8-80
JAN 2N2222	MIL-S-19500/255D	8-74
JAN 2N2222A	MIL-S-19500/255D	8-80
USN 2N2481	MIL-S-19500/268A	8-100
JAN 2N2904	MIL-S-19500/290A	8-115
JAN 2N2904A	MIL-S-19500/290A	8-115
JAN 2N2905	MIL-S-19500/290A	8-115
JAN 2N2905A	MIL-S-19500/290A	8-115
JAN 2N2906	MIL-S-19500/291A	8-115
JAN 2N2906A	MIL-S-19500/291A	8-115
JAN 2N2907	MIL-S-19500/291A	8-115
JAN 2N2907A	MIL-S-19500/291A	8-115
JAN 2N3250A	MIL-S-19500/323	8-141
JAN 2N3251A	MIL-S-19500/323	8-141

For case outline dimensions, see page 1-186.

QUICK SELECTION GUIDES — HIGH-FREQUENCY SILICON ANNULAR TRANSISTORS

The following three tables provide type numbers of preferred silicon (metal-cased) transistors that should receive first consideration for the design of new equipment. The tables are arranged to permit preselection in terms of electrical characteristics.

Table 8-1 list the preferred device type number in terms of operating current range and breakdown voltage as well as conductivity (i.e., NPN or PNP). In addition, the type number printed in bold face should receive first consideration for high-speed switching applications. Other type numbers should be considered for general purpose switching and amplifier needs.

Table 8-1, moreover, can be used in conjunction with Tables 8-2 and 8-3 to pin-point still further devices needed for high-speed switching. Note that Table 8-1 is divided into two parts - one for low-current, high-speed switching, the other for high-current core driver and pulse amplifiers applications. For these two applications categories, initial selections according to current and voltage is made from the bold-face type numbers in Table 8-1, and subsequent quick comparisons of other characteristics for these type numbers can be obtained from Table 8-2 or 8-3. The latter two tables are accompanied by graphs showing typical variation of dynamic switching characteristics over a wide current range for each of the devices listed in the tables.

TABLE 8-1 — CURRENT versus VOLTAGE SILICON TRANSISTOR SELECTION GUIDE

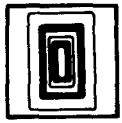
	BOLD FACE TYPES RECOMMENDED FOR LOW-CURRENT SATURATED SWITCHING, EXCEPT* FOR CURRENT-MODE SWITCHING. (SEE TABLE 8-2)				BOLD FACE TYPES RECOMMENDED FOR HIGH-CURRENT CORE DRIVER AND PULSE AMPLIFIER APPLICATIONS. (SEE TABLE 8-3).					
	OPTIMUM COLLECTOR CURRENT RANGE									
BV_{CEO}	10 μA - 10 mA		1 mA - 50 mA		10 mA - 400 mA		150 mA - 800 mA		800 mA - 3 A	
	NPN	PNP	NPN	PNP	NPN	PNP	NPN	PNP	NPN	PNP
5-19 Volts	**2N706, A, B** **2N708** **2N914** **2N3493** **MM709**	**2N4260-1***	**2N744** **2N753** **2N834-5** **2N2256-7*** **2N2368-9** **2N2481** **2N3959-60***	**2N3248-9** **2N3546** **MM2894** 2N869 2N995	**2N3510-1** **2N3647-8**					
20-39 Volts	2N916		**2N2501** **2N3227** **2N3508-9** 2N2330-1		**2N2537-40** 2N697 2N718 2N956 2N1420 2N2218-2 2N2958-9 2N3115-6	2N722 2N1131-2 2N1991 2N2303 2N2800-1 2N2837-8 2N3133-6	**2N3252**		**2N3734** **2N3736**	
40-79 Volts	**2N707A** 2N915 2N930 MM2483 MM2484	2N3798-9	2N3946-7	2N3250-1 2N3250A-1A	2N2218A-22A 2N3053	2N1132A, B 2N2904-7 2N2904A-7A 2N3485-6 2N3485A-6A	**2N3253** **2N3444** 2N2192-5, A, B	**2N3467-8** 2N3244-5	**2N3506-7** **2N3735** **2N3737** 2N3719-20	**2N3762-5**
80-149 Volts			2N1893 2N2405	2N3494-7 2N3634-5	2N3498-9		2N3019-20			
150-300 Volts			2N3742	2N3636-7 2N3743	2N3500-1					

TABLE 8-2 — SILICON HIGH-SPEED SWITCHING TRANSISTORS
(For low-current, saturated switching, except* for current-mode switching)

Devices listed in this table should receive first consideration for low-current, high-speed switching applications. To determine, quickly, the devices best suited for a specific circuit design, first consult Table 8-1 for preselection in terms of voltage, current and conductivity. Then use this table to compare dynamic characteristics of the preselected devices.

The graphs on the facing page show typical variations of $V_{CE(sat)}$, h_{FE}, switching time and storage time as a function of collector current for each device in this table. The appropriate curves are referenced in the "curve" column of the table. Device geometries can be identified from the "Geometry" column.

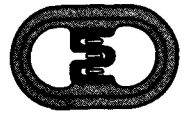
Type Number	Curve Code	Geometry Code	h_{FE} min/max @ I_C = 10 mA, V_{CE} = 1 V (unless otherwise indicated)	$V_{CE(sat)}$ Volts @ I_C = 10 mA, I_B = 1 mA (unless otherwise indicated)	Switching Time		
					t_{on} (ns)	t_{off} (ns)	t_{on} and t_{off} Test Conditions
2N706, A, B	A	1	20/-	0.6	40	75	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, I_{B2} = 1 mA
2N707, A	B	1	9/50	0.18	—	—	
2N708	A	1	30/120	0.4	—	—	
2N744	A	1	40/120	0.35(+170°C)	16	24	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, I_{B2} = 1 mA
2N753	A	1	40/120	0.6	40	75	
2N834	A	1	25/-	0.25	16	30	
2N835	A	1	20/-	0.3	20	35	
2N914	A	1	30/120	0.25	40	40	
2N2368	C	2	20/60	0.25	12	15	I_C = 10 mA, $V_{BE(off)}$ = 1.5 V
2N2369	C	2	40/120	0.25	12	18	V_{CC} = 3 V, I_{B1} = 3 mA, I_{B2} = 1.5 mA
2N2481	A	1	40/120	0.25	40	55	I_C = 10 mA, V_{CC} = 3 V
2N2501	A	1	50/150	0.2	—	—	I_C = 10 mA, I_{B1} = 1mA, V_{CC} = 3 V, I_{B2} = 0.5 mA, $V_{BE(off)}$ = 2 V
2N3227	C	2	100/300	0.25	12	18	I_C = 10 mA, $V_{BE(off)}$ = 1.5 V V_{CC} = 3 V, I_{B1} = 3 mA, I_{B2} = 1.5 mA
2N3248	E	1	50/150	0.125	20	80	I_C = 100 mA, V_{CC} = 3 V,
2N3249	E	1	100/300	0.125	20	80	$V_{BE(off)}$ = 0.5 V, I_{B1} = I_{B2} = 10 mA
2N3493	F	4	40/12 (I_C = 0.5 mA)	0.13 @ I_C = 0.1 mA I_B = 0.01 mA)	—	—	
2N3508	C	2	40/120	0.25	12	18	I_C = 10 mA, V_{CC} = 3 V, $V_{BE(off)}$ = 1.5 V,
2N3509	C	2	100/300	0.25	12	18	I_{B1} = 3 mA, I_{B2} = 1.5 mA
2N3546	D	2	30/120	0.15	25	35	I_C = 50 mA, V_{CC} = 3 V, I_{B1} = I_{B2} = 5 mA
2N3959*	G	3	40/400	0.2	5.4	4.9	I_C = 10 mA, V_{out} = 1 V,
2N3960*	G	3	40/200	0.2	5.4	4.9	V_{BB} = 1 V
2N4260*	H	5	30/150	0.35	1.5	2.0	V_{in} = V_{out} = 2V, V_{BB} = 1 V,
2N4261*	H	5	30/15	0.35	1.5	2.0	I_C = 10 mA
MM709	H	1	15/120 @ V_{CE} = 0.5 V	0.35(max) @ I_C = 3 mA I_B = 0.15 mA	12	10	I_C = 10 mA, I_{B1} = 2.0 mA, I_{B2} = 5.0 mA
MM2894	D	2	30/-	0.15	60	60	I_C = 30 mA, I_{B1} = I_{B2} = 1.5 mA, V_{CC} = 2 V


1

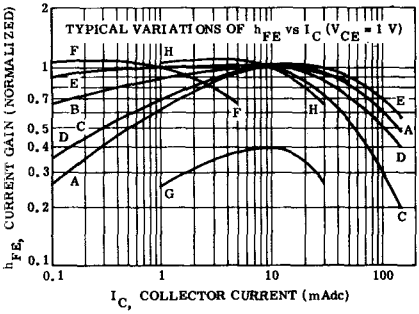

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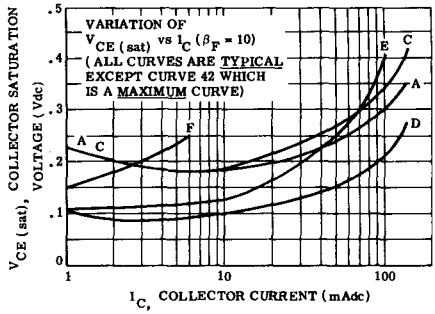

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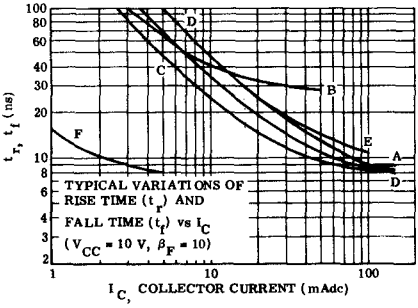

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5

HIGH SPEED SILICON TRANSISTOR CHARACTERISTIC CURVES







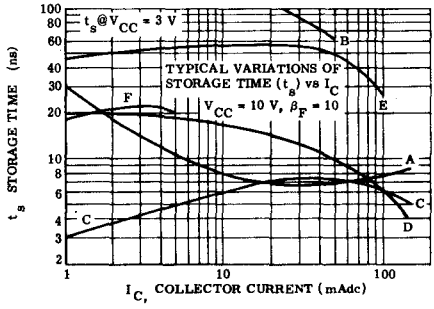


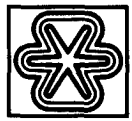
TABLE 8-3 — HIGH CURRENT SILICON TRANSISTORS FOR CORE DRIVERS AND PULSE AMPLIFIERS

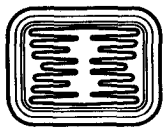
Devices listed in this table should receive first consideration as core drivers or pulse amplifiers. To determine, quickly, the devices best suited for a specific circuit design, first consult Table 8-1 for preselection in terms of voltage, current and conductivity. Then use this table to compare dynamic characteristics of preselected devices.

The graphs on the facing page show typical variations of $V_{CE(sat)}$, h_{FE}, switching time and storage time as a function of collector current for each device in this table. The appropriate curves are referenced in the "curve" column of the table. Device geometries can be identified from the "Geometry" column.

Type Number	Curve Code	Geometry Code	h_{FE} min/max @ I_C = 150 mA, V_{CE} = 10 V (unless otherwise indicated)	$V_{CE(sat)}$ Volts @ I_C = 150 mA (unless otherwise indicated)	Switching Time t_{on} (ns)	Switching Time t_{off} (ns)	Switching Time t_{on} and t_{off} Test Conditions
2N2537	J	1	50/150	0.45 @ I_B = 15 mA	40	40	I_C = 150 mA, V_{CC} = 7 V, R_L = 40 Ω ↓
2N2538	J	1	100/300	0.45 @ I_B = 15 mA	40	40	
2N2539	J	1	50/150	0.45 @ I_B = 15 mA	40	40	
2N2540	J	1	100/300	0.45 @ I_B = 15 mA	40	40	
2N3252	K	2	30/90 @ I_C = 500 mA V_{CC} = 2 V	0.5 @ I_C = 500 mA I_B = 50 mA	45	70	I_C = 500 mA, V_{CC} = 30 V ↓
2N3253	K	2	25/75 @ I_C = 500 mA V_{CC} = 2 V	0.6 @ I_C = 500 mA I_B = 50 mA	50	70	
2N3444	K	2	20/60 @ I_C = 500 mA V_{CC} = 2 V	0.5 @ I_C = 500 mA I_B = 50 mA	50	70	
2N3467	L	2	40/200 @ I_C = 1.5 A V_{CE} = 2 V	0.5 @ I_C = 500 mA I_B = 50 mA	40	90	
2N3468	L	2	30/150 @ I_C = 1.5 A V_{CE} = 2 V	0.6 @ I_C = 500 mA I_B = 50 mA	40	90	
2N3506	M	3	40/200 @ I_C = 1.5 A V_{CE} = 2V	1.0 @ I_C = 1.5 A I_B = 150 mA	45	90	I_C = 1.5 A V_{CC} = 30 V ↓
2N3507	M	3	30/150 @ I_C = 1.5 A V_{CE} = 2 V	0.6 @ I_C = 1.5 A I_B = 150 mA	45	90	
2N3510	N	4	25/150 @ I_C = 150 mA V_{CE} = 1 V	0.4 @ I_B = 15 mA	20	25	I_C = 150 mA V_{CC} = 6 V ↓
2N3511	N	4	30/120 @ I_C = 150 mA V_{CE} = 1 V	0.4 @ I_B = 15 mA	16	18	
2N3647	N	4	25/150 @ I_C = 150 mA V_{CE} = 1 V	0.4 @ I_B = 15 mA	20	25	
2N3648	N	4	30/120 @ I_C = 150 mA V_{CE} = 1 V	0.4 @ I_B = 15 mA	16	18	
2N3734	P	5	35/-	0.2	48	60	I_C = 1 A, I_{B1} = I_{B2} = 100 mA, V_{CC} = 12 V, $V_{BE(off)}$ = 0 V ↓
2N3735	P	5	35/-	0.2	48	60	
2N3736	P	5	35/-	0.2	48	60	
2N3737	P	5	35/-	0.2	48	60	
2N3762	R	5	35/-	0.1	43	115	
2N3763	R	5	35/-	0.1	43	115	
2N3764	R	5	35/-	0.1	43	115	
2N3765	R	5	35/-	0.1	43	115	


1

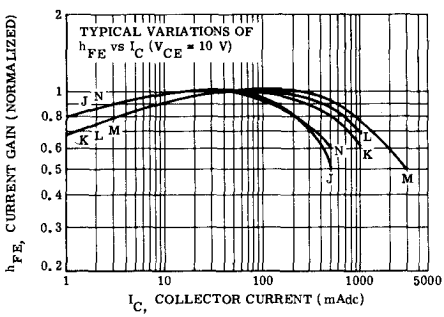

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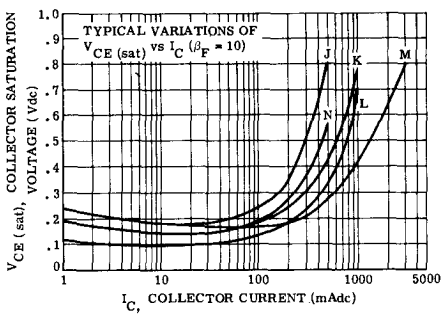

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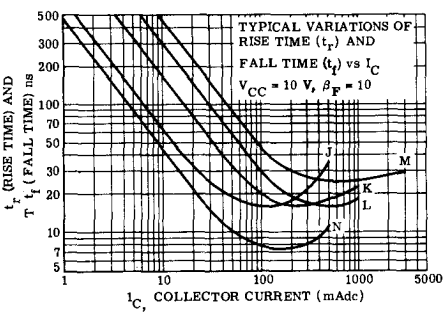

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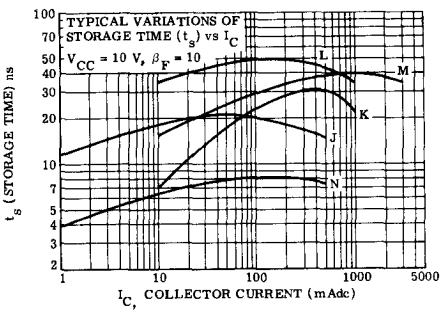

5

HIGH CURRENT SILICON TRANSISTOR CHARACTERISTIC CURVES









QUICK SELECTION GUIDE — HIGH-SPEED GERMANIUM SWITCHING TRANSISTORS

The following tables list germanium transistors recommended for high-speed switching applications. All are PNP devices.

Preselection of devices for this applications category can be made by first selecting those devices that fill the voltage and current requirements (from Table 8-4), then comparing the dynamic characteristics of the devices selected by consulting Table 8-5 for a further narrowing of the field.

Final device selection can then be made by consulting the complete data sheets.

TABLE 8-4 — CURRENT versus VOLTAGE SELECTOR GUIDE
(PNP Germanium High-Speed Switching Transistors)

BV_{CEO} MINIMUM VOLTS	OPTIMUM COLLECTOR CURRENT RANGE		
	1 mA - 50 mA	10 mA - 100 mA	100 mA - 500 mA
5 - 9	2N705 2N710 2N711 2N968 2N969 2N970 2N971 2N972 2N973 2N974 2N975	2N711A 2N711B 2N960 2N961 2N962 2N963 2N964 2N964A 2N965 2N966 2N967 2N985	—
10 - 15	MM2550	2N2635 MM2552 MM2554	2N1204 2N1204A 2N1494 2N1494A 2N2096 2N2099 2N2381 2N3883
16 - 20	—	2N2956 2N2957	2N2097 2N2100 2N2382
more than 21	—	2N2955	2N1495 2N1496

GERMANIUM HIGH SPEED SWITCHING TRANSISTORS (continued)

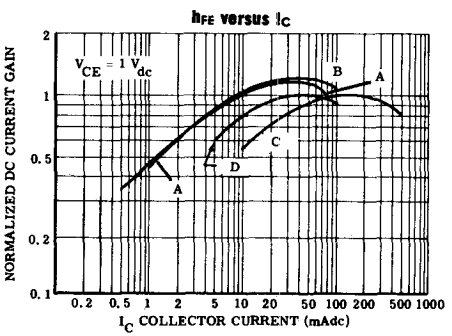
TABLE 8-5 — PNP GERMANIUM HIGH-SPEED SWITCHING TRANSISTORS
(Dynamic Characteristics)

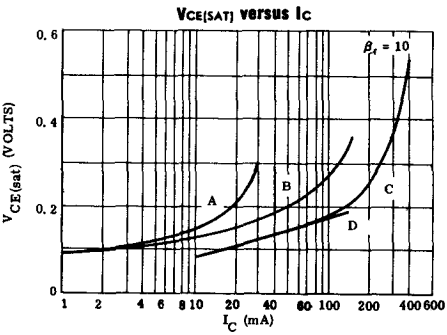
Type Number	Curve Code	f_T (MHz)	h_{FE} @ I_C (min/max) (mA)	$V_{CE(sat)}$ @ I_C/I_B (max) (Volts) (mA)	Switching Times (max) t_{on} (ns)	t_{off} (ns)	t_{on} and t_{off} Test Conditions
2N705	A	325	25/— 10	0.3 10/1	75	200	I_C = 10 mA,
2N710	A	325	25/—	0.5	75	200	I_{B1} = 1 mA, I_{B2} = 0.25 mA
2N711	A	300	20/—	0.5	100	350	
2N711A	B	150	25/150	0.55	100	300	
2N711B	B	150	30/150	0.45	100	300	
2N960	B	300	20/—	0.4 50/5	50	85	
2N961	B	300	20/—	0.4	50	85	
2N962	B	300	20/—	0.4	50	100	
2N963	B	300	20/—	0.2 10/1	60	120	I_{B1} = 1.0 mA, I_{B2} = 1.25 mA
2N964	B	300	40/—	0.35 50/5	50	85	I_{B1} = 1.0 mA, I_{B2} = 0.25 mA
2N964A	B	300	40/—	0.28	50	85	
2N965	B	300	40/—	0.35	50	85	
2N966	B	300	40/—	0.35	50	100	
2N967	B	300	40/—	0.2 10/1	60	120	I_{B1} = 1 mA, I_{B2} = 1.25 mA
2N968	A	250	17/—	0.25	75	150	I_C = 10 mA,
2N969	A	250	17/—	0.25	75	150	I_{B1} = 1 mA, I_{B2} = 0.25 mA
2N970	A	250	17/—	0.25	100	275	
2N971	A	250	17/—	0.25	100	275	
2N972	A	250	40/—	0.25	75	175	
2N973	A	250	40/—	0.25	75	175	
2N974	A	250	40/—	0.25	100	275	
2N975	A	250	40/—	0.25	100	275	
2N985	B	300	40/—	0.15	35	80	I_{B1} = 5 mA, I_{B2} = 1.25 mA
2N1204	C	110	15/— 400	0.5 200/10	—	—	
2N1204A	C	110	25/— 200	0.5	—	—	
2N1494	C	110	15/— 400	0.4	—	—	
2N1494A	C	110	25/— 200	0.4	—	—	
2N1495	C	150	25/— 200	0.3 200/20	—	—	
2N1496	C	150	25/— 400	0.3	—	—	

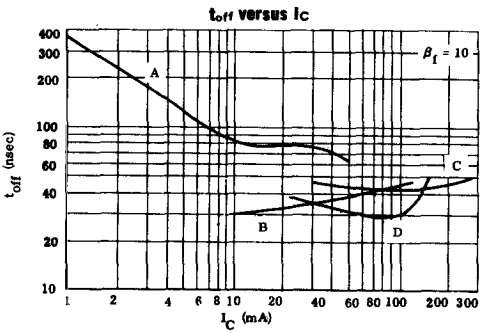
GERMANIUM HIGH SPEED SWITCHING TRANSISTORS (continued)

Type Number	Curve Code	f_T (MHz)	h_{FE} (min/max)	@ I_C (mA)	$V_{CE(sat)}$ (max) (Volts)	@ I_C/I_B (mA)	Switching Times t_{on} (ns)	Switching Times t_{off} (ns)	Switching Times t_{on} and t_{off} Test Conditions
2N2096	C	—	15/—	400	0.6	200/10	—	130	I_C = 200 mA,
2N2097	C	—	20/—	↓	0.5	↓	—	90	I_{B1} = 20 mA, I_{B2} = 20 mA
2N2099	C	—	15/—	↓	0.6	↓	—	130	↓
2N2100	C	—	20/—	↓	0.5	↓	—	90	↓
2N2381	C	300	40/—	200	0.4	200/20	22	45	↓
2N2382	C	300	40/—	↓	0.4	↓	22	45	↓
2N2635	D	300	45/300	50	0.4	50/2.5	50	250	I_{B1} = 1 mA, I_{B2} = 0.25 mA
2N2955	D	200	20/60	↓	0.3	50/5	55	80	I_C = 50 mA,
2N2956	D	250	40/120	↓	0.25	↓	45	90	I_{B1} = 5 mA, I_{B2} = 5 mA
2N2957	D	300	100/—	↓	0.2	↓	40	95	↓
2N3883	C	300	30/—	200	0.35	200/40	36	68	I_C = 200 mA, I_{B1} = 40 mA, I_{B2} = 40 mA
MM2550*	—	1000	20/—	10	0.2	10/1	2.5	2.5	I_C = 10 mA, V_{CE} = 5 V
MM2552*	—	1000	30/—	25	0.2	25/2.5	2.5	2.5	I_C = 25 mA, V_{CE} = 5 V
MM2554*	—	1000	20/—	40	0.25	40/4	2.5	2.5	I_C = 40 mA, V_{CE} = 5 V

*Current Mode Switches







ADDITIONS AND MODIFICATIONS

2N697 (SILICON)
2N718
2N1420

V_{CER} = 30-40 V
f_T = 300 Mc



CASE 22
(TO-18)

NPN silicon annular Star transistors for medium-current switching and amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage 2N697, 2N718 2N1420	V_{CER}	 40 30		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
		2N697 2N1420 TO-5	2N718 TO-18	
Total Device Dissipation at 25°C Case Temperature Derating Factor Above 25°C	P_D	3 20	1.5 10	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperatures Derating Factor Above 25°C	P_D	0.6 4.0	0.4 2.66	Watts mW/°C
Junction Temperature	T_J	+ 175		°C
Storage Temperature range	T_{stg}	-65 to + 200		°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	 —	.001 —	I.0 100	μAdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	60	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_B \leq$ I0 Ohms) 2B697, 2N718 2N1420	BV_{CER}	 40 30	 — —	 — —	Vdc
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE(sat)}$	—	0.3	1.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE(sat)}$	—	—	1.3	Vdc

2N697, 2N718, 2N1420 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DC Forward Current Transfer Ratio* (I_C = 1 mAdc, V_{CE} = 10 Vdc)	h_{FE}				–
2N697, 2N718		–	20	–	
2N1420		–	35	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)					
2N697, 2N718		40	–	120	
2N1420		100	–	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)					
2N697, 2N718		–	20	–	
2N1420		–	35	–	
Small Signal Forward Current Transfer Ratio (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 mc)	h_{fe}	2.5	15	–	–
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	–	5	35	pf

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N705 (GERMANIUM)
2N705 USN/JAN

V_{CES} = 15 V
I_C = 50 mA
f_T = 400 Mc Typ

CASE 22
(TO-18)



PNP germanium mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

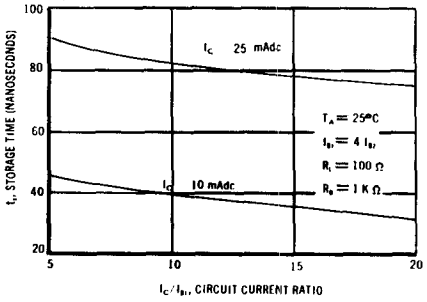
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector Current	I_C	50	mAdc
Emitter Current	I_E	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65°C to +100°C	°C
Collector Dissipation @ 25°C Case Temp. (Derate 4 mW/°C above 25°C)	P_C	300	mW
Collector Dissipation in Free Air	P_C	150	mW

2N705 (continued)

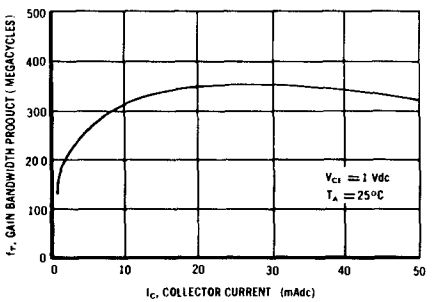
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_{CE} = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	I_{CBO}	—	0.2	3	μAdc
DC Forward Current Transfer Ratio (V_{CE} = .3 Vdc, I_C = 10 mAdc)	h_{FE}	25	40	—	—
Collector Saturation Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	$V_{CE(sat)}$	—	0.18	0.3	Vdc
(I_B = 5 mAdc, I_C = 50 mAdc)		—	0.45	—	
Base-Emitter Voltage (I_B = .4 mAdc, I_C = 10 mAdc)	V_{BE}	0.34	0.39	0.44	Vdc
Small Signal Forward Current Transfer Ratio (V_{CE} = 1.0 Vdc, I_C = 10 mAdc, f = 100 mc)	h_{fe}	—	9	—	db
Collector Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 mc)	C_{ob}	—	5.0	—	pf
Input Capacitance (V_{EB} = 2 Vdc)	C_{ib}	—	3.5	—	pf
Common Base Alpha Cutoff Frequency (V_{CB} = 5 Vdc, I_C = 10 mAdc)	$f_{\alpha b}$	—	300	—	mc
Delay + Rise Time (I_C = 10 mAdc, I_B = 1 mAdc)	$t_d + t_r$	—	55	75	nsec
Storage Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_s	—	65	100	nsec
Fall Time (I_{B1} = 1.0 mAdc, I_{B2} = .25 mAdc)	t_f	—	70	100	nsec

STORAGE TIME versus CIRCUIT CURRENT RATIO

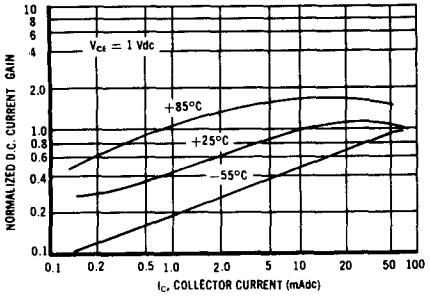


CURRENT GAIN — BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT

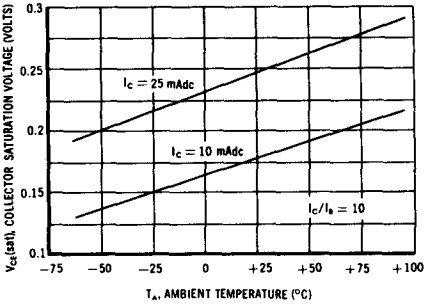


2N705 (continued)

NORMALIZED D.C. CURRENT GAIN
versus COLLECTOR CURRENT



COLLECTOR SATURATION VOLTAGE
versus AMBIENT TEMPERATURE



2N706, A, B (SILICON)

2N706 JAN
2N753

V_{CEO} = 15 V
h_{FE} = 20-40 min
f_T = 400 Mc



CASE 22
(TO-18)
Collector connected to case

NPN silicon annular switching transistors for high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	25	Volts
Collector-Emitter Voltage *	V_{CER}*	20	Volts
Emitter-Base Voltage 2N706 2N706A 2N706B 2N753	V_{EB}	3 5 5 5	Volts
Junction Temperature	T_j	175	°C
Storage Temperature	T_{stg}	-65 to +175	°C
Total Device Dissipation at 25° C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25° C Ambient Temperature (Derate 2 mW/°C above 25°C)	P_D	0.3	Watt
Total Device Dissipation at 100°C Case Temperature (Derate 6.67 mW/°C above 100°C)	P_D	0.5	Watt

**Refers to collector breakdown voltage in the high current region when $R_{be} = 10\Omega$*

2N706,A,B, 2N753 (continued)

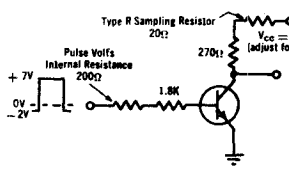
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Type	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 15Vdc, I_E = 0) (V_{CB} = 15Vdc, I_E = 0, T_A = 150 °C) (V_{CB} = 25Vdc, I_E = 0)	All Types All Types 2N706A, 2N706B, 2N753	I_{CBO}	- - -	005 3 -	0.5 30 10	μAdc
Collector-Emitter Cutoff Current (V_{CE} = 20Vdc, R_{be} = 100k)	2N706A, 2N706B, 2N753	I_{CER}	-	-	10	μAdc
Emitter Cutoff Current (V_{EB} = 3Vdc, I_C = 0) (V_{EB} = 5Vdc, I_C = 0)	2N706 2N706A, 2N706B, 2N753	I_{EBO}	- -	- -	10 10	μAdc
Collector-Emitter Breakdown Voltage* (I_C = 10mAdc, I_B = 0)	All Types	BV_{CEO}*	15	24	-	Vdc
Collector-Emitter Breakdown Voltage* (R = 10 ohms, I_C = 10mAdc)	All Types	BV_{CER}*	20	48	-	Vdc
Forward-Current Transfer Ratio* (I_C = 10mAdc, V_{CE} = 1Vdc)	2N706 2N706A, 2N706B, 2N753	h_{FE}*	20 20 40	40 40 -	- 60 120	
Base-Emitter Voltage* (I_C = 10mAdc, I_B = 1mAdc)	2N706 2N706A, 2N706B, 2N753	V_{BE}(sat)*	- 0.7	0.75 0.75	0.9 0.9	Vdc
Collector Saturation Voltage* (I_C = 10mAdc, I_B = 1mAdc) (I_C = 50mAdc, I_B = 5mAdc)	2N706, 2N706A 2N706B 2N753 2N753	V_{CE}(sat)*	- - - -	0.3 0.3 0.18 0.3	0.6 0.4 0.6 -	Vdc
Collector Capacitance (V_{CB} = 5Vdc, I_E = 0 (V_{CB} = 10Vdc, I_E = 0)	2N706A, 2N706B, 2N753 2N706	C_{ob}	- -	4.5 5	5 6	pf
Small-Signal Forward Current Transfer Ratio (V_{CE} = 15Vdc, I_E = 10mAdc, f = 100mc)	All types	h_{fe}	2	4	-	-
Current Gain-Bandwidth Product (V_{CE} = 15Vdc, I_E = 10mAdc, f = 100mc)	All types	f_T	-	400	-	mc
Base Resistance (V_{CE} = 15Vdc, I_E = 10mAdc, f = 300mc)	2N706B	r_b	-	39	50	ohms
Charge Storage Time Constant	2N706 2N706A 2N753	τ_s**	- - -	16 16 19	60 25 35	nsec
Storage Time	2N706B	t_s	-	19	25	nsec
Turn-On Time	All types	ton**	-	30	40	nsec
Turn-Off Time	All Types	t_{off}**	-	50	75	nsec

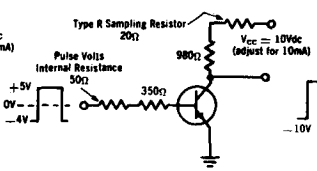
**Pulse Test: PW ≤ 12msec, Duty Cycle ≤ 2%*

***Switching Times Measured with Tektronix Type R Plug-In (50Ω Internal Impedance) and Circuits Shown Below.*

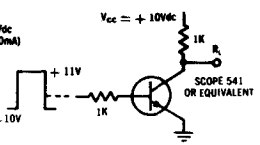
SWITCHING TIME TEST CIRCUIT



STORAGE TIME TEST CIRCUIT

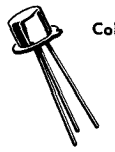


MEASUREMENT CIRCUIT



2N708 (SILICON)

V_{CEO} = 15 V
f_T = 450 Mc Typ



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	5.0	Vdc
Total Device Dissipation 25°C Case Temperature (Derate 6.9 mW/°C above 25°C) 100°C Case Temperature (Derate 6.9 mW/°C above 100°C)	P_D	1.2 0.68	Watts
Total Device Dissipation 25°C Ambient Temperature (Derate 2 mW/°C above 25°C)	P_D	0.36	Watts
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	.005 —	025 15	μAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	—	—	.08	μAdc
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)	BV_{CBO}	40	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, $R_{BE} \leq$ 10 Ω)	BV_{CER}	20	—	—	Vdc
Emitter-Base Breakdown Vnltage (I_E = I0 μAdc, I_C = 0)	BV_{EBO}	5.0	—	—	Vdc
Forward Current Transfer Ratio (I_C = 0.5 mAdc, V_{CE} = 1.0 Vdc) (I_C = I0 mAdc, V_{CE} = 1.0 Vdc)* (I_C = I0 mAdc, V_{CE} = I.0 Vdc, T_A = -55°C)*	h_{FE}	15 30 15	— — —	— 120 —	—
Small Signal Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	h_{fe}	3.0	4.5	—	—
Collector Saturation Voltage (I_C = I0 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55 to 125°C)	$V_{CE(sat)}$	— —	0.2 —	0.4 0.40	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 7.0 mAdc, I_B = 0.7 mAdc, T_A = -55°C)	$V_{BE(sat)}$	0.72 —	— —	0.80 0.90	Vdc
Output Capacitance (V_{CB} = I0 Vdc, I_E = 0)	C_{ob}	—	3.0	6.0	pf
Storage Time (I_C = I_{B1} = I_{B2} = 10 mAdc)	t_s	—	15	25	nsec
Collector Current (V_{CE} = 20 Vdc, V_{BE} = 0.25 Vdc, T_A = 125°C)	I_{CEX}	—	—	10	μAdc
Base Resistance (I_C = I0 mAdc, V_{CE} = 10 Vdc, f = 300 mc)	r_b'	—	—	50	Ohms

* Pulse Test: Pulse width ≤ 300 μsec, duty cycle ≤ 2%

2N710 (GERMANIUM)

$V_{CES} = 15$ V
$I_C = 50$ mA



CASE 22
(TO-18)

PNP germanium mesa transistor for saturated and and non-saturated switching applications.

Collector connected to case

MAXIMUM RATINGS (At 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CE}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2	Vdc
Collector Current	I_C	50	mAdc
Emitter Current	I_E	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2	mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4	mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_{CE} = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	15	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	I_{CBO}	-	3	0.2	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	h_{FE}	25	-	-	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 0.4 mAdc)	$V_{CE(sat)}$	-	0.5	-	Vdc

2N710 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.4 mAdc)	$V_{BE(sat)}$	0.34	0.42	0.5	Vdc
Delay + Rise Time (I_C = 10 mAdc, I_B = 1.0 mAdc)	$t_d + t_r$	-	60	75	ns
Storage Time (I_{B1} = 1.0 mAdc, I_{B2} = 0.25 mAdc)	t_s	-	65	100	ns
Fall Time (I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc)	t_f	-	70	100	ns

2N711, A, B (GERMANIUM)

$V_{CEO} = 7$ V
$I_C = 50$-100 mA
$f_T = 300$-320 Mc Typ

CASE 22
(TO-18)



PNP germanium mesa transistors for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N711	2N711A	2N711B	Unit
Collector-Base Voltage	V_{CBO}	12	15	18	Vdc
Collector-Emitter Voltage	V_{CES}	12	14	15	Vdc
Collector-Emitter Voltage	V_{CEO}	—	7	7	Vdc
Emitter-Base Voltage	V_{EBO}	1	1.5	2	Vdc
Collector Current (Continuous)	I_C	50	100	100	mAdc
Emitter Current (Continuous)	I_E	50	100	100	mAdc
Junction Temperature	T_J	← 100 →			°C
Storage Temperature	T_{stg}	← -65 to +100 →			°C
Device Dissipation @ T_C = 25°C	P_D	← 300 →			mW
Derating factor above 25°C		← 4 →			mW/°C
Device Dissipation @ T_A = 25°C	P_D	← 150 →			mW
Derating factor above 25°C		← 2 →			mW/°C

2N711,A,B (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Sym	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage		BV_{CBO}				Vdc
(I_C = 100 μAdc, I_E = 0)	2N711		12	—	—	
	2N711A		15	—	—	
(I_C = 20 μAdc, I_E = 0)	2N711B		18	—	—	
Collector-Emitter Breakdown Voltage		BV_{CES}				Vdc
(I_C = 100 μAdc)	2N711		12	—	—	
	2N711A		14	—	—	
(I_C = 20 μAdc)	2N711B		15	—	—	
Collector-Emitter Breakdown Voltage		BV_{CEO}				Vdc
(I_C = 5 mAdc, I_B = 0)	2N711A, 2N711B		7	—	—	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 0.1 mAdc, I_C = 0)	2N711		1.0	—	—	
	2N711A		1.5	—	—	
	2N711B		2.0	—	—	
Collector-Base Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 5 Vdc, I_E = 0)	2N711		—	0.2	3.0	
	2N711A		—	—	1.5	
(V_{CB} = 10 Vdc, I_E = 0)	2N711B		—	—	1.5	
Emitter-Base Cutoff Current		I_{EBO}				μAdc
(V_{EB} = 1 Vdc)	2N711A		—	—	100	
	2N711B		—	—	20	
DC Current Gain		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N711		20	30	—	
	2N711A		25	—	150	
	2N711B		30	—	150	
(I_C = 50 mAdc, V_{CE} = 0.7 Vdc)	2N711A, 2N711B		40	—	—	
Collector Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 0.5 mAdc)	2N711		—	0.2	0.5	
	2N711A		—	—	0.30	
(I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711B		—	—	0.25	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		—	—	0.55	
	2N711B		—	—	0.45	
Small-Signal Current Gain		h_{fe}				—
(I_C = 10 mAdc, V_{CE} = 5 Vdc, f = 100 mc)	2N711A, 2N711B		1.5	—	—	
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc, f = 100 mc)	2N711A		1.1	—	—	
	2N711B		1.2	—	—	
Base-Emitter Voltage		V_{BE}				Vdc
(I_C = 10 mAdc, I_B = 0.4 mAdc)	2N711, 2N711A		0.30	0.38	0.44	
	2N711B		0.30	—	0.44	
(I_C = 50 mAdc, I_B = 2 mAdc)	2N711A		0.40	—	0.65	
	2N711B		0.40	—	0.65	
Collector Output Capacitance		C_{ob}				pf
(V_{CB} = 5 Vdc, I_E = 0, f = 1 mc)	2N711A, 2N711B		—	—	6	
(V_{CB} = 10 Vdc, I_E = 0, f = 1 mc)	2N711		—	5.0	—	
Fall Time		t_f				nsec
Figure 1:	2N711A		—	—	150	
	2N711B		—	—	110	
Figure 2:	2N711A		—	—	110	
	2N711B		—	—	100	
	2N711		—	90	150	
Minority Carrier Storage Time		t_s				nsec
Figure 1:	2N711A		—	—	150	
	2N711B		—	—	140	
Figure 2:	2N711A		—	—	120	
	2N711B		—	—	100	
	2N711		—	90	200	
Delay Plus Rise Time		$t_d + t_r$				nsec
Figure 1:	2N711A, 2N711B		—	—	100	
Figure 2:	2N711A, 2N711B		—	—	75	
	2N711		—	70	100	

2N711,A,B (continued)

SWITCHING CIRCUITS

FIGURE 1

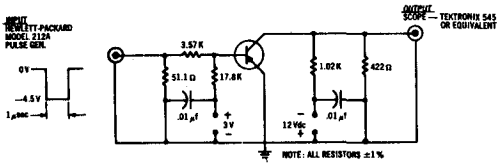
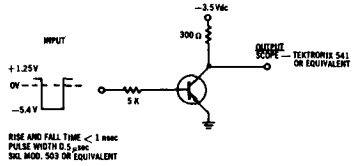
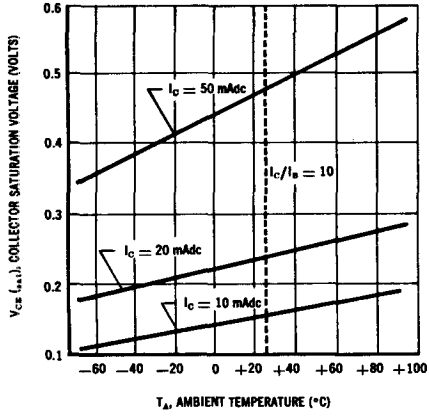


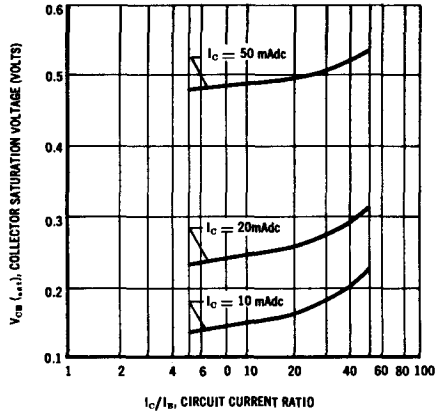
FIGURE 2



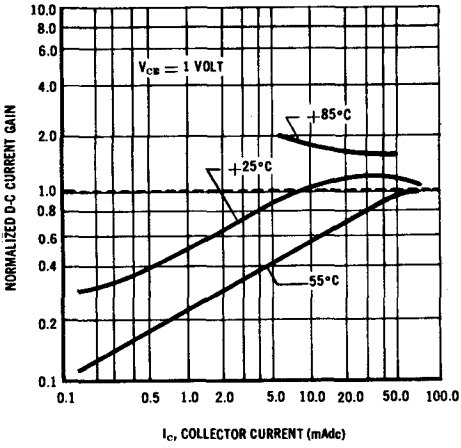
COLLECTOR SATURATION VOLTAGE versus AMBIENT TEMPERATURE



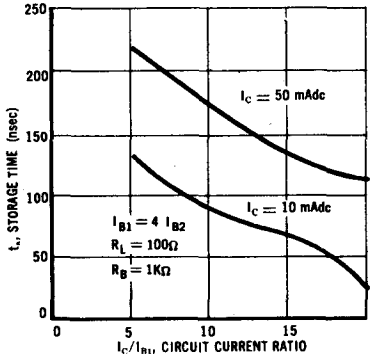
COLLECTOR SATURATION VOLTAGE STORAGE TIME versus CIRCUIT CURRENT RATIO



NORMALIZED DC CURRENT GAIN versus COLLECTOR CURRENT



STORAGE TIME versus CIRCUIT CURRENT RATIO



2N718 (SILICON)

For Specifications, See 2N697 Data Sheet

2N718A (SILICON)
2N956
2N1613
2N1711



$V_{CER} = 50$ V
$f_T = 300$ Mc Typ



CASE 22
(TO-18)
2N718A
2N956



CASE 31
(TO-5)
2N1613
2N1711

Collector connected to case

NPN silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N1613 2N1711 (TO-5)	2N718A 2N956 (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	75	75	Vdc
Collector-Emitter Voltage	V_{CER}	50	50	Vdc
Emitter-Base Voltage	V_{EBO}	7	7	Vdc
Total Device Dissipation at 25°C Case Temperature Derate	P_D	3 17.1	1.8 10.3	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperature Derate	P_D	0.8 4.57	0.5 2.86	Watt mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

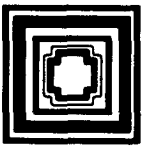
2N718A, 2N956, 2N1613, 2N1711 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)		I_{CBO}	–	.001	.01	μAdc
Collector Cutoff Current (V_{CB} = 60 Vdc, T_A = 150°C)		I_{CBO}	–	–	10	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	2N1613, 2N718A	I_{EBO}	–	–	.010	μAdc
	2N1711, 2N956		–	–	.005	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	75	–	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed; $R_{BE} \leq 10\ \Omega$)		BV_{CER}	50	–	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7	–	–	Vdc
Collector Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	–	0.24	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	–	1.0	1.3	Vdc
DC Forward Current Transfer Ratio		h_{FE}				–
(I_C = .01 mAdc, V_{CE} = 10 Vdc)	2N1711, 2N956		20	–	–	
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N1613, 2N718A		20	–	–	
	2N1711, 2N956		35	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N1613, 2N718A		35	–	–	
	2N1711, 2N956		75	–	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N1613, 2N718A		20	–	–	
	2N1711, 2N956		35	–	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N1613, 2N718A		40	–	120	
	2N1711, 2N956		100	–	300	
(I_C = 500 mAdc, V_{CE} = I0 Vdc)*	2N1613, 2N718A		20	–	–	
	2N1711, 2N956		40	–	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	–	4	25	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	–	20	80	pf
Small Signal Forward Current Transfer Ratio		h_{fe}				–
(V_{CE} = 10 Vdc, I_C = 50 mAdc, f = 20 mc)	2N1613, 2N718A		3.0	15	–	
	2N1711, 2N956		3.5	15	–	
Current Gain		h_{fe}				–
(I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N1613, 2N718A		30	–	100	
	2N1711, 2N956		50	–	200	
(I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	2N1613, 2N718A		35	–	150	
	2N1711, 2N956		70	–	300	
Input Resistance		h_{ib}				Ohms
(I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kc)			24	–	34	
(I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kc)			4	–	8	
Voltage Feedback Ratio		h_{rb}				–
(I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kc)	2N1613, 2N718A		–	–	3×10^{-4}	
	2N1711, 2N956		–	–	5×10^{-4}	
(I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kc)	2N1613, 2N718A		–	–	3×10^{-4}	
	2N1711, 2N956		–	–	5×10^{-4}	
Output Conductance		h_{ob}				μmho
(I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kc)			0.1	–	0.5	
(I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kc)			0.1	–	1.0	
Noise Figure		NF				db
(V_{CB} = 10 Vdc, I_C = 300 μAdc, f = 1 kc)	2N1613, 2N718A		–	–	12	
	2N1711, 2N956		–	–	8	

*Pulse Test: Pulse width ≤ 300 μsec Duty cycle ≤ 2%

2N722 (SILICON)
2N1132, A, B
2N1132 USN/JAN
2N2303



V_{CEO} = 35-45 V
I_C = 500-600 mA
f_T = 200 Mc Typ





PNP silicon annular transistors for medium-current switching applications.

CASE 22 (TO-18)
2N1132, A
2N2303
Collector connected to case

CASE 31 (TO-5)
2N722

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}		Vdc
2N722, 2N1132, 2N2303		50	
2N1132A		60	
2N1132B		70	
Collector-Emitter Voltage	V_{CEO}		Vdc
2N722, 2N1132, 2N2303		35	
2N1132A		40	
2N1132B		45	
Emitter-Base Voltage	V_{EBO}		Vdc
2N722, 2N1132, 2N1132A, 2N2303		5	
2N1132B		6	
Collector-Emitter Voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}		Vdc
2N722, 2N1132, 2N1132A, 2N2303		50	
2N1132B		60	
Collector Current	I_C		mAdc
2N2303		500	
2N1132A, 2N1132B		600	
Total Device Dissipation @ T_C = 25°C	P_D		
TO-5: 2N1132, 2N1132A, 2N1132B, 2N2303		2	Watts
Derating Factor Above 25°C		13.3	mW/°C
TO-18: 2N722		1.5	Watts
Derating Factor Above 25°C		10	mW/°C
Total Device Dissipation @ T_A = 25°C	P_D		
TO-5: 2N1132, 2N1132A, 2N1132B, 2N2303		0.6	Watt
Derating Factor Above 25°C		4.0	mW/°C
TO-18: 2N722		0.4	Watt
Derating Factor Above 25°C		2.67	mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

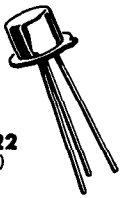
2N722, 2N1132,A,B, 2N2303 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Types	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N722, 2N1132, 2N2303	BV_{CBO}	50	—	Vdc
	2N1132A		60	—	
	2N1132B		70	—	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N722, 2N1132, 2N2303	BV_{EBO}	5	—	Vdc
(I_E = 1 mAdc, I_C = 0)	2N1132A		5	—	
	2N1132B		6	—	
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulsed)	2N722, 2N1132, 2N2303	BV_{CEO}	35	—	Vdc
	2N1132A		40	—	
	2N1132B		50	—	
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulsed, $R_{BE} \leq 10\ \Omega$)	2N722, 2N1132, A, 2N2303	BV_{CER}	50	—	Vdc
	2N1132B		60		
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	2N722, 2N1132, 2N2303	I_{CBO}	—	1	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N722, 2N1132, 2N2303		—	100	
(V_{CB} = 50 Vdc, I_E = 0)	2N1132A		—	0.5	
	2N1132B		—	0.01	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N1132A		—	50	
	2N1132B		—	10	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	2N1132A	I_{EBO}	—	100	μAdc
	2N1132B		—	0.1	
(V_{EB} = 2 Vdc, I_C = 0)	2N2303		—	100	
DC Forward Current Transfer Ratio (I_C = 5 mAdc, V_{CE} = 10 Vdc)	2N722, 2N1132, A, B	h_{FE}	25	—	—
	2N2303		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N722, 2N1132, A, B		30	90	
	2N2303		75	200	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{CE(sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{BE(sat)}$	—	1.3	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	2N722, 2N1132, 2N2303	C_{ob}	—	45	pf
(V_{CB} = 10 Vdc, I_E = 0, f = 1 mc)	2N1132A, 2N1132B		—	30	
Input Capacitance (V_{EB} = 0.5 Vdc, I_E = 0, f = 100 kc)	All Types	C_{ib}	—	80	pf
Small-Signal Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N722, 2N1132	h_{fe}	25	100	—
	2N1132A, 2N1132B		25	75	
	2N2303		75	300	
(I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	2N722, 2N1132, A, B		30	—	
	2N2303		75	—	
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 mc)	All Types	f_T	60	—	mc
Small Signal Input Resistance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kc)	All Types	h_{ib}	25	35	ohms
(I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kc)			—	10	
Small Signal Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	All Types	h_{ob}	—	1	μmhos
(I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)			—	5	
Small Signal Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	All Types	h_{rb}	—	8	x 10^{-4}
(I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)			—	8	

2N744 (SILICON)

$V_{CEO} = 12$ V
$I_C = 200$ mA
$f_T = 450$ Mc Typ



CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

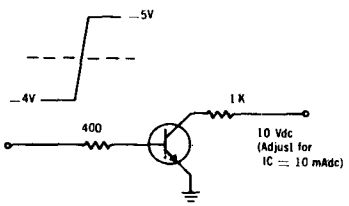
Collector connected to case

MAXIMUM RATINGS

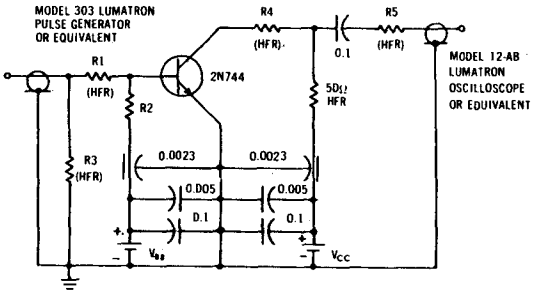
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	20	Vdc
Collector-Emitter Voltage*	V_{CE}	12	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector DC Current	I_C	200	mAdc
Total Device Dissipation at 25°C Case Temperature (Derate 6.67 mW/°C above 25°C)	P_D	1.0	Watt
Total Device Dissipation at 25°C Ambient Temperature (Derate 2 mW/°C above 25°C	P_D	0.3	Watt
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

*Refers to the voltage at which the magnitude of h_{FE} approaches one when the emitter base diode is open-circuited.

SWITCHING TIME TEST CIRCUIT



CHARGE STORAGE TEST CIRCUIT



2N744 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CE} = 20 Vdc, I_E = 0) (V_{CE} = 20 Vdc, I_B = 0, T_A = 170°C)	I_{CES}	– –	.005 –	1.0 100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.35 Vdc, T_A = 100°C)	I_{CEX}	–	–	30	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	–	–	10	μAdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)*	BV_{CEO}	12	30	–	Vdc
Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 0.25 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc) (I_C = 10 mAdc, V_{CE} = 0.35 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 1.0 Vdc)*	h_{FE}	20 40 20 20	– – – –	– 120 – –	–
Small Signal Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	h_{fe}	2.8	4.5	–	–
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 10 mAdc, I_B = 1 mAdc, T_A = -55°C) (I_C = 100 mAdc, I_B = 10 mAdc)* (I_C = 100 mAdc, I_B = 10 mAdc, T_A = -55°C)*	V_{BE}	0.7 – – –	– – – –	0.85 1.1 1.5 1.6	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc, T_A = 170°C) (I_C = 100 mAdc, I_B = 10 mAdc, T_A = 170°C)*	$V_{CE(sat)}$	– –	– –	0.35 1.0	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0)	C_{ob}	–	3.0	5.0	pf
Turn-on Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{on}	– – – –	26 10 7 6	– 16 – 12	nsec
Turn-off Time (Condition 1) (Condition 2) (Condition 3) (Condition 4)	t_{off}	– – – –	30 17 18 23	– 24 – 45	nsec
Charge Storage Time Constant (I_C = 10 mAdc, I_{B1} = -I_{B2} = 10 mAdc)	τ_s	–	–	18	nsec

* Pulse Test: Pulse width ≤ 300 μsec, duty cycle ≤ 2%

CONDITION	I_C mA	I_{B1} mA	I_{B2} mA	$V_{BE(off)}$ Vdc	V_{CC} Vdc	$R_1 = R_2$ Ω	R_3 Ω	R_4 Ω	R_5 Ω	t_{on}		t_{off}	
										V_{BB} V	V_{IN} V	V_{BB} V	V_{IN} V
1	3	1	-0.5	-0.9	3.4	6.8 K	50	1 K	0	-1.8	10.2	8.4	-10.2
2	10	3	-1.5	-1.5	3.0	3.3 K	50	220	0	-3.0	15.0	12.0	-15.0
3	50	15	-7.5	-1.8	4.0	680	50	18	1 K	-3.5	15.3	*11.7	-15.3
4	100	40	-20.0	-2.4	6.0	330	56	0	1 K	-4.5	20.0	*15.3	-20.0

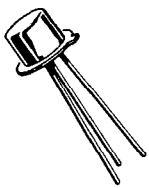
*V_{BB} is pulsed for 1.5 sec @ less than 10% duty cycle

2N753 (SILICON)

For Specifications, See 2N706 Data Sheet

2N827 (GERMANIUM)

$V_{CES} = 20$ V
$I_C = 100$ mA
$f_T = 350$ Mc Typ



CASE 22
(TO-18)

PNP germanium mesa transistor for high-speed switching applications.

Collector connected to case

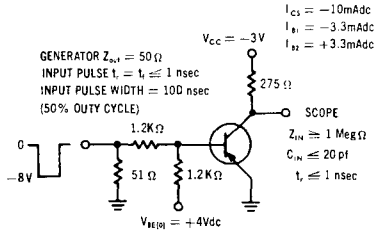
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	20	Vdc
Collector-Emitter Voltage	V_{CES}	20	Vdc
Collector-Emitter Voltage	V_{CEX}	10	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	^oC
Storage Temperature	T_{stg}	-65 to + 100	^oC
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW

2N827 (continued)

ELECTRICAL CHARACTERISTICS (At = 25°C unless otherwise specified)

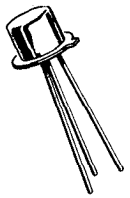
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	20	22	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	BV_{CES}	20	22	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	4	5	---	Vdc
Collector Latch-up Voltage	LV_{CEX}	10	---	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{EB} = 0)	I_{CES}	---	0.5	5	μAdc
Collector-Base Cutoff Current (V_{CB} = 15 Vdc)	I_{CBO}	---	0.5	5	μAdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	100	150	---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.16	0.25	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.39	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1 V, f = 100 mc)	h_{fe}	2.5	3.5	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 mc)	C_{ob}	---	4	9	pf
Delay Time	t_d	---	10	15	nsec
Rise Time	t_r	---	10	20	nsec
Storage Time	t_s	---	15	30	nsec
Fall Time	t_f	---	15	30	nsec



SWITCHING TIME TEST CIRCUIT

2N828 (GERMANIUM)

$V_{CES} = 15$ V
$I_C = 200$ mA
$f_T = 400$ Mc Typ



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector-Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

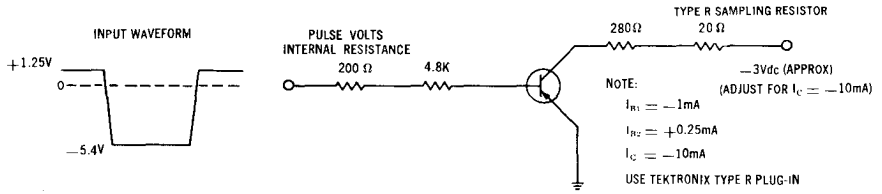
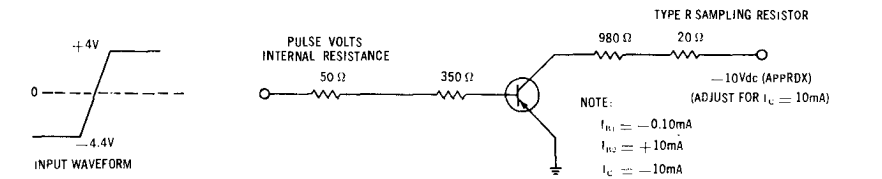


FIGURE 2 — CHARGE STORAGE TIME TEST CIRCUIT



2N828 (continued)

FIGURE 3 — RISE TIME FACTOR

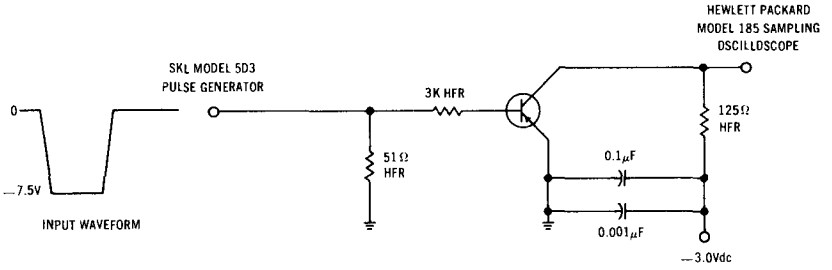
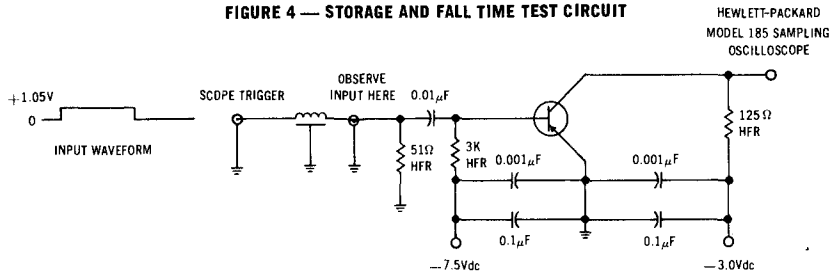


FIGURE 4 — STORAGE AND FALL TIME TEST CIRCUIT



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	-	10	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	15	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100μAdc, I_E = 0)	BV_{CBO}	15	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	2.5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	I_{CBO}	-	0.4	3	μAdc
ON CHARACTERISTICS					
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	25	40	-	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)	$(V_{CE(sat)}$	- -	0.12 0.18	0.2 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.34	0.39	0.44	Vdc

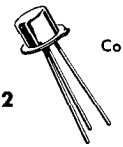
2N828 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	300	400	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	-	3.5	-	pF
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	h_{fe}	3	4	-	-
Delay Plus Rise Time (Figure 1)	$t_d + t_r$	-	50	70	ns
Storage Time (Figure 1)	t_s	-	33	50	ns
Fall Time (Figure 1)	t_f	-	35	50	ns
Charge Storage Time Constant (Figure 2)	τ_s	-	14	25	ns
Rise Time (Figure 3)	t_r	-	7	-	ns
Storage Time (Figure 4)	t_s	-	5	-	ns
Fall Time (Figure 4)	t_f	-	3	-	ns

2N828A (GERMANIUM)
2N829

V_{CES} = 15 V
I_C = 200 mA
f_T = 300 Mc Min



Collector connected to case

CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector to Base Voltage	V_{CBO}	15	Vdc
Collector to Emitter Voltage	V_{CES}	15	Vdc
Emitter to Base Voltage	V_{EBO}	2.5	Vdc
Collector Current (Continuous)	I_C	200	mAdc
Total Device Dissipation at 25°C case Temperature (Derate 4.0mw/°C above 25°C)	P_D	300	mW
Total Device Dissipation at 25°C Ambient Temperature (Derate 2.0mw/°C)	P_D	150	mW
Junction Temperature	T_j	+100	°C
Storage Temperature	T_{stg}	-65 to +100	°C

2N828A, 2N829 (continued)

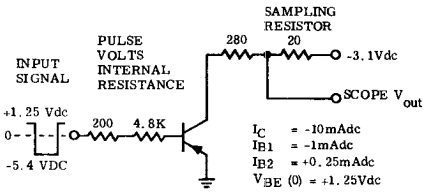
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector to Base Breakdown Voltage $I_E = 0$, $I_C = -100\mu$Adc		BV_{CBO}	15	25	--	Vdc
Collector to Emitter Breakdown Voltage $B_{EB} = 0$, $I_C = -100\mu$Adc		BV_{CES}	15	25	--	Vdc
Emitter to Base Breakdown Voltage $I_C = 0$, $I_E = -100\mu$ Adc		BV_{EBO}	2.5	--	--	Vdc
Collector Cutoff Current $I_E = 0$, $V_{CB} = -6$Vdc		I_{CBO}	--	.4	3	μAdc
Forward Current Transfer Ratio $I_C = -10$mAdc, $V_{CE} = -.3$Vdc	2N828A 2N829	h_{FE}	 25 50	 40 80	--	--
Forward Current Transfer Ratio $I_C = -150$mAdc, $V_{CE} = -1$Vdc	2N828A 2N829	h_{fe}	 25 50	 40 80	--	--
Collector Saturation Voltage $I_C = -10$mAdc, $I_B = -1.0$ mAdc $I_C = -10$mAdc, $I_B = -0.5$mAdc	 2N828A 2N829	$V_{CE(sat)}$	--	 0.11 0.11	 0.20 0.20	Vdc
Collector Saturation Voltage $I_C = -50$mAdc, $I_B = -5.0$mAdc		$V_{CE(sat)}$	--	--	0.25	Vdc
Collector Saturation Voltage $I_C = -150$mAdc, $I_B = -15$mAdc $I_C = -150$mAdc, $I_B = -7.5$mAdc	 2N828A 2N829	$V_{CE(sat)}$	--	 0.35 0.38	 0.50 0.50	Vdc
Base to Emitter Voltage $I_C = -10$mAdc, $I_B = -1$mAdc $I_C = -10$mAdc, $I_B = -0.5$mAdc	 2N828A 2N829	V_{BE}	 0.34 .30	 0.40 0.38	 0.44 0.44	Vdc
Base to Emitter Voltage $I_C = -150$mAdc, $I_B = -15$mAdc $I_C = -150$mAdc, $I_B = -7.5$mAdc	 2N828A 2N829	V_{BE}	--	 0.70 0.65	 0.85 0.85	Vdc
Collector Capacitance $I_E = 0$, $V_{CB} = -6$Vdc		C_{ob}	--	2.2	4	pf

2N828A, 2N829 (continued)
ELECTRICAL CHARACTERISTICS (continued)

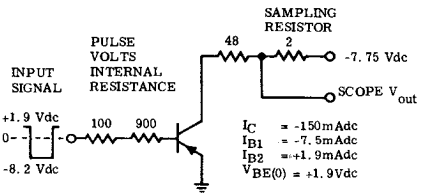
Characteristic	Symbol	Min	Typ	Max	Unit
Input Capacitance V_{EB} = 1Vdc	C_{ib}	--	2.2	3.5	pf
Small Signal Forward Current Transfer Ratio I_C = -10mAdc, V_{CE} = -1Vdc, f = 100mc	h_{fe}	3.0	4.0	--	--
Current Gain Bandwidth Product V_{CE} = -1Vdc, I_C = -10mAdc, f = 100mc	f_t	300	400	--	Mc
Delay Plus Rise Time (Fig. 1) I_C = -10mAdc	td+tr	--	35	50	nsec
Storage Time (Fig. 1) I_C = -10mAdc	ts	--	30	50	nsec
Fall Time (Fig. 1) I_C = -10mAdc	tf	--	30	50	nsec
Total Control Charge (Fig. 3) I_C = -10mAdc	Q_T	--	50	80	pC
Delay Plus Rise Time (Fig. 2) I_C = -150mAdc	t_d+t_r	--	25	50	nsec
Turn Off Time (Fig. 2) I_C = -150mAdc	t_{off}	--	60	100	nsec
Total Control Charge (Fig. 4) I_C = -150mAdc	Q_T	--	120	175	pC

FIGURE 1 — 10mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20pf
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE $t_r = t_f$ = 2nsec

FIGURE 2 — 150mA SWITCHING TIME TEST CIRCUIT



SCOPE INPUT IMPEDANCE = 1Megohm
SCOPE INPUT CAPACITANCE = 20pf
GENERATOR OUTPUT IMPEDANCE = 50 ohms
INPUT PULSE $t_r = t_f$ = 2nsec

FIGURE 3 — 10mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -5.4 VOLT PULSE AT POINT A

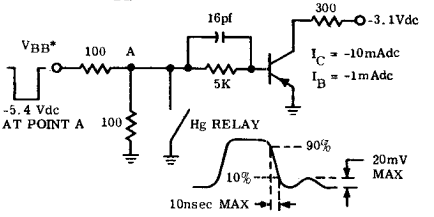
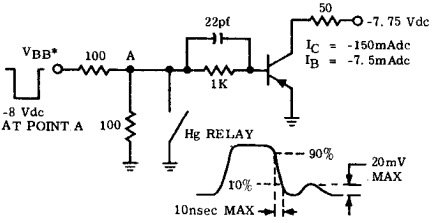


FIGURE 4 — 150mA TOTAL CONTROL CHARGE TEST CIRCUIT

*ADJUST V_{BB} FOR -8 VOLT PULSE AT POINT A



2N834 (SILICON)
2N835

V_{CES} = 20-30 V
I_C = 200 mA
f_T = 500 Mc Typ



CASE 22
(TO-18)

Collector connected to case

NPN silicon epitaxial mesa transistors for high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N834	2N835	Unit
Collector-Emitter Voltage	V_{CES}	30	20	Vdc
Collector-Base Voltage	V_{CB}	40	25	Vdc
Emitter-Base Voltage	V_{EB}	5	3	Vdc
Collector Current-Continuous Peak	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	0.3 2		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.0 6.67		Watt mW/°C
Total Device Dissipation @ T_C = 100°C Derate above 100°C	P_D	0.5 6.67		Watt mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		°C

FIGURE 1 — TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT

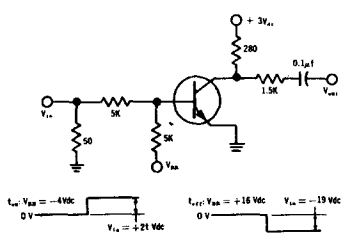
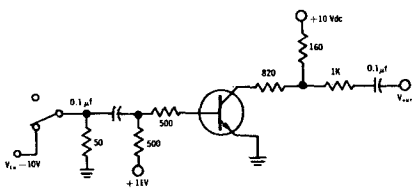


FIGURE 2 — CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

2N834, 2N835 (continued)

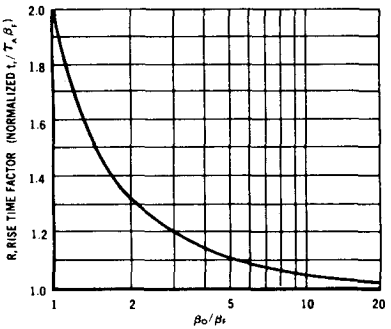
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N834 2N835	BV_{CBO}	40 25	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	2N834 2N835	BV_{EBO}	5 3	- -	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0)	2N834	I_{CES}	-	10	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N835		-	10	
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	0.5	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			-	30	
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N834 2N835	h_{FE}*	25 20	- -	-
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N834 2N835	$(V_{CE(sat)}$	- -	0.25 0.30	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)*	2N834 2N835		- -	0.4 -	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	-	0.9	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	f_T	350	-	MHz
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		300	-	
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N834	$\|h_{fe}\|$	3.5	-	-
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N835		3.0	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	4.0	pF
Charge-Storage Time Constant (Figure 2) (I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc)	2N834 2N835	t_s	- -	25 35	ns
Turn-On Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834 2N835	t_{on}	- -	33 20	ns
Turn-Off Time (Figure 1) (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	2N834 2N835	t_{off}	- -	75 35	ns

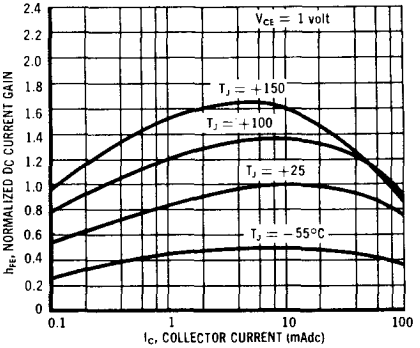
*Pulse Test: Pulse Width ≤ 12 ms, Duty Cycle ≤ 2%

2N834, 2N835 (continued)

RISE TIME FACTOR



NORMALIZED CURRENT GAIN CHARACTERISTICS



2N838 (GERMANIUM)

V_{CES} = 30 V
I_C = 100 mA
f_T = 300 Mc



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	30	Vdc
Collector-Emitter Voltage	V_{CES}	30	Vdc
Collector-Emitter Voltage	V_{CEX}	15	Vdc
Emitter-Base Boltage	V_{EBO}	2.5	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	°C
Storage Temperature	T_{stg}	-65 to+ 100	°C
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW

2N838 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C =100 μ Adc, I_E =0)	BV_{CBO}	30	35	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μ Adc, V_{EB} = 0)	BV_{CES}	30	35	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μ Adc, I_C = 0)	BV_{EBO}	2.5	4.5	---	Vdc
Collector Latch-up Voltage (see Figure 2)	LV_{CEX}	15	---	---	Vdc
Collector-Emitter Cutoff Current (V_{CE} =15 Vdc, V_{EB} =0)	I_{CES}	---	1	10	μ Adc
Collector-Base Cutoff Current (V_{CB} = 15 V)	I_{CBO}	---	1	10	μ Adc
DC Forward Current Transfer Ratio (I_C = 10mAdc, V_{CE} = 0.3 Vdc)	h_{FE}	30	70	---	---
Collector-Emitter Saturation Voltage (I_C =10 mAdc, I_B = 3.3 mAdc)	$V_{CE(sat)}$	---	0.1	0.18	Vdc
Base-Emitter Voltage (I_C = 10 mAdc, I_B = 3.3 mAdc)	V_{BE}	---	0.39	0.5	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 1V, f = 100 mc)	h_{fe}	3	4.5	---	---
Collector Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 mc)	C_{ob}	---	2	4	pf
Delay Time (Figure 1)	t_d	---	10	15	nsec
Rise Time (Figure 1)	t_r	---	7	15	nsec
Storage Time (Figure 1)	t_s	---	10	20	nsec
Fall Time (Figure 1)	t_f	---	10	20	nsec

FIGURE 1 — SWITCHING TIME TEST CIRCUIT

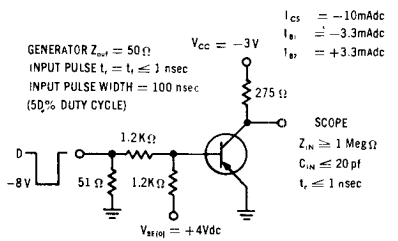
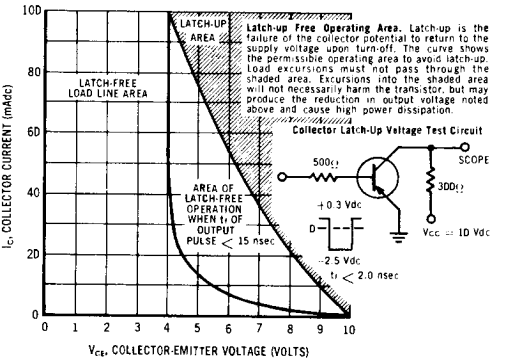
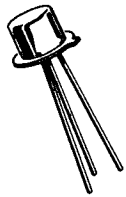


FIGURE 2 — AREA OF PERMISSIBLE LOAD LOCI



2N869 (SILICON)
2N995

V_{CBO} = 20-25 V
f_T = 300 Mc Typ



CASE 22
(TO-18)

PNP silicon annular transistors for high-frequency general-purpose amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Types	Rating	Unit
Base Voltage	V_{CBO}	2N869 2N995	25 20	Volts Volts
Collector-Emitter Voltage	V_{CEO}	2N869 2N995	18 15	Volts Volts
Emitter-Base Voltage	V_{EBO}	2N869 2N995	5 4	Volts Volts
Total Device Dissipation at 25°C Case Temperature at 100°C Case Temperature (Derate 6.86 mW/°C above 25°C)	P_D	Both Types	 1.2 0.68	 Watts Watt
Total Device Dissipation at 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	Both Types	0.36	Watt
Storage Temperature	T_{stg}	Both Types	-65 to +200	°C
Junction Temperature	T_j	Both Types	+200	°C

2N869, 2N995 (continued)

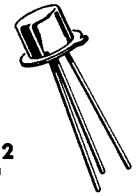
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0) 2N869	BV_{CBO}	25	---	---	Volts
2N995		20	---	---	
Collector-Emitter Sustaining Voltage * (I_C = 10 mAdc, I_B = 0) 2N869	$V_{CEO(sust)}$*	18	---	---	Volts
2N995		15	---	---	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0) 2N869	BV_{EBO}	5	---	---	Volts
2N995		4	---	---	
Collector Cutoff Current (V_{CB} = -15 Vdc, I_E = 0) 2N869	I_{CBO}	---	---	.010	μ Adc
2N995		---	---	.005	
(V_{CB} = -15 Vdc, I_E = 0, T_A = 150°C) Both Types		---	---	25	
Emitter Current (V_{EB} = -4.0 Vdc, I_C = 0) 2N995	I_{EBO}	---	---	10	μ Adc
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N869	$V_{CE\ (sat)}$	---	0.17	1.0	Volt
(I_C = 20 mAdc, I_B = 2.0 mAdc) 2N995		---	---	0.2	
Base Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) 2N869	$V_{BE\ (sat)}$	---	0.78	1.0	Volt
(I_C = 20 mAdc, I_B = 2.0 mAdc) 2N995		---	---	0.95	
DC Forward-Current Transfer Ratio *	h_{FE}*				---
(I_C = 10 mAdc, V_{CE} = -5.0 Vdc) 2N869		20	---	120	
(I_C = 1.0 mAdc, V_{CE} = -1.0 Vdc) 2N995		25	---	---	
(I_C = 20 mAdc, V_{CE} = -1.0 Vdc) 2N995		35	---	140	
(I_C = 50 mAdc, V_{CE} = -1.0 Vdc) 2N995		25	---	---	
Open-Circuit Output Capacitance (V_{CB} = -10 V, I_E = 0) 2N869	C_{ob}	---	3	9	pf
2N995		---	3	10	
Open-Circuit Input Capacitance (V_{EB} = -0.5 V, I_C = 0) Both Types	C_{ib}	---	7	11	pf
Small-Signal Forward-Current Transfer Ratio	h_{fe}				---
(I_C = 10 mA, V_{CE} = -15 V, f = 100 Mc) 2N869		1.0	3.0	---	
(I_C = 10 mA, V_{CE} = -10 V, f = 100 Mc) 2N995		1.0	3.0	---	

*Pulse Note: Pulse Width = 300 μsec, Duty Cycle = 1%

2N914 (SILICON)

$V_{CEO} = 15$ V
$f_T = 500$ Mc



CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

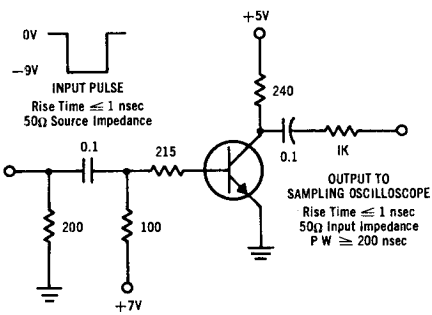
Collector connected to case

MAXIMUM RATINGS

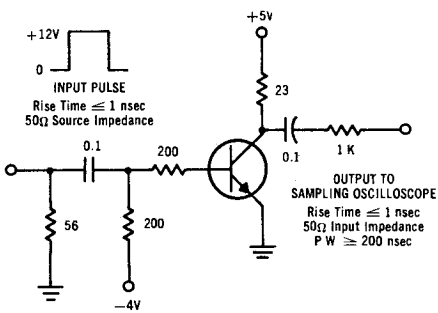
Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	20	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current*	I_C*	150*	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.36 2.06	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.2 6.9	Watts $mW/^oC$
Total Device Dissipation @ $T_C = 100^oC$	P_D	0.68	Watt
Operating Junction Temperature Range	T_J	200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

*Limited by Power Dissipation

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



T_{on} and T_{off} TEST CIRCUIT



2N914 (continued)

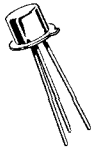
ELECTRICAL CHARACTERISTICS (At 25° unless otherwise specified.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)	$BV_{CEO(sus)}$*	15	-	Vdc
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, $R_{BE} \leq$ 10 ohms)	$BV_{CER(sus)}$*	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 1 μAdc, I_E = 0)	BV_{CBO}	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μAdc, I_C = 0)	BV_{EBO}	5.0	-	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 125°C)	I_{CEX}	-	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	0.025 15	μAdc
Emitter Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)	I_{EBO}	-	0.1	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 500 mAdc, V_{CE} = 5 Vdc)	h_{FE}*	30 12 10	120 - -	-
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc) (I_C = 10 I_B = 1 mAdc thru 20 mAdc, T_A = -55 to +125°C)	$V_{CE(sat)}$	- -	0.70 0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	0.70	0.80	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0)	C_{ob}	-	6.0	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0)	C_{ib}	-	9.0	pF
Charge Storage Time Constant** (I_C = I_{B1} = I_{B2} = 20 mAdc)	τ_s**	-	20	ns
Turn-On Time ** (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{on}**	-	40	ns
Turn-Off Time** (I_C = 200 mAdc, I_{B1} = 40 mAdc, I_{B2} = 20 mAdc)	t_{off}**	-	40	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 1%
**Measured on Sampling Scope: Pulse Width ≥ 200 ns

2N915 (SILICON)

$V_{CEO} = 50$ V
$h_{FE} = 50$
$f_T = 400$ Mc Typ



CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}	70	Vdc
Collector-Emitter Voltage	V_{CEO}	50	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.9	 W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 .36 2.06	 W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

2N915 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		10	nA
Collector Cutoff Current @ 150°C $I_E = 0$ $V_{CB} = 60V$	I_{CBO}		30	μ A
Collector Breakdown Voltage $I_C = 100\ \mu$ A $I_E = 0$	BV_{CBO}	70		Volts
Collector to Emitter Sustaining Voltage $I_C = 10mA$ $I_B = 0$	$*V_{CEO}$	50		Volts
Emitter Breakdown Voltage $I_C = 0$ $I_E = 100\ \mu A$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Volts
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		1.0	Volts
DC Pulse Current Gain $I_C = 10mA$ $V_{CE} = 5.0V$	h_{FE}	50	200	
Output Capacitance $I_E = 0$ $V_{CB} = 10V$	C_{ob}		3.5	pf
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pf
High Frequency Current Gain f = 100mc $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	2.5		
Small Signal Current Gain f = 1kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	μmho μmho

*pw = 300 μ s
duty cycle ≤ 1%

2N916 (SILICON)

$V_{CEO} = 25$ V
$h_{FE} = 50$
$f_T = 400$ Mc Typ



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency amplifier, oscillator and switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}	45	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.9	 W mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 .36 2.06	 W mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +300	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	nA
Collector Cutoff Current @150° C $I_E = 0$ $V_{CB} = 30V$	I_{CBO}		10	μA
Collector Breakdown Voltage $I_C = 10\mu A$ $I_E = 0$	BV_{CBO}	45		Volts
Collector to Emitter Sustaining Voltage $I_C = 30mA$ $I_B = 0$	$*V_{CEO}$	25		Volts
Emitter Breakdown Voltage $I_C = 0$ $I_E = 10\mu A$	BV_{EBO}	5.0		Volts
Base Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{BE(sat)}$		0.9	Volts
Collector Saturation Voltage $I_C = 10mA$ $I_B = 1.0mA$	$V_{CE(sat)}$		0.5	Volts
DC Pulse Current Gain $I_C = 10mA$ $V_{CE} = 1.0V$	$*h_{FE}$	50	200	
Output Capacitance $I_E = 0$ $V_{CB} = 5.0V$	C_{ob}		6.0	pf
Emitter Transition Capacitance $I_C = 0$ $V_{EB} = 0.5V$	C_{TE}		10	pf
High Frequency Current Gain f = 100mc $I_C = 10mA$ $V_{CE} = 15V$	h_{fe}	3.0		
Small Signal Current Gain f = 1kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{fe}	40 50	200 250	
Input Resistance f = 1kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{ie}		6000 2000	ohms ohms
Output Conductance f = 1 kc $I_C = 1.0mA$ $V_{CE} = 5.0V$ $I_C = 5.0mA$ $V_{CE} = 5.0V$	h_{oe}		75 125	μmho μmho

*pw = 300μs duty cycle ≤ 1%

2N929 (SILICON)
2N930

V_{CEO} = 45 V
NF = 3-4 db @ 10 cps to 15.7 Kc



CASE 22
(TO-18)

Collector connected to case

NPN silicon annular transistors for low-level, low-noise amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	.030	Adc
Total Device Dissipation @ T_A = 25°C	P_D	0.3	Watt
Derating Factor above 25°C		2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	0.6	Watt
Derating Factor above 25°C		4.0	mW/°C
Junction Temperature, Op.	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +300	°C

2N929, 2N930 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage* I_C = 10 mA, I_B = 0		BV_{CEO}	45		V
Emitter-Base Breakdown Voltage I_E = 10 nA, I_C = 0		BV_{EBO}	5		V
Collector-Base Cutoff Current V_{CB} = 45 V, I_E = 0		I_{CBO}		.010	μA
Collector-Emitter Cutoff Current V_{CE} = 45 V, V_{EB} = 0		I_{CES}		.010	μA
V_{CE} = 45 V, V_{EB} = 0, T_A = 170°C				10	
Collector-Emitter Cutoff Current V_{CE} = 5 V, I_B = 0		I_{CEO}		.002	μA
Emitter-Base Cutoff Current V_{EB} = 5 V, I_C = 0		I_{EBO}		.010	μA
DC Forward Current Transfer Ratio		h_{FE}			—
I_C = 10 μA, V_{CE} = 5 V	2N929		40	120	
	2N930		100	300	
I_C = 10 μA, V_{CE} = 5 V, T_A = -55°C	2N929		10		
	2N930		20		
I_C = 500 μA, V_{CE} = 5 V	2N929		60		
	2N930		150		
I_C = 10 mA, V_{CE} = 5 V*	2N929			350	
	2N930			600	
Collector-Emitter Saturation Voltage* I_C = 10 mA, I_B = .5 mA		$V_{CE(sat)}$		1.0	V
Base-Emitter Voltage* I_C = 10 mA, I_B = .5 mA		V_{BE}	0.6	1.0	V
Output Capacitance V_{CB} = 5 V, I_E = 0, f = 1 mc		C_{ob}		8.0	pf
High-Frequency Current Gain I_C = 500 μA, V_{CE} = 5 V, f = 30 mc		h_{fe}	1.0		—
Small-Signal Current Gain I_C = 1.0 mA, V_{CE} = 5 V, f = 1 kc	2N929	h_{fe}	60	350	—
	2N930		150	600	
Input Resistance I_C = 1.0 mA, V_{CB} = 5 V, f = 1 kc		h_{ib}	25	32	ohms
Output Conductance I_C = 1.0 mA, V_{CB} = 5 V, f = 1 kc		h_{ob}		1.0	μmho
Voltage Feedback Ratio I_C = 1.0 mA, V_{CB} = 5 V, f = 1 kc		h_{rb}		600	$X10^{-6}$
Noise Figure I_C = 10 μA, V_{CE} = 5 V, f = 10 cps to		NF			db
15.7 kc, R = 10 KΩ	2N929			4.0	
	2N930			3.0	

*Pulse Conditions: Width ≤ 300 μsec
Duty Cycle ≤ 2%

2N956

For Specifications, See 2N718A Data Sheet

2N960 (GERMANIUM)
2N961
2N962
2N962 USA/JAN
2N964
2N964 USA/JAN
2N965
2N966

V_{CE} = 12-15 V
I_C = 100 mA
f_T = 460 Mc



CASE 22
(TO-18)

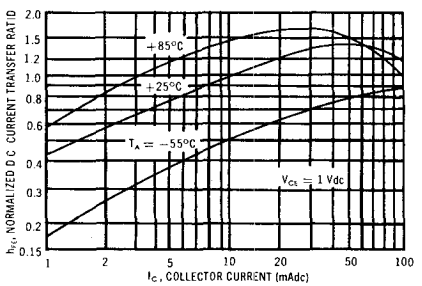
PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

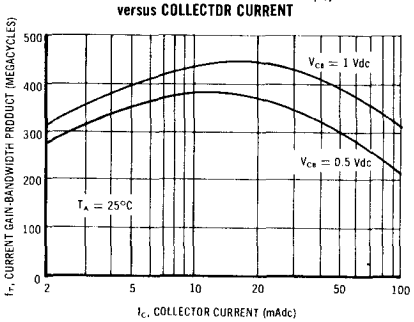
MAXIMUM RATINGS

Characteristic	Symbol	2N960 2N964	2N961 2N965	2N962 2N966	Unit
Collector-Emitter Voltage	V_{CE}	15	12	12	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	Vdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2			mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	300 4			mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100			°C

NORMALIZED D C CURRENT TRANSFER RATIO versus COLLECTOR CURRENT

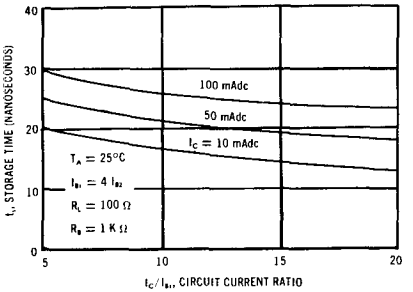


CURRENT GAIN-BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT

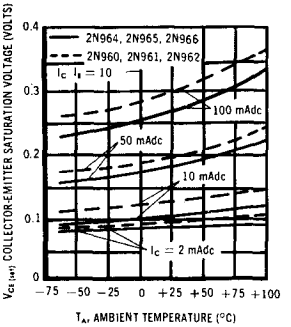


2N960 SERIES (continued)

STORAGE TIME versus CIRCUIT RATIO



COLLECTOR-EMITTER SATURATION VOLTAGE versus AMBIENT TEMPERATURE



ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N960, 2N964	BV_{CBO}	15	25	-	Vdc
	2N961, 2N962, 2N965, 2N966		12	20	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N960, 2N964	BV_{EBO}	2.5	-	-	Vdc
	2N961, 2N965		2.0	-	-	
	2N962, 2N966		1.25	-	-	
Collector-Latch-up Voltage V_{CC} = 11.5 Vdc	All Types	LV_{CEX}	11.5	-	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc)	2N960, 2N964	I_{CES}	-	-	100	μAdc
(V_{CE} = 12 Vdc)	2N961, 2N962, 2N965, 2N966		-	-	100	
Collector-Base Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)	All Types	I_{CBO}	-	0.4	3	μAdc
DC Current Gain		h_{FE}				-
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N960, 2N961, 2N962		20	40	-	
	2N964, 2N965, 2N966		40	70	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	55	-	
	2N964, 2N965, 2N966		40	90	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N960, 2N961, 2N962		20	50	-	
	2N964, 2N965, 2N966		40	85	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N964, 2N965, 2N966		-	0.11	0.18	
	2N960, 2N961, 2N962		-	0.13	0.20	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N964, 2N965, 2N966		-	0.18	0.35	
	2N960, 2N961, 2N962		-	0.20	0.40	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N964, 2N965, 2N966		-	0.27	0.60	
	2N960, 2N961, 2N962		-	0.30	0.70	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		0.30	0.40	0.50	
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types		0.40	0.55	0.75	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N960, 2N961, 2N964, 2N965		0.40	0.65	1.00	
	2N962, 2N966		0.40	0.75	1.25	
Current-Gain – Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1.0 Vdc, f = 100 MHz)	All Types	f_T	300	460	-	MHz

2N960 SERIES (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	All Types	C_{ob}	-	2.2	4	pF
Emitter Transition Capacitance (V_{EB} = 1 Vdc)	All Types	C_{Te}	-	2.0	3.5	pF
Turn-On Time	All Types	t_{on}				ns
(I_C = 10 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)			-	35	50	
(I_C = 100 mAdc, I_{B1} = 5 mAdc, $V_{BE(off)}$ = 1.25 Vdc)			-	30	50	
Turn-Off Time		t_{off}				ns
(I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc)						
	2N960, 2N961, 2N964, 2N965		-	60	85	
	2N962, 2N966		-	80	100	
(I_C = 100 mAdc, I_{B1} = 5 mAdc, I_{B2} = 1.25 mAdc)						
	2N960, 2N961, 2N964, 2N965		-	50	85	
	2N962, 2N966		-	60	100	
Rise Time Constant	All Types	τ_{RE}	-	0.6	-	ns
Hole Storage Factor	All Types	K'_s	-	16	-	ns
Fall Time Constant	All Types	τ_{FE}	-	0.5	-	ns
Total Control Charge		Q_T				pC
(I_C = 10 mAdc, I_B = 1 mAdc)	2N960, 2N961, 2N964, 2N965		-	50	80	
	2N962, 2N966		-	60	90	
(I_C = 100 mAdc, I_B = 5 mAdc)	2N960, 2N961, 2N964, 2N965		-	80	125	
	2N962, 2N966		-	100	150	

2N963 (GERMANIUM)
2N967

V_{CES} = 12 V
I_C = 100 mA
f_T = 300 MHz



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CES}	12	Vdc
Collector-Base Voltage	V_{CB}	12	Vdc
Total Device Dissipation @ T_A = 25°C	P_D	150	mW
Derate above 25°C		2	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	300	mW
Derate above 25°C		4	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	100	°C

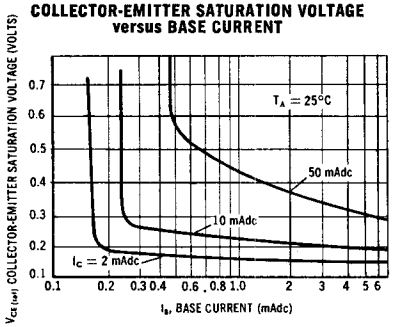
2N963, 2N967 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

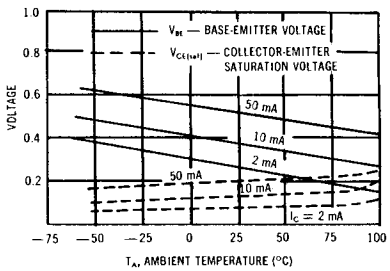
Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	12	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2	-	Vdc
Collector-Latch-up Voltage (V_{CC} = 10 Vdc)		LV_{CEX}	10	-	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, V_{BE} = 0)		I_{CES}	-	100	μAdc
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, T_A = 55°C)		I_{CEX}	-	20	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	5	μAdc
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	-	1	mAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{BE} = 0.3 Vdc, T_A = 55°C)		I_{BL}	-	20	μAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	2N963 2N967	h_{FE}	20 40	- -	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc		$V_{CE(sat)}$	-	0.2	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	0.3	0.5	Vdc
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)		f_T	300	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	5	pF
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kHz)		C_{ib}	-	4	pF
Turn-On Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, $V_{BE(off)}$ = 1.25 Vdc)		t_{on}	-	60	ns
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 1.25 mAdc)		t_{off}	-	120	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)		Q_T	-	120	pC

2N963, 2N967 (continued)

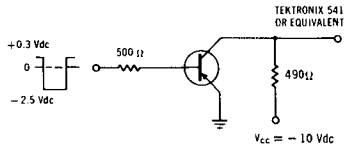
COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT



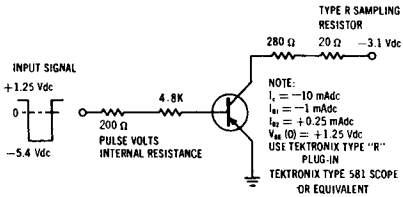
VOLTAGE versus TEMPERATURE CHARACTERISTICS



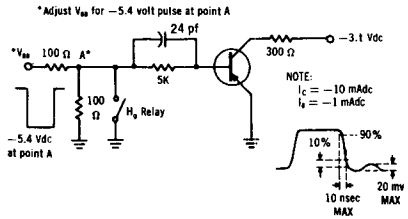
COLLECTOR LATCH-UP VOLTAGE TEST CIRCUIT



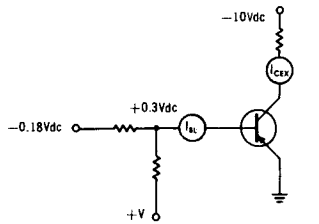
10-mA (I_C) SWITCHING TIME TEST CIRCUIT



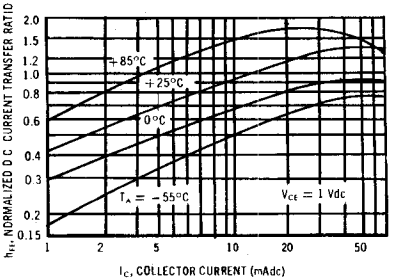
BASE AND COLLECTOR CUTOFF CURRENT TEST CIRCUIT



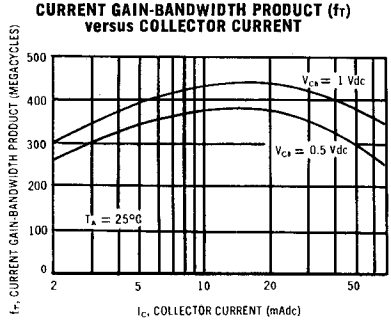
10-mA (I_C) TOTAL CONTROL CHARGE TEST CIRCUIT



NORMALIZED DC CURRENT TRANSFER RATIO versus COLLECTOR CURRENT



CURRENT GAIN-BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT

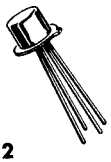


2N964 (GERMANIUM)

For Specifications, See 2N960 Data Sheet

2N964A (GERMANIUM)

$V_{CEO} = 7$ V
$I_C = 100$ mA
$f_T = 460$ Mc Typ



PNP germanium epitaxial mesa transistor for high-speed switching applications.

Collector connected to case

CASE 22
(TO-18)

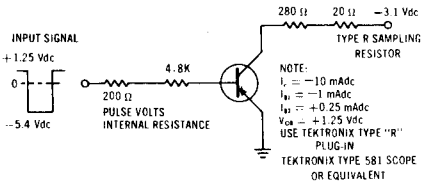
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CE}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	2.5	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100	^oC

THERMAL CHARACTERISTICS

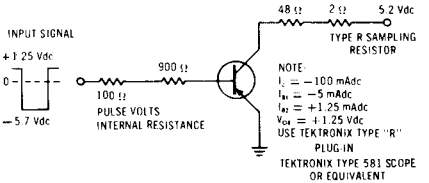
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.25	$^oC/mW$
Thermal Resistance, Case to Ambient	θ_{CA}	0.5	$^oC/mW$

FIGURE 1



10-mA (I_C) SWITCHING TIME TEST CIRCUIT

FIGURE 2



100-mA (I_C) SWITCHING TIME TEST CIRCUIT

2N964A (continued)

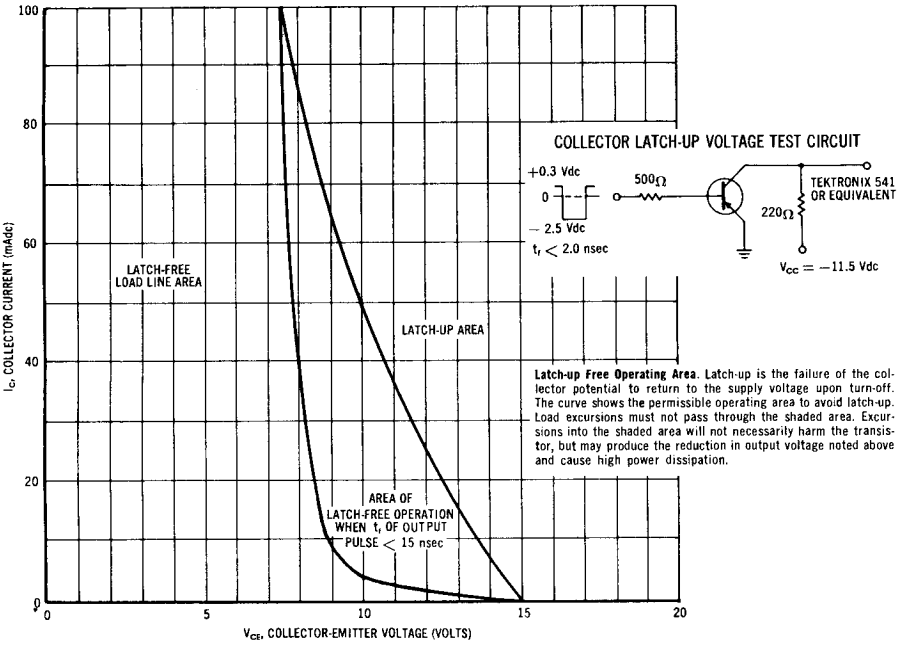
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Fig.	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	7	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	15	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	2.5	-	-	Vdc
Collector Latch-up Voltage	3	LV_{CEX}	11.5	-	-	Vdc
Collector-Emitter Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	-	-	100	μAdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	0.4	3	μAdc
Base Leakage Current (V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc)	4	I_{BL}	-	-	4	μAdc
(V_{CE} = 6 Vdc, $V_{BE(off)}$ = 0.5 Vdc, T_J = 85°C)			-	50	140	
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 0.3 Vdc)	8	h_{FE}	40	80	-	-
(I_C = 10 mAdc, V_{CE} = 0.3 Vdc, T_J = -55°C)			20	45	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)			48	105	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)			40	95	-	
(I_C = 100 mAdc, V_{CE} = 1 Vdc, T_J = 85°C)			35	85	-	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	5	$V_{CE(sat)}$	-	0.1	0.18	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			-	0.16	0.28	
(I_C = 100 mAdc, I_B = 10 mAdc)			-	0.22	0.4	
Base-Emitter Saturation Voltage	6	$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.3	0.38	0.44	
(I_C = 50 mAdc, I_B = 5 mAdc)			0.4	0.48	0.58	
(I_C = 100 mAdc, I_B = 10 mAdc)			0.4	0.6	0.72	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 20 mAdc, V_{CB} = 1 Vdc, f = 100 MHz)		f_T	300	460	-	MHz
High-Frequency Current Gain (I_C = 20 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)		h_{fe}	3.0	4.6	-	-
Output Capacitance (V_{CB} = 1 Vdc, I_E = 0, f = 1 MHz)	11	C_{ob}	-	2.7	5	pF
(V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)			-	2.2	4	
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kHz)	11	C_{ib}	-	2	3.5	pF
Delay Time Plus Rise Time (I_C = 10 mAdc)	1	$t_d + t_r$	-	35	50	ns
(I_C = 100 mAdc)	2		-	30	50	
Storage Time Plus Fall Time (I_C = 10 mAdc)	1	$t_s + t_f$	-	60	85	ns
(I_C = 100 mAdc)	2		-	50	85	
Active Region Time Constant (I_C = 10 mAdc)	9	τ_A	-	0.6	1.5	ns
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	10	Q_T	-	50	75	pC

2N964A (continued)

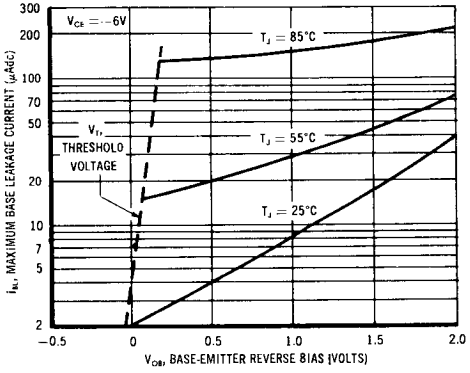
2N964A LIMIT CURVES

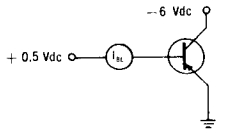
FIGURE 3—AREA OF PERMISSIBLE LOAD LOCI



Latch-up Free Operating Area. Latch-up is the failure of the collector potential to return to the supply voltage upon turn-off. The curve shows the permissible operating area to avoid latch-up. Load excursions must not pass through the shaded area. Excursions into the shaded area will not necessarily harm the transistor, but may produce the reduction in output voltage noted above and cause high power dissipation.

FIGURE 4—COMMON EMITTER DC LEAKAGE CHARACTERISTICS





BASE LEAKAGE CURRENT TEST CIRCUIT

Base Leakage Current. I_{BL} is defined as base leakage current with both junctions reverse biased. I_e is always less than I_{BL} for $V_{OB} > V_T$. (V_{OB} is off condition base bias, V_T is base voltage at threshold of conduction.)

NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N964A (continued)

2N964A LIMIT CURVES

FIGURE 5—COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

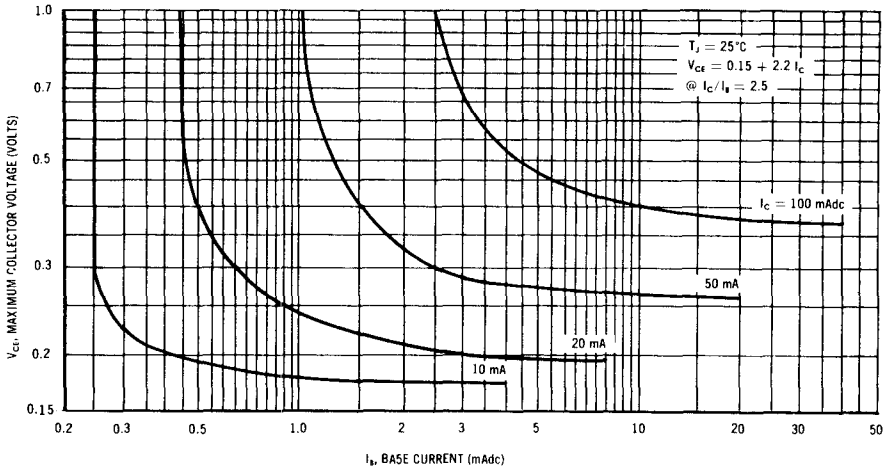


FIGURE 6—BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

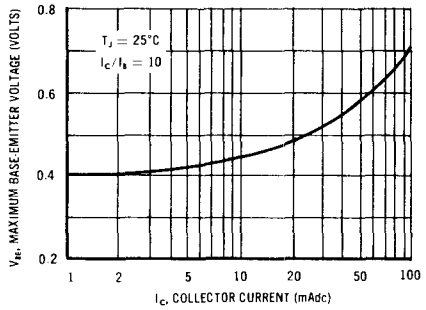


FIGURE 7—TEMPERATURE CO-EFFICIENTS

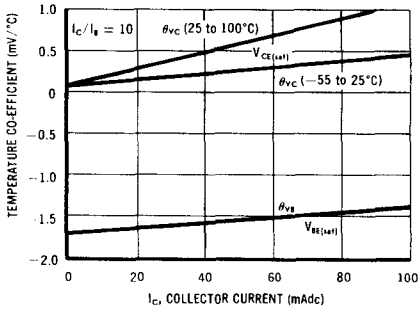
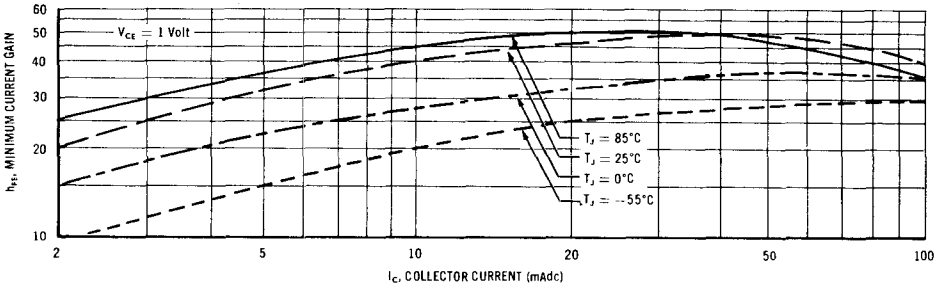


FIGURE 8—CURRENT GAIN CHARACTERISTICS



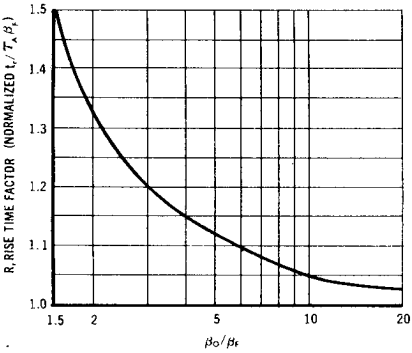
NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N964A (continued)

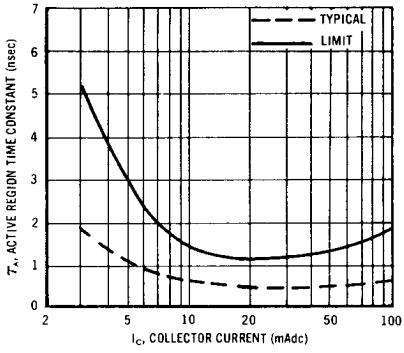
2N964A LIMIT CURVES

FIGURE 9—SWITCHING TIME CURVES FOR RESISTOR COUPLED CIRCUITS

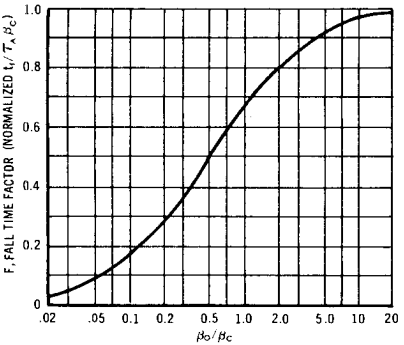
9a—RISE TIME FACTOR



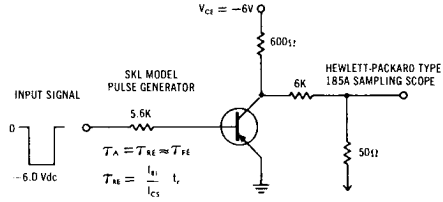
9b—ACTIVE REGION TIME CONSTANT



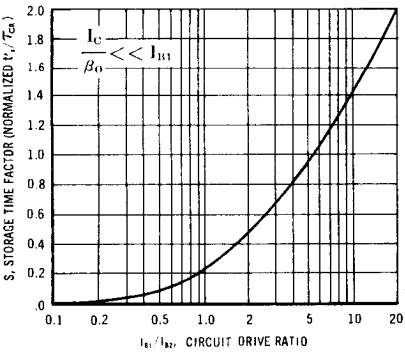
9c—FALL TIME FACTOR



ACTIVE REGION TIME CONSTANT TEST CIRCUIT



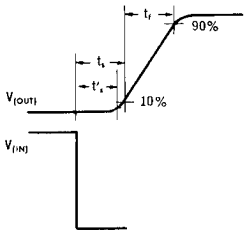
9d—STORAGE TIME



SWITCHING TIME EQUATIONS

RISE-TIME = $t_r = \tau_A\beta_f R$
FALL-TIME = $t_f = \tau_A\beta_C F$
STORAGE TIME = $t'_s = \tau_{CR} S$
t_r = 10 to 90% rise-time
t_f = 10 to 90% fall-time
$t_s = t'_s + \frac{1}{8} t_f$
τ_{CR} = the effective collector recovery time and is virtually uninfluenced by current levels. 20 nsec typical and 60 nsec maximum for this transistor.

τ_A = active region time constant
$\tau_A = \tau_{RE} \approx \tau_{FE}$ (Figure 9b)
$\beta_O = h_{FE}$ at edge of saturation ($\beta_O \approx h_{FE}$ on Figure 8)
$\beta_f = I_C$ in saturation/I_{B1} (base "on" current)
$\beta_C = I_C$ in saturation/I_{B2} (base "off" current)
R see Figure 9a
F see Figure 9c
S see Figure 9d

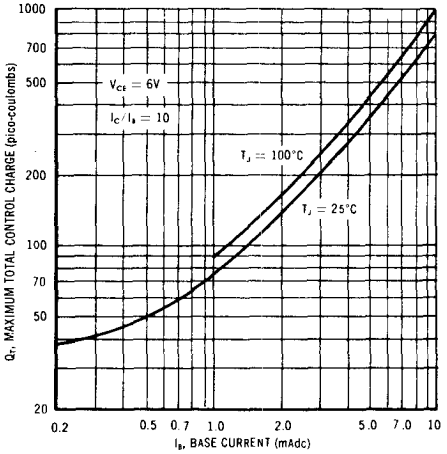


NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

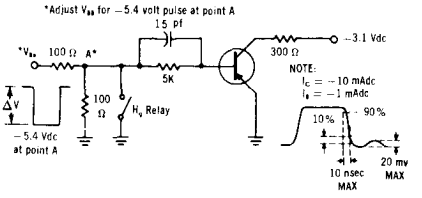
2N964A (continued)

2N964A LIMIT CURVES

FIGURE 10—TOTAL CONTROL CHARGE



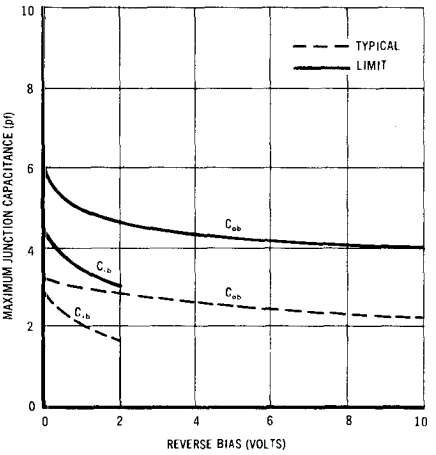
10a



10b

Total Control Charge. When a transistor is held in a conductive state by a current, I_{B1}, a charge Q_S is developed in the active region. A charge Q_T of opposite polarity, equal in magnitude, can be stored on an external capacitor C to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 10b shows the test circuit and turn-off waveform. Given Q_T from Figure 10a, the external C for worst case turn-off in any circuit is: $C = Q_T/\Delta V$, where ΔV is defined in Figure 10b.

FIGURE 11— JUNCTION CAPACITANCE VARIATIONS



NOTE: Limit Curves are based on periodic engineering evaluation. Production Tests are made at points indicated in the Electrical Characteristics Table.

2N965 (GERMANIUM)
2N966

For Specifications, See 2N960 Data Sheet

2N967 (GERMANIUM)

For Specifications, See 2N963 Data Sheet

2N968 thru 2N975 (GERMANIUM)

$V_{CES} = 7\text{-}15$ V
$I_C = 100$ mA
$f_T = 320$ MHz



CASE 22
(TO-18)

Collector connected to case

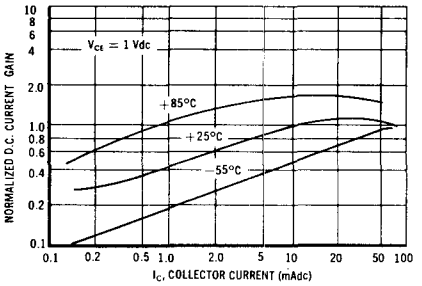
PNP germanium mesa transistors for high-speed switching applications.

MAXIMUM RATINGS

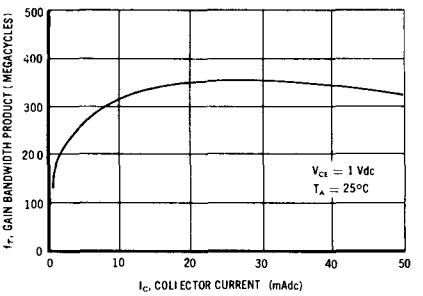
Characteristic	Symbol	2N968 2N972	2N969 2N973	2N970 2N974	2N971 2N975	Unit
Collector-Emitter Voltage	V_{CE}	15	12	12	7	Vdc
Collector-Base Voltage	V_{CB}	15	12	12	7	Vdc
Emitter-Base Voltage	V_{EB}	2.5	2.0	1.25	1.25	Vdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2				mW mW/^oC
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4				mW mW/^oC
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				^oC

2N968 thru 2N975 (continued)

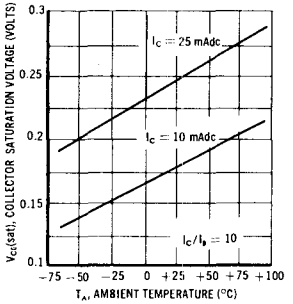
NORMALIZED D.C. CURRENT GAIN versus COLLECTOR CURRENT



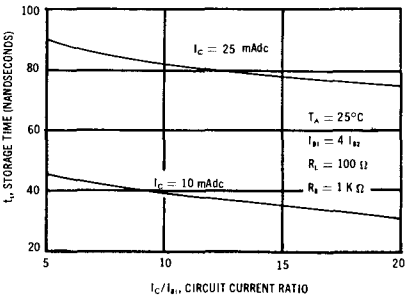
CURRENT GAIN-BANDWIDTH PRODUCT (f_T) versus COLLECTOR CURRENT



COLLECTOR SATURATION VOLTAGE versus AMBIENT TEMPERATURE



STORAGE TIME versus CIRCUIT CURRENT RATIO



ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N968, 2N972	BV_{CBO}	15	25	-	Vdc
	2N969, 2N970, 2N973, 2N974		12	20	-	
	2N971, 2N975		7	15	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N968, 2N972	BV_{EBO}	2.5	-	-	Vdc
	2N969, 2N973		2.0	-	-	
	2N970, 2N974		1.25	-	-	
	2N971, 2N975		1.25	-	-	
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N968, 2N972	I_{CES}	-	-	100	μAdc
(V_{CE} = 12 Vdc, V_{BE} = 0)	2N969, 2N970, 2N973, 2N974		-	-	100	
(V_{CE} = 7 Vdc, V_{BE} = 0)	2N971, 2N975		-	-	100	
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	-		μAdc
	2N968, 2N969, 2N970,		-	-	3	
	2N972, 2N973, 2N974		-	-	3	
	2N971, 2N975		-	-	10	

2N968 thru 2N975 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				—
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)	2N968, 2N969, 2N970, 2N971		17	35	-	
	2N972, 2N973, 2N974, 2N975		40	75	-	
(I_C = 25 mAdc, V_{CE} = 0.7 Vdc)	2N968, 2N969, 2N970, 2N971		20	40	-	
	2N972, 2N973, 2N974, 2N975		40	85	-	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		-	0.19	0.25	
(I_C = 25 mAdc, I_B = 1.5 mAdc)	All Types		-	0.25	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N968, 2N969, 2N972, 2N973		0.30	0.39	0.55	
	2N970, 2N971, 2N974, 2N975		0.30	0.43	0.65	
(I_C = 25 mAdc, I_B = 1.5 mAdc)	2N968, 2N969, 2N972, 2N973		-	0.45	0.80	
	2N970, 2N971, 2N974, 2N975		-	0.60	1.0	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 10 mAdc, V_{CB} = 1 Vdc, f = MHz)	All Types	f_T	250	320	-	MHz
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)	All Types	C_{ob}	-	4.0	9.0	pF
Emitter Transition Capacitance (V_{EB} = 1 Vdc, I_C = 0)	All Types	C_{Te}	-	3.5	-	pF
Turn-On Time ($V_{BE(off)}$ = 1.25 Vdc, I_C = 10 mAdc, I_{B1} = 1 mA)		t_{on}				ns
	2N968, 2N969, 2N972, 2N973		-	50	75	
	2N970, 2N971, 2N974, 2N975		-	65	100	
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 1 mAdc, I_{B2} = 0.25 mAdc)		t_{off}				ns
	2N968, 2N969		-	70	150	
	2N972, 2N973		-	75	175	
	2N970, 2N971, 2N974, 2N975		-	100	275	
Total Control Charge		Q_T				pC
(I_C = 10 mAdc, I_B = 1 mAdc)	2N968, 2N969, 2N972, 2N973		-	75	100	
	2N970, 2N971, 2N974, 2N975		-	80	150	
(I_C = 25 mAdc, I_B = 1.5 mAdc)	2N968, 2N969, 2N972, 2N973		-	90	175	
	2N970, 2N971, 2N974, 2N975		-	175	300	

2N985 (GERMANIUM)

$V_{CEO} = 7$ V
$I_C = 200$ mA
$f_T = 300$ Mc



CASE 22
(TO-18)

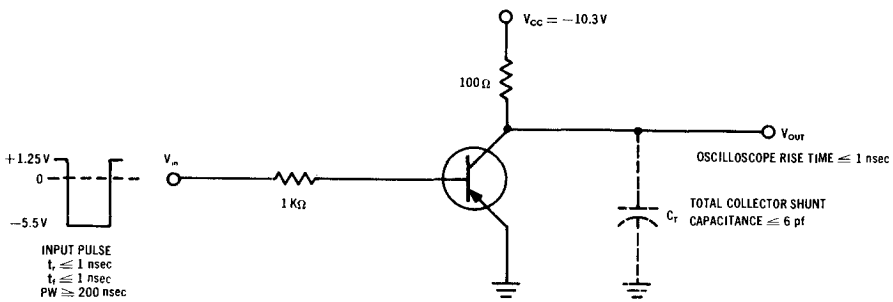
Collector connected to case

PNP germanium epitaxial mesa transistor for high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Ratings	Unit
Collector-Base Voltage	V_{CBO}	-15	Vdc
Collector-Emitter Voltage	V_{CEO}	-7	Vdc
Emitter-Base Voltage	V_{EBO}	-3	Vdc
Collector Current	I_C	-200	mAdc
Junction Temperature	T_J	100	^oC
Storage Temperature	T_{stg}	-65 to +100	^oC
Device Dissipation @ $T_C = 25^oC$ Derating factor above 25^oC	P_D	300 4	mW mW/^oC
Device Dissipation @ $T_A = 25^oC$ Derating factor above 25^oC	P_D	150 2	mW mW/^oC

SWITCHING TIME TEST CIRCUIT



2N985 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

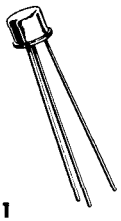
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = -100 μAdc, I_E = 0)	BV_{CBO}	-15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = -5 mAdc, I_B = 0)	BV_{CEO}	-7	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = -100 μAdc, R_{BE} = 0)	BV_{CES}	-15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = -100 μAdc, I_C = 0)	BV_{EBO}	-3	—	Vdc
Collector Cutoff Current (V_{CB} = -5 Vdc, I_E = 0)	I_{CBO}	—	-3	μAdc
Emitter Cutoff Current (V_{EB} = -3 Vdc, I_C = 0)	I_{EBO}	—	-100	μAdc
DC Current Gain (I_C = -10 mAdc, V_{CE} = -0.25 Vdc) (I_C = -100 mAdc, V_{CE} = -0.5 Vdc)	h_{FE}	40 60	— —	—
Collector Saturation Voltage (I_C = -10 mAdc, I_B = -0.5 mAdc) (I_C = -100 mAdc, I_B = -5 mAdc)	$V_{CE(sat)}$	— —	-0.15 -0.30	Vdc
Base-Emitter Voltage (I_C = -10 mAdc, I_B = 0.5 mAdc) (I_C = -100 mAdc, I_B = -5 mAdc)	V_{BE}	-0.28 -0.40	-0.40 -0.60	Vdc
Small Signal Current Gain (V_{CE} = -2 Vdc, I_C = -30 mAdc, f = 100 mc)	$\|h_{fe}\|$	3.0	—	—
Collector Output Capacitance (V_{CB} = -5 Vdc, I_E = 0, f = 1 mc)	C_{ob}	—	6	pf
Turn-on Time (I_C = -10 mAdc, I_{B1} = -5 mAdc, $V_{BE(0)}$ = +1.25 Vdc)	t_{on}	—	35	nsec
Turn-off Time (I_C = -10 mAdc, I_{B1} = -5 mAdc, I_{B2} = +1.25 mA)	t_{off}	—	80	nsec

2N995 (SILICON)

For Specifications, See 2N869 Data Sheet

2N1131 (SILICON)
2N1131 USN/JAN
2N1991

$V_{CEO} = 20\text{-}35\ V$
$I_C = 600\ mA$
$f_T = 120\ Mc\ Typ$



PNP silicon annular transistors for medium-current switching applications.

Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage 2N1131 2N1991	V_{CBO}	 50 30	Vdc
Collector-Emitter Voltage 2N1131 2N1991	V_{CEO}	 35 20	Vdc
Emitter-Base Voltage 2N1131, 2N1991	V_{EBO}	 5	Vdc
Collector-Emitter Voltage ($R_{be} \leqq 10\ \Omega$) 2N1131	V_{CER}	 50	Vdc
Collector Current 2N1131	I_C	 600	mAdc
Total Device Dissipation @ 25°C Case Temperature Both Types Derating Factor Above 25°C 2N1131 2N1991	P_D	 2 13.3 16.0	 Watts mW/°C mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Both Types Derating Factor Above 25°C 2N1131 2N1991	P_D	 0.6 4.0 4.8	 Watt mW/°C mW/°C
Junction Temperature 2N1131 2N1991	T_J	 +175 +150	°C
Storage Temperature Range 2N1131 2N1991	T_{stg}	 -65 to +300 -65 to +150	°C

2N1131, 2N1991 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Types	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) (I_C = 1.0 mA, I_E = 0)	 2N1131 2N1991	BV_{CBO}	 50 30	 — —	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulse, I_B = 0)	 2N1131 2N1991	BV_{CEO}	 35 20	 — —	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc pulsed, $R_{be} \leq 10\Omega$)	2N1131	BV_{CER}	50	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0) (V_{CB} = 10 Vdc, I_E = 0, T_A = 150°C)	 2N1131 2N1131 2N1131 2N1991 2N1991	I_{CBO}	 — — — — —	 1 100 100 5 200	μ Adc
Emitter Cutoff Current (V_{EB} = 2 Vdc, I_C = 0) (V_{EB} = 1 Vdc, I_C = 0)	 2N1131 2N1991	I_{EBO}	 — —	 100 200	μ Adc
DC Forward Current Transfer Ratio (I_C = 5 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc) (I_C = 150 mAdc, V_{CE} = 10 Vdc)	 2N1131 2N1991 2N1131 2N1991	h_{FE}	 15 15 20 15	 — — 60 45	—
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE\ (sat)}$	—	1.5	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	 2N1131 2N1991	$V_{BE\ (sat)}$	 — —	 1.3 1.5	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	45	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)	2N1131	C_{ib}	—	80	pf
AC Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 mc)	 2N1131 2N1991	$\|h_{fe}\|$	 2.5 2.0		—
Small-Signal Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	 2N1131 2N1131	h_{fe}	 15 20	 50 —	—
Small Signal Input Resistance (I_C = 1 mAdc, V_{CB} = 5 Vdc, f = 1 kc) (I_C = 5 mAdc, V_{CB} = 10 Vdc, f = 1 kc)	2N1131	h_{ib}	 25 —	 35 10	ohms
Small Signal Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	2N1131	h_{ob}	 — —	 1 5	μ mhos
Small Signal Voltage Feedback Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc) (I_C = 5 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	2N1131	h_{rb}	 — —	 8 8	x 10^{-4}

Pulse Test: Pulse width ≤ 300 μsec, Duty Cycle ≤ 2%

2N1132, A, B (SILICON)

For Specifications, See 2N722 Data Sheet

2N1204, A (GERMANIUM)
2N1494,A
2N1495
2N1496
2N2096
2N2097
2N2099
2N2100

$V_{CEO} = 12\text{-}25$ V
$I_C = 500$ mA
$f_T = 200$ Mc Typ

PNP germanium epitaxial mesa transistors for high-speed, high-current switching in line and core driver applications.



CASE 31
(TO-5)
2N1204,A
2N1495
2N2099
2N2100



Collector connected to case

CASE 25
2N1494,A
2N1496
2N2096
2N2097

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}		Vdc
2N1204, 2N1204A, 2N1494, 2N1494A		20	
2N2096, 2N2099		25	
2N1495, 2N1496, 2N2097, 2N2100		40	
Collector-Emitter Voltage	V_{CEO}		Vdc
2N2096, 2N2099		12	
2N1204, 2N1204A, 2N1494A		15	
2N2097, 2N2100		20	
2N1495, 2N1496		25	
Collector-Emitter Voltage	V_{CES}		Vdc
2N1204, 2N1204A, 2N1494, 2N1494A		20	
2N2096, 2N2099		25	
2N1495, 2N1496, 2N2097, 2N2100		40	
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ $T_C = 25°C$	P_D		
All Types		750	mW
derating factor above 25°C		10	mW/°C
Total Device Dissipation @ $T_A = 25°C$	P_D		
TO-5 Case			
2N1204, 2N1204A, 2N1495, 2N2099, 2N2100		300	mW
derating factor above 25°C		4.0	mW/°C
Case 25			
2N1494, 2N1494A, 2N1496, 2N2096, 2N2097		500	mW
derating factor above 25°C		6.67	mW/°C
Operating Junction Range Storage Temperature Range	T_J T_{stg}	-65 to +100	°C

2N1204,A SERIES (continued)

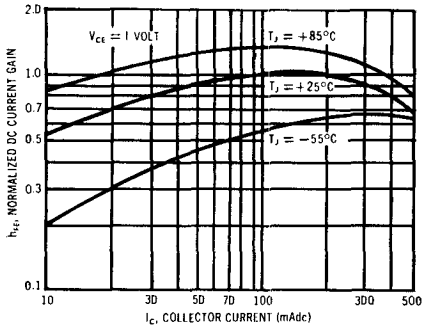
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2Nt204, 2N1204A, 2N1494, 2N1494A	BV_{CBO}	20	40	–	Vdc
	2N2096, 2N2095		25	–	–	
	2N1495, 2Nt496, 2N2097, 2N2100		40	–	–	
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{EB} = 0)	2N1204, 2Nt204A, 2N1494, 2Nt494A	BV_{CES}	20	40	–	Vdc
	2N2096, 2N2099		25	–	–	
	2Nt495, 2N1496, 2N2097, 2N2100		40	–	–	
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	2N1204, 2N1204A, 2N1494, 2N1494A	BV_{CEO}	15	25	–	Vdc
(I_C = 10 mAdc, t_B = 0)	2N2096, 2N2099		12	–	–	
	2N2097, 2N2100		20	–	–	
	2N1495, 2N1496		25	–	–	
Emitter-Base Breakdown Voltage (I_E = 1 mAdc, I_C = 0)	2Nt204, 2N1204A, 2N1494 thru 2N1496, 2N1494A	BV_{EBO}	4	–	–	Vdc
(I_E = 10 mAdc, I_C = 0)	2N2096, 2N2097, 2N2099, 2N2100		4	–	–	
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A	I_{CBO}	–	0.4	7	μAdc
(V_{CB} = 12 Vdc, I_E = 0)	2N2096, 2N2099		–	–	12	
(V_{CB} = 15 Vdc, I_E = 0)	2N2097, 2N2100		–	–	12	
Emitter Cutoff Current (V_{OB} = 0.5 Vdc, I_C = 0)	2N1494 thru 2N1496, 2Nt494A	I_{EBO}	–	–	5	μAdc
(V_{OB} = 1 Vdc, I_C = 0)	2N2096, 2N2097, 2N2099, 2N2100		–	10	50	
DC Current Gain (I_C = 200 mAdc, V_{CE} = 0.5 Vdc)	2N1204A, 2N1494A, 2Nt495, 2N1496	h_{FE}	25	–	–	–
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N2097, 2N2100		30	70	–	
(I_C = 400 mAdc, V_{CE} = 1.5 Vdc)*	2N1204, 2N1494, 2N2096, 2N2099		15	35	–	
	2N2097, 2N2100		20	50	–	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc)	2N2097, 2N2100	$V_{CE(sat)}$	–	–	0.3	Vdc
(I_C = 200 mAdc, I_B = 10 mAdc)	2N1204, 2N1204A, 2N1494, 2N1494A		–	–	0.4	
	2N2097, 2N2100		–	–	0.5	
	2N2096, 2N2099		–	–	0.6	
(I_C = 200 mAdc, I_B = 20 mAdc)	2Nt495, 2N1496		–	–	0.3	
(I_C = 400 mAdc, I_B = 25 mAdc)**	2N1204A, 2N1494A, 2N1495, 2N1496		–	–	0.7	
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 2.5 mAdc)	2N2097, 2N2100	$V_{BE(sat)}$	–	–	0.5	Vdc
(I_C = 200 mAdc, I_B = 10 mAdc)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A		0.40	0.60	0.72	
	2N2097, 2N2100		–	–	0.6	
	2N2096, 2N2099		–	–	0.9	
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4 mc)	2N1204, 2N1204A, 2N1494 thru 2N1496, 2N1494A	C_{ob}	–	3.5	6.5	pf
	2N2096, 2N2097, 2N2099, 2N2100		–	2.5	20	
Input Capacitance (V_{OB} = 1 Vdc, I_C = 0, f = 4 mc)	All Types	C_{ib}	–	8	50	pf
AC Current Gain (I_C = 20 mA, V_{CE} = 10 V, f = 100 mc)	2N1204, 2N1204A, 2N1494, 2N1494A	h_{fe}	1.1	2	–	–
	2N1495, 2N1496		1.5	–	–	
Rise Time	2N2097, 2N2100	t_r	–	–	20	nsec
	2N1204, 2N1204A, 2N1494, 2N1494A, 2N2096, 2N2099		–	–	35	
	2N1495, 2N1496		–	–	55	
Minority Carrier Storage Time Constant	2N1204, 2N1204A, 2N1494, 2N1494A	τ_s	–	30	75	nsec
	2N1495, 2N1496		–	–	90	
Storage Time	2N2097, 2N2100	t_s	–	–	50	nsec
	2N2096, 2N2099		–	–	70	
Fall Time	2N2097, 2N2100	t_f	–	–	40	nsec
	2N2096, 2N2099		–	–	60	

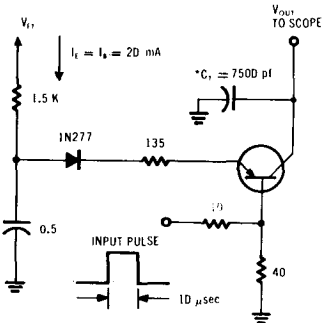
*Pulse Test: Pulse width ≤ 1 msec, Duty cycle ≤ 6%
**Pulse Test: Pulse width ≤ 5 msec, Duty cycle ≤ 2%

2N1204,A SERIES (continued)

NORMALIZED CURRENT GAIN CHARACTERISTICS



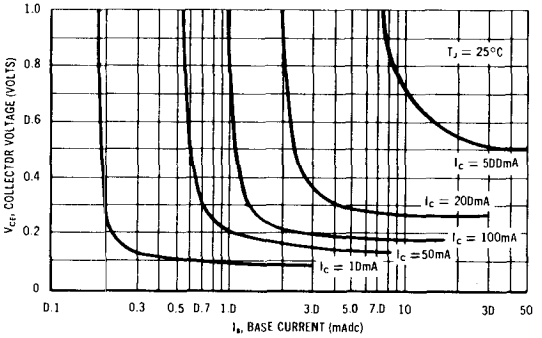
CARRIER STORAGE TIME CONSTANT TEST CIRCUIT



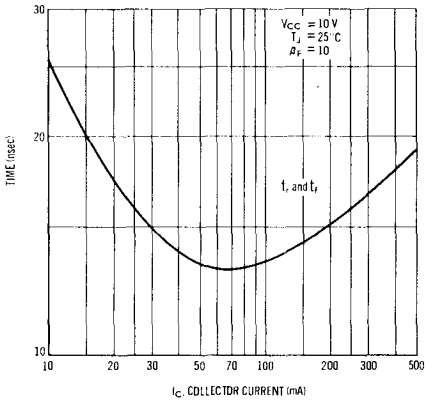
*ADD SCOPE AND PROBE CAPACITANCE TO C_t FOR CORRECT CALCULATION OF T_s (K'_s)

$$T_s = \frac{C_t V_{OUT}}{I_f}$$

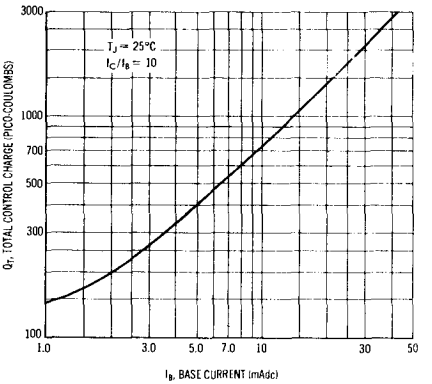
COLLECTOR EMITTER SATURATION VOLTAGES versus BASE CURRENT



TYPICAL RISE AND FALL-TIME BEHAVIOR

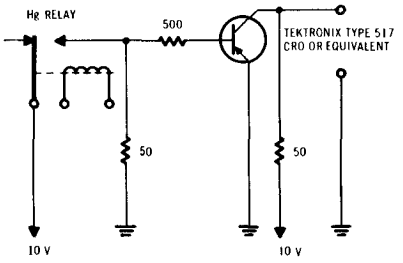


TOTAL CONTROL CHARGE

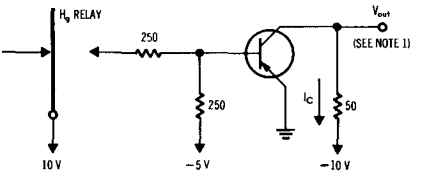


2N1204,A SERIES (continued)

RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



NOTE 1: SCOPE IMPEDANCE SUFFICIENTLY HIGH SO THAT DOUBLING OR HALVING ITS VALUE DOES NOT CHANGE THE READING.
SCOPE RISE TIME FAST ENOUGH SO THAT DOUBLING OR HALVING ITS VALUE DOES NOT CHANGE THE READING.

2N1420 (SILICON)

For Specifications, See 2N697 Data Sheet

2N1494, A thru 2N1496 (GERMANIUM)

For Specifications, See 2N1204 Data Sheet

2N1613 (SILICON)

2N1711

For Specifications, See 2N718A Data Sheet

2N1893 (SILICON)
2N2405

V_{CEO} = 80-90 V
I_C = 0.5-1 A
f_T = 50 MHz



Collector connected to case

CASE 31
(TO-5)

NPN silicon annular transistors designed for medium-power amplifier and switching applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N1893	2N2405	Unit
Collector-Base Voltage	V_{CBO}	120	120	Vdc
Collector-Emitter Voltage	V_{CEO}	80	90	Vdc
Collector-Emitter Voltage	V_{CER}	100	140	Vdc
Emitter-Base Voltage	V_{EBO}	7	7	Vdc
Collector Current	I_C	0.5	1	Adc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.8 4.57	1 5.71	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	3 17.2	5 28.6	Watts mW/°C
Junction Temperature, Operating	T_J	200	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	-65 to +200	°C
Thermal Resistance: Junction-to-Case Junction-to-Air	 θ_{JC} θ_{JA}	 58.3 219	 35 175	 °C/W °C/W

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N1893		2N2405		Unit
		Min	Max	Min	Max	
Collector-Emitter Sustaining Voltage*						Vdc
(I_C = 30 mA, I_B = 0)	$V_{CEO(sus)}$	80	—	—	—	
(I_C = 100 mA, I_B = 0)		—	—	90	—	
(I_C = 100 mA, R_{BE} = 10 ohms)	$V_{CER(sus)}$	100	—	140	—	
Collector-Base Breakdown Voltage (I_C = 100 μA, I_E = 0)	BV_{CBO}	120	—	120	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μA, I_C = 0)	BV_{EBO}	7	—	7	—	Vdc
DC Forward Current Transfer Ratio*						—
(I_C = 0.1 mA, V_{CE} = 10 V)	h_{FE}	20	—	—	—	
(I_C = 10 mA, V_{CE} = 10 V)		35	—	—	—	
(I_C = 150 mA, V_{CE} = 10 V)		40	120	60	200	
(I_C = 10 mA, V_{CE} = 10 V, T_A = -55°C)		20	—	—	—	
Collector Saturation Voltage						Vdc
(I_C = 50 mA, I_B = 5 mA)	$V_{CE(sat)}$	—	1.2	—	—	
(I_C = 150 mA, I_B = 15 mA)		—	5	—	0.5	

2N1893 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N1893		2N2405		Unit
		Min	Max	Min	Max	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$					Vdc
(I_C = 50 mA, I_B = 5 mA)		—	0.9	—	—	
(I_C = 150 mA, I_B = 15 mA)		—	1.3	—	1.1	
Collector Cutoff Current	I_{CBO}					μAdc
(V_{CB} = 90 V, I_E = 0)		—	0.01	—	0.01	
(V_{CB} = 90 V, I_E = 0, T_A = 150°C)		—	15	—	10	
Emitter Cutoff Current (V_{EB} = 5 V, I_C = 0)	I_{EBO}	—	0.01	—	0.01	μAdc
Output Capacitance (V_{CB} = 10 V, I_E = 0)	C_{ob}	—	15	—	15	pF
Input Capacitance (V_{EB} = 0.5 V, I_C = 0)	C_{ib}	—	85	—	—	pF
Small Signal Current Gain	h_{fe}					—
(I_C = 1 mA, V_{CE} = 5 V, f = 1 kHz)		30	100	—	—	
(I_C = 5 mA, V_{CE} = 5 V, f = 1 kHz)		—	—	50	275	
(I_C = 5 mA, V_{CE} = 10 V, f = 1 kHz)		45	—	—	—	
(I_C = 50 mA, V_{CE} = 10 V, f = 20 MHz)		2.5	—	—	—	
Input Resistance	h_{ib}					ohms
(I_C = 1 mA, V_{CB} = 5 V, f = 1 kHz)		20	30	—	—	
(I_C = 5 mA, V_{CB} = 10 V, f = 1 kHz)		4	8	4	8	
Voltage Feedback Ratio	h_{rb}					X10-4
(I_C = 1 mA, V_{CB} = 5 V, f = 1 kHz)		—	1.25	—	—	
(I_C = 5 mA, V_{CB} = 10 V, f = 1 kHz)		—	1.5	—	3	
Output Conductance	h_{ob}					μmho
(I_C = 1 mA, V_{CB} = 5 V, f = 1 kHz)		—	0.5	—	—	
(I_C = 5 mA, V_{CB} = 10 V, f = 1 kHz)		—	0.5	—	0.5	

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N1991 (SILICON)

For Specifications, See 2N1131 Data Sheet

2N2096 (GERMANIUM)
2N2097
2N2099
2N2100

For Specifications, See 2N1204 Data Sheet

2N2192, A, B thru 2N2195, A, B
(SILICON)

$V_{CEO} = 25\text{-}50$ V
$I_C = 1$ A
$f_T = 250$ Mc



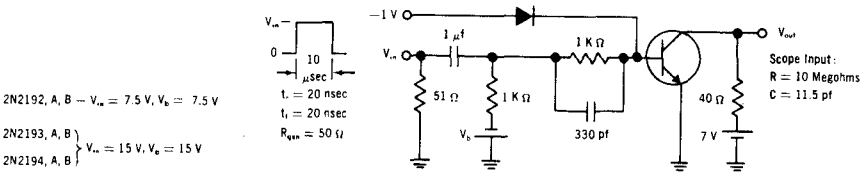
CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistors for high-current switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N2192 2N2192A 2N2192B 2N2194 2N2194A 2N2194B	2N2193 2N2193A 2N2193B	2N2195 2N2195A 2N2195B	Unit
Collector-Base Voltage	V_{CBO}	60	80	45	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	25	Vdc
Emitter-Base Voltage	V_{EBO}	5	8	5	Vdc
Collector Current	I_C	1.0	1.0	1.0	Adc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.8 4.56	0.8 4.56	0.6 3.43	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	← 2.8 → ← 16 →			Watts mW/°C
Junction Temperature, Operating	T_J	-65 to +200			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C



2N2192,A,B thru 2N2195,A,B (continued)

ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N2192, A, B, 2N2194, A, B	BV_{CBO}	60	-	Vdc
	2N2193, A, B		80	-	
	2N2195, A, B		45		
Collector Emitter-Open Base Sustain Voltage* (I_C = 25 mA pulsed, I_B = 0)	2N2192, A, B, 2N2194, A, B	$V_{CEO(sus)}$*	40	-	Vdc
	2N2193, A, B		50	-	
	2N2195, A, B		25	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N2192, A, B, 2N2194, A, B, 2N2195, A, B	BV_{EBO}	5	-	Vdc
	2N2193, A, B		8	-	
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)	2N2192, A, B, 2N2194, A, B	I_{CBO}	-	.010	μAdc
	2N2195, A, B		-	.100	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N2192, A, B		-	15	
	2N2194, A, B		-	25	
	2N2195, A, B		-	50	
(V_{CB} = 60 Vdc, I_E = 0)	2N2193, A, B		-	.010	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N2193, A, B		-	25	
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	2N2192, A, B, 2N2194, A, B	I_{EBO}	-	.050	μAdc
	2N2195, A, B		-	.100	
(V_{EB} = 5 Vdc, I_C = 0)	2N2193, A, B		-	.050	
Collector-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	2N2192 thru 2N2195	$V_{CE(sat)}$	-	0.35	Vdc
	2N2192A thru 2N2195A		-	0.25	
	2N2192B thru 2N2195B		-	0.18	
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{BE(sat)}$	-	1.3	Vdc
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B, 2N2193, A, B	h_{FE}*	15	-	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		75	-	
	2N2193, A, B		30	-	
	2N2194, A, B		15	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2192, A, B		35	-	
	2N2193, A, B		20	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		100	300	
	2N2193, A, B		40	120	
	2N2194, A, B		20	60	
	2N2195, A, B		20	-	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N2192, A, B		70	-	
	2N2193, A, B		30	-	
	2N2194, A, B		15	-	
	2N2195, A, B		10	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N2192, A, B		35	-	
	2N2193, A, B		20	-	
	2N2194, A, B		12	-	
(I_C = 1.0 Adc, V_{CE} = 10 Vdc)	2N2192, A, B, 2N2193, A, B		15	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1.0 mc)	All Types	C_{ob}	-	20	pf
Small Signal Current Gain (I_C = 50 mA, V_{CE} = 10 V, f = 20 mc)	All Types	h_{fe}	2.5	-	-
Rise Time	2N2192-94, 2N2192A-94A, 2N2192B-94B	t_r	-	70	nsec
Storage Time		t_s	-	150	nsec
Fall Time		t_f	-	50	nsec

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N2218 (SILICON)
2N2219
2N2221
2N2222
2N2904 thru 2N2907

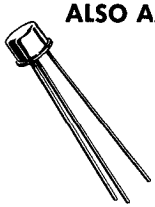
$V_{CEO} = 30$ V
$f_T = 400$ Mc Typ

ALSO AVAILABLE AS JAN AND HI-REL UNITS



CASE 22
(TO-18)

2N2221
2N2222
2N2906
2N2907



CASE 31
(TO-5)

2N2218, 2N2219,
2N2904, 2N2905

Silicon annular star transistors for high-speed switching and DC to UHF amplifier applications. NPN types 2N2218 thru 2N2222 are complementary to PNP types 2N2904 thru 2N2907.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	NPN	PNP	Unit
Collector - Base Voltage	V_{CBO}	60	60	Vdc
Collector - Emitter Voltage	V_{CEO}	30	40	Vdc
Emitter - Base Voltage	V_{EBO}	5	5	Vdc
Collector Current	I_C	800	600	mAdc
Total Device Dissipation @ 25°C Case Temperature	P_D			
To - 5: 2N2218, 2N2219		3		W
Derate Above 25°C		20		mW/°C
2N2904, 2N2905			3	W
Derate Above 25°C			17.2	mW/°C
To - 18: 2N2221, 2N2222		1.8		W
Derate Above 25°C		12		mW/°C
2N2906, 2N2907			1.8	W
Derate Above 25°C			10.3	mW/°C
Total Device Dissipation @ 25°C Ambient Temperature	P_D			
To - 5: 2N2218, 2N2219		0.8		W
Derate Above 25°C		5.33		mW/°C
2N2904, 2N2905			0.6	W
Derate Above 25°C			3.43	mW/°C
To - 18: 2N2221, 2N2222		0.5		W
Derate Above 25°C		3.33		mW/°C
2N2906, 2N2907			0.4	W
Derate Above 25°C			2.28	mW/°C
Operating Junction Temperature	T_J	-65 to +175	-65 to+200	°C
Storage Temperature	T_{stg}	-65 to +200	-65 to +200	°C

2N2218 SERIES, 2N2904 SERIES (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Static Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	All Types	---	BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N2218-19, 2N2221-22 2N2984 thru 2N2987	9	BV_{CEO*}	30 48	--- ---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	---	BV_{EBO}	5	---	Vdc
Collector Cutoff Current (V_{CB} = 58 Vdc, I_E = 0)	2N2218-19, 2N2221-22 2N2984 thru 2N2987	---	I_{CBO}	--- ---	.81 .02	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N2218-19, 2N2221-22 2N2984 thru 2N2907			--- ---	18 28	
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0.5 Vdc)	2N2984 thru 2N2907	---	I_{CEX}	---	50	nAdc
Base Cutoff Current (V_{CE} = 38 Vdc, V_{BE} = 0.5 Vdc)	2N2904 thru 2N2907	---	I_{BL}	---	58	nAdc
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	12, 15	$V_{CE\ (sat)}$*	---	8.4	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types			---	1.6	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	13, 16	$V_{BE\ (sat)}$*	---	1.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types			---	2.6	
DC Forward Current Transfer Ratio (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2218, 2N2221, 2N2904, 2N2906 2N2219, 2N2222, 2N2905, 2N2907	10 11	h_{FE}	20 35	--- ---	---
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218, 2N2221, 2N2904, 2N2986 2N2219, 2N2222, 2N2985, 2N2907			25 50	--- ---	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218, 2N2221, 2N2984, 2N2986 2N2219, 2N2222, 2N2905, 2N2907			35 75	--- ---	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N2218, 2N2221, 2N2984, 2N2906 2N2219, 2N2222, 2N2905, 2N2987			40 100	120 300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N2218, 2N2221, 2N2984, 2N2906 2N2219, 2N2222, 2N2905, 2N2987			20 30	--- ---	

Dynamic Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	All Types	4	C_{ob}	---	---	8	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)	2N2218-19, 2N2221-22	4	C_{ib}	---	---	30	pf
(V_{EB} = 2 Vdc, I_C = 0, f = 100 kc)	2N2904 thru 2N2907			---	---	30	
Current Gain - Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N2218-19, 2N2221-22	8	f_T	250	---	---	mc
(I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N2904 thru 2N2907			200	---	---	
Delay Time	2N2904 thru 2N2907	1	t_d	---	6	10	nsec
Rise Time	2N2904 thru 2N2907	1	t_r	---	20	40	nsec
Turn-On Time	2N2218-19, 2N2221-22	1	t_{on}	---	20	---	nsec
	2N2904 thru 2N2907			---	20	45	
Storage Time	2N2904 thru 2N2907	2	t_s	---	50	80	nsec
Fall Time	2N2984 thru 2N2907	2	t_f	---	20	30	nsec
Turn-Off Time	2N2218-19, 2N2221-22	2	t_{off}	---	70	---	nsec
	2N2904 thru 2N2907			---	---	100	
Total Switching Time	All Types	3	t_{total}	---	100	---	nsec

*Pulse Test, Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

PNP SWITCHING-TIME CIRCUITS

For NPN Switching Tests, reverse diodes, polarities, and input pulses.

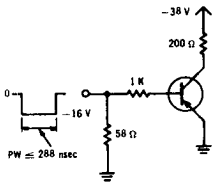


FIGURE 1 — SATURATED TURN-ON SWITCHING-TIME TEST CIRCUIT

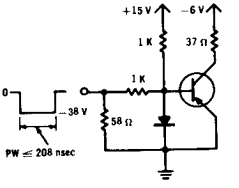


FIGURE 2 — SATURATED TURN-OFF SWITCHING-TIME TEST CIRCUIT

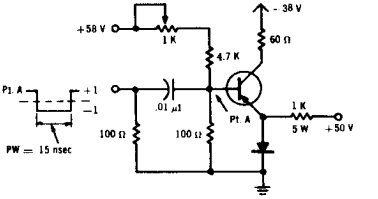


FIGURE 3 — NON-SATURATED SWITCHING-TIME TEST CIRCUIT

2N2218 SERIES, 2N2904 SERIES (continued)

FIGURE 4 — CAPACITANCE VARIATIONS versus VOLTAGE

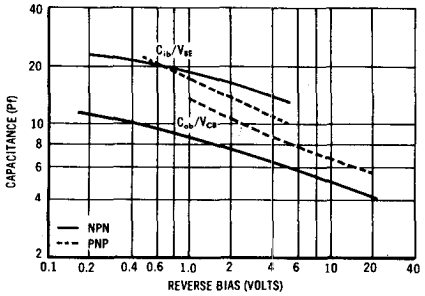


FIGURE 5 — ACTIVE REGION TIME CONSTANT versus COLLECTOR CURRENT

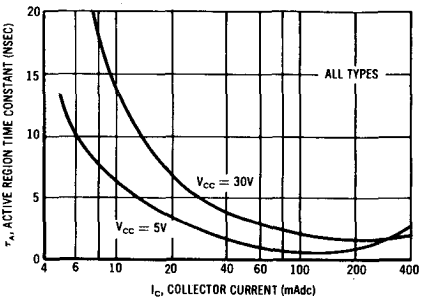


FIGURE 6 — TOTAL CONTROL CHARGE versus BASE CURRENT

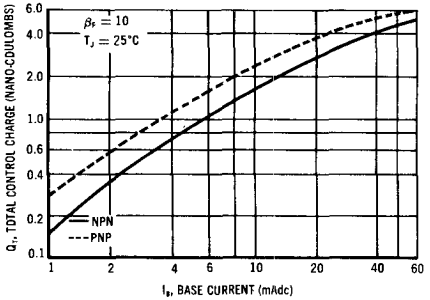
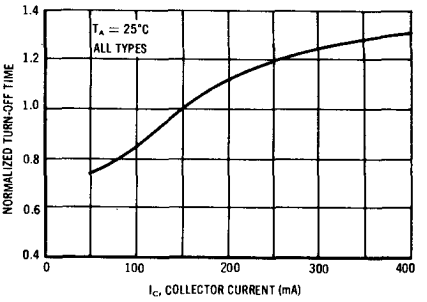
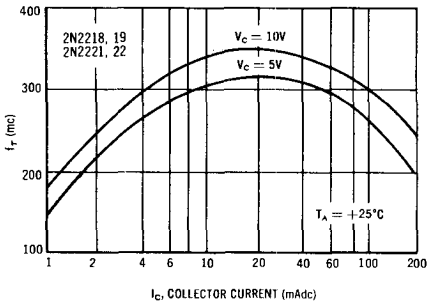


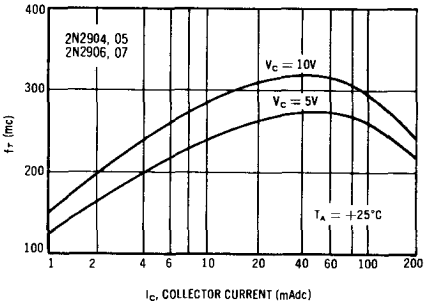
FIGURE 7 — NORMALIZED TURN-OFF TIME versus COLLECTOR CURRENT



NPN PNP

FIGURE 8 — CURRENT-GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

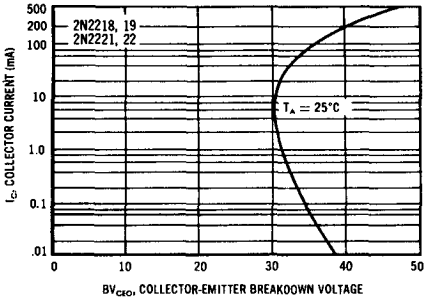




2N2218 SERIES, 2N2904 SERIES (continued)

NPN PNP

FIGURE 9 — COLLECTOR CURRENT versus MINIMUM COLLECTOR-EMITTER BREAKDOWN VOLTAGE



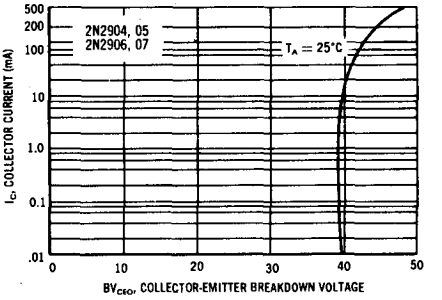
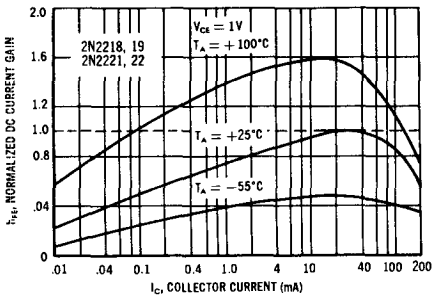


FIGURE 10 — LOW CURRENT GAIN



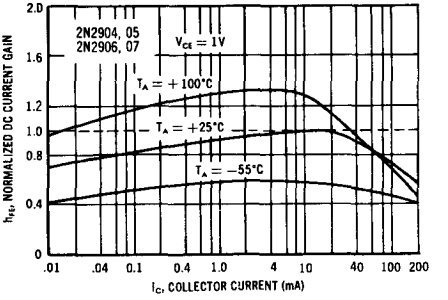
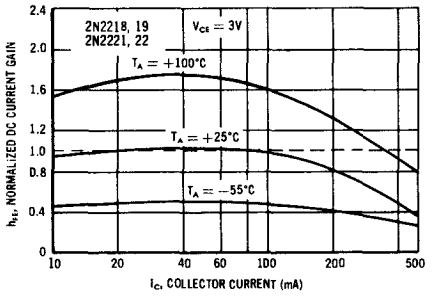
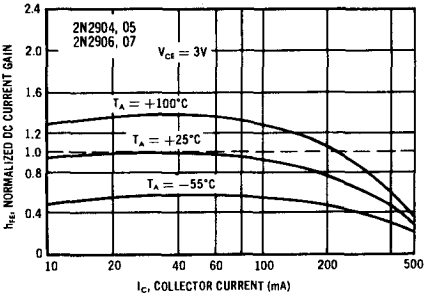


FIGURE 11 — HIGH CURRENT GAIN





2N2218 SERIES, 2N2904 SERIES (continued)

NPN

FIGURE 12 — COLLECTOR SATURATION VOLTAGE versus BASE CURRENT

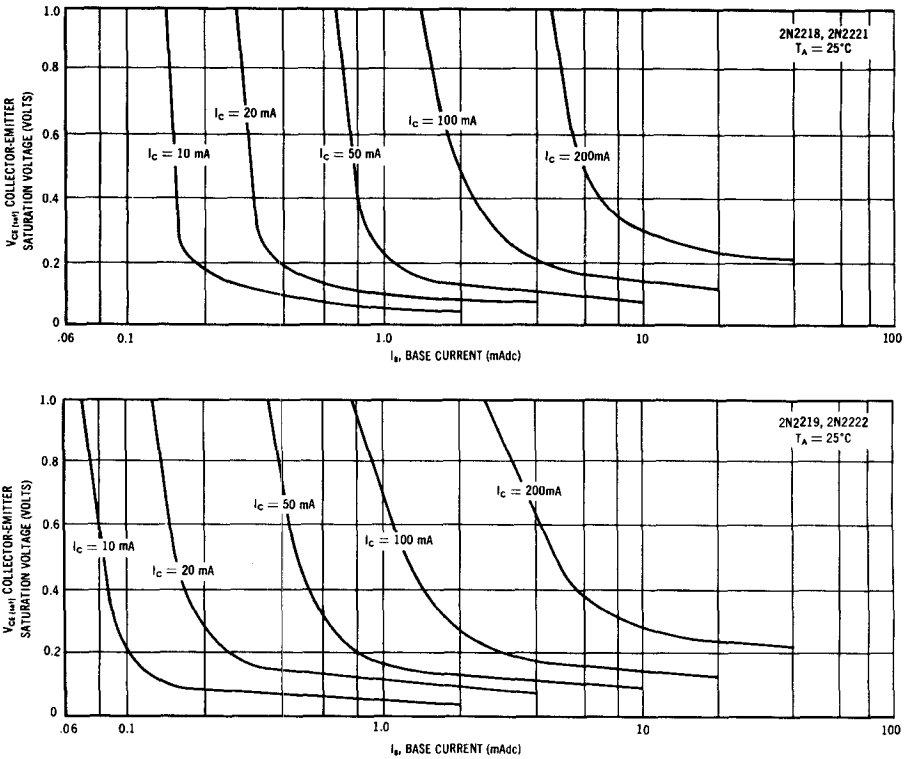


FIGURE 13 — BASE SATURATION VOLTAGE versus BASE CURRENT

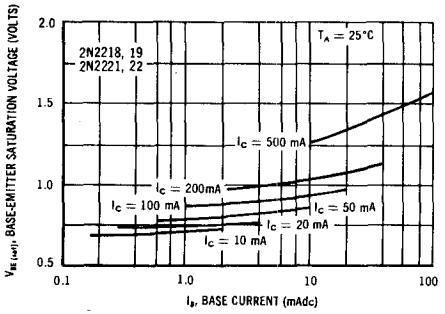
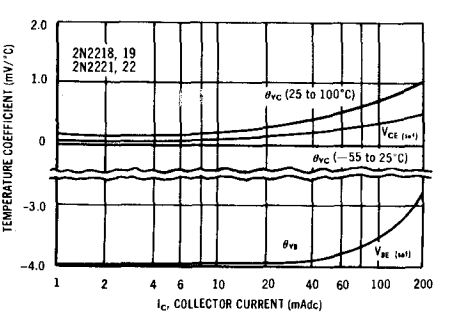


FIGURE 14 — TEMPERATURE COEFFICIENTS



2N2218 SERIES, 2N2904 SERIES (continued)

PNP

FIGURE 15 — COLLECTOR SATURATION VOLTAGE versus BASE CURRENT

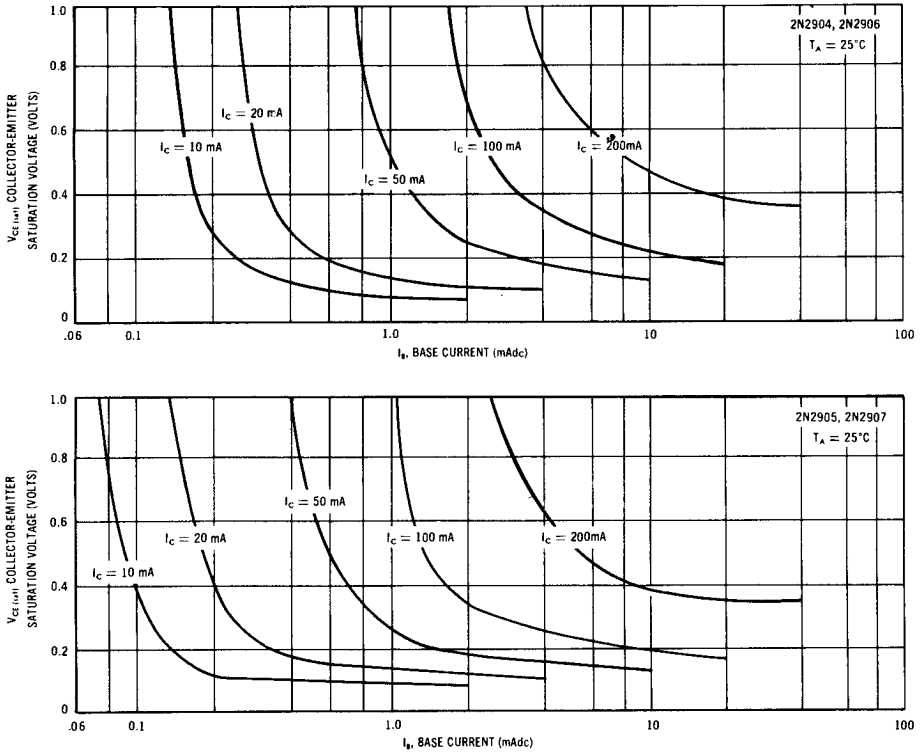


FIGURE 16 — BASE SATURATION versus BASE CURRENT

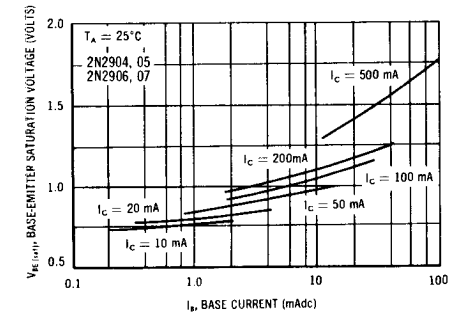
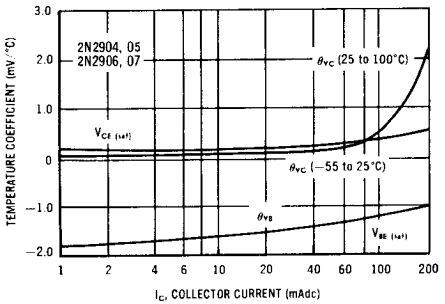


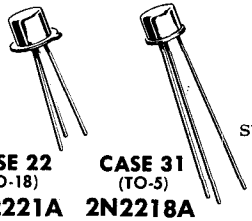
FIGURE 17 — TEMPERATURE COEFFICIENTS



2N2218A (SILICON)
2N2219A
2N2221A
2N2222A

ALSO AVAILABLE AS JAN AND HI-REL UNITS

$V_{CEO} = 40$ V
$f_T = 400$ Mc Typ



CASE 22 (TO-18)
2N2221A
2N2222A

CASE 31 (TO-5)
2N2218A
2N2219A

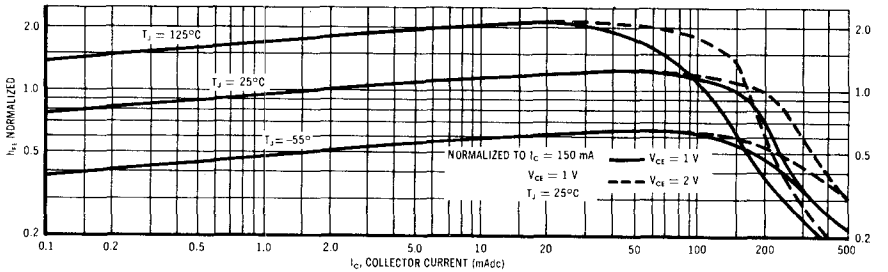
NPN silicon annular Star transistors for high-speed switching and DC to VHF amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N2218A 2N2219A (TO-5)	2N2221A 2N2222A (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	75	75	Vdc
Collector-Emitter Voltage	V_{CEO}	40	40	Vdc
Emitter-Base Voltage	V_{EBO}	6	6	Vdc
Total Device Dissipation at 25°C Case Temperature Derating Factor Above 25°C	P_D	3 20	1.8 12	Watts mW/°C
Total Device Dissipation at 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.8 5.33	0.5 3.33	Watts mW/°C
Junction Temperature Range	T_J	-65 to +175		°C
Storage Temperature Range	T_{stg}	-65 to + 200		°C

TYPICAL CURRENT GAIN CHARACTERISTICS



2N2218A, 2N2219A, 2N2221A , 2N2222A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Static Characteristics		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	All Types	BV_{CBO}	75	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	All Types	BV_{CEO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	6	—	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0)	All Types	I_{CBO}	—	0.01	μ Adc
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	All Types		—	10	
Collector Cutoff Current (V_{CE} = 60 Vdc, V_{OB} = 3Vdc)	All Types	I_{CEX}	—	10	nAdc
Base Cutoff Current (V_{CE} = 60 Vdc, V_{OB} = 3 Vdc)	All Types	I_{BL}	—	20	nAdc
Emitter Cutoff Current (V_{OB} = 3 Vdc, I_C = 0)	All Types	I_{EBO}	—	10	nAdc
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{CE\ (sat)}$*	—	0.3	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	1.0	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	All Types	$V_{BE(sat)}$*	0.6	1.2	Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)	All Types		—	2.0	
DC Forward Current Transfer Ratio* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2218A, 2N2221A	h_{FE}*	20	—	—
	2N2219A, 2N2222A		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2218A, 2N2221A		25	—	
	2N2219A, 2N2222A		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2218A, 2N2221A		35	—	
	2N2219A, 2N2222A		75	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N2218A, 2N2221A		15	—	
	2N2219A, 2N2222A		35	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N2218A, 2N2221A		40	120	
	2N2219A, 2N2222A		100	300	
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N2218A, 2N2221A		20	—	
	2N2219A, 2N2222A		50	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N2218A, 2N2221A		25	—	
	2N2219A, 2N2222A		40	—	

* Pulse Test ≤300 μsec, duty cycle ≤2%

V_{OB} - Base-Emitter Reverse Bias

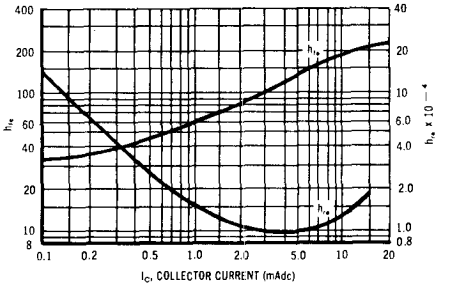
SMALL SIGNAL CHARACTERISTICS		Symbol	Min	Max	Unit
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A	h_{fe}	30	150	—
	2N2219A, 2N2222A		50	300	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A		50	300	
	2N2219A, 2N2222A		75	375	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A	h_{re}	-	5	$X10^{-4}$
	2N2219A, 2N2222A		-	8	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A		-	2.5	
	2N2219A, 2N2222A		-	4	
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A	h_{ie}	1	3.5	k ohms
	2N2219A, 2N2222A		2.0	8	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A		0.2	1.0	
	2N2219A, 2N2222A		0.25	1.25	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A	h_{oe}	3	15	μ mhos
	2N2219A, 2N2222A		5	35	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N2218A, 2N2221A		10	100	
	2N2219A, 2N2222A		25	200	
Collector-Base Time Constant (I_C = 20 mA, V_{CE} = 20 V, f = 31.8 mc)		$r'_b C_c$	-	150	psec
Noise Figure (I_C = 100 μ A, V_{CE} = 10 V, Rg = 1 kΩ, f = 1 kc)	2N2219A, 2N2222A	NF	-	4	db

2N2218A, 2N2219A, 2N2221A, 2N2222A (continued)

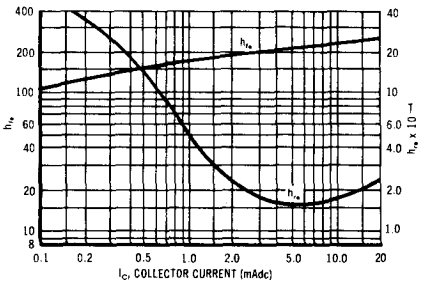
SMALL SIGNAL FORWARD CURRENT GAIN AND VOLTAGE FEEDBACK RATIO versus COLLECTOR CURRENT

$V_{CE} = 10$ V @ 1 Kc

2N2218A, 2N2221A



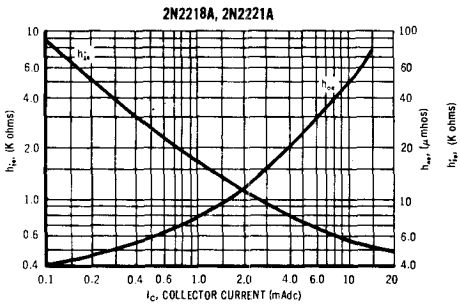
2N2219A, 2N2222A



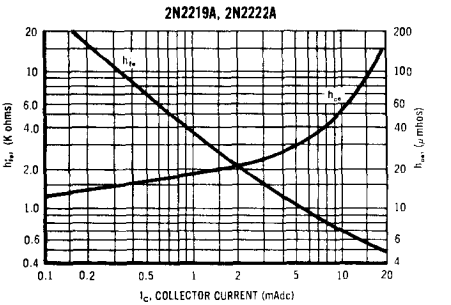
SMALL SIGNAL INPUT IMPEDANCE AND OUTPUT CONDUCTANCE versus COLLECTOR CURRENT

$V_{CE} = 10$ V @ 1 Kc

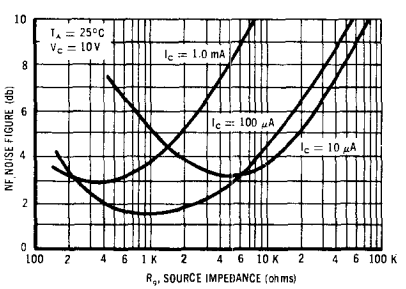
2N2218A, 2N2221A



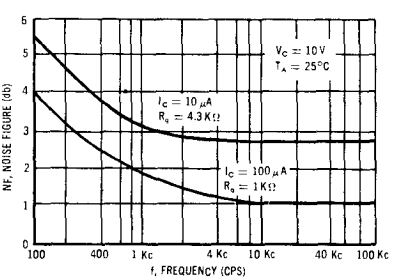
2N2219A, 2N2222A



1 KC NOISE FIGURE versus SOURCE IMPEDANCE

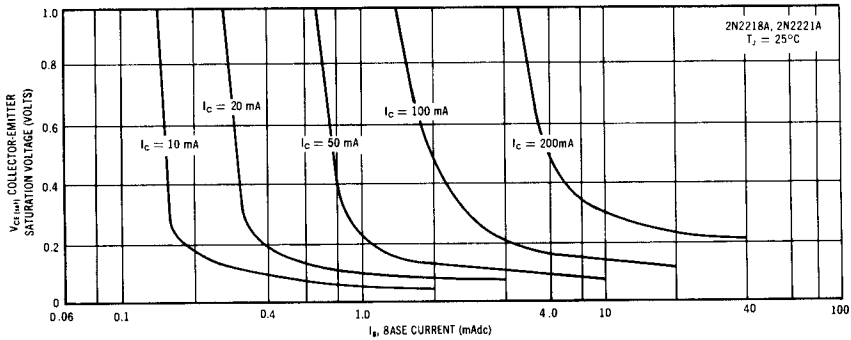


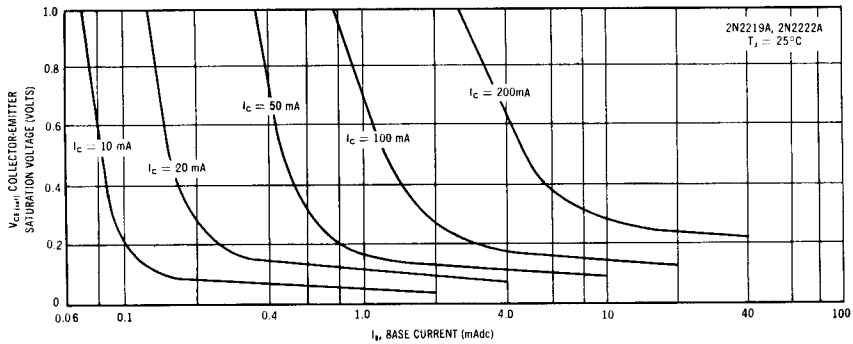
NOISE FIGURE versus FREQUENCY



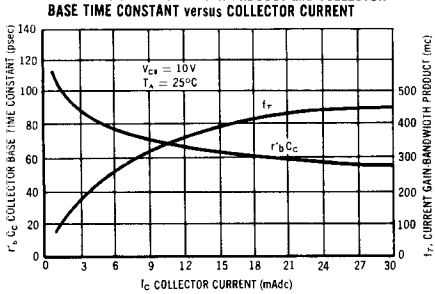
2N2218A, 2N2219A, 2N2221A, 2N2222A (continued)

COLLECTOR SATURATION VOLTAGE versus BASE CURRENT

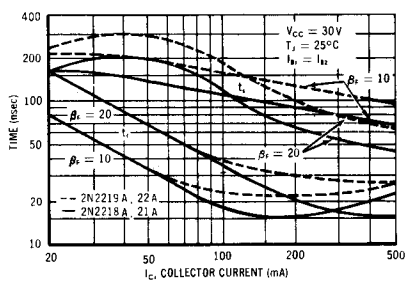




CURRENT GAIN — BANDWIDTH PRODUCT and COLLECTOR BASE TIME CONSTANT versus COLLECTOR CURRENT



STORAGE AND FALL TIME versus COLLECTOR CURRENT



2N2256, 2N2257 (SILICON)
2N2258 (GERMANIUM)
2N2225 (GERMANIUM)

$V_{CES} = 7$ V
$I_C = 100$ mA
$f_T = 320$ MHz



CASE 22
(TO-18)

Collector connected to case

NPN silicon and PNP germanium mesa complementary transistors for high-speed non-saturated switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N2256 2N2257	2N2258 2N2259	Unit
Collector-Emitter Voltage	V_{CEO}	7	7	Vdc
Collector-Base Voltage	V_{CB}	7	7	Vdc
Emitter-Base Voltage	V_{EB}	1	1	Vdc
Collector Current-Continuous	I_C	100	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 2	150 2	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1000 6.67	300 4	mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	-65 to +100	^oC

TRANSISTOR SELECTION CHART

TYPE	TYPE		h_{FE} @ I_C = 25 mA	
	NPN	PNP	20	40
2N2256	X		X	
2N2257	X			X
2N2258		X	X	
2N2259		X		X

2N2256 thru 2N2259 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	7	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	7	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1	-	-	Vdc
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	3	10	μAdc
(V_{CB} = 6 Vdc, I_E = 0, T_A = 65°C)			-	30	100	
ON CHARACTERISTICS						
DC Current Gain		h_{FE}				-
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2258		17	30	-	
	2N2257, 2N2259		40	50	-	
(I_C = 25 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2258		20	35	-	
	2N2257, 2N2258		40	55	-	
Base-Emitter On Voltage		$V_{BE(on)}$				Vdc
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257		-	0.70	0.8	
	2N2258, 2N2259		-	0.35	0.5	
(I_C = 25 mAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257		-	0.8	0.9	
	2N2258, 2N2259		-	0.45	0.6	
Conduction Threshold Base-Emitter Voltage*		V_T				Vdc
(I_C = 200 μAdc, V_{CE} = 1 Vdc)	2N2256, 2N2257		0.5	-	-	
	2N2258, 2N2259		0.1	-	-	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 10 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	2N2258, 2N2259		250	320	-	
(I_C = 10 mAdc, V_{CE} = 15 Vdc, f = 100 MHz)	2N2256, 2N2257		250	320	-	
Output Capacitance		C_{ob}				pF
(V_{CB} = 5 Vdc, I_E = 0, f = 4 MHz)	2N2256, 2N2257		-	4	5	
	2N2258, 2N2259		-	4	8	
Base Resistance		r'_b				Ohms
(I_E = 5 mAdc, V_{CB} = 2 Vdc, f = 300 MHz)						
	2N2256, 2N2257		-	50	100	
	2N2258, 2N2259		-	75	125	
Turn-On Time		t_{on}				ns
	2N2256, 2N2257 See Fig. 1		-	3	7	
	2N2258, 2N2259 See Fig. 2		-	4	8	
Turn-Off Time		t_{off}				ns
	2N2256, 2N2257 See Fig. 1		-	4	7	
	2N2258, 2N2259 See Fig. 2		-	3	7	

*Base-to-emitter forward bias voltage at which transistor will be at the threshold of conduction; i. e. that base-to-emitter voltage at which the collector current is less than or equal to the specified amount under a given collector-to-emitter voltage condition.

2N2256 thru 2N2259 (continued)

FIGURE 1 — NPN SWITCHING TIME TEST CIRCUIT

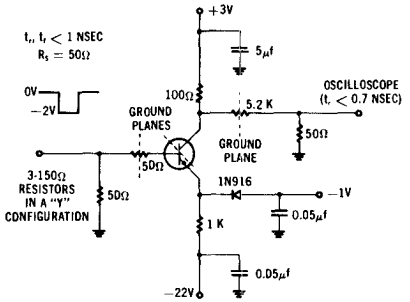


FIGURE 2 — PNP SWITCHING TIME TEST CIRCUIT

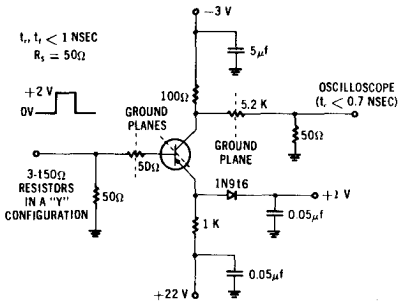


FIGURE 3 — CASCADE COMPLEMENTARY GATE

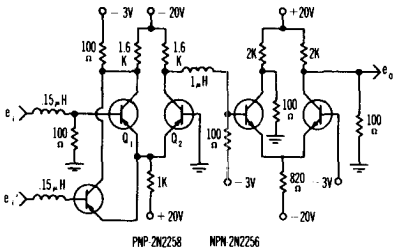


FIGURE 4 —CURRENT MODE INVERTER FOR USE WITH DIODE LOGIC PROPAGATION DELAY TIME 10 ns

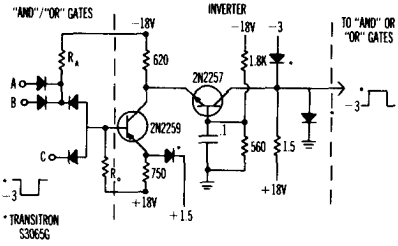


FIGURE 5 — CURRENT GAIN CHARACTERISTICS

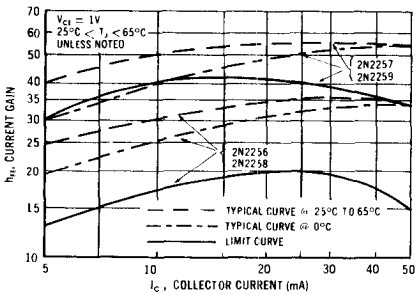
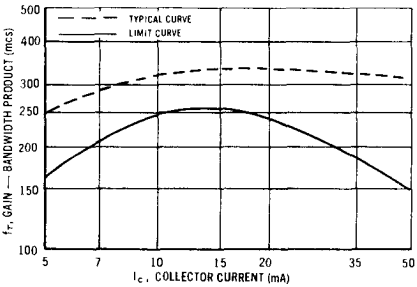


FIGURE 6 — GAIN-BANDWITH PRODUCT CHARACTERISTICS



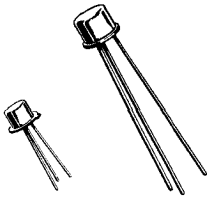
2N2303 (SILICON)

For Specifications, See 2N722 Data Sheet

2N2330 (SILICON)
2N2331



$V_{CBO} = 30$ V
$V_{EC(sat)} = 3$ mV



CASE 22 (TO-18)

CASE 31 (TO-5)

Collector connected to case

NPN silicon annular Star transistors for low-level DC/AC chopper applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N2330 (TO-5)	2N2331 (TO-18)	Unit
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Collector-Base Voltage	V_{CB}	30	30	Vdc
Emitter-Base Voltage	V_{EB}	5	5	Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	0.8	0.5	Watt
Derate above 25^oC		5.33	3.33	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	3	1.8	Watts
Derate above 25^oC		20	12	$mW/^oC$
Operating Junction Temperature Range	T_J	-65 to +175		^oC
Storage Temperature Range	T_{stg}	-65 to +200		^oC

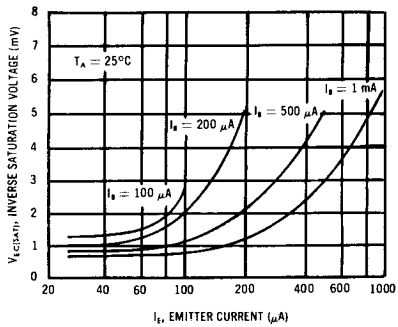
2N2330, 2N2331 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

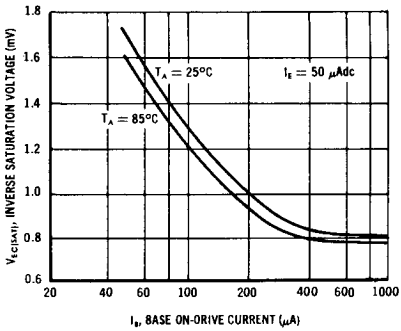
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 4.5 Vdc, I_E = 0)	I_{CBO}	-	1.0	nAdc
Emitter Cutoff Current (V_{BE} = 4.5 Vdc)	I_{EBO}	-	5.0	nAdc
Offset Current (V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 25°C)	$I_{(off)}$	-	1	nAdc
(V_{BC} = 2 Vdc, V_{CE} = 0, T_A = 85°C)		-	10	
ON CHARACTERISTICS				
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	h_{FE}	50	-	-
Offset Voltage (I_B = 200 μAdc, I_E = 0)	$V_{(off)}$	-	0.75	mVdc
Inverse Saturation Voltage (I_B = 200 μAdc, I_E = 50 μAdc)	$V_{EC(sat)}$	-	3.0	mVdc
DYNAMIC CHARACTERISTICS				
Current-Gain — Bandwidth Product (I_C = 1 mAdc, V_{CE} = 1 Vdc, f = 100 MHz)	f_T	100	-	MHz
Output Capacitance (V_{CB} = 2 Vdc, I_E = 0)	C_{ob}	-	10	pF
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0)	C_{ib}	-	20	pF

2N2330, 2N2331 (continued)

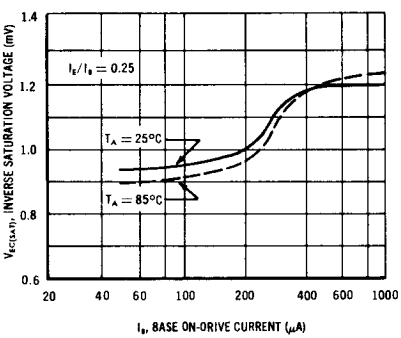
INVERSE SATURATION VOLTAGE versus EMITTER CURRENT



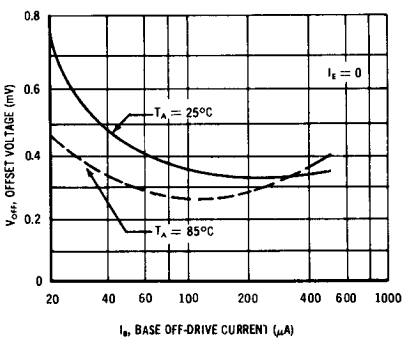
INVERSE SATURATION VOLTAGE versus BASE CURRENT



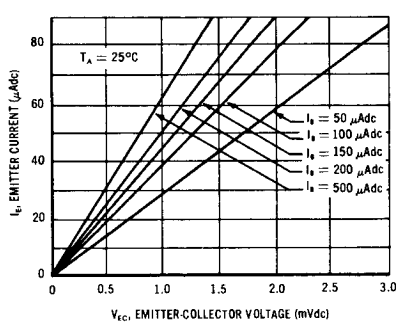
INVERSE SATURATION VOLTAGE versus BASE CURRENT



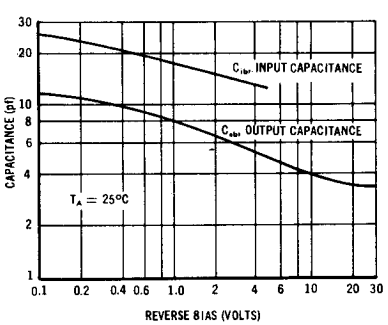
OFFSET VOLTAGE versus BASE CURRENT



INVERSE SATURATION CHARACTERISTICS

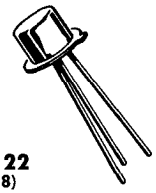


OUTPUT CAPACITANCE versus COLLECTOR-BASE VOLTAGE and INPUT CAPACITANCE versus EMITTER-BASE VOLTAGE



2N2368 (SILICON)

$V_{CEO} = 15$ Vdc
$f_T = 400$ Mc
$t_{on} + t_{off} = 27$ ns



CASE 22
(TO-18)

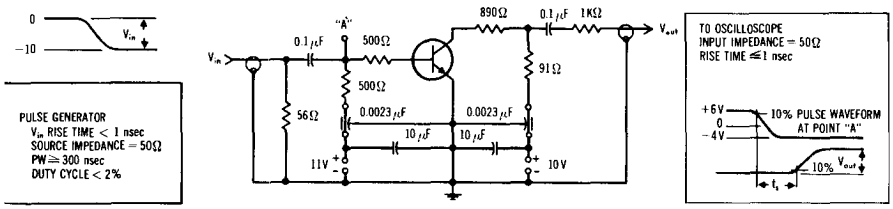
NPN silicon Annular transistor designed for high-speed, low-level, saturated-switching application.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Base Voltage	V_{CB}	40	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Total Device Dissipation@ $T_A = 25^oC$	P_D	0.36	Watt
Derate above 25^oC		2.06	$mW/^oC$
Total Device Dissipation@ $T_C = 25^oC$	P_D	1.2	Watt
Derate above 25^oC		6.85	$mW/^oC$
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200	^oC

FIGURE 1 — STORAGE TIME TEST CIRCUIT



2N2368 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 μAdc, V_{BE} = 0)	BV_{CES}	40	—	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.4 30	μAdc
ON CHARACTERISTICS				
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C) (I_C = 100 mAdc, V_{CE} = 2.0 Vdc)	h_{FE}*	20 10 10	60 — —	—
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{CE(sat)}$	—	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc)	$V_{BE(sat)}$	0.7	0.85	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	f_T	400	—	mc
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 140 kc)	C_{ob}	—	4	pF
Storage Time (Figure 1) (I_C = I_{B1} = 10 mAdc, I_{B2} = -10 mAdc)	t_s	—	10	nsec
Turn-On Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{on}	—	12	nsec
Turn-Off Time (Figure 2) (I_C = 10 mAdc, I_{B1} = 3.0 mAdc, I_{B2} = -1.5 mAdc)	t_{off}	—	15	nsec

*Pulse Test: Pulse Width = 300 μsec; Duty Cycle ≤ 2%

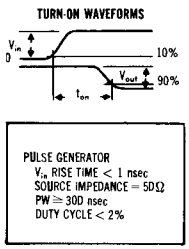
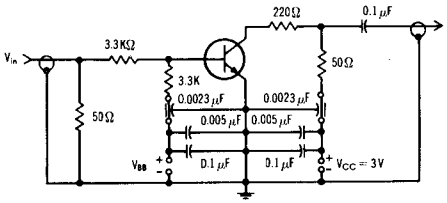
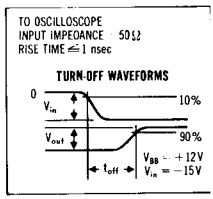


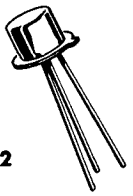
FIGURE 2 — TURN-ON AND TURN-OFF TIME TEST CIRCUIT





2N2369 (SILICON)
2N3227

V_{CEO} = 15-20 V
f_T = 600 Mc Typ



CASE 22
(TO-18)

NPN silicon annular transistors for low-current, high-speed switching applications.

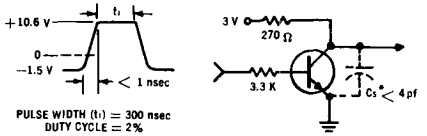
Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage 2N2369 2N3227	V_{CEO}	15 20	Vdc
Emitter-Base Voltage 2N2369 2N3227	V_{EBO}	4.5 6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	 0.36 2.06	 Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	 1.2 6.85	 Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

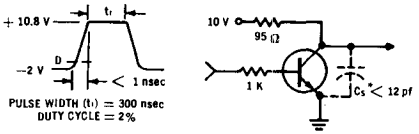
SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 1 – t_{on} CIRCUIT – 10 mA



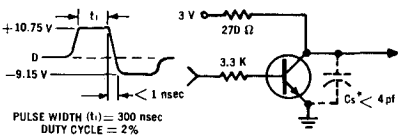
PULSE WIDTH (t_1) = 300 nsec
DUTY CYCLE = 2%

FIGURE 2 – t_{on} CIRCUIT – 100 mA



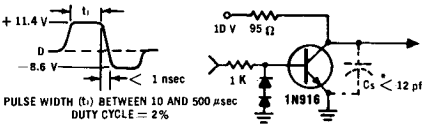
PULSE WIDTH (t_1) = 300 nsec
DUTY CYCLE = 2%

FIGURE 3 – t_{off} CIRCUIT – 10 mA



PULSE WIDTH (t_1) = 300 nsec
DUTY CYCLE = 2%

FIGURE 4 – t_{off} CIRCUIT – 100 mA



PULSE WIDTH (t_1) BETWEEN 10 AND 500 μsec
DUTY CYCLE = 2%

*Total shunt capacitance of test jig and connectors.

2N2369, 2N3227 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 20 Vdc)	2N2369		I_{CBO}	—	0.4	μAdc
	2N3227			—	0.2	
(V_{CB} = 20 Vdc, T_A = 150°C)	2N2369			—	30	
	2N3227			—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{OB} = 3 Vdc)	2N3227		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{OB} = 3 Vdc)	2N3227		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μ Adc, I_C = 0)	2N2369		BV_{EBO}	4.5	—	Vdc
	2N3227			6.0	—	
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc)	2N2369		BV_{CEO}*	15	—	Vdc
	2N3227			20	—	
Collector-Emitter Voltage (I_C = 10μ Adc, I_B = 0)			BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	11,13	$V_{CE(sat)}$*	—	0.25	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			—	0.45	
Base-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc)	Both Types	13	$V_{BE(sat)}$*	0.70	0.85	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)	2N3227			0.8	1.4	
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N2369		h_{FE}*	40	120	—
	2N3227	12		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N2369			20	—	
	2N3227	12		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3227	12		30	—	
(I_C = 100 mAdc, V_{CE} = 2 Vdc)	2N2369			20	—	
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)			h_{fe}	5	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kc)		5	C_{ob}	—	4	pf
Input Capacitance (V_{OB} = 1 Vdc, I_C = 0, f = 140 kc)	2N3227		C_{ib}		4	pf
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		10	$t_s(\tau_s)$	—	13	nsec
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, V_{OB} = 1.5 V)		1,6	t_{on}	—	12	nsec
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		3,6	t_{off}	—	18	nsec
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)	2N3227	7,8	Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{OB} = 2 V, I_C = 100 mA, I_{B1} = 10 mA	2,6	t_d	—	5	nsec
Rise Time	2N3227		t_r	—	18	nsec
Storage Time	V_{CC} = 10 V I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	4,6	t_s	—	13	nsec
Fall Time	2N3227		t_f	—	15	nsec

*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2%

2N2369, 2N3227 (continued)

FIGURE 5 — JUNCTION CAPACITANCE VARIATIONS

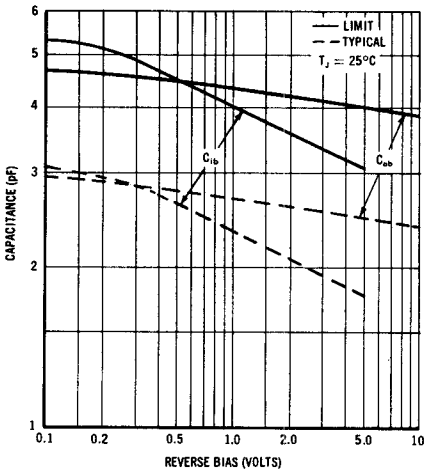


FIGURE 6 — TYPICAL SWITCHING TIMES

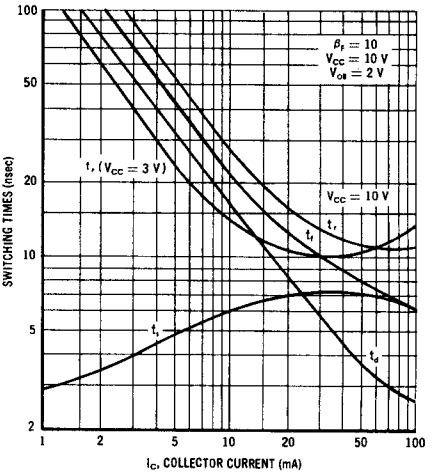


FIGURE 7 — MAXIMUM CHARGE DATA

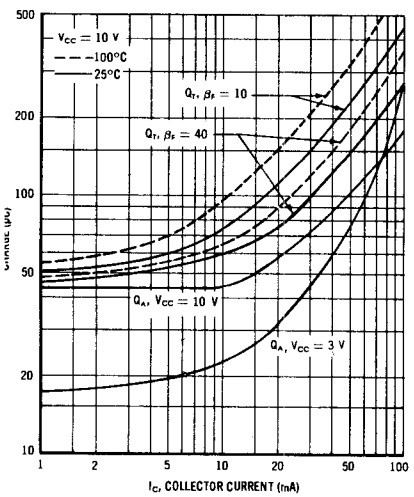


FIGURE 8 — Q_T TEST CIRCUIT

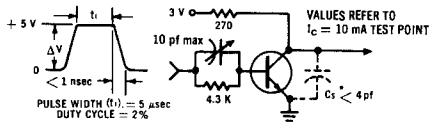


FIGURE 9 — TURN-OFF WAVE FORM

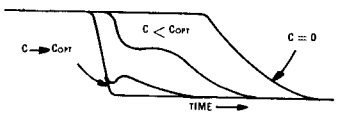
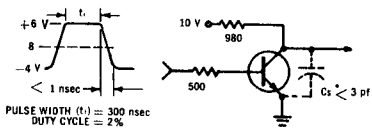


FIGURE 10 — STORAGE TIME EQUIVALENT TEST CIRCUIT



*Total shunt capacitance of test jig and connectors.

2N2369, 2N3227 (continued)

FIGURE 11 – MAXIMUM COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

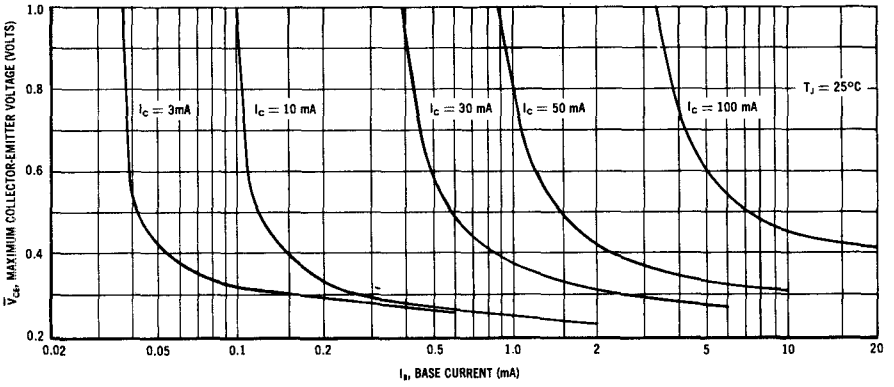


FIGURE 12 – MINIMUM CURRENT GAIN CHARACTERISTICS

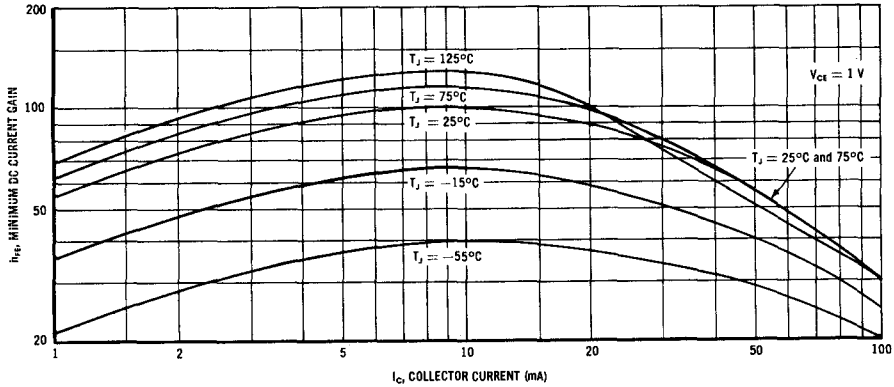


FIGURE 13 – SATURATION VOLTAGE LIMITS

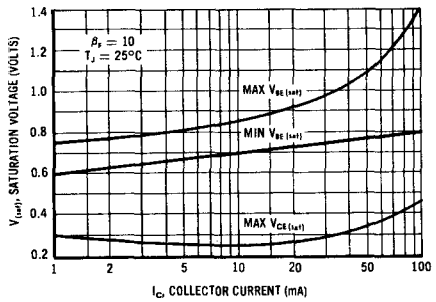
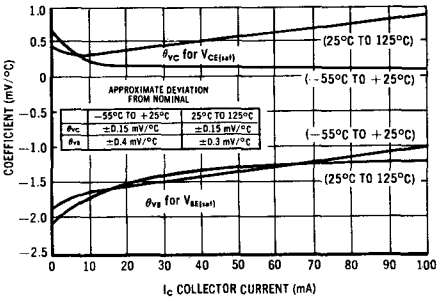


FIGURE 14 – TYPICAL TEMPERATURE COEFFICIENTS



2N2381 (GERMANIUM)
2N2382

V_{CEO} = 15-20 V
I_C = 500 mA
f_T = 300 MHz min



PNP germanium epitaxial mesa transistors for high-speed, high-current switching applications.

Collector connected to case

CASE 31
(TO-5)

MAXIMUM RATINGS

Characteristic	Symbol	2N2381	2N2382	Unit
Collector-Emitter Voltage	V_{CEO}	15	20	Vdc
Collector-Base Voltage	V_{CB}	30	45	Vdc
Emitter-Base Voltage	V_{EB}	4	4	Vdc
Collector Current-Continuous	I_C	500		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 4		mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 10		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		°C

FIGURE 1 — ACTIVE REGION TIME CONSTANT

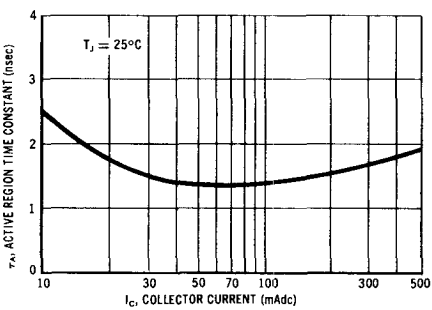
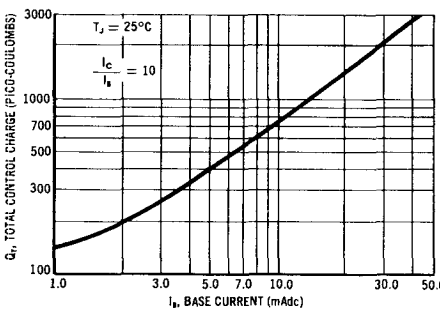


FIGURE 2 — TOTAL CONTROL CHARGE



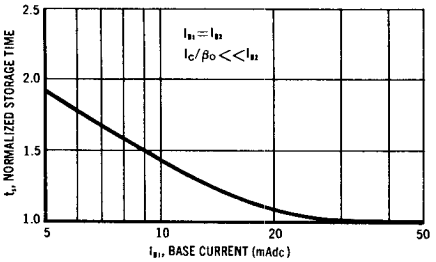
2N2381, 2N2382 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_E = 0) 2N2381		BV_{CEO}	15	-	-	Vdc
2N2382			20	-	-	
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0) 2N2381		BV_{CBO}	30	-	-	Vdc
2N2382			45	-	-	
Latch-Up Voltage 2N2381	7	LV_{CEX}	20	-	-	Vdc
2N2382			25	-	-	
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = 0) 2N2381		I_{CES}	-	-	100	μAdc
(V_{CE} = 45 Vdc, V_{BE} = 0) 2N2382			-	-	100	
Collector Cutoff Current (V_{CB} = 5 Vdc, I_E = 0)		I_{CBO}	-	1.0	7	μAdc
(V_{CB} = 5 Vdc, I_E = 0, T_A = 85°C)			-	-	100	
(V_{CB} = 20 Vdc, I_E = 0) 2N2381			-	-	25	
2N2382			-	-	15	
Emitter Cutoff Current (V_{BE} = 0.5 Vdc, I_C = 0)		I_{EBO}	-	-	0.005	mAdc
(V_{BE} = 4 Vdc, I_C = 0)			-	-	1	
ON CHARACTERISTICS						
DC Current Gain (I_C = 200 mAdc, V_{CE} = 0.5 Vdc)	11	h_{FE}	40	-	-	-
(I_C = 400 mAdc, V_{CE} = 1.0 Vdc)			25	-	-	
Collector-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	8,10	$V_{CE(sat)}$	-	0.25	0.4	Vdc
(I_C = 400 mAdc, I_B = 40 mAdc)			-	0.4	0.7	
Base-Emitter Saturation Voltage (I_C = 200 mAdc, I_B = 20 mAdc)	9,10	$V_{BE(sat)}$	0.45	0.54	0.7	Vdc
(I_C = 400 mAdc, I_B = 40 mAdc)			-	0.71	0.9	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)		f_T	300	-	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 4 MHz)	13	C_{ob}	-	3.5	6	pF
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 4 MHz)	13	C_{ib}	-	8	15	pF
Delay Time	4	t_d	-	4.5	7	ns
Rise Time	4	t_r	-	8	15	ns
Storage Time	3,4	t_s	-	20	30	ns
Fall Time	4	t_f	-	8	15	ns
Active Region Time Constant	1,4	τ_A	-	1.6	3.0	ns

2N2381, 2N2382 (Continued)

FIGURE 3 — STORAGE TIME VARIATIONS



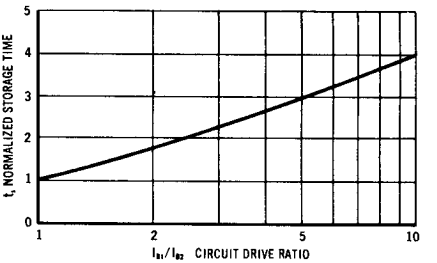


FIGURE 4 — SWITCHING TIME EQUATIONS & TEST CIRCUIT

Rise Time $= t_r = \tau_A \beta_f R$ = 10 to 90% Rise Time (fig. 5)
Fall Time $= t_f = \tau_A \beta_C F$ = 10 to 90% Fall Time (fig. 6)
$\beta_O = h_{FE}$ at Edge of Saturation
$\beta_C = I_C$ in Saturation / I_{B2} (Base "OFF" Current)
$\beta_f = I_C$ in Saturation / I_{B1} (Base "ON" Current)

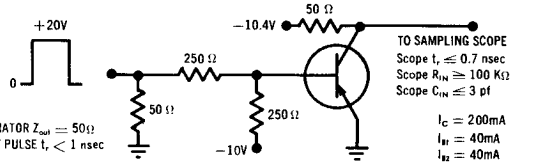


FIGURE 5 — RISE TIME FACTOR

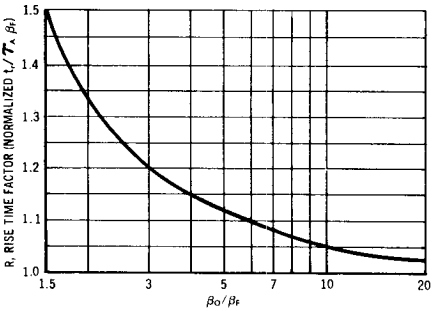


FIGURE 6 — FALL TIME FACTOR

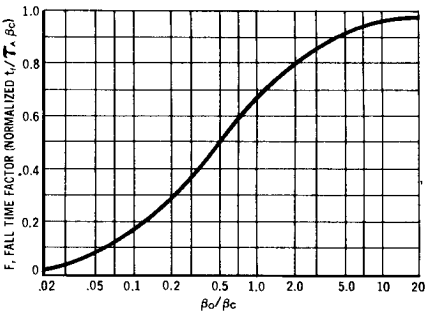
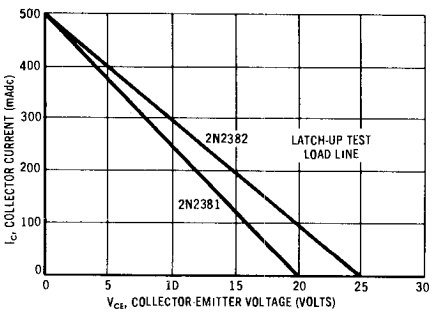
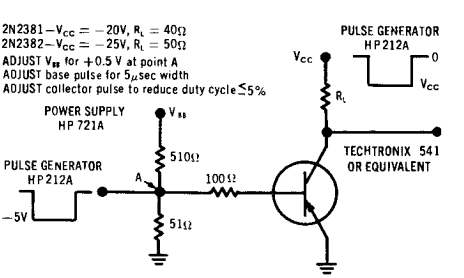


FIGURE 7 — COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT





2N2381, 2N2382 (Continued)

FIGURE 8 — COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT

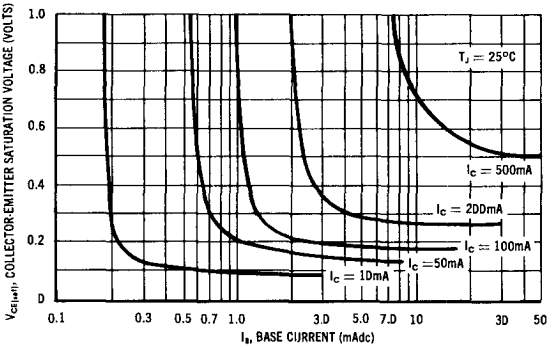


FIGURE 9 — BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

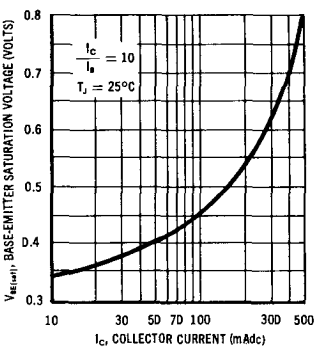


FIGURE 10 — TEMPERATURE COEFFICIENTS

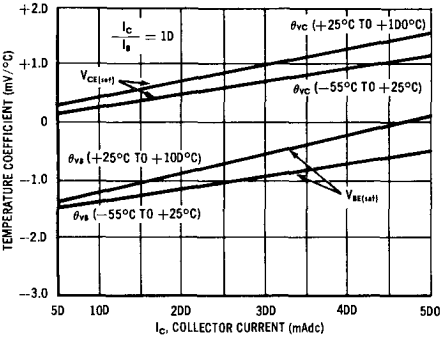


FIGURE 11 — NORMALIZED GAIN CHARACTERISTICS

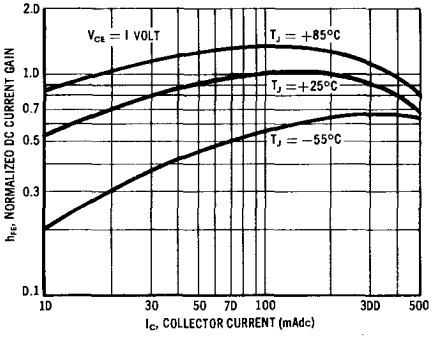


FIGURE 12 — LEAKAGE CHARACTERISTICS COMMON EMITTER

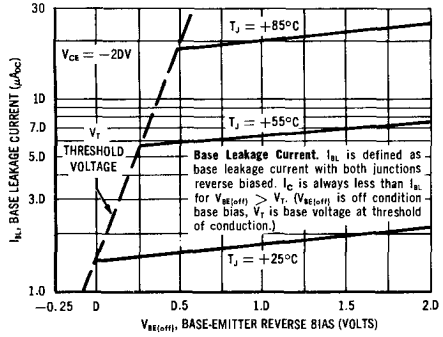
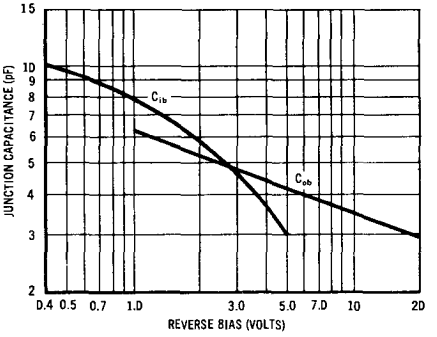


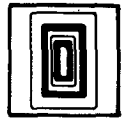
FIGURE 13 — JUNCTION CAPACITANCE versus REVERSE VOLTAGE



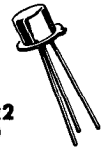
2N2405 (SILICON)

For Specifications, See 2N1131 Data Sheet

2N2481 (SILICON)
2N2481 USN/JAN
2N2481 HI-REL



$V_{CEO} = 15$ V
$f_T = 450$ Mc Typ



CASE 22
(TO-18)

NPN silicon annular transistor for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watt
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts
Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to + 200	°C

2N2481 (Continued)

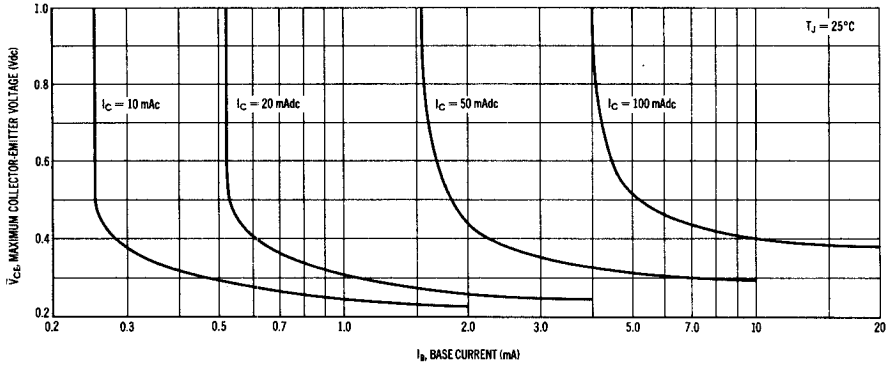
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}	15	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 μAdc, V_{BE} = 0)	BV_{CES}	30	---	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc) (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc, T_A = 150°C)	I_{CEX}	--- ---	.050 15	μAdc
Base Leakage Current (V_{CE} = 20 Vdc, V_{BE} = 3 Vdc)	I_{BL}	---	50	nAdc
Emitter Cutoff Current (V_{EB} = 4.0 Vdc, I_C = 0)	I_{EBO}	---	100	nAdc
DC Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc) (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)* (I_C = 150 mAdc, V_{CE} = I.0 Vdc)*	h_{FE}	25 40 20 20	--- 120 --- ---	---
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)*	V_{CE} (sat)	--- ---	0.25 0.40	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1.0 mAdc) (I_C = I00 mAdc, I_B = 10 mAdc)*	V_{BE} (sat)	0.7 ---	0.82 1.25	Vdc
Output Capacitance (V_{CB} = 5 V, I_C = 0, f = 1 Mc)	C_{ob}	---	5	pf
Input Capacitance (V_{EB} = 0.5 V, f = 1 Mc)	C_{ib}	---	7	pf
Small-Signal Forward Current Transfer Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 100 Mc)	h_{fe}	3	---	---
Small-Signal, Short-Circuit, Input Impedance (Real part) (I_C = 10 mA, V_{CE} = 10 V, f = 250 Mc)	h_{ie} (real)	---	60	ohms
Turn-On Time (I_C = 100 mA, I_{B1} = 10 mA, $V_{BE(off)}$ = -2 V) (I_C = 10 mA, I_{B1} = 1.0 mA, $V_{BE(off)}$ = -2 V)	t_{on}	--- ---	40 75	nsec
Turn-Off Time (I_C = 100 mA, I_{B1} = 10 mA, I_{B2} = -5 mA) (I_C = 10 mA, I_{B1} = 1.0 mA, I_{B2} = -0.5 mA)	t_{off}	--- ---	55 45	nsec
Storage Time (I_C = 10 mA, I_{B1} = 10 mA, I_{B2} = -10 mA)	t_s	---	20	nsec

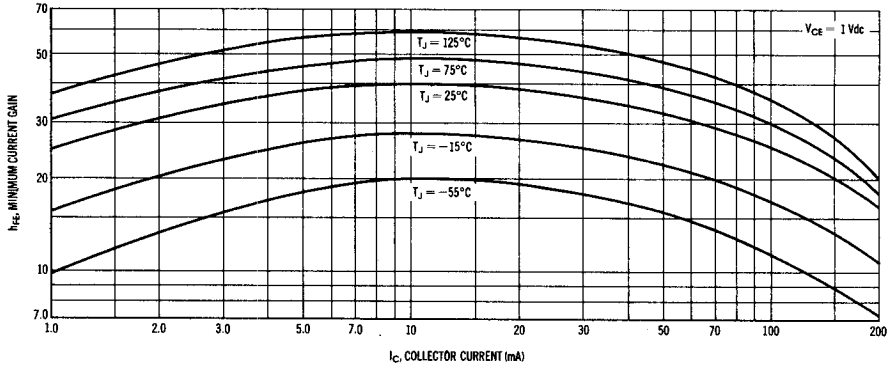
*Pulse width ≤ 300 μsec, Duty Cycle ≤ 2%

2N2481 (Continued)

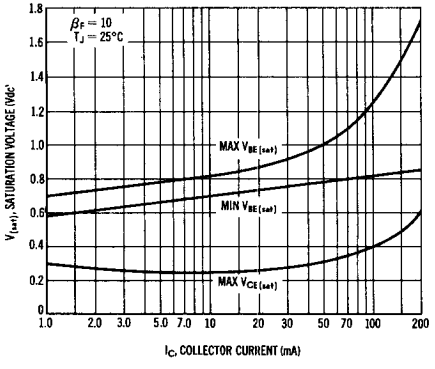
COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



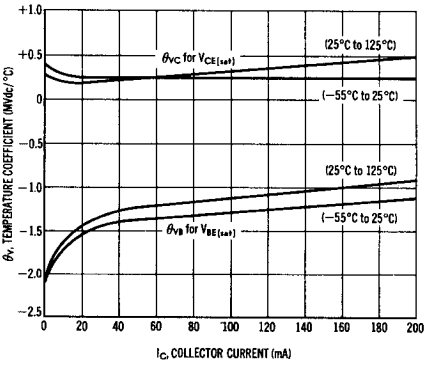
MINIMUM CURRENT GAIN CHARACTERISTICS



LIMITS OF SATURATION VOLTAGES



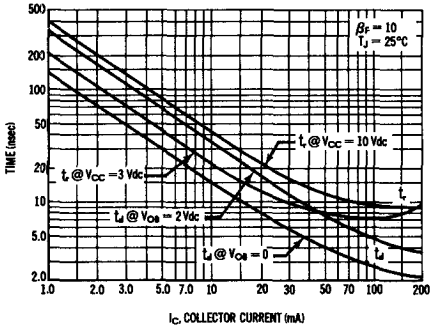
TYPICAL TEMPERATURE COEFFICIENTS



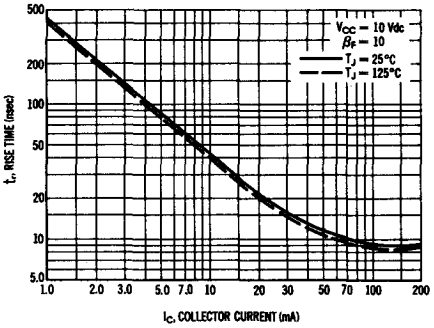
2N2481 (Continued)

TYPICAL SWITCHING CHARACTERISTICS

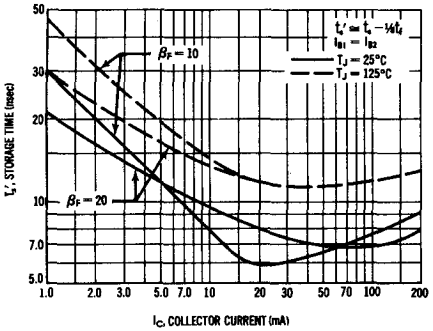
TURN-ON TIME VARIATIONS WITH VOLTAGE



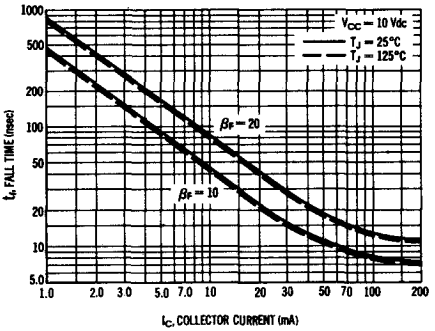
RISE TIME BEHAVIOR



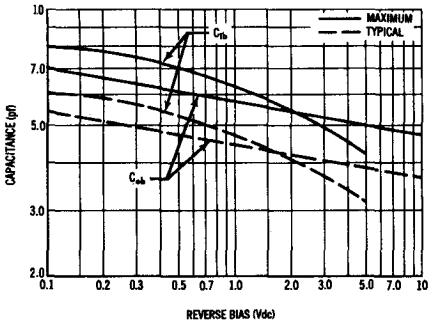
STORAGE TIME BEHAVIOR



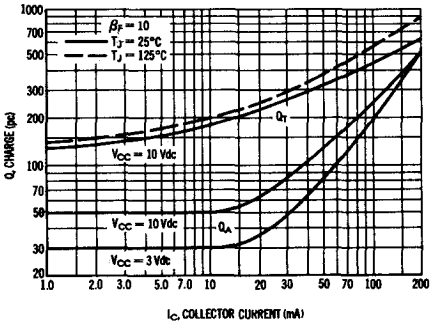
FALL TIME BEHAVIOR



JUNCTION CAPACITANCE VARIATIONS



MAXIMUM CHARGE DATA



2N2501 (SILICON)

$V_{CEO} = 20$ V
$f_T = 450$ Mc Typ



CASE 22
(TO-18)

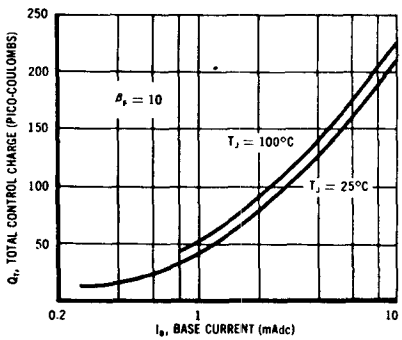
Collector connected to case

NPN silicon annular transistor for high-speed switching applications.

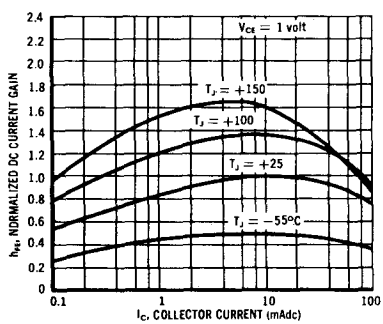
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Total Device Dissipation @ 25°C Ambient Temperature (Derate 2.06 mW/°C above 25°C)	P_D	0.36	Watts
Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 6.9 mW/°C above 25°C)	P_D	1.2	Watts

TOTAL CONTROL CHARGE



NORMALIZED CURRENT GAIN CHARACTERISTICS



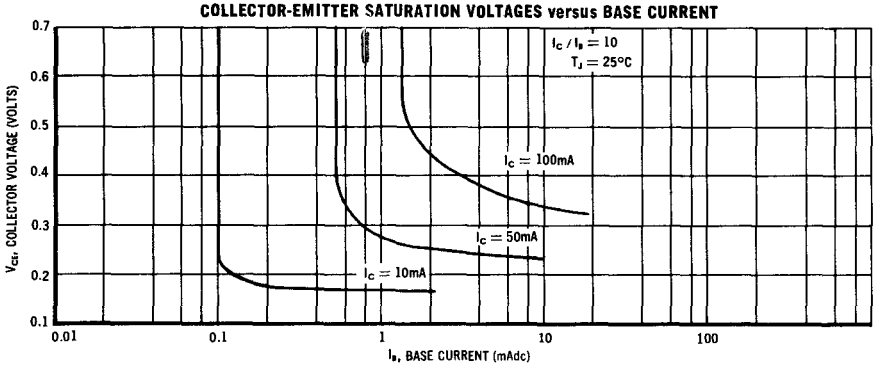
2N2501 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 30 mAdc, I_B = 0, Pulsed)	BV_{CEO}	20	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6	–	Vdc
Collector Leakage Current (V_{CE} = 20 Vdc, V_{BE} = -3 Vdc)	I_{CEX}	–	25	nAdc
Base Leakage Current (V_{CE} = 20 Vdc, V_{BE} = -3 Vdc) (V_{CE} = 20 Vdc, V_{BE} = -3 Vdc, T_A = 150°C)	I_{BL}	– –	25 50	nAdc μAdc
DC Forward Current Transfer Ratio* (I_C = 100 μAdc, V_{CE} = 1 Vdc) (I_C = 1 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 5 Vdc)	h_{FE}	 20 30 50 20 40 30 10	 – – 150 – – – –	–
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$	 – – –	 0.2 0.3 0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{BE(sat)}$	 – – –	 0.85 1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	–	4	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)	C_{ib}	–	7	pf
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 100 mc)	h_{fe}	3.5	–	–
Current-Gain-Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc)	f_T	350	–	mc
Charge Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_S	–	15	nsec
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	Q_T	–	60	pico-coulombs
Active Region Time Constant (I_C = 10 mAdc)	τ_A	–	2.5	nsec

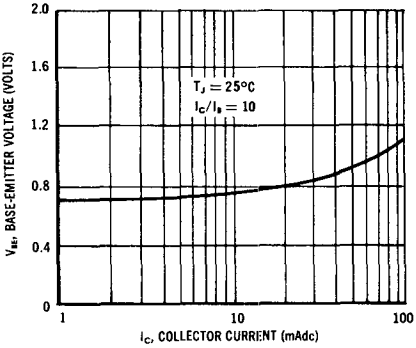
*Pulse Test: Pulse width ≤ 300 μsec, duty cycle ≤ 2%

COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT

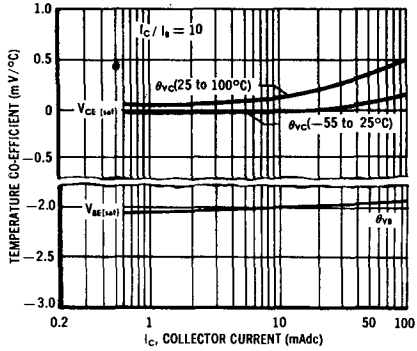


2N2501 (Continued)

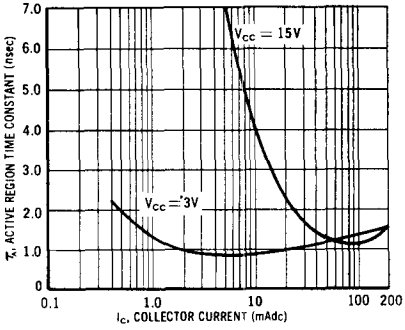
BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT



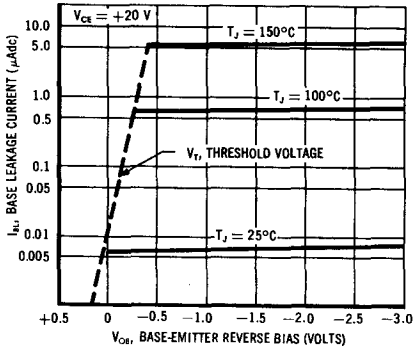
TEMPERATURE COEFFICIENTS



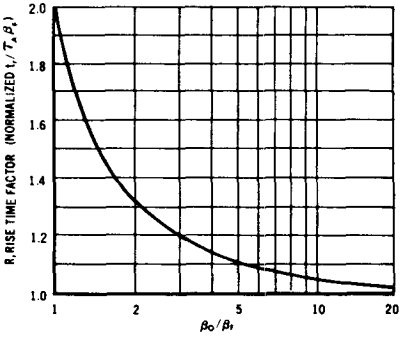
ACTIVE REGION TIME CONSTANT



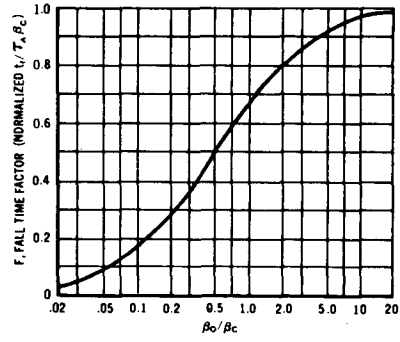
COMMON EMITTER DC LEAKAGE CHARACTERISTICS



RISE TIME FACTOR

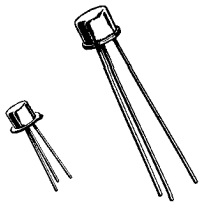


FALL TIME FACTOR



2N2537 thru 2N2540 (SILICON)

$V_{CEO} = 30$ V
$f_T = 400$ Mc Typ



NPN silicon annular Star transistors for high-speed switching.

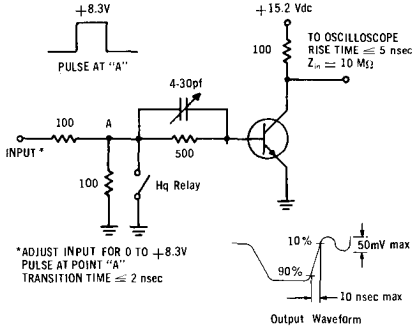
CASE 22 (TO-18)	CASE 31 (TO-5)
2N2539	2N2537
2N2540	2N2538

Collector connected to case

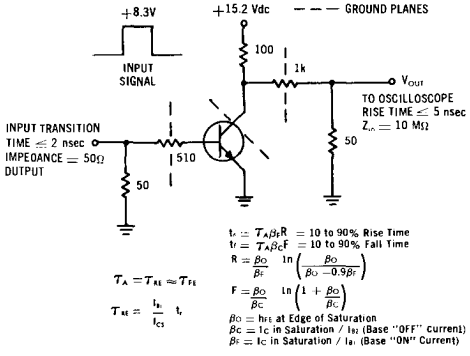
MAXIMUM RATINGS

Characteristic	Symbol	2N2537 2N2538 (TO-5)	2N2539 2N2540 (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	30	30	Vdc
Collector-Emitter Voltage	V_{CER}	40	40	Vdc
Emitter-Base Voltage	V_{EBO}	5	5	Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	 3 17.2	 1.8 10.3	Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	 0.8 4.57	 0.5 2.86	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

TOTAL CONTROL CHARGE TEST CIRCUIT



ACTIVE REGION TIME CONSTANT TEST CIRCUIT



$t_r \simeq \tau_A \beta_F R$ = 10 to 90% Rise Time
$t_f = \tau_A \beta_C F$ = 10 to 90% Fall Time

$R = \frac{\beta_O}{\beta_F} \ln\left(\frac{\beta_O}{\beta_O - 0.9\beta_F}\right)$

$F = \frac{\beta_O}{\beta_C} \ln\left(1 + \frac{\beta_O}{\beta_C}\right)$

$\tau_A = \tau_{RE} \simeq \tau_{FE}$

$\tau_{RE} \simeq \frac{I_{b_1}}{I_{cs}} t_r$

$\beta_O = h_{FE}$ at Edge of Saturation
$\beta_C = I_C$ in Saturation / I_{B_2} (Base "OFF" Current)
$\beta_F = I_C$ in Saturation / I_{B_1} (Base "ON" Current)

2N2537 thru 2N2540 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)		I_{CBO}	– –	0.250 200	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)		I_{EBO}	–	0.05	μAdc
Collector Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc)		I_{CEX}	–	0.250	μAdc
Base Cutoff Current (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc) (V_{BE} = 0.2 Vdc, V_{CE} = 20 Vdc, T_A = 150°C)		I_{BL}	– –	0.250 200	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, I_B = 0)		BV_{CEO}	30	–	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, pulsed, $R_{BE} \leq 10\ \Omega$)		BV_{CER}	40	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	–	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{CE(sat)}$	– –	0.45 1.6	Vdc
Base-Emitter Saturation Voltage (I_C = 150 mAdc, I_B = 15 mAdc)* (I_C = 500 mAdc, I_B = 50 mAdc)		$V_{BE(sat)}$	– –	1.3 2.6	Vdc
DC Forward Current Transfer Ratio		h_{FE}			–
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	2N2537, 2N2539		20	–	
	2N2538, 2N2540		35	–	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2537, 2N2539		30	–	
	2N2538, 2N2540		50	–	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N2537, 2N2539		50	150	
	2N2538, 2N2540		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N2537, 2N2539		20	–	
	2N2538, 2N2540		30	–	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	–	8	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	–	25	pf
Small Signal Forward Current Transfer Ratio (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 mc)		h_{fe}	2.5	–	–

*Pulse Test: Pulse width ≤ 300 μsec, duty cycle ≤ 2%

SWITCHING CHARACTERISTICS

Characteristic	Symbol	Max.	Unit
Total Control Charge	Q_T	750	pico-coulombs
Storage Time (I_C = I_{B1} = I_{B2} = 20 mAdc, V_{CC} = 5 V)	τ_S	20	nsec
Active Region Time Constant (See Figure 2)	τ_A	2.0	nsec
Turn-on Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{on}	40	nsec
Turn-off Time (I_{B1} = I_{B2} = 15 mAdc, I_C = 150 mAdc, V_{CC} = 7 Vdc, R_L = 40 Ω)	t_{off}	40	nsec

2N2635 (GERMANIUM)

$V_{CEO} = 15$ V
$I_C = 100$ mA
$f_T = 150$ MHz min



CASE 22
(TO-18)

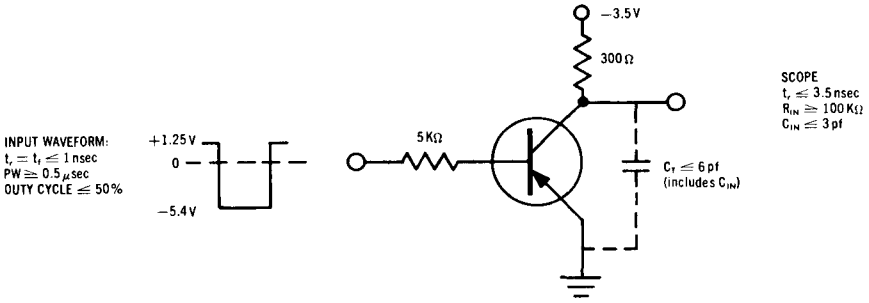
Collector connected to case

PNP germanium epitaxial mesa transistor for high-speed switching applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	30	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	2.5	Vdc
Collector Current (Continuous)	I_C	100	mAdc
Junction Temperature	T_J	+100	^oC
Storage Temperature	T_{stg}	-65 to + 100	^oC
Device Dissipation @ 25°C Ambient Temperature (Derate 2mW/°C above 25°C)	P_D	150	mW

SWITCHING TIME TEST CIRCUIT

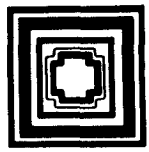


2N2635 (Continued)

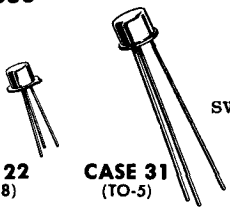
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μ Adc, I_E = 0)	BV_{CBO}	30	50	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	BV_{CEO}	15	30	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μ Adc, I_C = 0)	BV_{EBO}	2.5	4.5	---	Vdc
Collector-Base Cutoff Current (V_{CB} = 25V, I_E = 0) (V_{CB} = 25V, I_E = 0, T_A = +55°C)	I_{CBO}	--- ---	1 5	5 20	μ Adc
Emitter-Base Cutoff Current (V_{EB} = 1V, I_C = 0)	I_{EBO}	---	2	20	μ Adc
Static Forward Current Transfer Ratio (I_C = 10 mA, V_{CE} = 0.5V) (I_C = 50 mA, V_{CE} = 1V) (I_C = 50 mA, V_{CE} = 1V, T_A = -55°C) (I_C = 100 mA, V_{CE} = 1V)	h_{FE}	30 45 25 30	--- --- --- ---	--- 300 --- ---	---
Base-Emitter Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 2.5 mA) (I_C = 50 mA, I_B = 2.5 mA, T_A = -55°C) (I_C = 100 mA, I_B = 10 mA)	V_{BE}	--- --- --- ---	0.36 0.47 0.56 0.57	0.45 0.70 0.85 0.90	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 mA, I_B = 0.5 mA) (I_C = 50 mA, I_B = 2.5 mA) (I_C = 50 mA, I_B = 2.5 mA, T_A = +55°C) (I_C = 100 mA, I_B = 10 mA)	$V_{CE(sat)}$	--- --- --- ---	0.13 0.20 0.22 0.23	0.20 0.40 0.45 0.75	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 30 mA, V_{CE} = 2V, f = 100 mc)	$\lvert h_{fe} \rvert$	1.5	---	---	---
Collector Output Capacitance (V_{CB} = 5 V, I_E = 0, f = 1 mc)	C_{ob}	---	2.5	5	pf
Input Capacitance (V_{EB} = 1V, I_C = 0, f = 1 mc)	C_{ib}	---	---	4	pf
Delay Time	t_d	---	15	20	nsec
Rise Time	t_r	---	20	30	nsec
Storage Time	t_s	---	100	185	nsec
Fall Time	t_f	---	35	65	nsec

2N2800 (SILICON)
2N2801
2N2837
2N2838



$V_{CEO} = 35$ V
$I_C = 800$ mA
$f_T = 120$ Mc



PNP silicon annular transistors for medium-speed switching applications.

CASE 22 (TO-18) — 2N2837, 2N2838

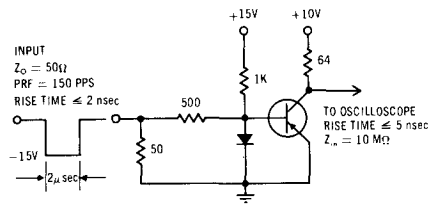
CASE 31 (TO-5) — 2N2800, 2N2801

Collector connected to case

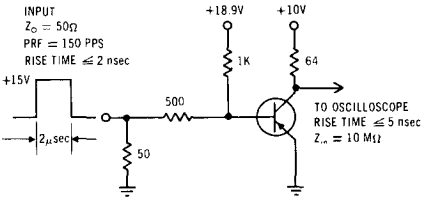
MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	800	mA
Total Device Dissipation @ 25°C Ambient Temperature	P_D		
2N2800, 2N2801 — TO-5		0.8	Watt
Derating Factor Above 25°C		4.57	mW/°C
2N2837, 2N2838 — TO-18		0.5	Watt
Derating Factor Above 25°C		2.86	mW/°C
Total Device Dissipation @ 25°C Case Temperature	P_D		
2N2800, 2N2801 — TO-5		3	Watts
Derating Factor Above 25°C		17.3	mW/°C
2N2837, 2N2838 — TO-18		1.8	Watts
Derating Factor Above 25°C		10.3	mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

DELAY AND RISE TIME TEST CIRCUIT



STORAGE AND FALL TIME TEST CIRCUIT



2N2800, 2N2801, 2N2837, 2N2838 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 mAdc, I_B = 0)	BV_{CEO}	35	-	Vdc
Collector Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{CEX}	-	100	nAdc
Base Cutoff Current (V_{CE} = 25 Vdc, V_{BE} = 0.5 Vdc)	I_{BL}	-	100	nAdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)				
2N2800, 2N2837		20	-	
2N2801, 2N2838		30	-	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*				
2N2800, 2N2837		30	90	
2N2801, 2N2838		75	225	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)*				
2N2800, 2N2837		15	-	
2N2801, 2N2838		30	-	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*				
2N2800, 2N2837		25	-	
2N2801, 2N2838		40	-	
Collector Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.2	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)		-	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)		-	1.8	
Output Capacitance (V_{CB} = 10 Vdc, f = 100 kc)	C_{ob}	-	25	pf
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	f_T	120	-	mc

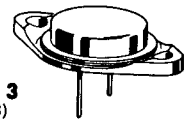
SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typical	Maximum	Unit
Delay Time	t_d	9	25	nsec
Rise Time	t_r	25	45	nsec
Storage Time	t_s	100	225	nsec
Fall Time	t_f	30	45	nsec

*Pulse Test: Pulse Width ≤ 300 μsec, duty cycle ≤ 2%

2N2832 (GERMANIUM)
2N2834

$V_{CEO} = 50\text{-}100$ V
$I_C = 20$ A
$P_D = 85$ W



CASE 3
(TO-3)

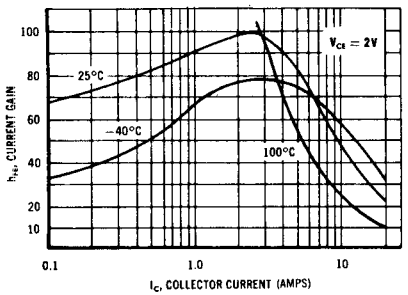
PNP germanium transistors for switching and amplifier applications.

Collector connected to case

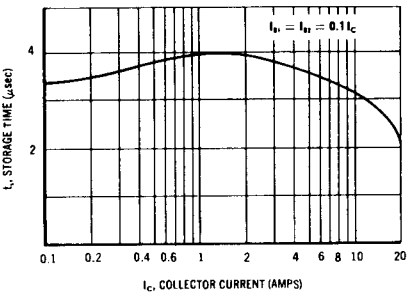
MAXIMUM RATINGS

Characteristic	Symbol	2N2832	2N2834	Unit
Collector-Base Voltage	V_{CBO}	80	140	Volts
Collector-Emitter Voltage	V_{CEO}	50	100	Volts
Emitter-Base Voltage	V_{EBO}	2	2	Volts
Collector Current (Continuous)	I_C	20	20	Amps
Base Current (Continuous)	I_B	5	5	Amps
Power Dissipation	P_C	85	85	Watts
Junction Operating Temperature Range	T_J	-65 to +110°		°C

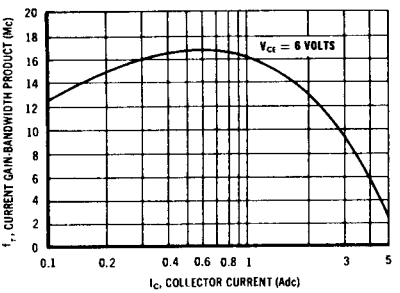
CURRENT GAIN VARIATIONS



STORAGE TIME versus COLLECTOR CURRENT



CURRENT GAIN BANDWIDTH PRODUCT versus COLLECTOR CURRENT



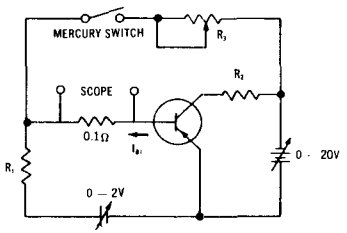
2N2832, 2N2834 (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Cutoff Current*		I_{CBO}*				mA
(V_{CB} = 2V, I_E = 0)	All Types		---	---	0.3	
(V_{CB} = 80V, I_E = 0)	2N2832		---	---	10	
(V_{CB} = 140V, I_E = 0)	2N2834		---	---	10	
Collector-Emitter Current*		I_{CES}*				mA
(V_{CE} = 100V, V_{BE} = 0)	2N2832		---	---	20	
(V_{CE} = 160V, V_{BE} = 0)	2N2834		---	---	20	
Collector-Emitter Cutoff Current**		I_{CEX}**				mA
(V_{CE} = 50V, V_{BE} = 0.2V, T_C = +85°C)	2N2832		---	---	40	
(V_{CE} = 100V, V_{BE} = 0.2V, T_C = +85°C)	2N2834		---	---	40	
Emitter-Base Breakdown Voltage		BV_{EBO}				Vdc
(I_E = 50 mAdc, I_C = 0)			2	---	---	
Collector-Emitter Breakdown Voltage**		$BV_{CEO(sus)}$**				Volts
(I_E = 100 mA, I_B = 0)	2N2832		50	---	---	
	2N2834		100	---	---	
Emitter Floating Potential*		V_{EBF}*				Volts
(V_{CB} = 80V, I_E = 0)	2N2832		---	---	0.5	
(V_{CB} = 140V, I_E = 0)	2N2834		---	---	0.5	
DC Current Transfer Ratio		h_{FE}				---
(I_C = 1.0 A, V_{CB} = 2V)			50	75	---	
(I_C = 10A, V_{CB} = 2V)			25	---	100	
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 1.0 Adc, I_B = 100 mAdc)			---	---	0.15	
(I_C = 10 Adc, I_B = 1.0 Adc)			---	---	0.30	
(I_C = 20 Adc, I_B = 2.0 Adc)			---	---	0.5	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$				Vdc
(I_C = 1 A, I_B = 100 mAdc)			---	---	0.6	
(I_C = 10 A, I_B = 1Adc)			---	---	0.75	
(I_C = 20 A, I_B = 2 Adc)			---	---	1.0	
Small Signal Current Gain		h_{fe}				---
(I_C = 1.0 A, V_{CE} = 10 V, f = 5 mc)			2	3.5	---	
Rise Time		t_r	---	2	4	μsec
Storage Time		t_s	---	3	6	μsec
Fall Time		t_f	---	1	2.5	μsec

* SWEEP TEST: 1/2 Sine Wave, 60 cps min
** PULSE TEST: PW = 1 msec, 2% Duty Cycle

SWITCHING TIME TEST CIRCUIT



Characteristic	Sym	Max	Unit
Rise Time	t_r	4	μsec
Storage Time	t_s	6	μsec
Fall Time	t_f	2.5	μsec

ADJUST R_1, R_2, R_3, for $I_{B_1} = I_{B_2} = 0.1 I_C$
PULSE CONDITIONS; I_C = 5 AMP, I_{B_1} = 0.5 AMP

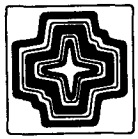
Switching times shown are for constant current drive conditions. Faster times can be realized by the use of a lower source impedance or a speed-up capacitor.

2N2837 (SILICON)
2N2838

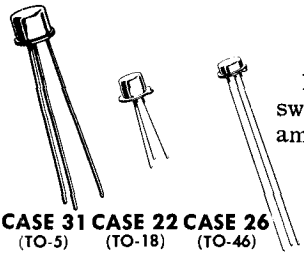
For Specifications, See 2N2800 Data Sheet

2N2904, A thru 2N2907, A (SILICON)

2N2904 thru 2N2907 USA/JAN and HI-REL
2N3485, A, 2N3486, A



V_{CEO} = 40-60 V
I_C = 600 mA
f_T = 200 Mc



CASE 31 (TO-5) 2N2904, A 2N2905, A
CASE 22 (TO-18) 2N2906, A 2N2907, A
CASE 26 (TO-46) 2N3485, A 2N3486, A

PNP silicon annular Star transistors for high-speed switching, complementary circuitry and DC to VHF amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage 2N2904-2N2907, 2N3485, 2N3486 2N2904A-2N2907A, 2N3485A, 2N3486A	V_{CEO}	 40 60	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	600	mAdc
Total Device Dissipation @ T_C = 25°C	P_D		
TO-5: 2N2904, 2N2904A, 2N2905, 2N2905A		3	W
DERATING FACTOR		17.2	mW/°C
TO-18: 2N2906, 2N2906A, 2N2907, 2N2907A		1.8	W
DERATING FACTOR		10.3	mW/°C
TO-46: 2N3485, 2N3485A, 2N3486, 2N3486A		2	W
DERATING FACTOR		11.43	mW/°C
Total Device Dissipation @ T_A = 25°C	P_D		
TO-5: 2N2904, 2N2904A, 2N2905, 2N2905A		600	mW
DERATING FACTOR		3.43	mW/°C
TO-18: 2N2906, 2N2906A, 2N2907, 2N2907A TO-46: 2N3485, 2N3485A, 2N3486, 2N3486A		400	mW
DERATING FACTOR		2.28	mW/°C
Operating Junction Temperature Range	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N2904, A-2N2907, A and 2N3485, A, 2N3486, A (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current					
(V_{CB} = 50 Vdc, I_E = 0)	2N2904 thru 2N2907, 2N3485, 2N3486	I_{CBO}	---	.020	μAdc
	2N2904A thru 2N2907A, 2N3485A, 2N3486A		---	.010	
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	2N2904 thru 2N2907, 2N3485, 2N3486		---	20	
	2N2904A thru 2N2907A, 2N3485A, 2N3486A		---	10	
Collector Cutoff Current (V_{CE} = 30V, V_{BE} = 0.5 V)		I_{CEX}	---	50	nAdc
Base Cutoff Current (V_{CE} = 30V, V_{BE} = 0.5 V)		I_{BL}	---	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 Adc, I_E = 0)		BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N2904 thru 2N2907, 2N3485, 2N3486	BV_{CEO}*	40	---	Vdc
	2N2904A thru 2N2907A, 2N3485A, 2N3486A		60	---	
Emitter-Base Breakdown Voltage (I_B = 10 Adc, I_C = 0)		BV_{EBO}	5	---	Vdc
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			---	0.4	
(I_C = 500 mAdc, I_B = 50 mAdc)			---	1.6	
Base-Emitter Saturation Voltage		$V_{BE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)*			---	1.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			---	2.6	
DC Forward Current Transfer Ratio		h_{FE}			---
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485		20	---	
	2N2905, 2N2907, 2N3486		35	---	
	2N2904A, 2N2906A, 2N3485A		40	---	
	2N2905A, 2N2907A, 2N3486A		75	---	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485		25	---	
	2N2905, 2N2907, 2N3486		50	---	
	2N2904A, 2N2906A, 2N3485A		40	---	
	2N2905A, 2N2907A, 2N3486A		100	---	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N2904, 2N2906, 2N3485		35	---	
	2N2905, 2N2907, 2N3486		75	---	
	2N2904A, 2N2906A, 2N3485A		40	---	
	2N2905A, 2N2907A, 2N3486A		100	---	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)*	2N2904, 2N2904A, 2N2906, 2N2906A, 2N3485, 2N3485A		40	120	
	2N2905, 2N2905A, 2N2907, 2N2907A, 2N3486, 2N3486A		100	300	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)*	2N2904, 2N2906, 2N3485		20	---	
	2N2905, 2N2907, 2N3486		30	---	
	2N2904A, 2N2906A, 2N3485A		40	---	
	2N2905A, 2N2907A, 2N3486A		50	---	
Output Capacitance (V_{CE} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	---	8	pf
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kc)		C_{ib}	---	30	pf
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 mc)		f_T	200	---	mc

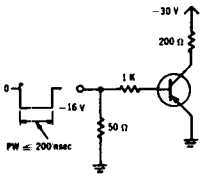
SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typ	Max	Unit
Delay Time	t_d	6	10	nsec
Rise Time	t_r	20	40	nsec
Turn-On Time	t_{on}	26	45	nsec
Storage Time	t_s	50	80	nsec
Fall Time	t_f	20	30	nsec
Turn-Off Time	t_{off}	70	100	nsec
Total Switching Time	t_{total}	12	---	nsec

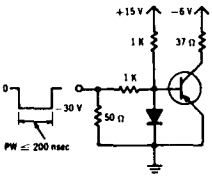
*Pulse Test: Pulse Width = 300 μsec; Duty Cycle ≤ 2%

2N2904, A-2N2907, A and 2N3485, A, 2N3486, A (Continued)

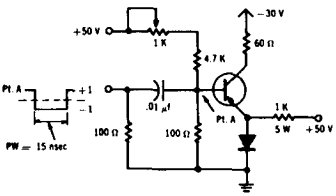
SATURATED TURN-ON SWITCHING-TIME TEST CIRCUIT



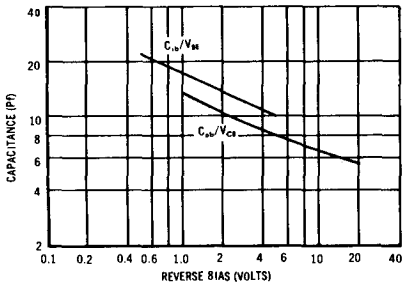
SATURATED TURN-OFF SWITCHING-TIME TEST CIRCUIT



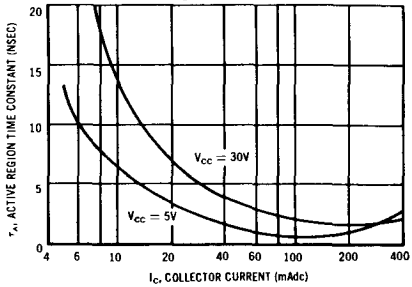
NON-SATURATED SWITCHING-TIME TEST CIRCUIT



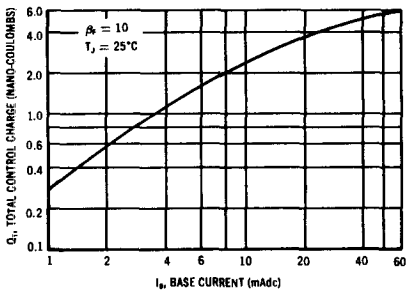
CAPACITANCE VARIATIONS versus VOLTAGE



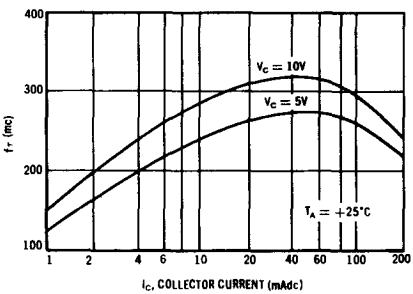
ACTIVE REGION TIME CONSTANT versus COLLECTOR CURRENT



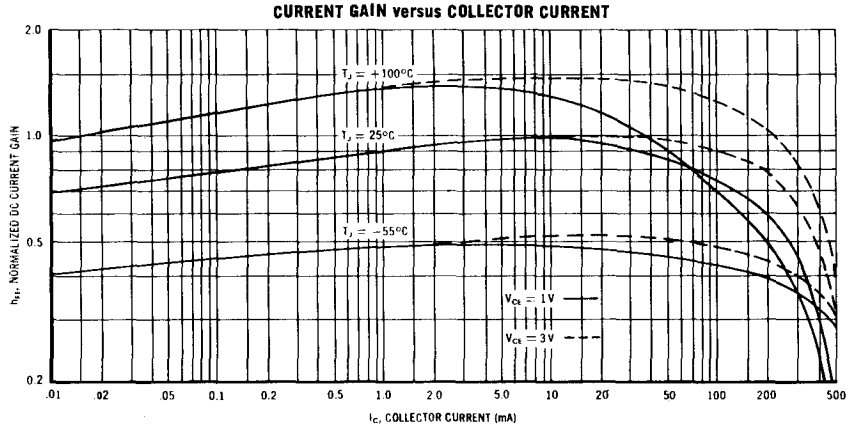
TOTAL CONTROL CHARGE versus BASE CURRENT



CURRENT GAIN-BANDWIDTH PRODUCT versus COLLECTOR CURRENT

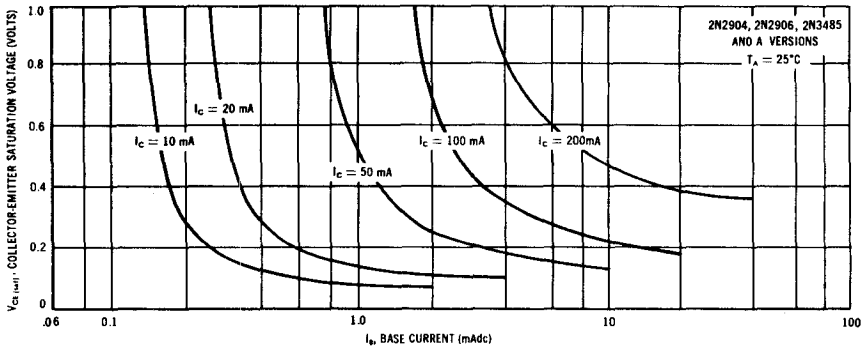


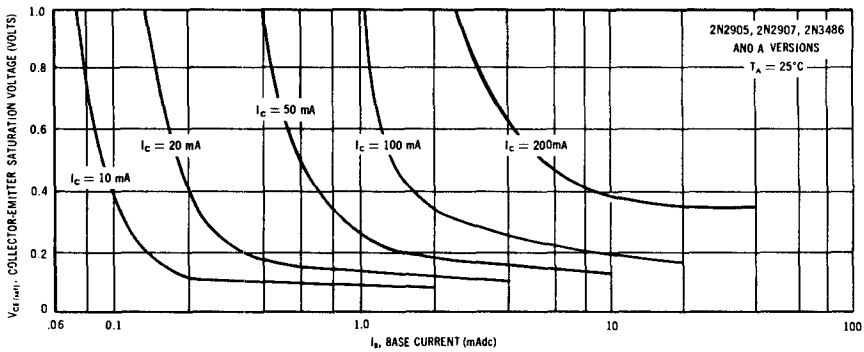
CURRENT GAIN versus COLLECTOR CURRENT



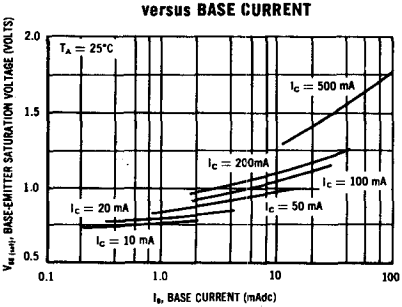
2N2904, A-2N2907, A and 2N3485, A, 2N3486, A (Continued)

COLLECTOR SATURATION VOLTAGE versus BASE CURRENT

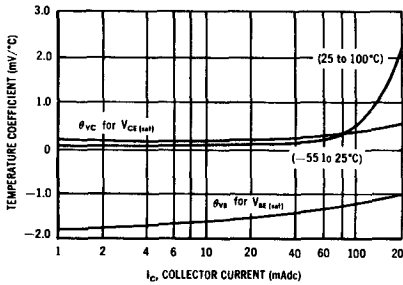




BASE SATURATION VOLTAGE versus BASE CURRENT

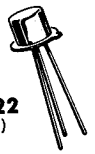


TEMPERATURE COEFFICIENTS



2N2955 (GERMANIUM)
2N2956
2N2957

V_{CEO} = 18-25 V
I_C = 100 mA
f_T = 350-400 MHz (typ)



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistors for high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	3.5	Vdc
Collector-Emitter Voltage 2N2955 2N2956 2N2957	V_{CEO}	25 20 18	Vdc
Collector Current	I_C	100	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{STG}	-65 to +100	°C
Total Device Dissipation at 25°C Case Temperature (Derate 4 mW/°C above 25°C)	P_D	300	mW
Total Device Dissipation at 25°C Ambient Temperature (Derate 2 mW/°C above 25°C)	P_D	150	mW

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	40	60	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	3.5	5	---	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, Emitter-Base Termination - Open) 2N2955 2N2956 2N2957	8	BV_{CEO}	25 20 18	35 28 25	--- --- ---	Vdc
Collector-Emitter Reverse Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)		I_{CEX}	---	---	10	μAdc
Base Leakage Current (V_{CE} = 25 Vdc, V_{EB} = 0.5 Vdc)	9	I_{BL}	---	---	10	μAdc

2N2955, 2N2956, 2N2957 (Continued).

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Fig. No.	Symbol	Min	Typ	Max	Unit
On Characteristics							
Forward Current Transfer Ratio			h_{FE}				---
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N2955	1		20	43	---	
	2N2956	2		30	64	---	
	2N2957	3		60	105	---	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N2955			20	43	60	
	2N2956			40	76	120	
	2N2957			100	130	---	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N2956			30	69	---	
	2N2957			60	115	---	
Collector-Emitter Saturation Voltage			$V_{CE(sat)}$				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N2955	5		---	0.12	0.20	
	2N2956	6		---	0.12	0.18	
	2N2957	7		---	0.09	0.15	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955			---	0.20	0.30	
	2N2956			---	0.16	0.25	
	2N2957			---	0.13	0.20	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956			---	0.23	0.34	
	2N2957			---	0.18	0.26	
Base-Emitter Voltage		4	V_{BE}				Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)	2N2955			---	0.38	0.50	
	2N2956			---	0.37	0.47	
	2N2957			---	0.36	0.44	
(I_C = 50 mAdc, I_B = 5 mAdc)	2N2955			---	0.51	0.65	
	2N2956			---	0.48	0.60	
	2N2957			---	0.45	0.55	
(I_C = 100 mAdc, I_B = 10 mAdc)	2N2956			---	0.56	0.70	
	2N2957			---	0.52	0.65	
Transient Characteristics							
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 1 mc)		10	C_{ob}	---	2.5	4	pf
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 1 mc)		10	C_{ib}	---	3.3	---	pf
Small Signal Forward Current			$\lvert h_{fe} \rvert$				---
Transfer Ratio (V_{CE} = 5 Vdc,	2N2955			2	3.5	---	
I_C = 10 mAdc, f = 100 mc)	2N2956			2.5	3.75	---	
	2N2957			3	4.0	---	
Delay Time (V_{CC} = 12 Vdc, I_{CS} = 50 mAdc, I_{B1} = 5 mAdc, V_{BE} (Off) = 2.2 Vdc)		12	t_d	---	7	15	nsec
Rise Time (same conditions as t_d)	2N2955	12, 13	t_r	---	25	40	nsec
	2N2956			---	18	30	
	2N2957			---	15	25	
Storage Time (V_{CC} = 12 Vdc, I_{CS} = 50 mAdc,	2N2955	12,16	t_s	---	28	40	nsec
I_{B1} = 5 mAdc, I_{B2} = 5 mAdc)	2N2956			---	37	55	
	2N2957			---	42	60	
Fall Time (same conditions as t_s)	2N2955	12, 15	t_f	---	25	40	nsec
	2N2956			---	18	35	
	2N2957			---	18	35	
Total Control Charge (I_C = 10 mAdc, I_B = 1 mAdc)	2N2955	17	Q_T	---	84	---	pc
	2N2956			---	88	---	
	2N2957			---	88	---	
Active Region Time Constant (I_C = 10 mAdc)		14	τ_A	---	2.9	---	nsec

2N2955, 2N2956, 2N2957 (Continued)

FIGURE 1 — CURRENT GAIN CHARACTERISTICS

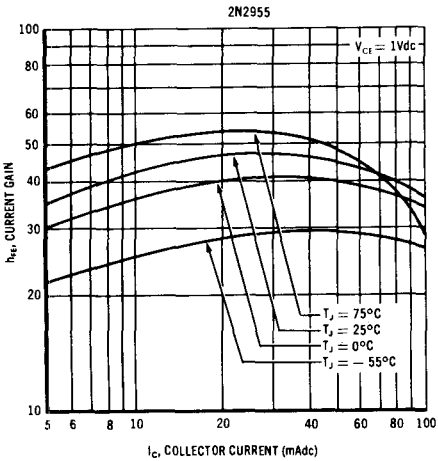


FIGURE 2 — CURRENT GAIN CHARACTERISTICS

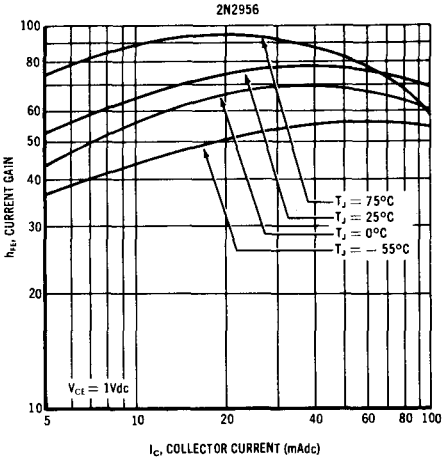


FIGURE 3 — CURRENT GAIN CHARACTERISTICS

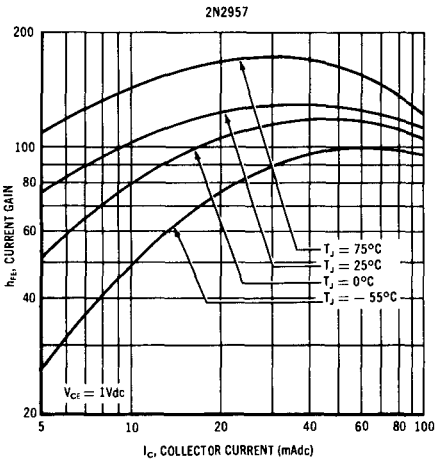
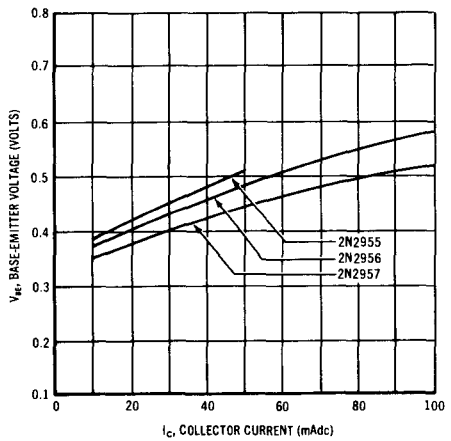


FIGURE 4 — BASE EMITTER VOLTAGE versus COLLECTOR CURRENT



2N2955, 2N2956, 2N2957 (Continued)

COLLECTOR-EMITTER SATURATION VOLTAGE versus BASE CURRENT

FIGURE 5 —2N2955

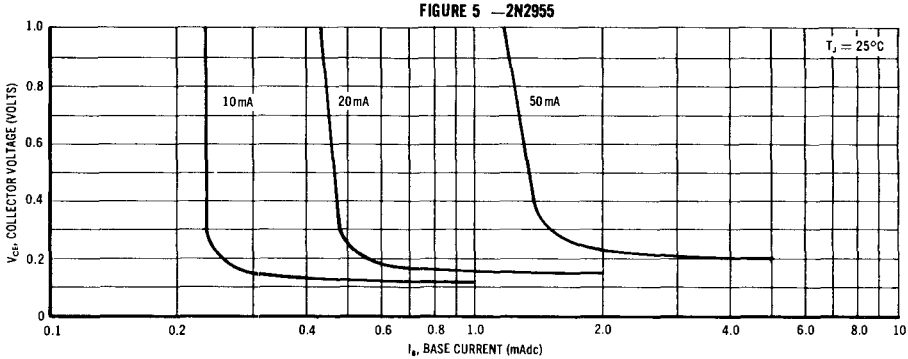


FIGURE 6 —2N2956

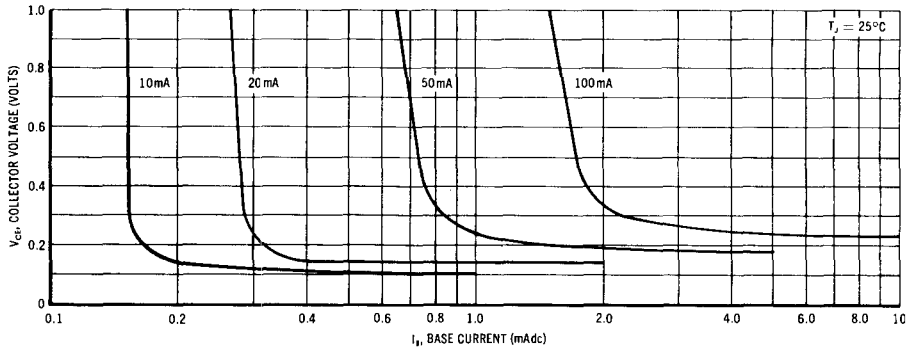
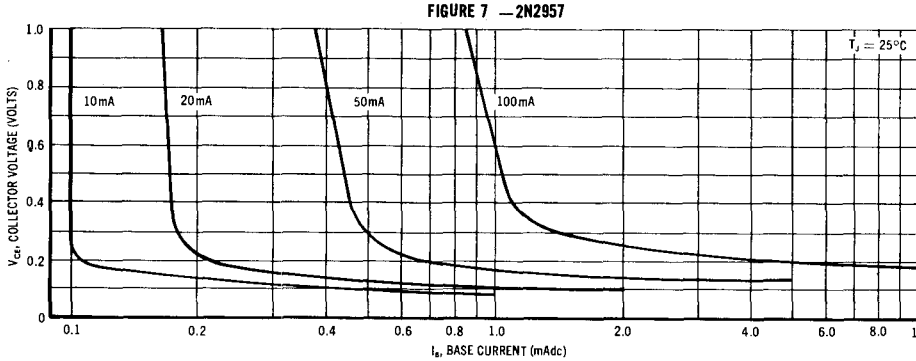
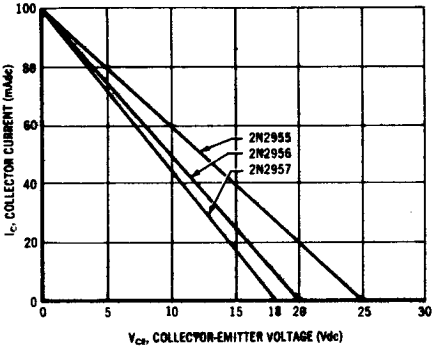


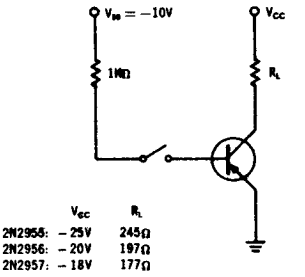
FIGURE 7 —2N2957



2N2955, 2N2956, 2N2957 (Continued)

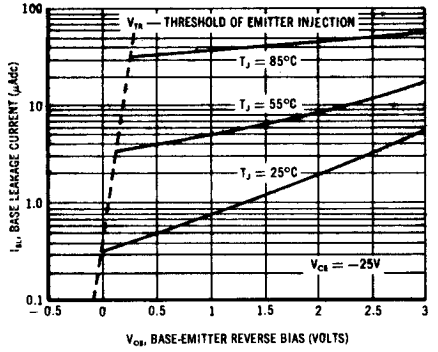
FIGURE 8 — OPEN BASE LOAD LINE RATING & TEST CIRCUIT



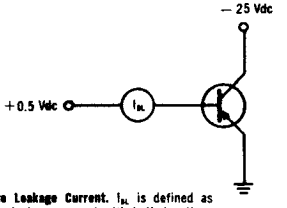


	V_{CC}	R_L
2N2955:	−25V	245Ω
2N2956:	−20V	197Ω
2N2957:	−18V	177Ω

FIGURE 9 — COMMON EMITTER DC LEAKAGE CHARACTERISTICS



BASE LEAKAGE CURRENT TEST CIRCUIT



Base Leakage Current. I_{BL} is defined as base leakage current with both junctions reverse biased. I_C is always less than I_{BL} for $V_{CB} > V_T$. (V_{CB} is off condition base bias, V_T is base voltage at threshold of condition.)

FIGURE 10 — JUNCTION CAPACITANCE versus REVERSE BIAS

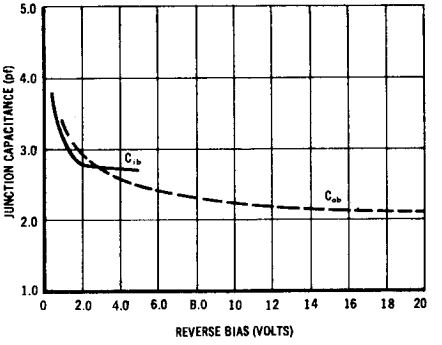
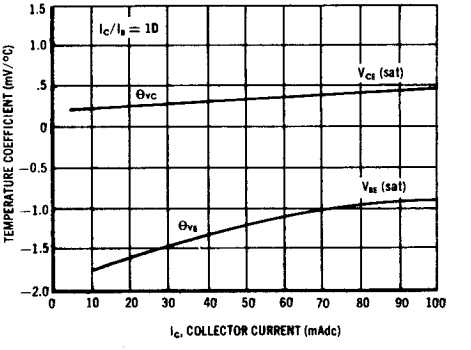


FIGURE 11 — TEMPERATURE COEFFICIENTS



2N2955, 2N2956, 2N2957 (Continued)

FIGURE 12 — SWITCHING TIME TEST CIRCUIT

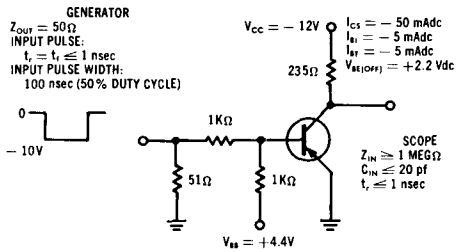


FIGURE 13 — RISE TIME FACTOR

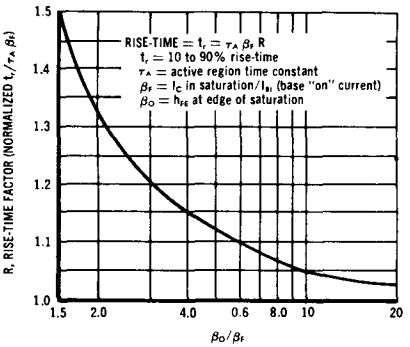


FIGURE 14 — ACTIVE REGION TIME CONSTANT

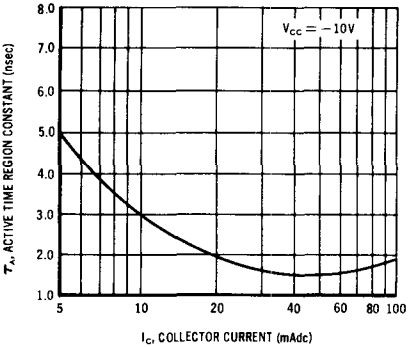


FIGURE 15 — FALL TIME FACTOR

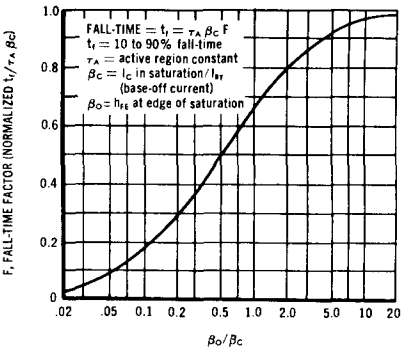


FIGURE 16 — STORAGE TIME

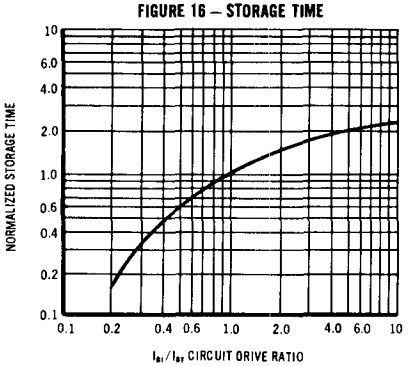
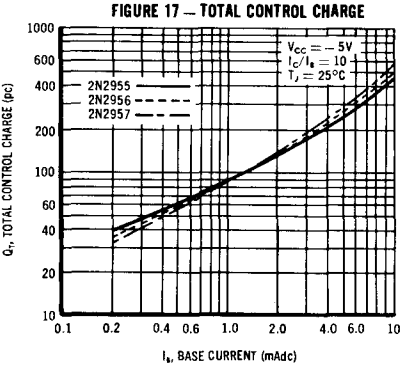


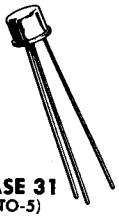
FIGURE 17 — TOTAL CONTROL CHARGE



2N2958 (SILICON)
2N2959
2N3115
2N3116



$V_{CEO} = 20$ V
$I_C = 600$ mA
$f_T = 400$ Mc Typ





NPN silicon annular Star transistors for high-speed switching and amplifier applications.

CASE 31
(TO-5)
2N2958
2N2959

CASE 22
(TO-18)
2N3115
2N3116

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N2958 2N2959 (TO-5)	2N3115 2N3116 (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	60	60	Vdc
Collector-Emitter Voltage	V_{CEO}	20	20	Vdc
Emitter-Base Voltage	V_{EBO}	5	5	Vdc
Collector-Current	I_C	600	600	mAdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	 3 20	 1.8 12	 Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	 0.6 4.00	 0.4 2.67	 Watts mW/°C
Junction Temperature	T_J	-65 to +175		°C
Storage Temperature	T_{stg}	-65 to +200		°C

2N2958, 2N2959, 2N3115, 2N3116 (Continued)

ELECTRICAL CHARACTERISTICS $T_A = 25°C$ unless otherwise noted

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	0.025 15	μ Adc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = -0.5 Vdc)	I_{CEX}	---	.050	μ Adc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{BE} = -0.5 Vdc)	I_{BL}	---	.050	μ Adc
Collector-Base Breakdown Voltage (I_C = 10 μ Adc, I_E = 0)	BV_{CBO}	60	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, pulsed, I_B = 0)	BV_{CEO}*	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μ Adc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE\ (sat)}$*	---	0.5	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE\ (sat)}$*	---	1.3	Vdc
DC Forward Current Transfer Ratio (I_C = 150 mAdc, 2N2958, 2N3115 V_{CE} = 10 Vdc) 2N2959, 2N3116	h_{FE}	40 100	120 300	---
Common-Base Open Circuit Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 100 kc)	C_{ob}	---	8	pf
Delay Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_d	---	20	nsec
Rise Time (V_{CC} = 30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_r	---	75	nsec
Storage Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = +15 mA, I_{B2} = -15 mA)	t_s	---	300	nsec
Fall Time (V_{CC} = 6 V, I_{CS} = 150 mA, I_{B1} = +15 mA, I_{B2} = -15 mA)	t_f	---	200	nsec
Current Gain-Bandwidth Product (I_C = 20 mA, V_{CE} = 20 V, f = 100 mc)	f_T	250	---	mc

*PULSE TEST: Pulse width $\leq$ 300 μsec, duty cycle $\leq$ 2%

2N3019 (SILICON)
2N3020

$V_{CEO} = 80\ V$
$I_C = 1\ A$
$P_D = 5\ W$



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistors designed for high-current, high-frequency amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	80	Vdc
Collector-Base Voltage	V_{CB}	140	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current	I_C	1	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.8 4.6	W mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5 28.6	W mW/°C
Operating Junction Temperature Range	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N3019, 2N3020 (continued)

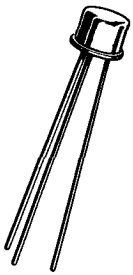
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)		BV_{CEO}*	80	–	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	140	–	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	7	–	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)		I_{CBO}	–	0.010	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)			–	10	
Emitter Cutoff Current (V_{BE} = 5 Vdc, I_C = 0)		I_{EBO}	–	0.010	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3019	h_{FE}*	50	–	–
	2N3020		30	100	
(I_C = 10 mAc, V_{CE} = 10 Vdc)	2N3019		90	–	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3019		100	300	
	2N3020		40	120	
(I_C = 150 mAdc, V_{CE} = 10 Vdc, T_C = -55°C)	2N3019		40	–	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3019		50	–	
	2N3020		30	100	
(I_C = 1 Adc, V_{CE} = 10 Vdc)	Both Types		15	–	
Collector-Emitter Saturation Voltage* (I_C = 150 mAc, I_B = 15 mAc)		$V_{CE(sat)}$*	–	0.2	Vdc
(I_C = 500 mAc, I_B = 50 mAc)			–	0.5	
Base-Emilter Saturation Voltage* (I_C = 150 mAc, I_B = 15 mAc)		$V_{BE(sat)}$*	–	1.1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain – Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 MHz)	2N3019	f_T	100	–	MHz
	2N3020		80		
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	–	12	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz)		C_{ib}	–	60	pF
Small-Signal Current Gain (I_C = 1 mAc, V_{CE} = 5 Vdc, f = 1 kHz)	2N3019	h_{fe}	80	400	–
	2N3020		30	200	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 4 MHz)		r'_bC_c	–	400	ps
Noise Figure (I_C = 100 μAdc, V_{CE} = 10 Vdc, f = 1 kHz, R_S = 1 kohm)	2N3019	NF	–	4	dB

*Pulse Test: Pulse Width ≤ 300 μs, duty cycle ≤ 1%

2N3114 (SILICON)

$V_{CEO} = 150\ V$
$I_C = 200\ mAdc$
$P_D = 5\ W$



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistor designed for high-voltage, low-power video amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	150	Vdc
Collector-Emitter Voltage*	V_{CEO}	150*	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derating Factor Above 25°C	P_D	0.8 4.57	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derating Factor Above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

*Between 0 and 30 mA.

2N3114 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$*	—	1	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{BE(sat)}$*	—	0.9	Vdc
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	15	—	—
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		30	120	
(I_C = 30 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)		12	—	
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	I_{CBO}	—	0.010	μAdc
(V_{CB} = 100 Vdc, I_E = 0, T_A = 150°C)		—	10	
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.10	μAdc
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 20 mc)	$\|h_{fe}\|$	2.0	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 140 kc)	C_{ob}	—	9	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 140 kc)	C_{ib}	—	80	pf
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 5 V, f = 1 kc)	h_{fe}	25	—	—
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 100 mc)	$Re(h_{ie})$	—	30	ohms

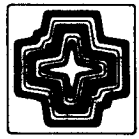
*PW ≤ 300 μsec, Duty Cycle ≤ 1%

2N3115 (SILICON)

2N3116

For Specifications, See 2N2958 Data Sheet

2N3133 thru 2N3136 (SILICON)



$V_{CEO} = 35$ V
$I_C = 600$ mA
$f_T = 200$ Mc





PNP silicon annular Star transistors for high-speed switching and DC to UHF amplifier applications.

CASE 31 (TO-5)
2N3133
2N3134

CASE 22 (TO-18)
2N3135
2N3136

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N3133 2N3134 (TO-5)	2N3135 2N3136 (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	50	50	Vdc
Collector-Emitter Voltage	V_{CEO}	35	35	Vdc
Emitter-Base Voltage	V_{EBO}	4	4	Vdc
Collector Current	I_C	600	600	mA
Total Device Dissipation @25°C Case Temperature Derate Above 25°C	P_D	3 17.3	1.8 10.3	Watts mW/°C
Total Device Dissipation @25°C Ambient Temperature Derate Above 25°C	P_D	0.6 3.43	0.4 2.28	Watts mW/°C
Junction Temperature	T_J	-65 to +200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Typ	Max	Unit
Turn-On Time (V_{CC} = -30 V, I_{CS} = 150 mA, I_{B1} = 15 mA)	t_{on}	26	75	nsec
Turn-Off Time (V_{CC} = -6V, I_{CS} = 150 mA, I_{B1} = I_{B2} = 15 mA)	t_{off}	70	150	nsec

2N3133 thru 2N3136 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	0.05 30	μAdc
Collector Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)	I_{CEX}	---	0.1	μAdc
Base Cutoff Current (V_{CE} = 30 V, V_{BE} = 0.5 V)	I_{BL}	---	0.1	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	50	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	35	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4	---	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{CE\ (sat)}$*	---	0.6	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	$V_{BE\ (sat)}$*	---	1.5	Vdc
DC Forward Current Transfer Ratio (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) 2N3133, 2N3135 2N3134, 2N3136 (I_C = 150 mAdc, V_{CE} = 10 Vdc)* 2N3133, 2N3135 2N3134, 2N3136	h_{FE}	 25 50 40 100	 --- --- 120 300	---
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	---	10	pf
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kc)	C_{ib}	---	40	pf
Current-Gain — Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	f_T	200	---	mc

*Pulse Test: Pulse Width ≤ 300 μsec, duty cycle ≤ 2%

2N3227 (SILICON)

For Specifications, See 2N2369 Data Sheet

2N3244 (SILICON)
2N3245

$V_{CEO} = 40\text{-}50$ V
$I_C = 1$ A
$f_T = 150\text{-}175$ Mc



CASE 31
(TO-5)

PNP silicon annular transistors for medium-current, high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N 3244	2N 3245	Unit
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	1		Adc
Total Device Dissipation @ 25° C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ 25° C Case Temperature Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance	θ_{JA} θ_{JC}	0.175 35		°C/mW °C/W

2N3244, 2N3245 (Continued)

ELECTRICAL CHARACTERISTICS (at $T_A = 25°C$ unless otherwise specified)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)			I_{CBO}	— —	.050 10	μAdc
Collector Cutoff Current (V_{CE} = 30 Vdc, V_{OB} = 3 Vdc)			I_{CEX}	—	50	nAdc
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)			I_{EBO}	—	30	nAdc
Base Cutoff Current (V_{CE} = 30 Vdc, V_{OB} = 3 Vdc)			I_{BL}	—	80	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μ Adc, I_E = 0)	2N3244 2N3245		BV_{CBO}	40 50	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3244 2N3245		BV_{CEO}*	40 50	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10μ Adc, I_C = 0)			BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)	2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	2,3	$V_{CE(sat)}$*	— — — — — —	0.3 0.35 0.5 0.6 1.0 1.2	Vdc
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc) (I_C = 1 Adc, I_B = 100 mAdc)		3	$V_{BE(sat)}$*	— 0.75 —	1.1 1.5 2.0	Vdc
DC Forward Current Transfer Ratio* (I_C = 150 mAdc, V_{CE} = 1.0 Vdc) (I_C = 500 mAdc, V_{CE} = 1.0 Vdc) (I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3244 2N3245 2N3244 2N3245 2N3244 2N3245	1	h_{FE}*	60 35 50 30 25 20	— — 150 90 — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		5	C_{ob}	—	25	pf
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)		5	C_{ib}	—	100	pf
Current-Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3244 2N3245		f_T	175 150	— —	mc
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA V_{OB} = 2 V, V_{CC} = 30 V)	6,8	t_d	—	15	nsec
Rise Time	2N3244 2N3245		t_r	— —	35 40	nsec
Storage Time	(I_C = 500 mA, V_{CC} = 30 V $I_{B1} = I_{B2}$ = 50 mA) 2N3244 2N3245	6,9	t_s	—	140 120	nsec
Fall Time			t_f	—	45	nsec
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)	2N3244 2N3245	7,10	Q_T	— —	14 12	nC

* Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N3244, 2N3245 (Continued)

FIGURE 1 — MINIMUM CURRENT GAIN CHARACTERISTICS

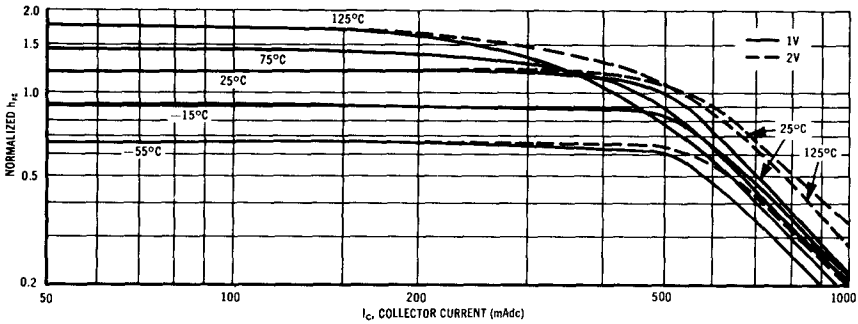
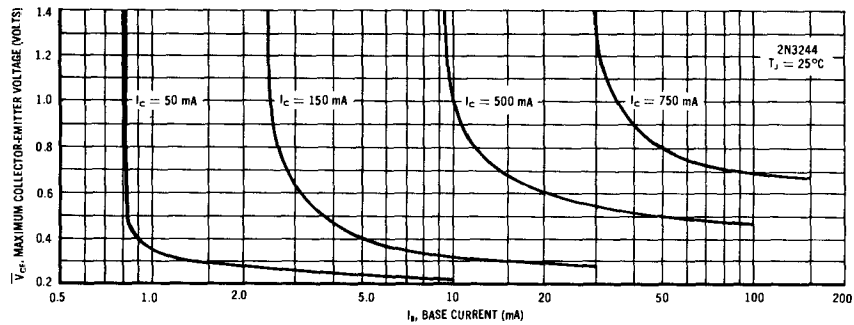
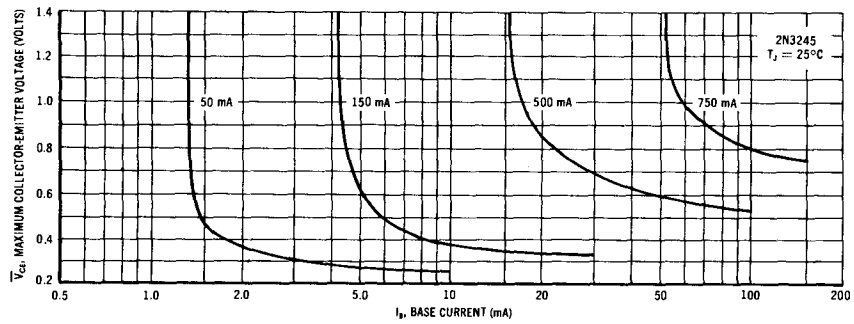


FIGURE 2 — COLLECTOR-EMITTER SATURATION VOLTAGE CHARACTERISTICS





2N3244, 2N3245 (Continued)

FIGURE 3 — MAXIMUM SATURATION VOLTAGES

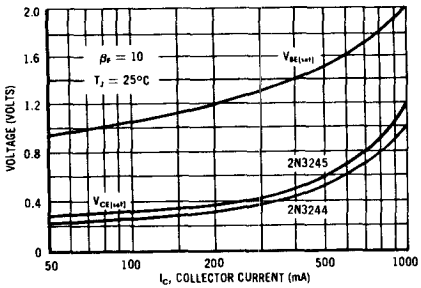


FIGURE 4 — TYPICAL TEMPERATURE COEFFICIENTS

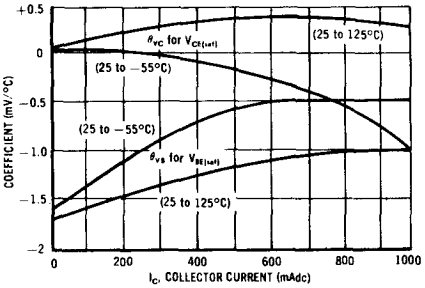


FIGURE 5 — JUNCTION CAPACITANCE

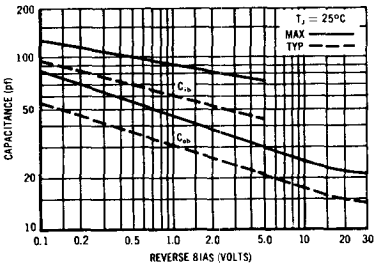


FIGURE 6 — TYPICAL SWITCHING TIMES

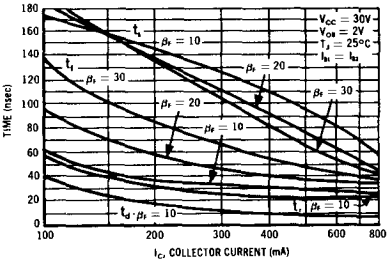


FIGURE 7 — CHARGE DATA

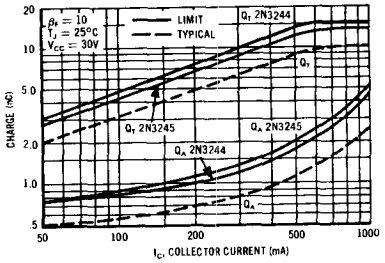


FIGURE 8 — TURN-ON EQUIVALENT TEST CIRCUIT

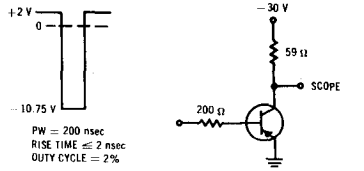


FIGURE 9 — TURN-OFF EQUIVALENT TEST CIRCUIT

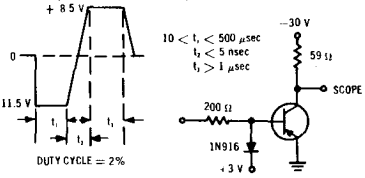


FIGURE 10 — Q_T TEST CIRCUIT

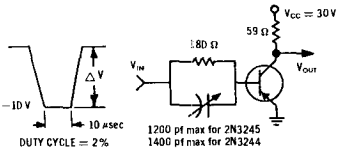
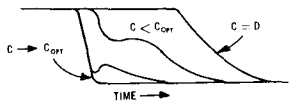
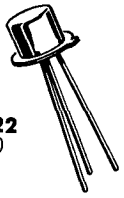


FIGURE 11 — TURN-OFF WAVEFORM



2N3248 (SILICON)
2N3249

$V_{CEO} = 12$ V
$f_T = 250$-300 Mc



CASE 22
(TO-18)

PNP silicon annular transistors for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristics	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 – t_{on} CIRCUIT

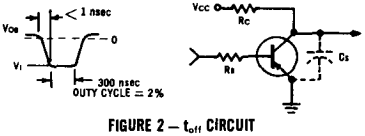
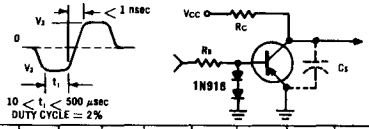


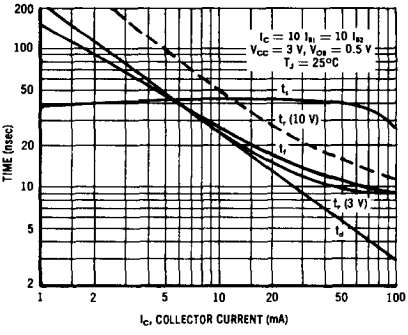
FIGURE 2 – t_{off} CIRCUIT



I_C mA	V_{CC} volts	R_B ohms	R_C ohms	$C_{S(max)}$* pf	V_{OS} volts	V_1 volts	V_2 volts	V_3 volts
10	3	10 K	285	4	+0.5	−10.6	−10.9	+9.1
100	10	1 K	95	12	+0.5	−10.7	−11.3	+8.7

*Total shunt capacitance of test jig and connectors.

FIGURE 3 – TYPICAL SWITCHING TIMES



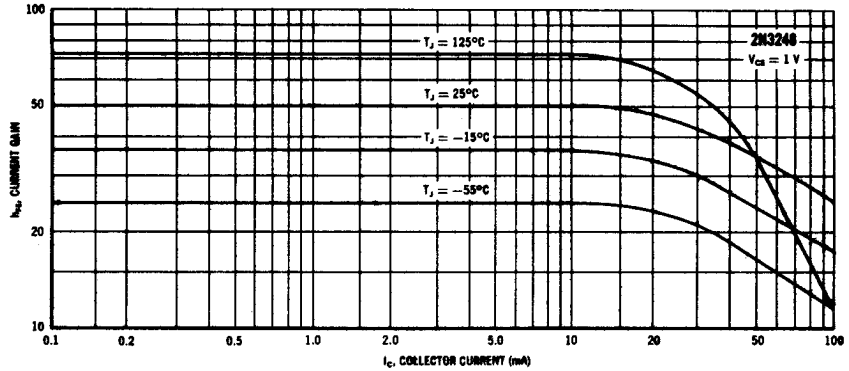
2N3248, 2N3249 (Continued)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector-Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc) (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc, T_A = 100°C)			I_{CEX}	— —	.05 5	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc)			I_{BL}	—	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	15	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)			BV_{CEO}*	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	 2N3248 2N3249	7,8	$V_{CE(sat)}$*	 — —	 0.125 0.25 0.4 0.45	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		8	$V_{BE(sat)}$*	 0.6 — 0.7	 0.9 1.1 1.3	Vdc
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	 2N3248 2N3249	4	h_{FE}*	 50 100	 — —	—
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3248 2N3249			50 100	— —	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3248 2N3249			50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3248 2N3249			35 75	— —	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3248 2N3249			25 35	— —	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		6	C_{ob}	—	8	pf
Input Capacitance (V_{BE} = 1 Vdc, I_C = 0, f = 100 kc)		6	C_{ib}	—	8	pf
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3248 2N3249		f_T	 250 300	 — —	mc
Total Control Charge (I_C = 10 mA, I_B = 0.25 mA, V_{CC} = 3 V)		5,10	Q_T	—	150	pC
Delay Time	I_C = 100 mA, I_B = 10 mA, V_{OB} = 0.5 V, V_{CC} = 10 V	1,3	t_d	—	5	nsec
Rise Time			t_r	—	15	nsec
Storage Time	I_C = 100 mA, I_{B1} = I_{B2} = 10 mA, V_{CC} = 10 V	2,3	t_s	—	60	nsec
Fall Time			t_f	—	20	nsec
Turn-On Time	I_C = 10 mA, I_{B1} = 1 mA, V_{OB} = 0.5 V, V_{CC} = 3 V	1,3	t_{on}	—	90	nsec
Turn-Off Time	I_C = 10 mA, I_{B1} = I_{B2} = 1 mA, V_{CC} = 3 V	2,3	t_{off}	—	100	nsec

*Pulse Test: PW = 300 μsec, Duty Cycle ≤ 2%

2N3248, 2N3249 (Continued)

FIGURE 4 – MINIMUM CURRENT GAIN CHARACTERISTICS



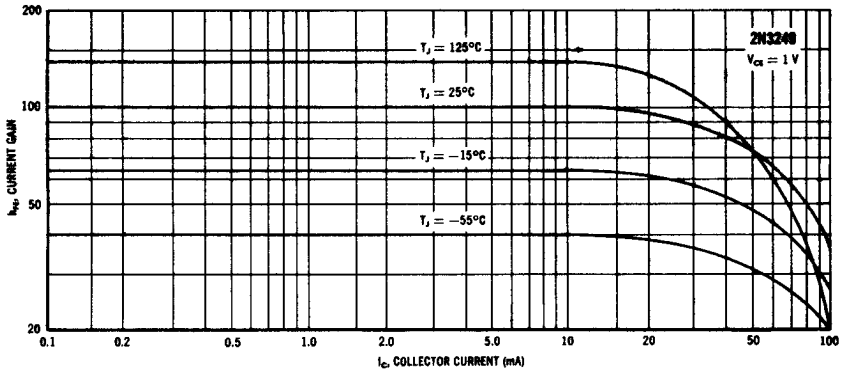


FIGURE 5 – MAXIMUM CHARGE DATA

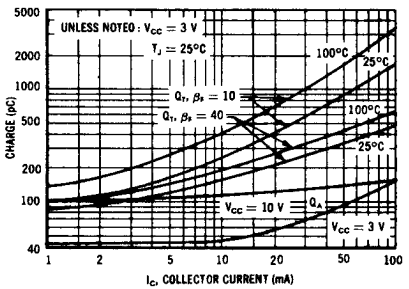
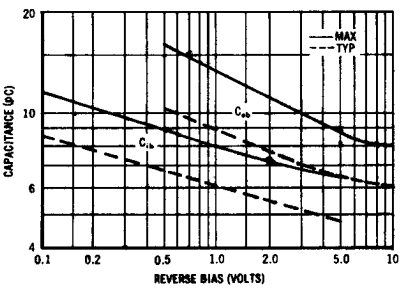
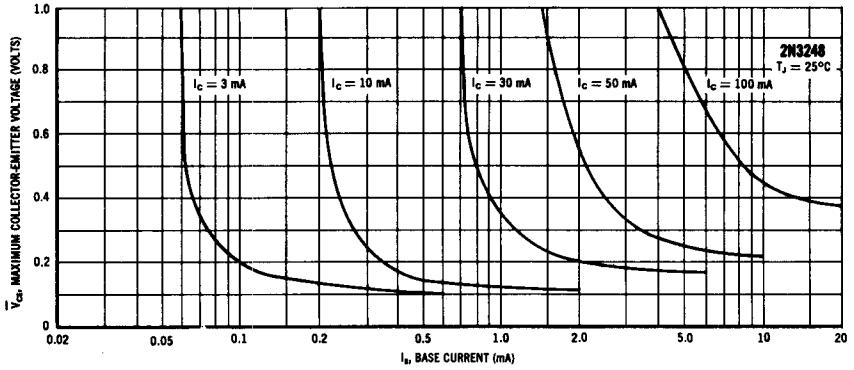


FIGURE 6 – JUNCTION CAPACITANCE



2N3248, 2N3249 (Continued)

FIGURE 7 COLLECTOR SATURATION VOLTAGE CHARACTERISTICS



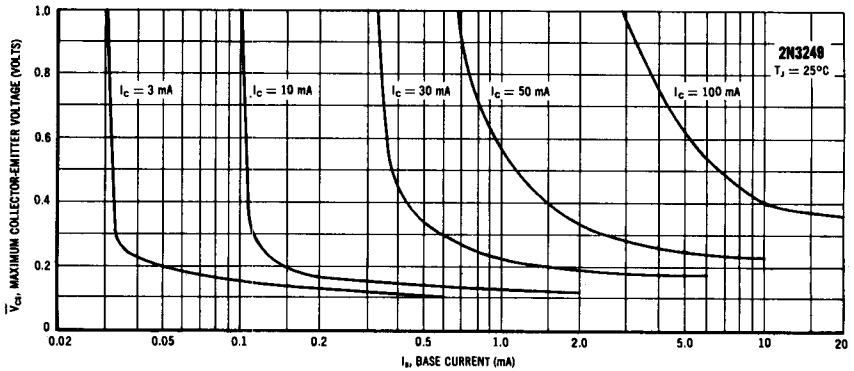


FIGURE 8 — SATURATION VOLTAGE LIMITS

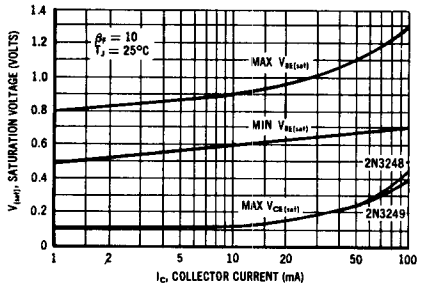


FIGURE 9 — TYPICAL TEMPERATURE COEFFICIENTS

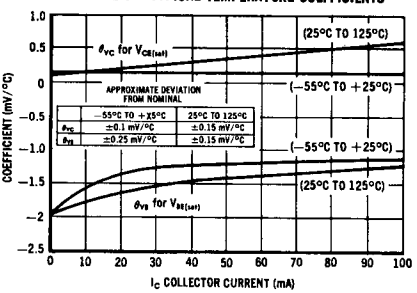


FIGURE 18 — Q_T TEST CIRCUIT

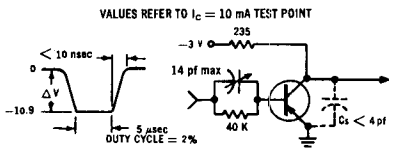
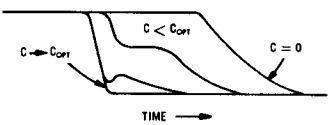


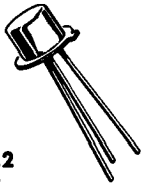
FIGURE 11 — TURN-OFF WAVE FORM



2N3250, A (SILICON)
2N3251, A
2N3250A, 2N3251A JAN
2N3250,A, 2N3251,A HI-REL



$V_{CEO} = 40\text{-}60$ V
$I_C = 200$ mA
$f_T = 250\text{-}300$ Mc



PNP silicon annular transistors for high-speed switching and amplifier applications.

Collector connected to case

CASE 22
(TO-18)

MAXIMUM RATINGS

Characteristic	Symbol	2N3250 2N3251	2N3250A 2N3251A	Unit
Collector-Base Voltage	V_{CBO}	50	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	1.2 6.9		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.36 2.06		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	−65 to +200		°C
Thermal Resistance	θ_{JA} θ_{JC}	0.49 0.15		°C/mW °C/mW

2N3250, A, 2N3251, A (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)		I_{CEX}	--	20	nAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)		I_{BL}	--	50	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CBO}	50 60	--	Vdc
Collector-Emitter Breakdown Voltage * (I_C = 10 mAdc)	2N3250, 2N3251 2N3250A, 2N3251A	BV_{CEO} *	40 60	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		BV_{EBO}	5	--	Vdc
Collector Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$ *	-- --	0.25 0.5	Vdc
Base-Emitter Saturation Voltage * (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{BE(sat)}$ *	0.6 --	0.9 1.2	Vdc
DC Forward Current Transfer Ratio * (I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{FE} *	40 80	-- --	--
(I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		45 90	-- --	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		50 100	150 300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3250, 2N3250A 2N3251, 2N3251A		15 30	-- --	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	--	6	pf
Input Capacitance (V_{OB} = 1 Vdc, I_C = 0, f = 100 kc)		C_{ib}	--	8	pf
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N3250, 2N3250A 2N3251, 2N3251A	f_T	250 300	-- --	mc

SMALL SIGNAL CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{fe}	50 100	200 400	--
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{re}	-- --	10 20	X10^{-4}
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{ie}	1 2	6 12	kohms
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3250, 2N3250A 2N3251, 2N3251A	h_{oe}	4 10	40 60	μ mhos
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V)		r'_bC_C	--	250	psec
Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_g = 1 kΩ, f = 100 cps)		NF	--	6	db

*Pulse Test: PW = 300 μsec, Duty Cycle = 2% V_{OB} = Base Emitter Reverse Bias

2N3250, A, 2N3251, A (Continued)

SWITCHING CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic			Symbol	Max	Unit
Delay Time	(V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc I_C = 10 mAdc, I_{B1} = 1 mA)		t_d	35	nsec
Rise Time			t_r	35	nsec
Storage Time	(I_{B1} = I_{B2} = 1 mAdc V_{CC} = 3V)	2N3250, 2N3250A	t_s	175	nsec
		2N3251, 2N3251A		200	
Fall Time			t_f	50	nsec

SWITCHING TIME CHARACTERISTICS

FIGURE 1 — DELAY AND RISE TIME

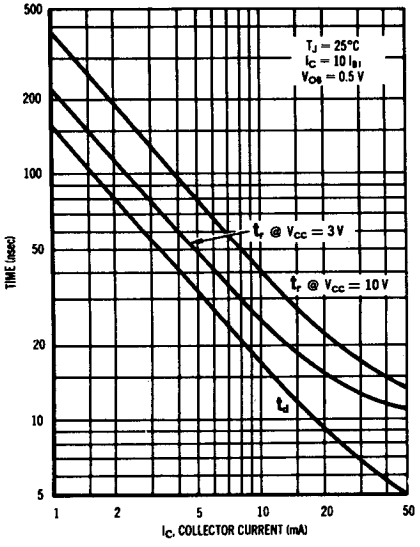
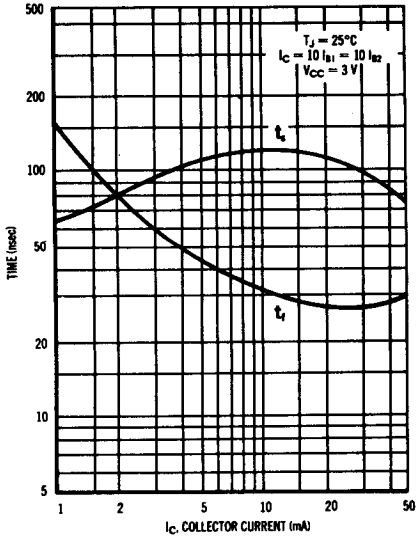


FIGURE 2 — STORAGE AND FALL TIME



2N3250, A, 2N3251, A (Continued)

AUDIO SMALL SIGNAL CHARACTERISTICS
NOISE FIGURE VARIATIONS
(V_{CE} = 6V, T_A = 25°C)

FIGURE 3 — FREQUENCY

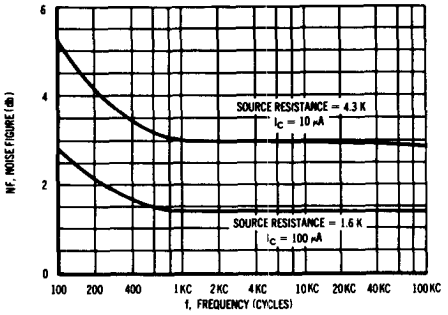
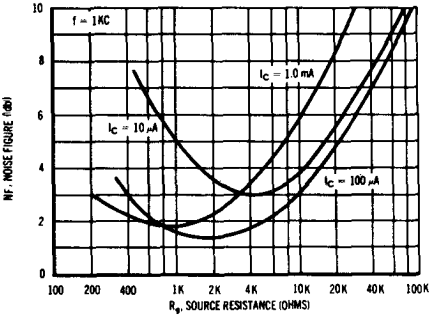


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS
V_{CE} = 10 V, f = 1 kc, T_A = 25°C

FIGURE 5 — CURRENT GAIN

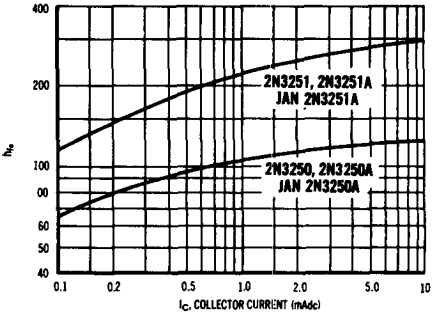


FIGURE 6 — OUTPUT ADMITTANCE

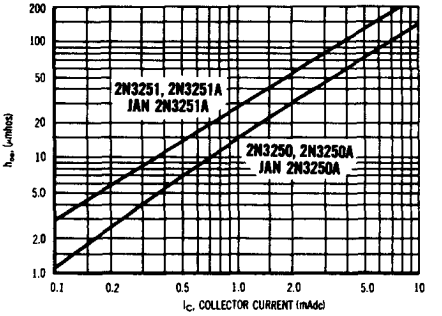


FIGURE 7 — VOLTAGE FEEDBACK RATIO

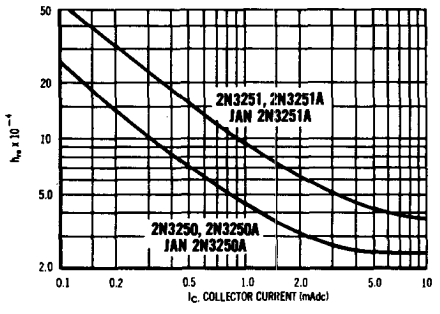
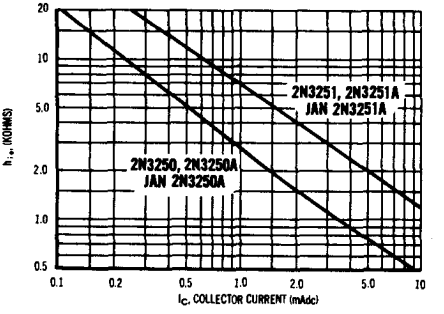


FIGURE 8 — INPUT IMPEDANCE



2N3250, A, 2N3251, A (Continued)

FIGURE 9 — NORMALIZED CURRENT GAIN CHARACTERISTICS

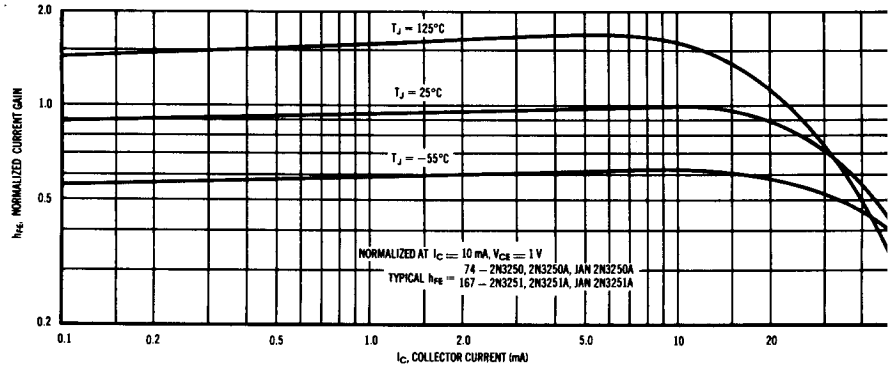
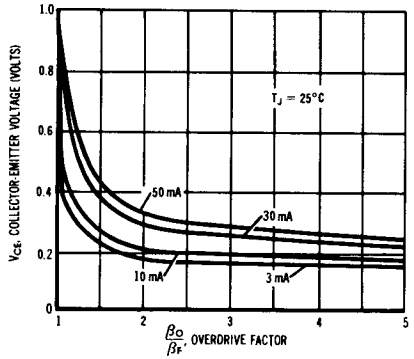


FIGURE 10 — COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_O is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3251, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 10 mA.

Observe that at I_C = 10 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 9, it is seen that h_{FE} @ 1 volt is typically 167 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design) . . .

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE} @ 1\ Volt}{I_C/I_{BF}} \qquad 2.5 = \frac{167}{10\ mA/I_{BF}} \qquad I_{BF} \approx 6.68\ mA\ typ$$

FIGURE 11 — SATURATION VOLTAGES

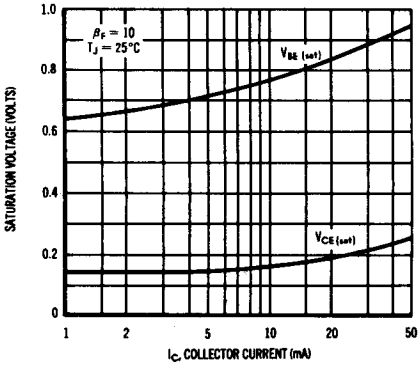
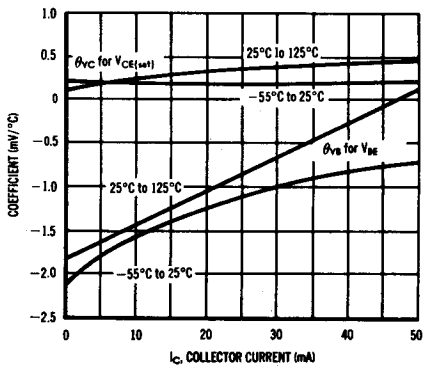


FIGURE 12 — TEMPERATURE COEFFICIENTS



2N3250, A, 2N3251, A (Continued)

FIGURE 13 — f_T AND $r_b'C_C$ versus I_C

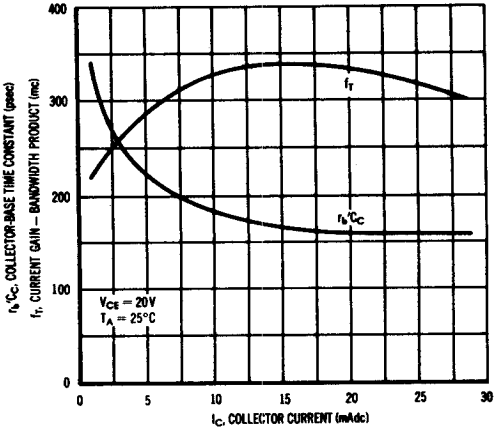


FIGURE 14 — 30 MC EQUIVALENT CIRCUIT

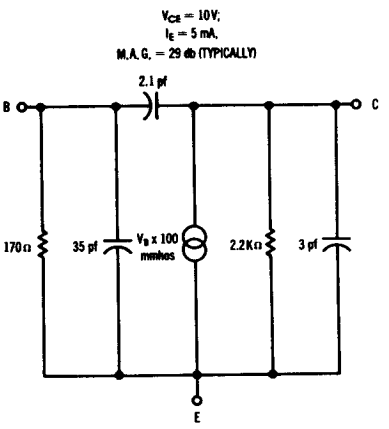


FIGURE 15 — JUNCTION CAPACITANCE

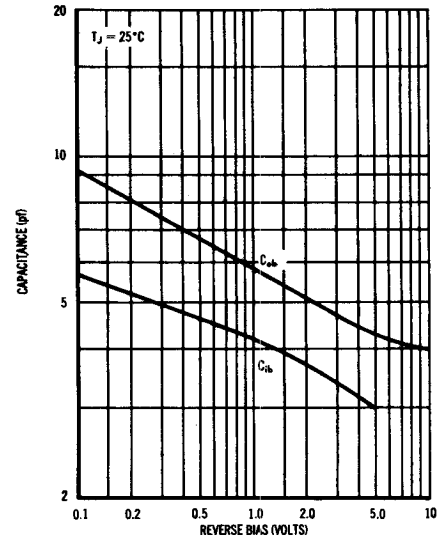
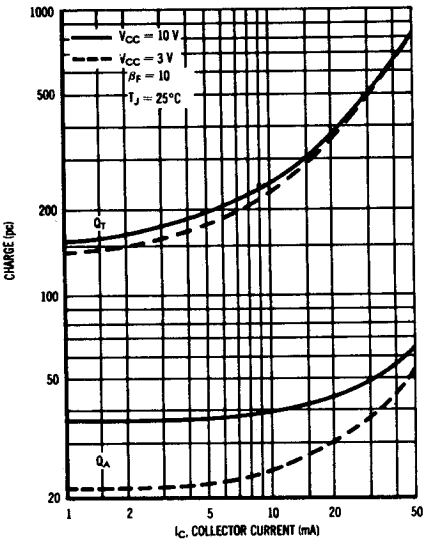


FIGURE 16 — CHARGE DATA



2N3252 (SILICON)
2N3253
2N3444

$V_{CEO} = 30\text{-}50$ V
$I_C = 1$ A
$f_T = 175\text{-}200$ Mc



CASE 31
(TO-5)

NPN silicon annular transistors for high-current saturated switching and core driver applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N3252	2N3253	2N3444	Unit
Collector-Base Voltage	V_{CBO}	60	75	80	Vdc
Collector-Emitter Voltage	V_{CEO}	30	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5			Vdc
Total Device Dissipation 25°C Case Temperature Derate above 25°C	P_D	5 28.6			Watts mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate above 25°C	P_D	1.0 5.71			Watt mW/°C
Junction Operating Temperature Range	T_J	-65 to +200			°C
Storage Temperature Range	T_{stg}	-65 to +200			°C
Thermal Resistance:	θ_{JC} θ_{JA}	35 0.175			°C/W °C/mW

SWITCHING CHARACTERISTICS

Characteristic		Symbol	Min	Max	Unit
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	12	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	80	pf
Current Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3252 2N3253, 2N3444	f_T	200 175	— —	mc
Total Control Charge (I_C = 500 mAdc, I_{B1} = 50 mAdc, V_{CC} = 30 V)		Q_T	—	5	nC
Delay Time	I_C = 500 mAdc, I_{B1} = 50 mAdc	t_d	—	15	nsec
Rise Time	V_{CC} = 30 V, V_{OB} = 2 V 2N3252 2N3253, 2N3444	t_r	— —	30 35	nsec
Storage Time	I_C = 500 mAdc, $I_{B1} = I_{B2}$ = 50 mAdc	t_s	—	40	nsec
Fall Time	V_{CC} = 30 V	t_f	—	30	nsec

2N3252, 2N3253, 2N3444 (Continued)

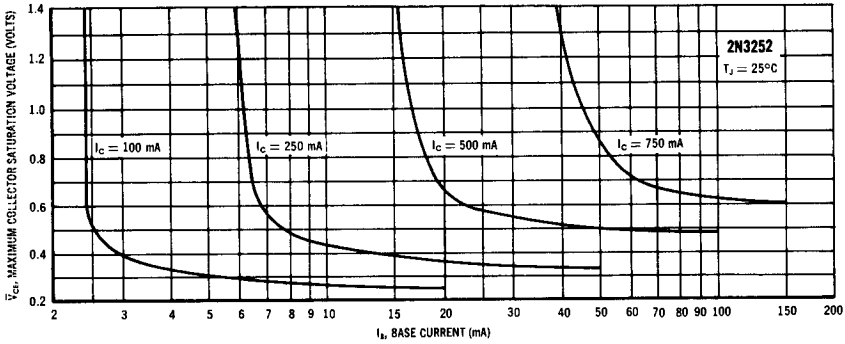
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

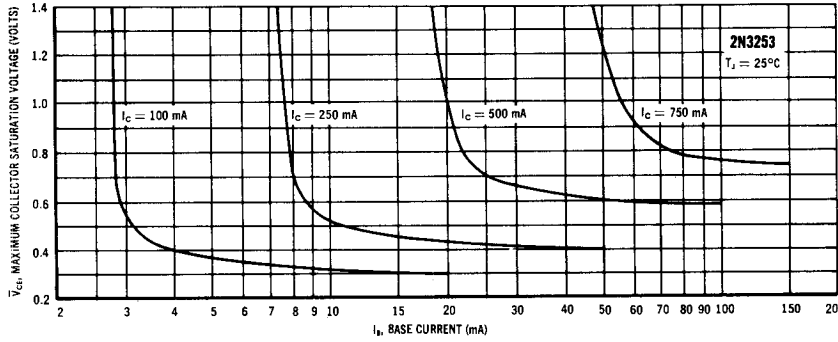
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 40 Vdc, I_E = 0)	2N3252		—	0.50	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 100°C)	2N3252			75.0	
(V_{CB} = 60 Vdc, I_E = 0)	2N3253, 2N3444			0.50	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 100°C)	2N3253, 2N3444			75.0	
Emitter Cutoff Current		I_{EBO}			μAdc
(V_{CB} = 4 Vdc, I_C = 0)			—	0.05	
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, V_{OB} = 4 Vdc)	2N3252		—	0.5	
(V_{CE} = 60 Vdc, V_{OB} = 4 Vdc)	2N3253, 2N3444,		—	0.5	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, V_{OB} = 4 Vdc)	2N3252		—	0.50	
(V_{CE} = 60 Vdc, V_{OB} = 4 Vdc)	2N3253, 2N3444		—	0.50	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N3252		60	—	
	2N3253		75	—	
	2N3444		80	—	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 10 mAdc, pulsed, I_B = 0)	2N3252		30	—	
	2N3253		40	—	
	2N3444		50	—	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3252		—	0.3	
	2N3253, 2N3444		—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3252		—	0.5	
	2N3253, 2N3444		—	0.60	
(I_C = 1.0 Adc, I_B = 100 mAdc)	2N3252		—	1.0	
	2N3253, 2N3444		—	1.2	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.7	1.3	
(I_C = 1.0 Adc, I_B = 100 mAdc)			—	1.8	
DC Forward Current Transfer Ratio*		h_{FE}*			—
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	2N3252		30	—	
	2N3253		25	—	
	2N3444		20	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3252		30	90	
	2N3253		25	75	
	2N3444		20	60	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3252		25	—	
	2N3253		20	—	
	2N3444		15	—	

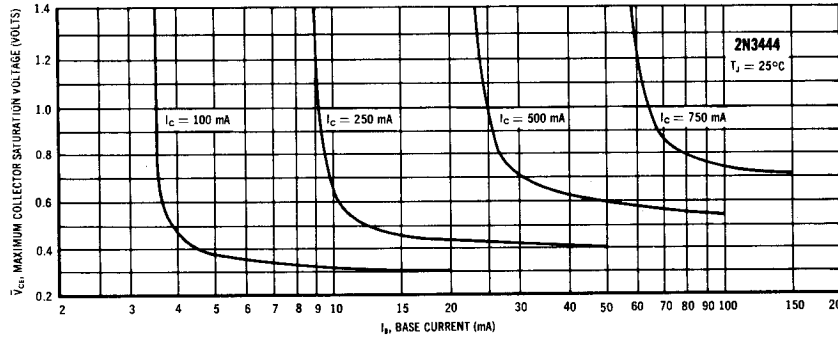
* Pulse Test: Pulse width = 300 μsec, duty cycle = 2%

2N3252, 2N3253, 2N3444 (Continued)

COLLECTOR SATURATION VOLTAGE CHARACTERISTICS

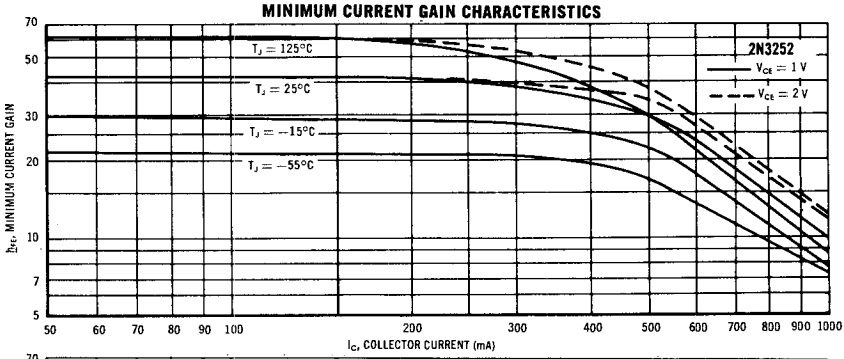


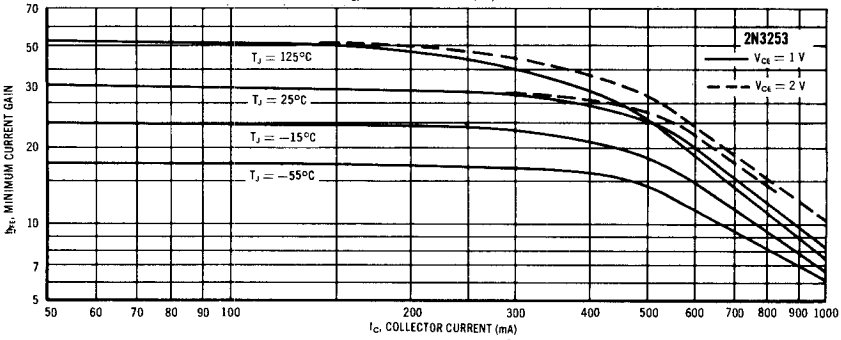


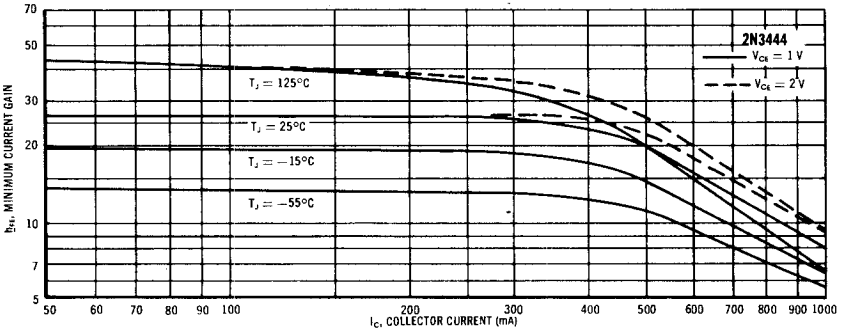


2N3252, 2N3253, 2N3444 (Continued)

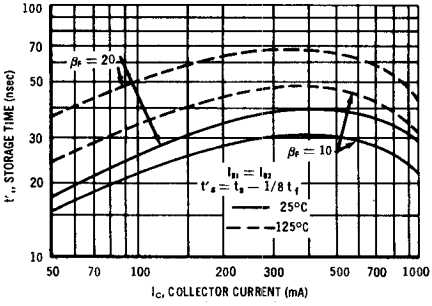
MINIMUM CURRENT GAIN CHARACTERISTICS



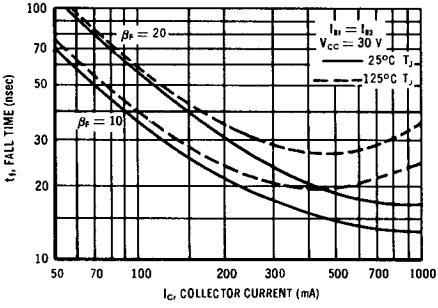




TYPICAL STORAGE TIME VARIATIONS

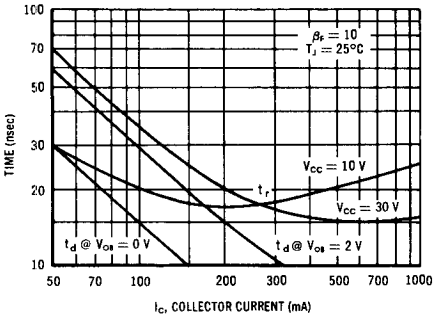


TYPICAL FALL TIME VARIATIONS

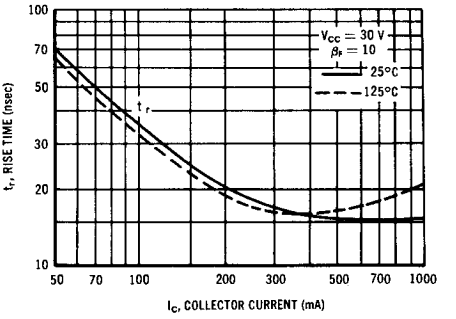


2N3252, 2N3253, 2N3444 (Continued)

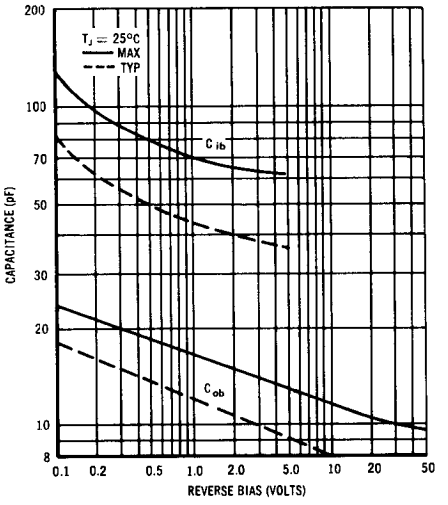
TYPICAL TURN-ON TIME VARIATIONS WITH VOLTAGE



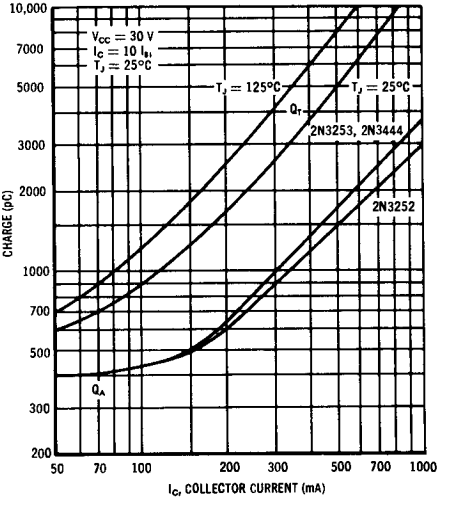
TYPICAL RISE TIME VARIATIONS WITH TEMPERATURE



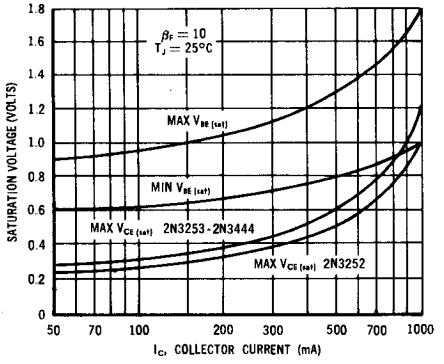
JUNCTION CAPACITANCE VARIATIONS



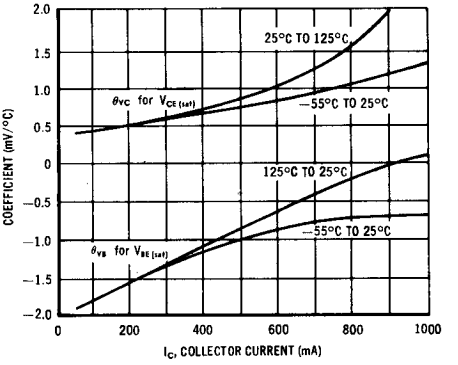
MAXIMUM CHARGE DATA



LIMITS OF SATURATION VOLTAGES



TYPICAL TEMPERATURE COEFFICIENTS



2N3303 (SILICON)

$V_{CEO} = 12$ V
$I_C = 1$ A
$f_T = 450$ MHz



CASE 94

NPN silicon annular transistor designed for high-speed, high-current switching and driving applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current-Continuous	I_C	1.0	Adc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.6 3.43	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	3 17.2	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	12	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.5 mAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_{CES}	-	100	μAdc
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)	I_B	-	100	μAdc

2N3303 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
ON CHARACTERISTICS				
DC Current Gain	h_{FE}			-
(I_C = 10 mAdc, V_{CE} = 0.5 Vdc)		20	-	
(I_C = 100 mAdc, V_{CE} = 0.5 Vdc)*		30	-	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc)*		30	120	
(I_C = 300 mAdc, V_{CE} = 0.5 Vdc, T_A = -55°C)*		10	-	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.25	
(I_C = 100 mAdc, I_B = 10 mAdc)*		-	0.23	
(I_C = 300 mAdc, I_B = 30 mAdc)*		-	0.33	
(I_C = 300 mAdc, I_B = 30 mAdc, T_A = 125°C)*		-	0.50	
(I_C = 1 Adc, I_B = 100 mAdc)*		-	0.70	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)		-	0.78	
(I_C = 100 mAdc, I_B = 10 mAdc)*		-	1.10	
(I_C = 300 mAdc, I_B = 30 mAdc)*		-	1.30	
(I_C = 1 Adc, I_B = 100 mAdc)*		-	2.1	
DYNAMIC CHARACTERISTICS				
Current-Gain – Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 100 MHz)	f_T	450	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kHz)	C_{ob}	-	15	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	C_{ib}	-	25	pF
Turn-On Time (Figure 1) ($V_{EB(off)} \approx$ 4 Vdc, $I_C \approx$ 1 Adc, $I_{B1} \approx$ 100 mAdc)	t_{on}	-	15	ns
Turn-Off Time (Figure 1) ($I_C \approx$ 1 Adc, $I_{B1} \approx -I_{B2} \approx$ 100 mAdc)	t_{off}	-	25	ns
Storage Time (Figure 2) ($I_C \approx$ 100 mAdc, $I_{B1} \approx -I_{B2} \approx$ 100 mAdc)	t_s	-	15	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle ≤ 2%

FIGURE 1 – TURN-ON AND TURN-OFF TIME TEST CIRCUIT

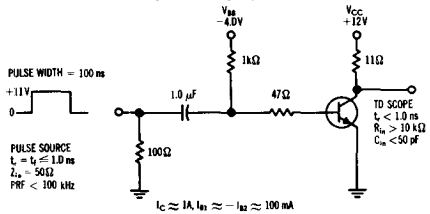
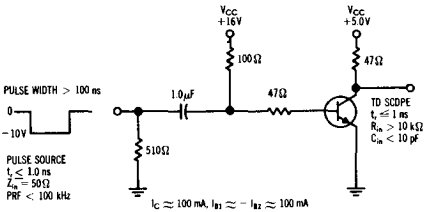


FIGURE 2 – STORAGE TIME TEST CIRCUIT



2N3444 (SILICON)

For Specifications, See 2N3252 Data Sheet

2N3467 (SILICON)
2N3468



$V_{CEO} = 40\text{-}50$ V
$I_C = 1$ A
$f_T = 150\text{-}175$ Mc



CASE 31
(TO-5)

PNP silicon annular transistors for high-speed switching and driver applications.

Collector connected to case

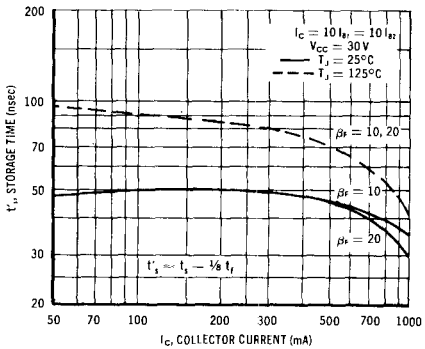
MAXIMUM RATINGS

Characteristic	Symbol	2N3467	2N3468	Unit
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

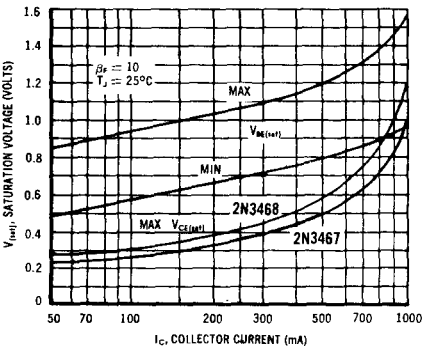
THERMAL RESISTANCE θ_{JA} (air) = 0.175°C/mW

θ_{JC} (case) = 35°C/W

STORAGE TIME VARIATION WITH TEMPERATURE



LIMITS OF SATURATION VOLTAGE



2N3467, 2N3468 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CBO}			μAdc
(V_{CB} = 30 Vdc, I_E = 0)			—	0.10	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 100°C)			—	15	
Collector Cutoff Current		I_{CEX}			nAdc
(V_{CE} = 30 Vdc, V_{OB} = 3 Vdc)			—	100	
Base Cutoff Current		I_{BL}			nAdc
(V_{CE} = 30 Vdc, V_{OB} = 3 Vdc)			—	120	
Collector-Base Breakdown Voltage		BV_{CBO}			Vdc
(I_C = 10 μAdc, I_E = 0)	2N3467		40	—	
	2N3468		50	—	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Vdc
(I_C = 10 mAdc, I_B = 0)	2N3467		40	—	
	2N3468		50	—	
Emitter-Base Breakdown Voltage		BV_{EBO}			Vdc
(I_E = 10 μAdc, I_C = 0)			5	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3467		—	0.3	
	2N3468		—	0.35	
(I_C = 500 mAdc, I_B = 50 mAdc)	2N3467		—	0.5	
	2N3468		—	0.6	
(I_C = 1 Adc, I_B = 100 mAdc)	2N3467		—	1.0	
	2N3468		—	1.2	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			0.8	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			—	1.6	
DC Forward Current Transfer Ratio*		h_{FE}*			—
(I_C = 150 mAdc, V_{CE} = 1.0 Vdc)	2N3467		40	—	
	2N3468		25	—	
(I_C = 500 mAdc, V_{CE} = 1.0 Vdc)	2N3467		40	120	
	2N3468		25	75	
(I_C = 1 Adc, V_{CE} = 5 Vdc)	2N3467		40	—	
	2N3468		25	—	
Output Capacitance		C_{ob}			pf
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)			—	25	
Input Capacitance		C_{ib}			pf
(V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)			—	100	
Current-Gain - Bandwidth Product		f_T			mc
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3467		175	—	
	2N3468		150	—	

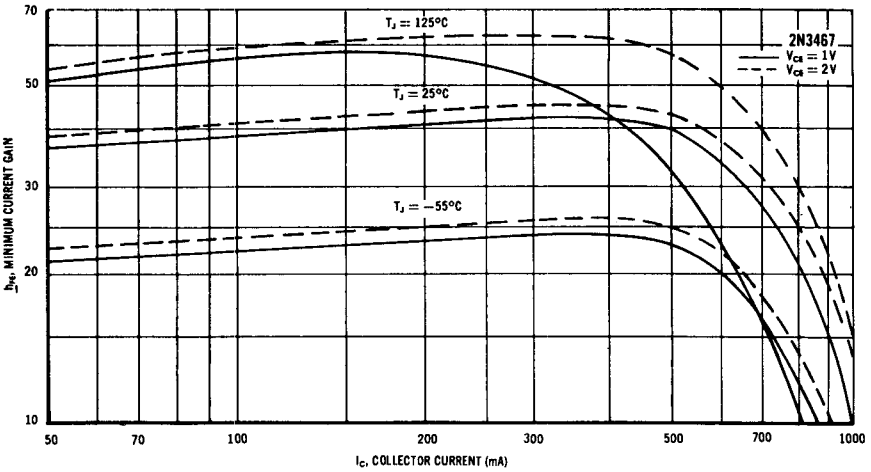
*Pulse Test: PW ≤300 μsec, Duty Cycle ≤2%

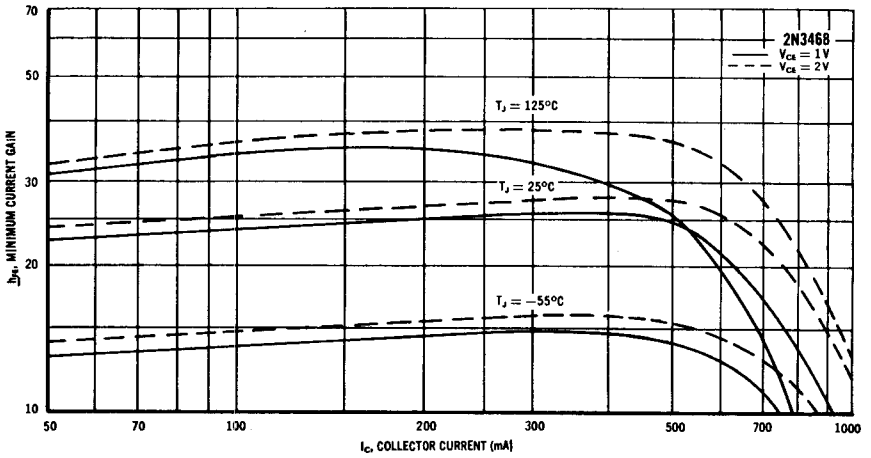
2N3467, 2N3468 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Delay Time	(I_C = 500 mA, I_{B1} = 50 mA, V_{OB} = 2 V, V_{CC} = 30 V)	t_d	—	10	nsec
Rise Time		t_r	—	30	nsec
Storage Time	(I_C = 500 mA, I_{B1} = I_{B2} = 50 mA, V_{CC} = 30 V)	t_s	—	60	nsec
Fall Time		t_f	—	30	nsec
Total Control Charge (I_C = 500 mA, I_B = 50 mA, V_{CC} = 30 V)		Q_T	—	6	nC

MINIMUM CURRENT GAIN CHARACTERISTICS

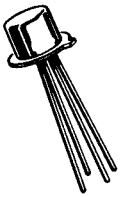




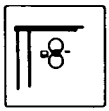
2N3485, A (SILICON)
2N3486, A

For Specifications, See 2N2904 Data Sheet

2N3493 (SILICON)



CASE 20
(TO-72)



$V_{CEO} = 8$ V
$C_{ob} = 0.7$ pF
$C_{ib} = 0.7$ pF

NPN silicon annular transistor for high-speed micro-power logic switching.

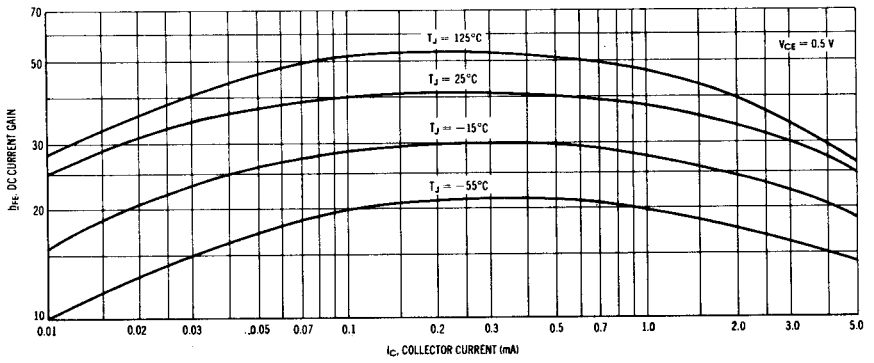
Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	12	Vdc
Collector-Emitter Voltage	V_{CEO}	8	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	250 1.43	mW mW/°C
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	150 0.86	mW mW/°C
Junction Operating Temperature Range	T_J	-65 to +200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

THERMAL RESISTANCE $\theta_{JA} = 1.16°C/mW$ $\theta_{JC} = 0.70°C/mW$

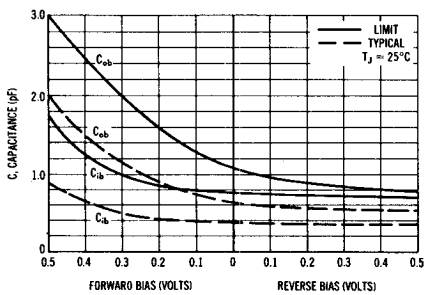
MINIMUM CURRENT GAIN CHARACTERISTICS

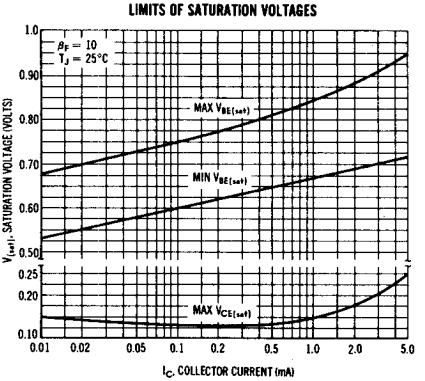


2N3493 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 6 V, V_{EB} = 2 V)	I_{CEX}	--	5	nAdc
Base Cutoff Current (V_{CE} = 6 V, V_{EB} = 2 V)	I_{BL}	--	5	nAdc
(V_{CE} = 6 V, V_{EB} = 2 V, T_A = 150 °C)		--	500	
Collector-Base Breakdown Voltage (I_C = 10 μA, I_E = 0)	BV_{CBO}	12	--	Vdc
Collector-Emitter Breakdown Voltage (I_E = 1 mA, I_B = 0)	BV_{CEO}	8	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μA, I_C = 0)	BV_{EBO}	5	--	Vdc
Collector-Emitter Saturation Voltage (I_C = 10 μAdc, I_B = 1 μAdc)	$V_{CE(sat)}$	--	0.15	Vdc
(I_C = 100 μA, I_B = 10 μA)		--	0.13	
(I_C = 5 mA, I_B = 0.5 mA)		--	0.25	
Base-Emitter Saturation Voltage (I_C = 100 μA, I_B = 10 μA)	$V_{BE(sat)}$	0.60	0.75	Vdc
(I_C = 5 mA, I_B = 0.5 mA)		--	0.95	
DC Forward Current Gain (I_C = 10 μA, V_{CE} = 0.5 V)	h_{FE}	25	--	--
(I_C = 100 μA, V_{CE} = 0.5 V)		40	--	
(I_C = 100 μA, V_{CE} = 0.5 V (-55°C))		20	--	
(I_C = 500 μA, V_{CE} = 0.5 V)		40	120	
(I_C = 5 mA, V_{CE} = 0.5 V)		25	--	
High Frequency Current Gain (I_C = 1 mA, V_{CE} = 3 V, f = 100 mc)	h_{fe}	4.0	--	--
Output Capacitance (V_{CB} = 3 V, I_E = 0, f = 100 kc - Includes 0.3 pF Can Capacitance)	C_{ob}	--	0.7	pF
Input Capacitance (V_{OB} = 0.5 V, I_C = 0, f = 100 kc)	C_{ib}	--	0.7	pF

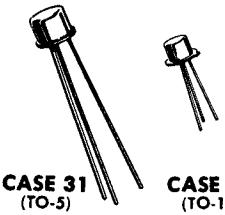




2N3494 thru 2N3497 (SILICON)



V_{CEO} = 80-120 V
I_C = 100 mA
f_T = 150-200 Mc



CASE 31 (TO-5) — 2N3494, 2N3495

CASE 22 (TO-18) — 2N3496, 2N3497

Collector connected to case

PNP silicon annular Star transistors for high voltage switching and DC to VHF amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N 3494 (TO-5)	2N 3495 (TO-5)	2N 3496 (TO-18)	2N 3497 (TO-18)	Unit
Collector-Base Voltage	V_{CBO}	80	120	80	120	Vdc
Collector-Emitter Voltage	V_{CEO}	80	120	80	120	Vdc
Emitter-Base Voltage	V_{EBO}	4.5		4.5		Vdc
Collector Current	I_C	100		100		mA
Total Device Dissipation @ T_C = 25°C Derate Above 25°C	P_D	3 17.2		1.8 10.3		Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	600 3.43		400 2.28		mW mW/°C
Junction Temperature	T_J	-65 to +200				°C
Storage Temperature	T_{stg}	-65 to +200				°C

SWITCHING CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic	Symbol	Min	Max	Unit
Turn-On Time (V_{CC} = 30 V, I_C = 10 mA, I_{B1} = 1 mA, V_{OB} = 0)	t_{on}	—	300	nsec
Turn-Off Time (V_{CC} = 30 V, I_C = 10 mA, I_{B1} = I_{B2} = 1 mA)	t_{off}	—	450	nsec

2N3494 thru 2N3497 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3494, 2N3496	BV_{CBO}	80	—	Vdc
	2N3495, 2N3497		120	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3494, 2N3496	BV_{CEO}*	80	—	Vdc
	2N3495, 2N3497		120	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	4.5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)	2N3494, 2N3496	I_{CBO}	—	100	nAdc
(V_{CB} = 90 Vdc, I_E = 0)	2N3495, 2N3497		—	100	
Emitter-Base Leakage Current (V_{CB} = 3 Vdc)	All Types	I_{EBO}	—	25	nAdc
DC Forward Current Transfer Ratio (I_C = 100 μAdc, V_{CE} = 10 Vdc)	All Types	h_{FE}	35	—	—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	All Types		40	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N3494, 2N3496		35	—	
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	2N3494, 2N3496	$V_{CE(sat)}$	—	0.3	Vdc
	2N3495, 2N3497		—	0.35	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	All Types	$V_{BE(sat)}$	0.6	0.9	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	2N3494, 2N3496	C_{ob}	—	7	pf
	2N3495, 2N3497		—	6	
Input Capacitance (V_{OB} = 2 Vdc, I_C = 0, f = 100 kc)	All Types	C_{ib}	—	30	pf
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3494, 2N3496	f_T	200	—	mc
	2N3495, 2N3497		150	—	
Small Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	All Types	h_{fe}	40	300	—
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	All Types	h_{ie}	0.1	1.2	kohms
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	All Types	h_{re}	—	2.0	$X10^{-4}$
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	All Types	h_{oe}	—	300	μ mhos
Extrinsic Base Resistance (V_{CE} = 10 V, I_C = 20 mA, f = 300 mc)	All Types	r_b	—	30	ohms

* Pulse width ≤ 300 μsec, Duty Cycle = 2%

2N3498 thru 2N3501 (SILICON)

V_{CEO} = 100-150 V
I_C = 300-500 mA
C_{ob} = 8-10 pf



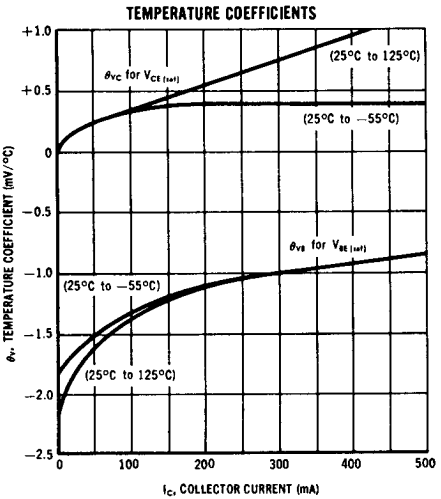
CASE 31
(TO-5)

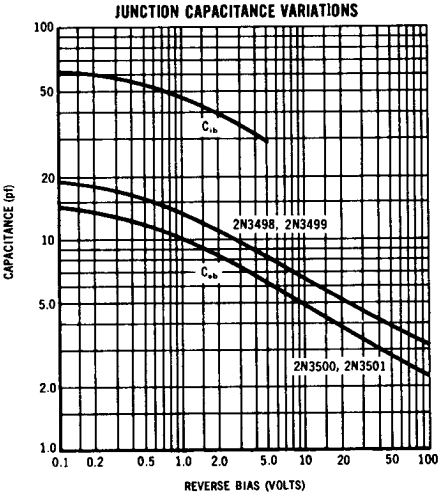
NPN silicon annular transistors for high voltage switching and low-power amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N3498 2N3499	2N3500 2N3501	Unit
Collector-Base Voltage	V_{CBO}	100	150	Vdc
Collector-Emitter Voltage	V_{CEO}	100	150	Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
Collector Current	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watt mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
Thermal Resistance	θ_{JA} θ_{JC}	0.175 35		°C/mW °C/W





2N3498 thru 2N3501 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current					
(V_{CB} = 50 Vdc, I_E = 0)	2N3498, 2N3499	I_{CBO}	—	0.050	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	50	
(V_{CB} = 75 Vdc, I_E = 0)	2N3500, 2N3501		—	0.050	
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)			—	50	
Emitter Cutoff Current					
(V_{OB} = 4 Vdc, I_C = 0)	All Types	I_{EBO}	—	25	nAdc
Collector-Base Breakdown Voltage	2N3498, 2N3499		100	—	
(I_C = 10 μAdc, I_E = 0)	2N3500, 2N3501	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage*	2N3498, 2N3499		100	—	
(I_C = 10 mAdc, I_B = 0)	2N3500, 2N3501	BV_{CEO}*	150	—	Vdc
Emitter-Base Breakdown Voltage					
(I_E = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	6	—	Vdc
Collector Saturation Voltage*					
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		—	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types		—	0.25	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501	$V_{CE(sat)}$*	—	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		—	0.6	
Base-Emitter Saturation Voltage*					
(I_C = 10 mAdc, I_B = 1 mAdc)	All Types		—	0.8	
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types		—	0.9	
(I_C = 150 mAdc, I_B = 15 mAdc)	2N3500, 2N3501	$V_{BE(sat)}$*	—	1.2	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)	2N3498, 2N3499		—	1.4	
DC Forward Current Transfer Ratio*					
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		20	—	
	2N3499, 2N3501		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		25	—	
	2N3499, 2N3501		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		35	—	
	2N3499, 2N3501		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3498, 2N3500		40	120	
	2N3499, 2N3501		100	300	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	2N3500		15	—	
	2N3501		20	—	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	2N3498		15	—	
	2N3499		20	—	
Small Signal Current Gain	2N3498, 2N3500		50	300	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3499, 2N3501	h_{fe}	75	375	—
Voltage Feedback Ratio	2N3498, 2N3500		—	2.5	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3499, 2N3501	h_{re}	—	4	X10^{-4}
Input Impedance	2N3498, 2N3500		0.2	1.0	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3499, 2N3501	h_{ie}	0.25	1.25	k ohms
Output Admittance	2N3498, 2N3500		10	100	
(I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3499, 2N3501	h_{oe}	20	200	μmhos
Output Capacitance	2N3498, 2N3499		—	10	
(V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	2N3500, 2N3501	C_{ob}	—	8	pF

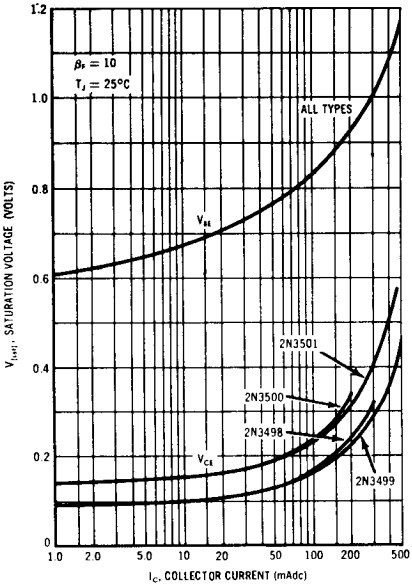
*Pulse Test: PW ≤ 300 μsec, duty cycle ≤ 2% V_{OB} - Base-Emitter, off bias

2N3498 thru 2N3501 (continued)

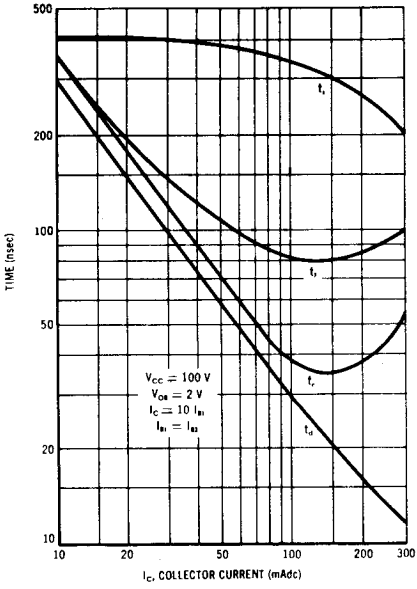
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc) All Types	C_{ib}	—	80	pF
Small Signal Current Gain (V_{CE} = 20 Vdc, I_C = 20 mAdc, f = 100 mc) All Types	$\|h_{fe}\|$	1.5	—	—
		Typ		
Delay Time (I_C = 150 mA, I_{B1} = 15 mA, V_{CC} = 100 V, V_{OB} = 2.0 V)	t_d	20		nsec
Rise Time (I_C = 150 mA, I_{B1} = 15 mA, V_{CC} = 100 V, V_{OB} = 2.0 V)	t_r	35		nsec
Storage Time (I_C = 150 mA, I_{B1} = I_{B2} = 15 mA, V_{CC} = 100 V)	t_s	300		nsec
Fall Time (I_C = 150 mA, I_{B1} = I_{B2} = 15 mA, V_{CC} = 100 V) 2N3498, 2N3499	t_f	80		nsec

SATURATION VOLTAGES

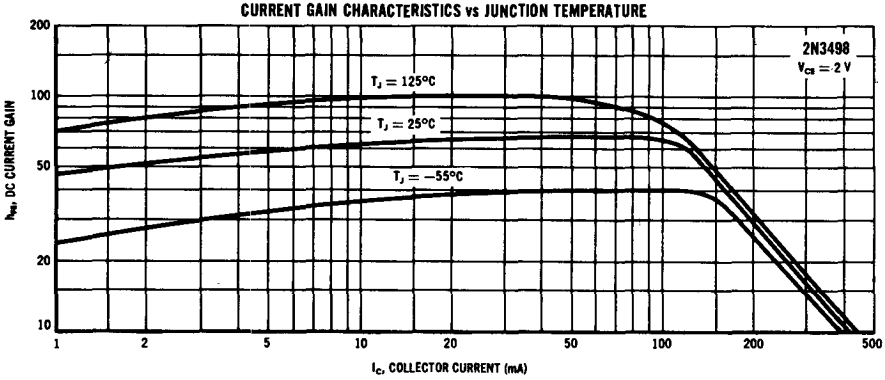


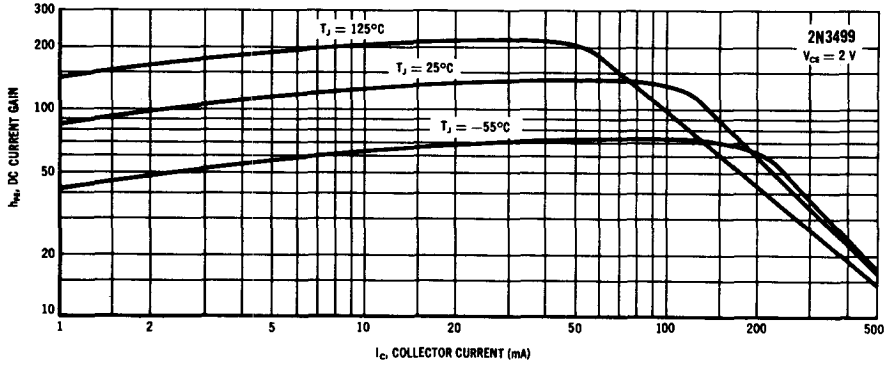
SWITCHING TIMES



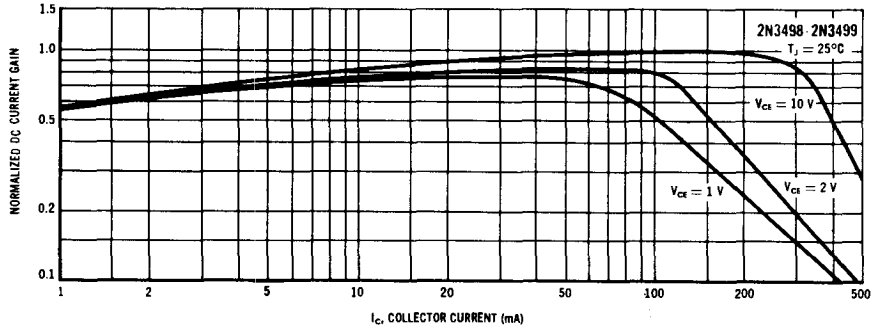
2N3498 thru 2N3501 (continued)

CURRENT GAIN CHARACTERISTICS vs JUNCTION TEMPERATURE



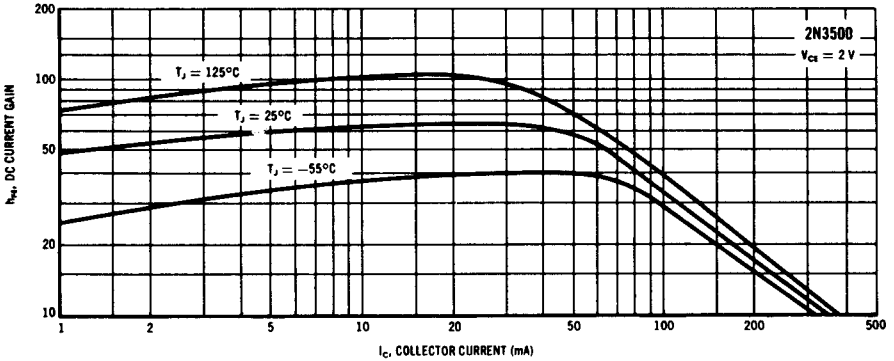


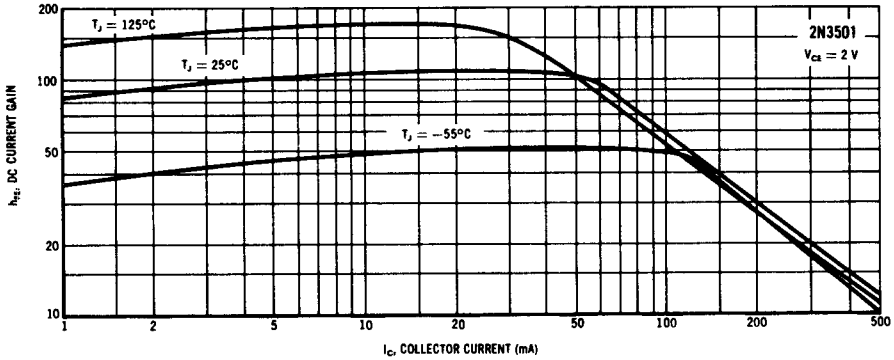
CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE



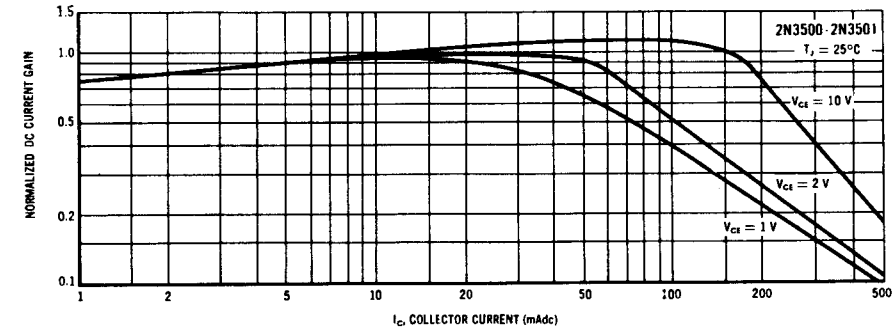
2N3498 thru 2N3501 (continued)

CURRENT GAIN CHARACTERISTICS vs JUNCTION TEMPERATURE





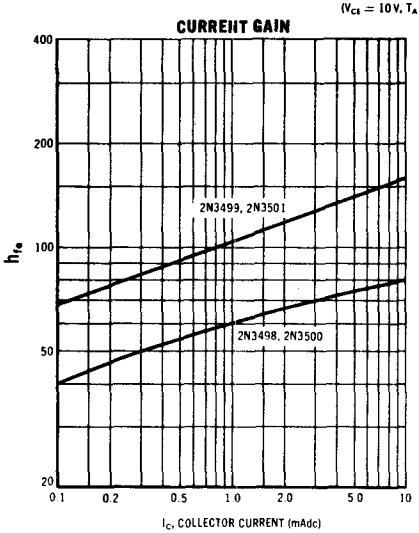
CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE

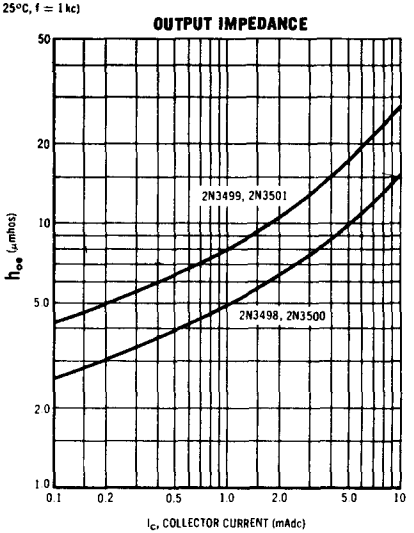


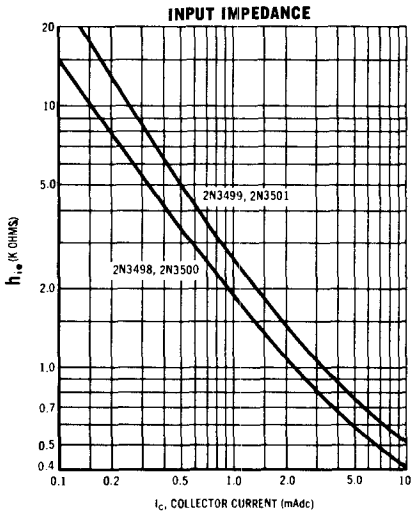
2N3498 thru 2N3501 (continued)

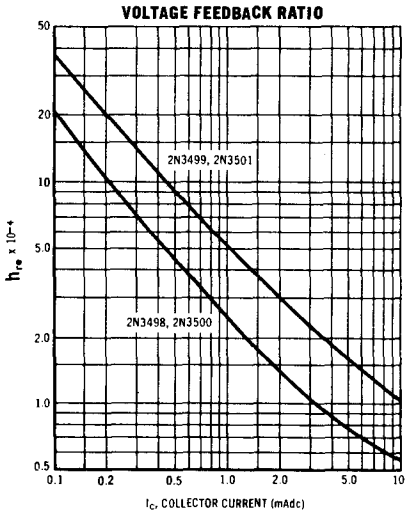
SMALL SIGNAL h PARAMETER CHARACTERISTICS

(V_{CE} = 10 V, T_A = 25°C, f = 1 kc)

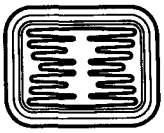








2N3506 (SILICON)
2N3507



V_{CEO} = 40-50 V
I_C = 3 A
f_T = 100 Mc Typ



CASE 31
(TO-5)

NPN silicon annular transistors for high-current, high-speed, saturated switching and core driver applications.

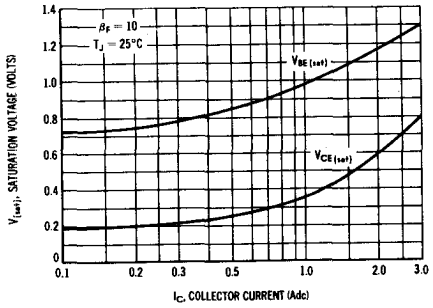
Collector connected to case

MAXIMUM RATINGS

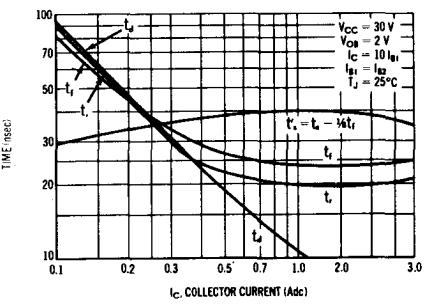
Characteristic	Symbol	2N3506	2N3507	Unit
Collector-Base Voltage	V_{CBO}	60	80	Vdc
Collector-Emitter Voltage	V_{CEO}	40	50	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	3		Adc
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	1.0 5.71		Watts mW/°C
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE $\theta_{JA} = 0.175°C/mW$
$\theta_{JC} = 35°C/W$

SATURATION VOLTAGES



SWITCHING TIMES



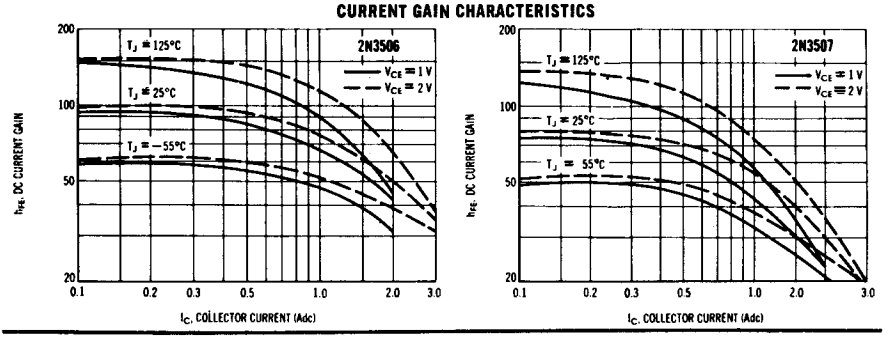
2N3506, 2N3507 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, V_{OB} = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 40 Vdc, V_{OB} = 4 Vdc, T_A = 100°C)			--	150	
(V_{CE} = 60 Vdc, V_{OB} = 4 Vdc)	2N3507		--	1.0	
(V_{CE} = 60 Vdc, V_{OB} = 4 Vdc, T_A = 100°C)			--	150	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 40 Vdc, V_{OB} = 4 Vdc)	2N3506		--	1.0	
(V_{CE} = 60 Vdc, V_{OB} = 4 Vdc)	2N3507		--	1.0	
Collector-Base Breakdown Voltage	2N3506	BV_{CBO}	60	--	Vdc
(I_C = 100 μAdc, I_E = 0)	2N3507		80	--	
Collector-Emitter Breakdown Voltage*	2N3506	BV_{CEO}*	40	--	Vdc
(I_C = 10 mAdc, pulsed, I_B = 0)	2N3507		50	--	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	--	Vdc
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	0.5	
(I_C = 1.5 Adc, I_B = 150 mAdc)			--	1.0	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	1.5	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 500 mAdc, I_B = 50 mAdc)			--	1.0	
(I_C = 1.5 Adc, I_B = 150 mAdc)			0.9	1.4	
(I_C = 2.5 Adc, I_B = 250 mAdc)			--	2.0	
DC Current Gain*		h_{FE}*			--
(I_C = 500 mAdc, V_{CE} = 1 Vdc)	2N3506		50	--	
	2N3507		35	--	
(I_C = 1.5 Adc, V_{CE} = 2 Vdc)	2N3506		40	200	
	2N3507		30	150	
(I_C = 2.5 Adc, V_{CE} = 3 Vdc)	2N3506		30	--	
	2N3507		25	--	
(I_C = 3.0 Adc, V_{CE} = 5 Vdc)	2N3506		25	--	
	2N3507		20	--	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	--	40	pf
Input Capacitance (V_{OB} = 3 Vdc, I_C = 0, f = 100 kc)		C_{ib}	--	300	pf
Current Gain-Bandwidth Product (I_C = 100 mAdc, V_{CE} = 5 Vdc, f = 20 mc)		f_T	60	--	mc
Delay Time	I_C = 1.5 Adc, I_{B1} = 150 mAdc	t_d	--	15	nsec
Rise Time	V_{CC} = 30 V, V_{OB} = 0 V	t_r	--	30	nsec
Storage Time	I_C = 1.5 Adc, I_{B1} = I_{B2} = 150 mAdc	t_s	--	55	nsec
Fall Time	V_{CC} = 30 V	t_f	--	35	nsec

*Pulse Test: Pulse width = 300 μsec, duty cycle = 2%

2N3506, 2N3507 (continued)



2N3508 (SILICON)
2N3509

V_{CEO} = 20 V
I_C = 500 mA
f_T = 500 Mc



CASE 26
(TO-46)

NPN silicon annular transistor for high-speed, low-current switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	6.0	Vdc
Collector Current (10 μsec pulse)	$I_{C(Peak)}$	500	mA
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor Above 25°C	P_D	0.40 2.29	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derating Factor Above 25°C	P_D	2.0 11.43	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance	θ_{JC} θ_{JA}	0.438 0.0875	°C/mW °C/mW

2N3508, 2N3509 (continued)

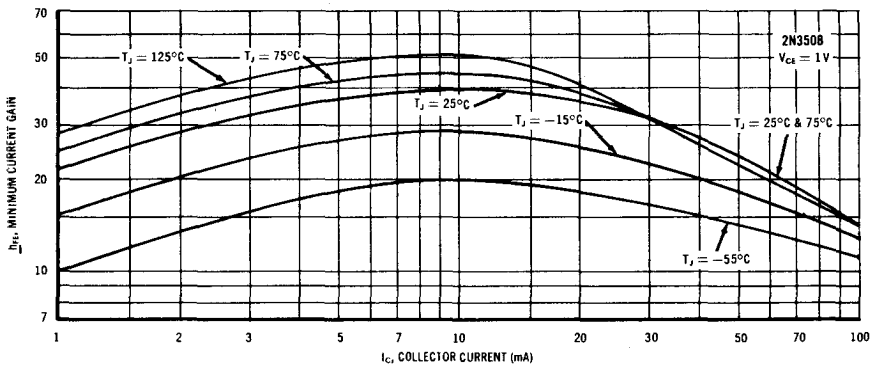
ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

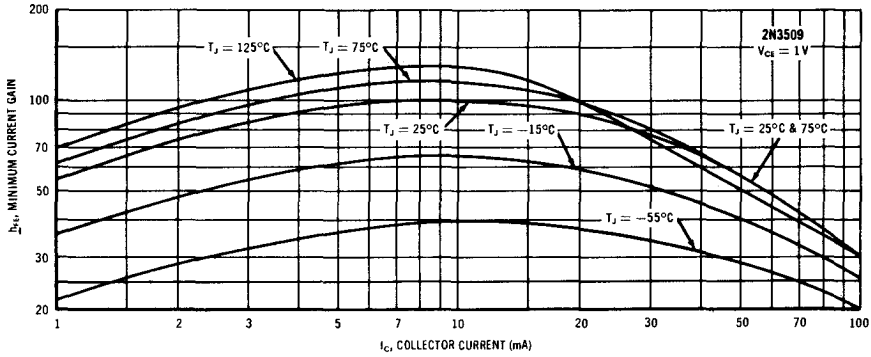
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 20 Vdc)	Both Types	I_{CBO}	—	0.2	μAdc
(V_{CB} = 20 Vdc, T_A = 150°C)	2N3308		—	30	
	2N3309		—	50	
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{OB} = 3 Vdc)		I_{CEX}	—	0.2	μAdc
Base Cutoff Current (V_{CE} = 20 Vdc, V_{OB} = 3 Vdc)		I_{BL}	—	0.5	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CBO}	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6.0	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)		BV_{CEO}*	20	—	Vdc
Collector-Emitter Voltage (I_C = 10 μAdc, I_B = 0)		BV_{CES}	40	—	Vdc
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$*	—	0.25	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			—	0.45	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	0.70	0.85	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)			0.8	1.4	
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1.0 Vdc)	2N3508	h_{FE}*	40	120	—
	2N3509		100	300	
(I_C = 10 mAdc, V_{CE} = 1.0 Vdc, T_A = -55°C)	2N3508		20	—	
	2N3509		40	—	
(I_C = 100 mAdc, V_{CE} = 1.0 Vdc)	2N3508		20	—	
	2N3509		30	—	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		h_{fe}	5	—	—
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kc)		C_{ob}	—	4	pf
Input Capacitance (V_{OB} = 1 Vdc, I_C = 0, f = 140 kc)		C_{ib}	—	4	pf
Storage Time (I_C = I_{B1} = I_{B2} = 10 mA)		t_s (τ_s)	—	13	nsec
Turn-On Time (I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 3 V, V_{OB} = 1.5 V)		t_{on}	—	12	nsec
Turn-Off Time (I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1.5 mA, V_{CC} = 3 V)		t_{off}	—	18	nsec
Total Control Charge (I_C = 10 mA, I_B = 1 mA, V_{CC} = 3 V)		Q_T	—	50	pC
Delay Time	V_{CC} = 10 V, V_{OB} = 2 V, I_C = 100 mA, I_{B1} = 10 mA	t_d	—	5	nsec
Rise Time		t_r	—	18	nsec
Storage Time	V_{CC} = 10 V, I_C = 100 mA, I_{B1} = I_{B2} = 10 mA	t_s	—	13	nsec
Fall Time		t_f	—	15	nsec

*Pulse Test: PW = 300μsec, Duty Cycle ≤ 2%

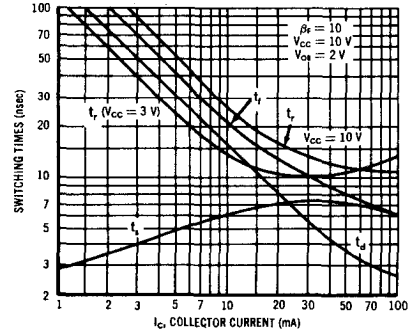
2N3508, 2N3509 (continued)

MINIMUM CURRENT GAIN CHARACTERISTICS

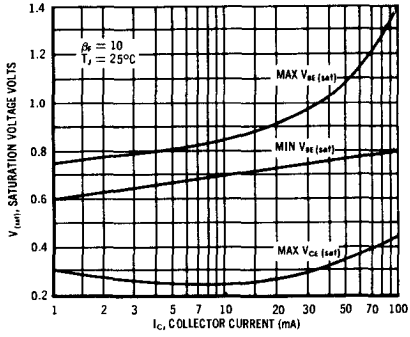




TYPICAL SWITCHING TIMES



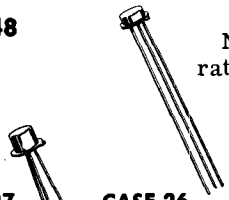
LIMITS OF SATURATION VOLTAGE



2N3510 (SILICON)
2N3511
2N3647
2N3648

V_{CEO} = 10-15 V
I_C = 500 mA
f_T = 350-450 Mc

NPN silicon annular transistors for high-speed saturated switching applications to 500 mA.



Collector connected to case



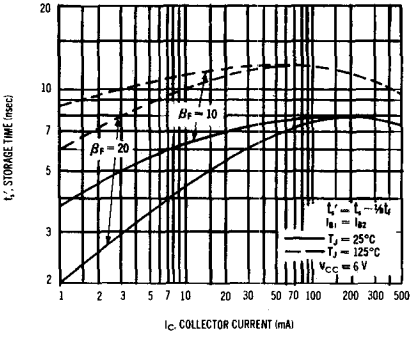
CASE 27 (TO-52)

CASE 26 (TO-46)

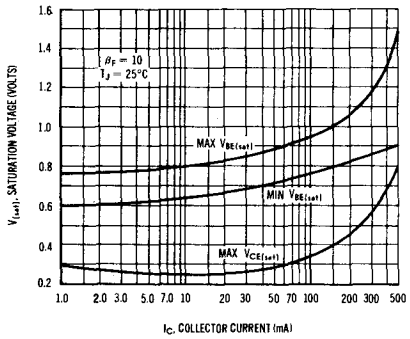
MAXIMUM RATINGS

Characteristic	Symbol	2N3510 2N3647	2N3511 2N3648	Unit
Collector-Base Voltage	V_{CBO}	40	40	Vdc
Collector-Emitter Voltage	V_{CEO}	10	15	Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
Collector Current	I_C	500		mAdc
		TO-46 2N3647 2N3648	TO-52 2N3510 2N3511	
Total Device Dissipation @T_A = 25°C Derating Factor Above 25°C	P_D	400 2.28	360 2.06	mW mW/°C
Total Device Dissipation @T_C = 25°C Derating Factor Above 25°C	P_D	2.0 11.43	1.2 6.9	Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

STORAGE TIME VARIATION



LIMITS OF SATURATION VOLTAGE



2N3510, 2N3511, 2N3647, 2N3648 (continued)

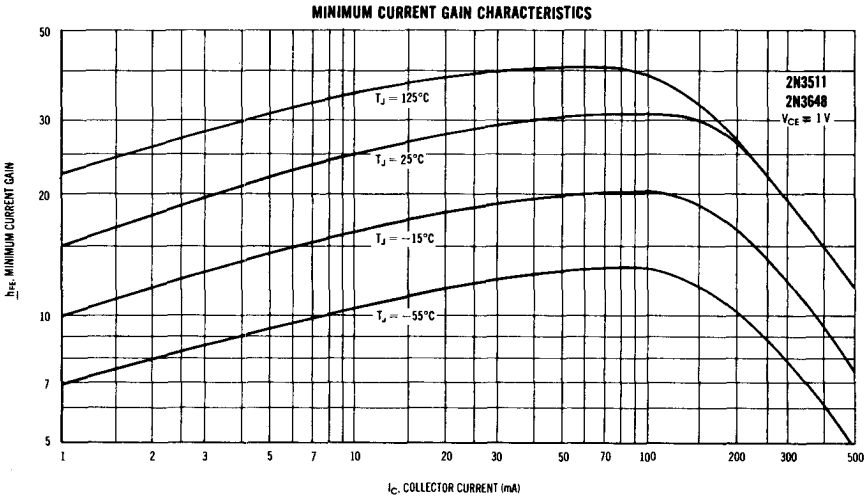
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

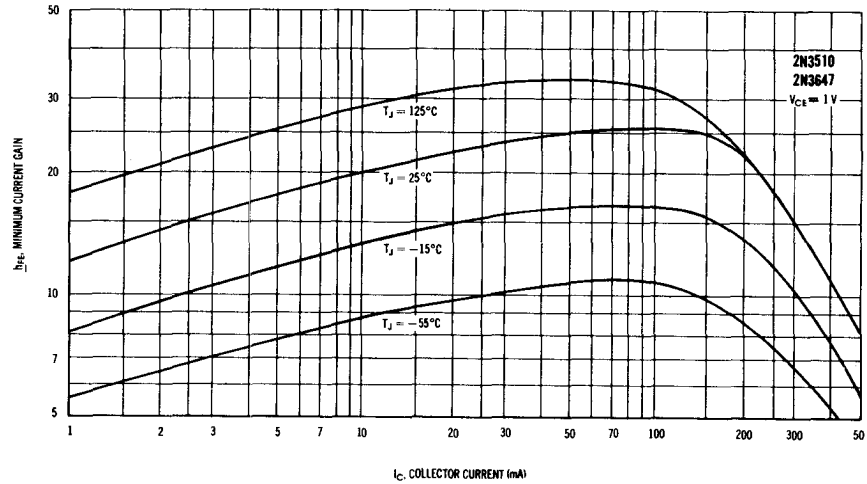
Characteristic			Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CE} = 10 Vdc, V_{OB}† = 1 Vdc) (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc, T_A = 150°C)			I_{CEX}	— —	.025 50	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{OB} = 1 Vdc)			I_{BL}	—	.025	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		2N3510, 2N3647 2N3511, 2N3648	BV_{CEO}*	10 15	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6	—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		All Types All Types 2N3510, 2N3647 2N3511, 2N3648	$V_{CE(sat)}$*	— — — —	0.25 0.4 0.6 0.8	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 150 mAdc, I_B = 15 mAdc) (I_C = 300 mAdc, I_B = 30 mAdc) (I_C = 500 mAdc, I_B = 50 mAdc)		All Types All Types 2N3510, 2N3647 2N3511, 2N3648	$V_{BE(sat)}$*	— 0.8 — —	0.8 1.0 1.15 1.5	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc) (I_C = 150 mAdc, V_{CE} = 1 Vdc, TA = -55°C) (I_C = 300 mAdc, V_{CE} = 1 Vdc) (I_C = 500 mAdc, V_{CE} = 1 Vdc)		2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648 2N3511, 2N3648 2N3510, 2N3647 2N3511, 2N3648	h_{FE}*	12 15 20 25 25 30 12 15 12	— — — — 150 120 — — —	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)			C_{ob}	—	4	pf
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)			C_{ib}	—	8	pf
Small Signal Current Gain (I_C = 15 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		2N3510, 2N3647 2N3511, 2N3648	h_{fe}	3.5 4.5	— —	mc
Delay Time	(I_C = 150 mA, I_{B1} = 15 mA, V_{OB} = 0.5 V, V_{CC} = 6 V)	2N3510, 2N3647 2N3511, 2N3648	t_d	— —	10 6	nsec
Rise Time		2N3510, 2N3647 2N3511, 2N3648	t_r	— —	12 10	nsec
Turn-On Time		2N3510, 2N3647 2N3511, 2N3648	t_{on}	— —	20 16	nsec
Storage Time	(I_C = 150 mA, I_{B1} = -I_{B2} = 15 mA, V_{CC} = 6 V)	2N3510, 2N3647 2N3511, 2N3648	t_s	— —	18 12	nsec
Fall Time		2N3510, 2N3647 2N3511, 2N3648	t_f	— —	12 8	nsec
Turn-Off Time		2N3510, 2N3647 2N3511, 2N3648	t_{off}	— —	25 16	nsec
Total Control Charge (I_C = 150 mA, I_B = 15 mA, V_{CC} = 6 V)			Q_T	—	300	pC
Small Signal Current Gain (I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)			h_{fe}	20	150	—
Voltage Feedback Ratio (I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)			h_{re}	—	25	X10^{-4}
Input Impedance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)			h_{ie}	0.6	4.5	kohms
Output Admittance (I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)			h_{oe}	10	100	μmhos

* Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

V_{OB} = Base-Emitter Reverse Bias

2N3510, 2N3511, 2N3647, 2N3648 (continued)





2N3546 (SILICON)

$V_{CEO} = 12$ V
$t_s = 20$ nsec



CASE 22
(TO-18)

PNP silicon annular transistor for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	0.36 2.06	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	1.2 6.9	Watts mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance	θ_{JA} θ_{JC}	0.49 0.15	°C/mW °C/mW

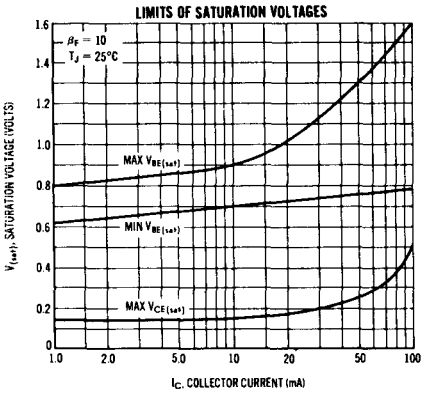
2N3546 (continued)

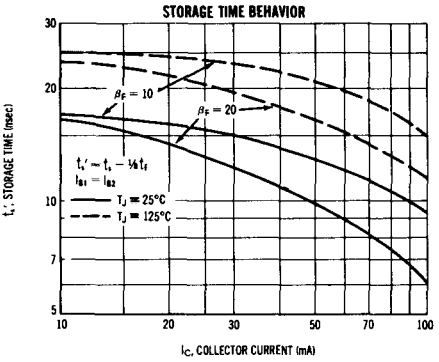
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

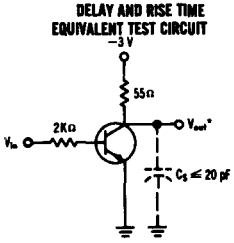
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 10 Vdc) (V_{CB} = 10 Vdc, T_A = 150°C)		I_{CBO}	-- --	0.010 10	μAdc
Collector Cutoff Current (V_{CB} = 10 Vdc, V_{OB} = 3 Vdc)		I_{CEX}	--	0.010	μAdc
Base Cutoff Current (V_{CB} = 10 Vdc, V_{OB} = 3 Vdc)		I_{BL}	--	0.10	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	15	--	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	--	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	12	--	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{CE(sat)}$*	-- -- --	0.15 0.25 0.50	Vdc
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)		$V_{BE(sat)}$*	0.7 0.8 --	0.9 1.3 1.6	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc) (I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C) (I_C = 50 mAdc, V_{CE} = 1 Vdc) (I_C = 100 mAdc, V_{CE} = 1Vdc)		h_{FE}*	20 30 15 25 15	-- 120 -- -- --	--
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = I mc)		C_{ob}	--	6	pF
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 1 mc)		C_{ib}	--	5	pF
Current-Gain - Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		f_T	700	--	mc
Total Control Charge (I_C = 50 mA, I_B = 5 mA, V_{CC} = 3 V)		Q_T	--	400	pC
Delay Time	I_C = 50 mA, I_{B1} = 5mA,	t_d	--	10	nsec
Rise Time	V_{OB} = 2 V, V_{CC} = 3 V	t_r	--	15	nsec
Storage Time	I_C = 50 mA, I_{B1} = I_{B2} = 5 mA,	t_s	--	20	nsec
Fall Time	V_{CC} = 3 V	t_f	--	15	nsec
Turn-On Time	Refer to Page 8-177 for Test Circuit	t_{on}	--	40	nsec
Turn-Off Time		t_{off}	--	30	nsec

*Pulse Test: PW = 300 μsec, Duty Cycle ≤ 2%

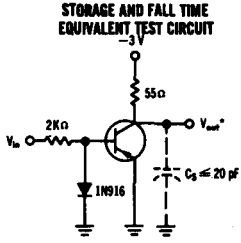
2N3546 (continued)



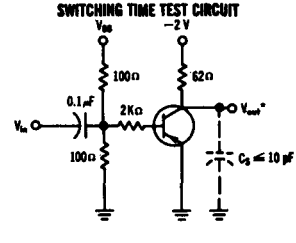




PULSE WIDTH = 200 nsec
RISE TIME ≤ 2 nsec
DUTY CYCLE ≤ 10%



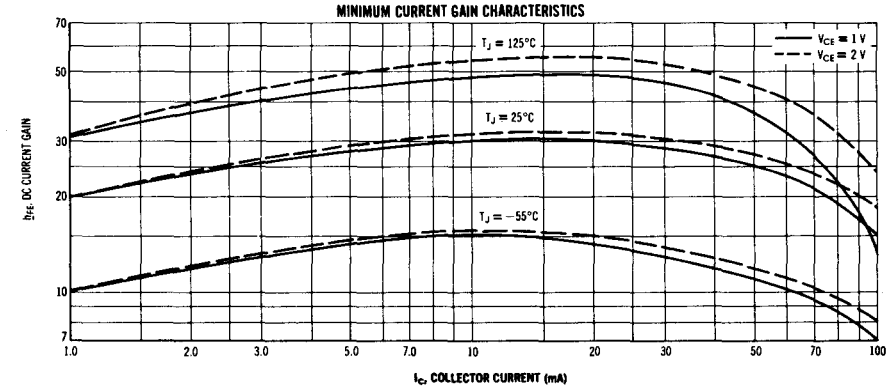
PULSE WIDTH = 200 nsec
RISE TIME ≤ 2 nsec
DUTY CYCLE ≤ 10%



PULSE WIDTH > 200 nsec
RISE TIME < 1 nsec
$Z_{in} = 50\Omega$

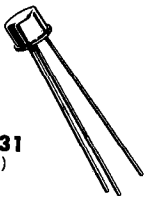
t_{on} : $V_{CE} = +3$ V, $V_{in} = -7$ V
t_{off} : $V_{CE} = -4$ V, $V_{in} = +6$ V

*OSCILLOSCOPE RISE TIME ≤ 1 nsec



2N3634 thru 2N3637 (SILICON)

V_{CEO} = 140-175 V
f_T = 150 - 200 Mc



CASE 31
(TO-5)

PNP silicon annular transistor for high-voltage switching and low-power amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Max 2N3634 2N3635	Max 2N3636 2N3637	Unit
Collector-Base Voltage	V_{CBO}	140	175	Vdc
Collector-Emitter Voltage	V_{CEO}	140	175	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	1		Adc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watts mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

FIGURE 1 — JUNCTION CAPACITANCE VARIATIONS

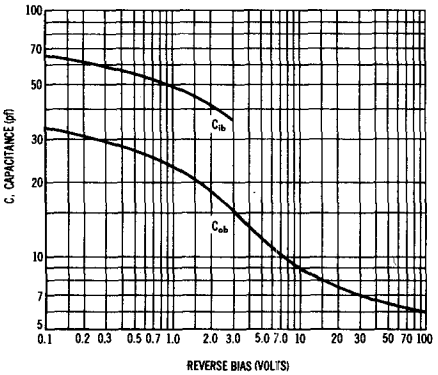
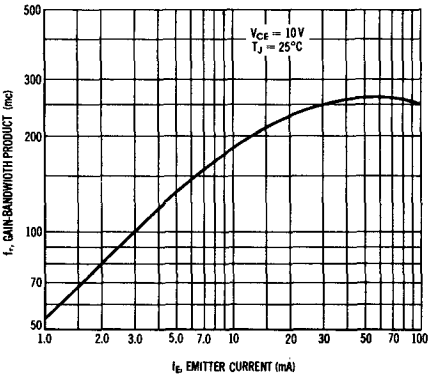


FIGURE 2 — GAIN-BANDWIDTH PRODUCT



2N3634 thru 2N3637 (continued)

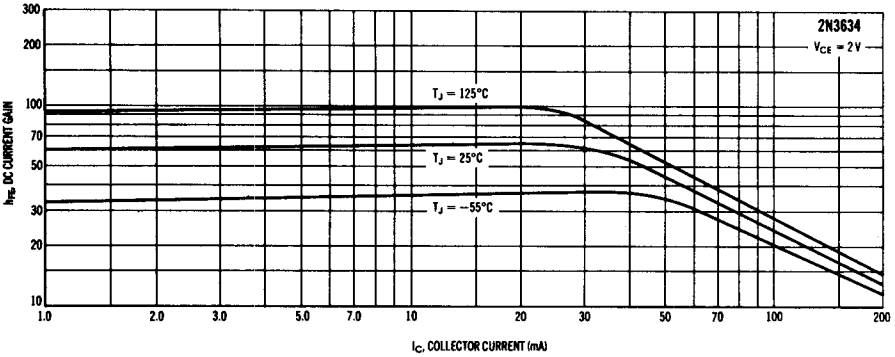
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N3634, 2N3635 2N3636, 2N3637	–	BV_{CBO}	140 175	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3634, 2N3635 2N3636, 2N3637	–	BV_{CEO}*	140 175	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	–	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)	All Types	11, 12	$V_{CE(sat)}$*	—	0.3	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types			—	0.5	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)	All Types	11, 12	$V_{BE(sat)}$*	—	0.8	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)	All Types			0.65	0.9	
DC Current Gain		3, 4, 5, 6	h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			40 80	— —	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			45 90	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			50 100	— —	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			50 100	150 300	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	2N3634, 2N3636 2N3635, 2N3637			25 50	— —	
Small Signal Current Gain (V_{CE} = 30 Vdc, I_C = 30 mAdc, f = 100 mc)	2N3634, 2N3636 2N3635, 2N3637	2	$\|h_{fe}\|$	1.5 2.0	— —	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kc)	All Types	1	C_{ob}	—	10	pf
Input Capacitance (V_{OB} = 1.0 Vdc, I_C = 0, f = 100 kc)	All Types	1	C_{ib}	—	75	pf
Collector Cutoff Current (V_{CB} = 100 Vdc, I_E = 0)	All Types	–	I_{CBO}	—	100	nAdc
Emitter Cutoff Current (V_{OB} = 3 Vdc, I_C = 0)	All Types	–	I_{EBO}	—	50	nAdc
Small Signal Current Gain (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3634, 2N3636 2N3635, 2N3637	9	h_{fe}	40 80	160 320	—
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	All Types	10	h_{re}	—	3	$X10^{-4}$
Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	2N3634, 2N3636 2N3635, 2N3637	7	h_{ie}	100 200	600 1200	ohms
Output Admittance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	All Types	8	h_{oe}	—	200	μmhos
Noise Figure (I_C = 0.5 mA, V_{CE} = 10 V, f = 1 kc, R_g = 1 kΩ)	All Types	–	NF	—	3	db
Turn-On Time	V_{CC} = 100V, I_C = 50 mA, All Types	13, 14	t_{on}	—	400	nsec
Turn-Off Time	I_{B1} = I_{B2} = 5 mA, V_{OB} = 4 V All Types	13, 15	t_{off}	—	600	nsec

*Pulse Width ≤ 300 μsec, duty cycle ≤ 2% V_{OB} – Base-Emitter Off Bias

2N3634 thru 2N3637 (continued)

FIGURE 3 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



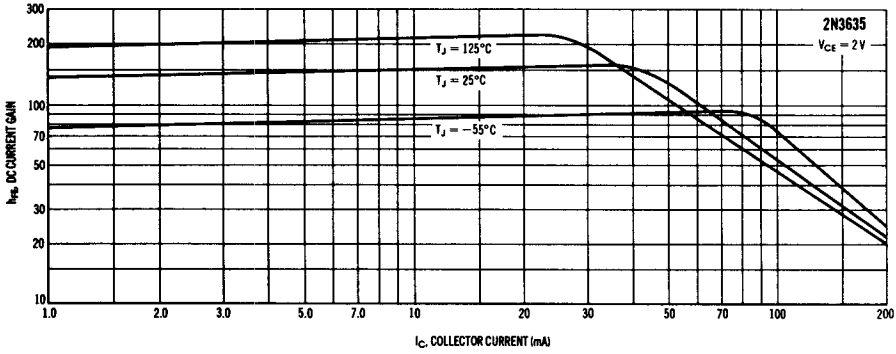
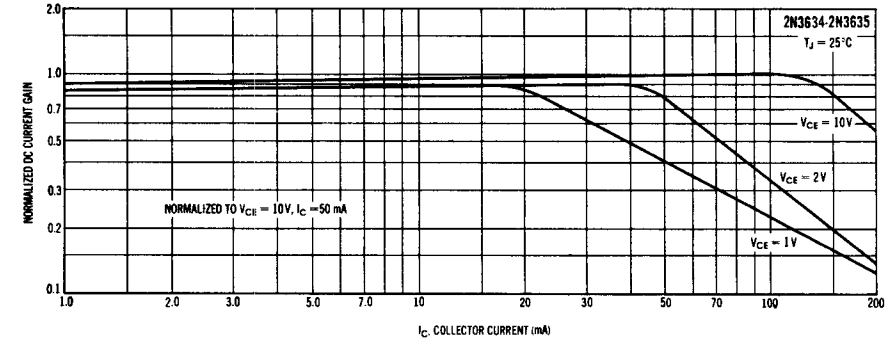


FIGURE 4 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE



2N3634 thru 2N3637 (continued)

FIGURE 5 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

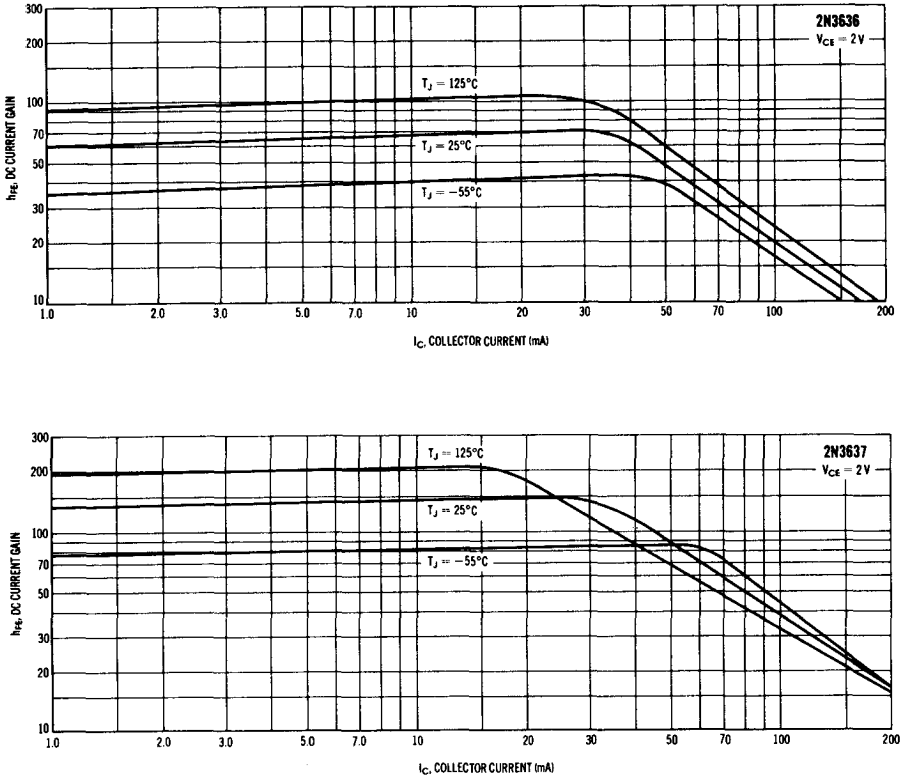
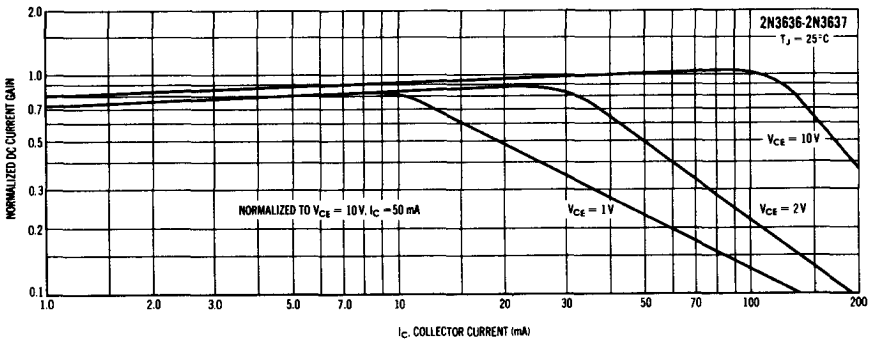


FIGURE 6 — CURRENT GAIN CHARACTERISTICS versus COLLECTOR EMITTER VOLTAGE



2N3634 thru 2N3637 (continued)

FIGURE 7 — INPUT IMPEDANCE

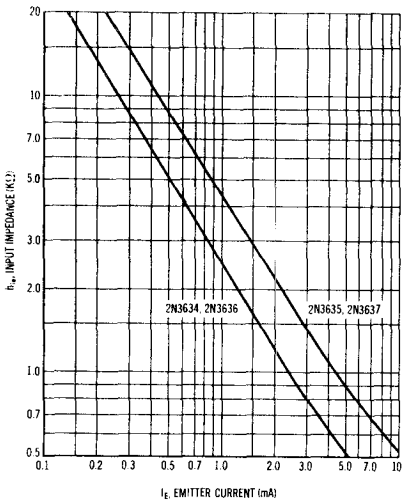


FIGURE 8 — OUTPUT IMPEDANCE

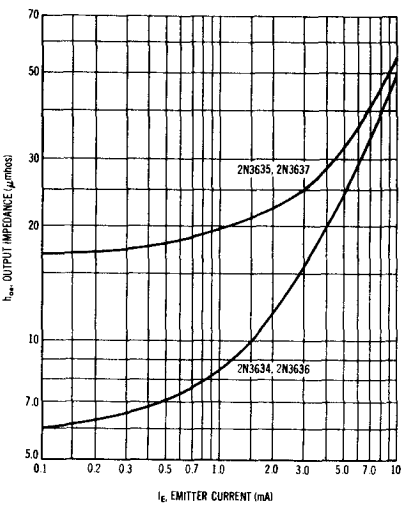


FIGURE 9 — CURRENT GAIN

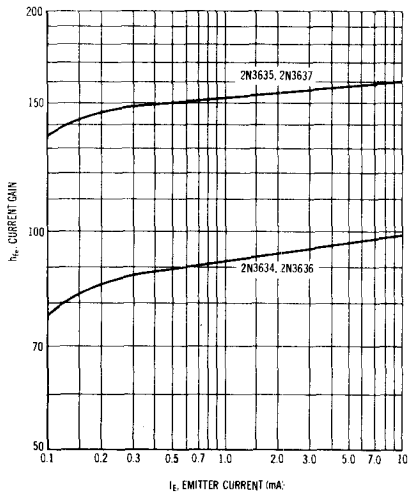
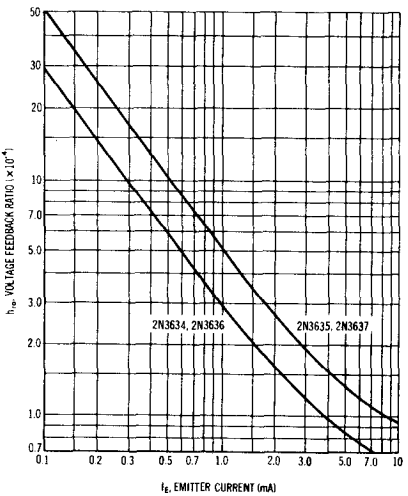


FIGURE 10 — VOLTAGE FEEDBACK RATIO



2N3634 thru 2N3637 (continued)

FIGURE 11 — SATURATION VOLTAGES

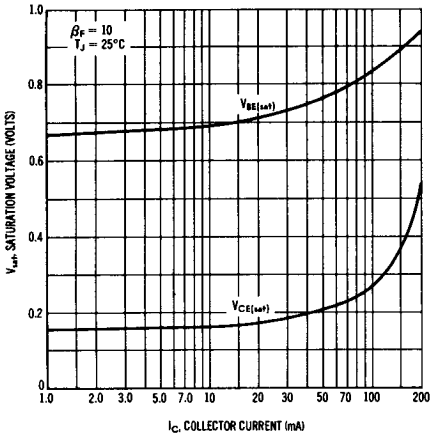


FIGURE 12 — TEMPERATURE COEFFICIENTS

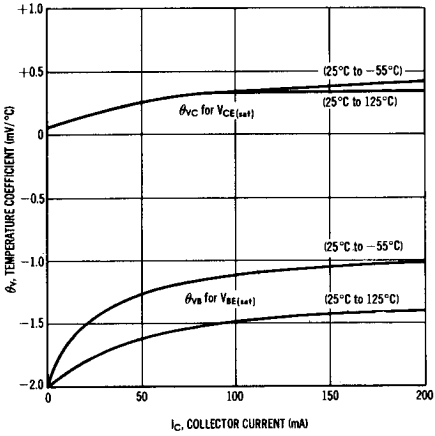
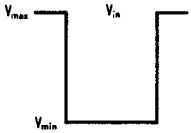


FIGURE 13 — SWITCHING TIME TEST CIRCUIT



P.W. ≅ 20 μ sec
DUTY CYCLE ≤ 2%
RISE TIME ≤ 20 nsec

	V_{max}	V_{min}
TURN-ON	+4 V	−5.65 V
TURN-OFF	+4.1 V	−5.9 V

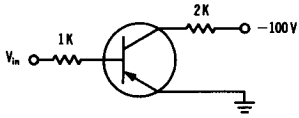


FIGURE 14 — TURN-ON TIME VARIATIONS WITH VOLTAGE

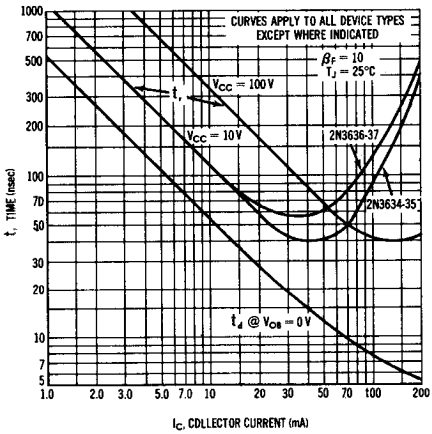
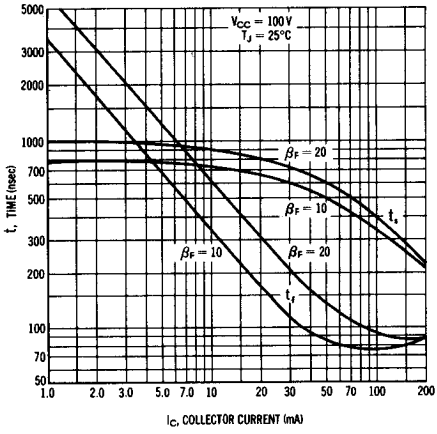


FIGURE 15 — TURN-OFF TIME VARIATIONS WITH CIRCUIT GAIN

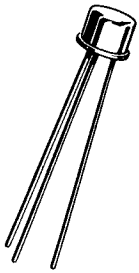


2N3647 (SILICON)
2N3648

For Specifications, See 2N3510 Data Sheet

2N3712 (SILICON)

$V_{CEO} = 150\ V$
$I_C = 200\ mAdc$
$P_D = 5\ W$



CASE 31
(TO-5)

Collector connected to case

NPN silicon annular transistor designed for high-voltage DC to VHF amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	150	Vdc
Collector-Emitter Voltage	V_{CEO}	150	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derating Factor Above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derating Factor Above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N3712 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	150	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)	BV_{CEO}*	150	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage** (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE(sat)}$**	—	2	Vdc
Base-Emitter Saturation Voltage** (I_C = 50 mA, I_B = 5 mA)	$V_{BE(sat)}$**	—	0.9	Vdc
DC Current Gain** (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 30 mAdc, V_{CE} = 10 Vdc)	h_{FE}**	25 30	— 150	—
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0) (V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —	0.010 50	μAdc
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)	I_{EBO}	—	0.010	μAdc
Small-Signal Current Gain (V_{CE} = 10 Vdc, I_C = 30 mAdc, f = 20 mc)	$\|h_{fe}\|$	2	12	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 1 mc)	C_{ob}	1	9	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 1 mc)	C_{ib}	—	80	pf
Small-Signal Current Gain (I_C = 30 mA, V_{CE} = 10 V, f = 1 kc)	h_{fe}	25	—	—
Collector-Base Time Constant (V_{CB} = 10 V, I_E = 30 mA, f = 31.9 mc)	$r_b'C_C$	—	100	psec

*PW ≤ 30 μsec, Duty Cycle ≤ 1%
**PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N3719 (SILICON)
2N3720



V_{CEO} = 40-60 V
I_C = 3 A
f_T = 60 Mc



CASE 31
(TO-5)

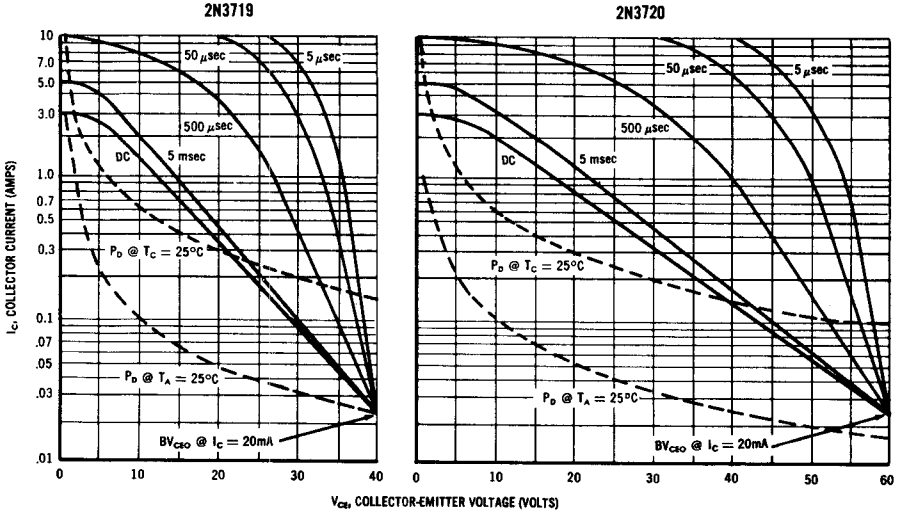
PNP silicon annular transistors for high-speed, high-current switching in core and driver applications and Class C power amplifiers.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N3719	2N3720	Unit
Collector-Base Voltage	V_{CBO}	40	60	Volts
Collector-Emitter Voltage	V_{CEO}	40	60	Volts
Emitter-Base Voltage	V_{EBO}	4	4	Volts
Collector Current—Continuous Collector Current—Peak	I_C	3 10	3 10	Amps Amps
Base Current	I_B	0.5	0.5	Amp
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	1.0 5.72		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	6 34.3		Watts mW/°C
Operating Junction and Storage Temperature Range	T_J and T_{stg}	-65 to +200		°C

SAFE OPERATING AREAS



The Safe Operating Area Curves indicate Ic-Vce limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating curve is also taken into consideration to insure operation below the maximum junction temperature.

2N3719, 2N3720 (continued)

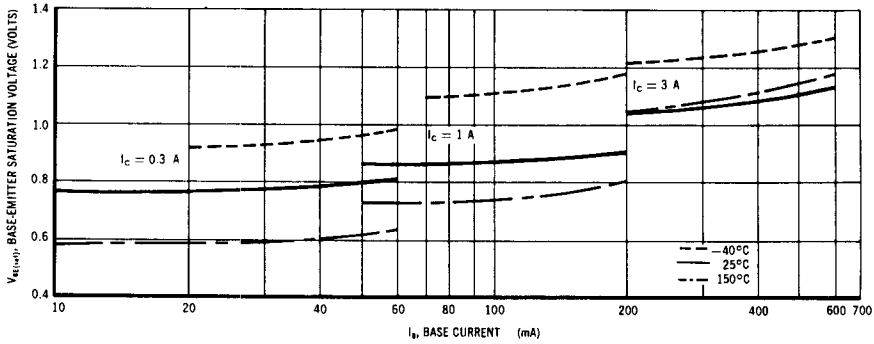
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Leakage Current		I_{CEX}			μAdc
(V_{CE} = 40 Vdc, V_{BE} = 2 Vdc)	2N3719		—	10	
(V_{CE} = 60 Vdc, V_{BE} = 2 Vdc)	2N3720		—	10	
Collector-Base Cutoff Current		I_{CBO}			mAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 25°C)	2N3719		—	.010	
(V_{CB} = 40 Vdc, I_E = 0, T_A = 150°C)	2N3719		—	1	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 25°C)	2N3720		—	.010	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N3720		—	1	
Emitter-Base Cutoff Current (V_{BE} = 4 Vdc, I_C = 0)		I_{EBO}	—	1	mAdc
DC Current Gain*		h_{FE}*			—
(I_C = 500 mA, V_{CE} = 1.5 V, T_A = 25°C)			20	—	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = 25°C)			25	180	
(I_C = 1 A, V_{CE} = 1.5 V, T_A = -40°C)			15	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA, T_A = -40 to +100°C)			—	0.75	
(I_C = 3 A, I_B = 300 mA, T_A = 25°C)			—	1.5	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Volts
(I_C = 1 A, I_B = 100 mA)			—	1.5	
(I_C = 3 A, I_B = 300 mA)			—	2.3	
Collector-Emitter Breakdown Voltage*		BV_{CEO}*			Volts
(I_C = 20 mA, I_B = 0)	2N3719		40	—	
	2N3720		60	—	
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	120	pf
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	1000	pf
Current-Gain — Bandwidth Product (V_{CE} = 10 Vdc, I_C = 500 mAdc, f = 30 mc)		f_T	60	—	mc
Delay Plus Rise Time (I_C = 1 Adc, I_{B1} = 100 mA)		t_{on}	—	75	nsec
Storage Time (I_C = 1 Adc, I_{B1} = I_{B2} = 100 mA)		t_s	—	150	nsec
Fall Time (I_C = 1 Adc, I_{B1} = I_{B2} = 100 mA)		t_f	—	75	nsec

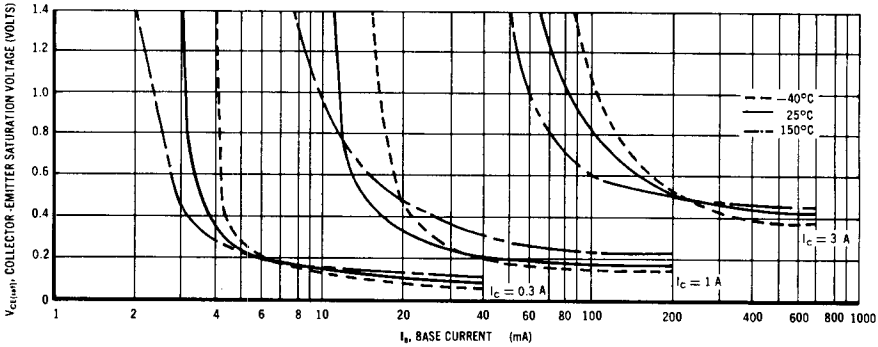
*Pulse Test:
Pulse Width ≤ 300 μsec
Duty Cycle ≤ 2%

2N3719, 2N3720 (continued)

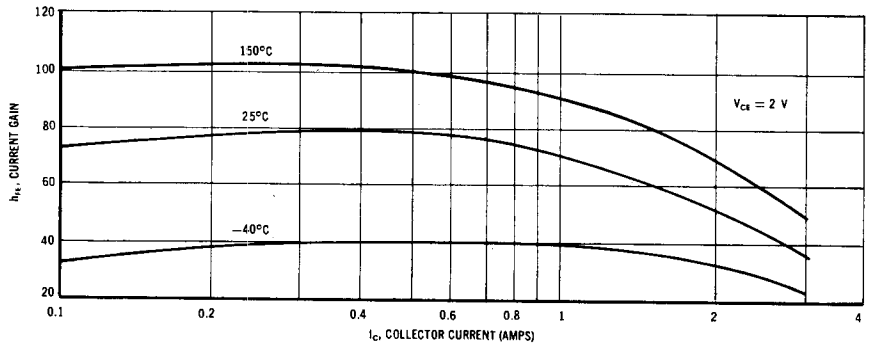
BASE EMITTER SATURATION VOLTAGE VARIATIONS



COLLECTOR EMITTER SATURATION VOLTAGE VARIATIONS

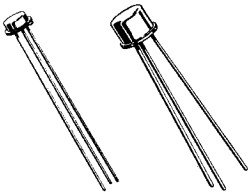


CURRENT GAIN VARIATIONS



2N3734 (SILICON)
2N3735
2N3736
2N3737

V_{CEO} = 30 - 50 V
I_C = 1.5 A
C_{ob} = 9 pf (max)



CASE 26 (TO-46) CASE 31 (TO-5)

Medium current NPN silicon annular transistor, designed for high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N3734 2N3736	2N3735 2N3737	Unit
Collector-Base Voltage	V_{CBO}	50	75	Vdc
Collector-Emitter Voltage	V_{CEO}	30	50	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3734 2N3735	TO-46 2N3736 2N3737	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Thermal Resistance Junction to Air Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	°C/mW
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

2N3734, 2N3735, 2N3736, 2N3737 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

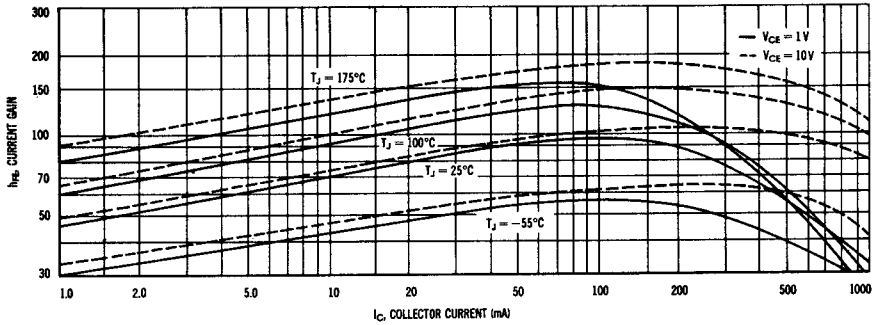
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3734, 2N3736	BV_{CBO}	50	—	Vdc
	2N3735, 2N3737		75	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3734, 2N3736	BV_{CEO}*	30	—	Vdc
	2N3735, 2N3737		50	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current		I_{CEX}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736		—	0.20	
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.20	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	20	
Base Cutoff Current		I_{BL}			μAdc
(V_{CE} = 25 Vdc, V_{EB} = 2 Vdc)	2N3734, 2N3736		—	0.3	
(V_{CE} = 40 Vdc, V_{EB} = 2 Vdc)	2N3735, 2N3737		—	0.3	
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 10 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	2N3734, 2N3736		30	120	
	2N3735, 2N3737		20	80	
(I_C = 1.5 Adc, V_{CE} = 5 Vdc)	2N3734, 2N3736		30	—	
	2N3735, 2N3737		20	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.3	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.8	
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			0.9	1.4	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	9	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	80	pf
High-Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		h_{fe}	2.5	—	—
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8	nsec
Rise Time		t_r	—	40	nsec
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	30	nsec
Fall Time		t_f	—	30	nsec
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	10	nC

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

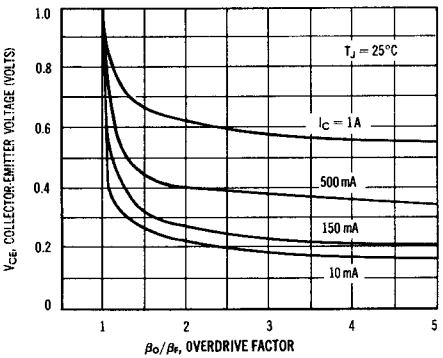
2N3734, 2N3735, 2N3736, 2N3737 (continued)

"ON" CONDITION CHARACTERISTICS

DC CURRENT GAIN



COLLECTOR SATURATION REGION

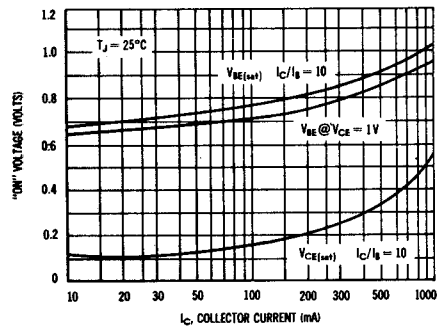


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 500 mA.

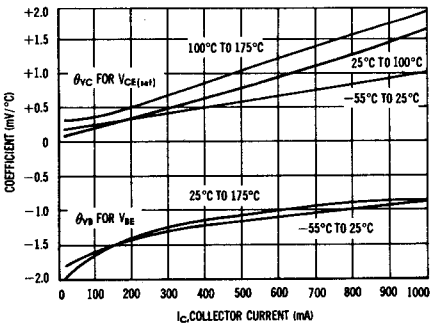
Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design). ∴

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE}\text{@ 1 Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\text{ mA}/I_{BF}} \qquad I_{BF} \approx 18.5\text{ mA typ}$$

"ON" VOLTAGES



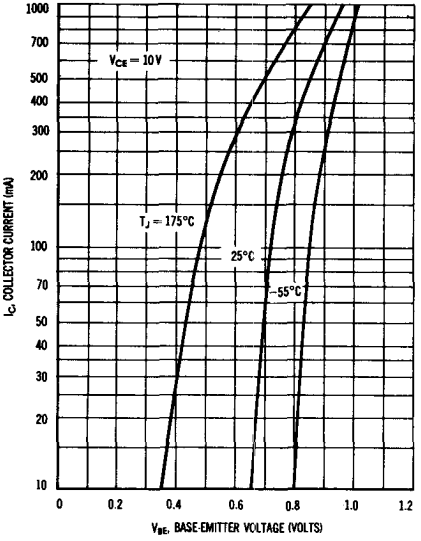
TEMPERATURE COEFFICIENTS



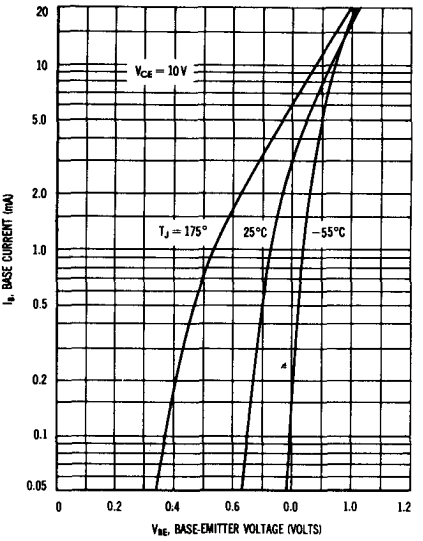
2N3734, 2N3735, 2N3736, 2N3737 (continued)

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

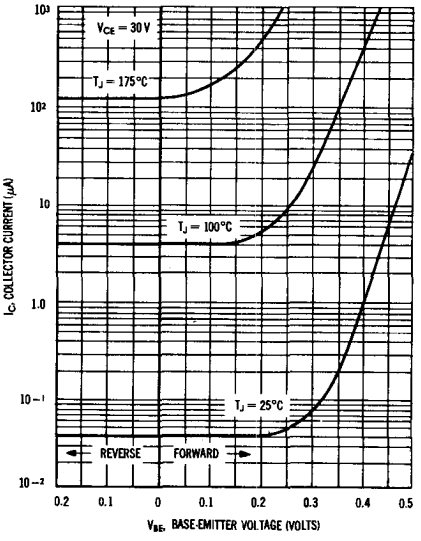


INPUT ADMITTANCE

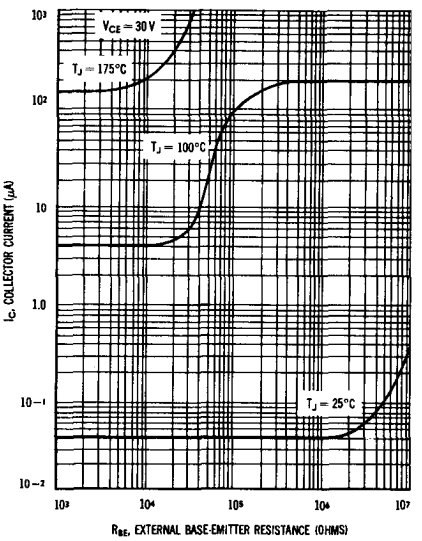


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE



EFFECT OF BASE-EMITTER RESISTANCE

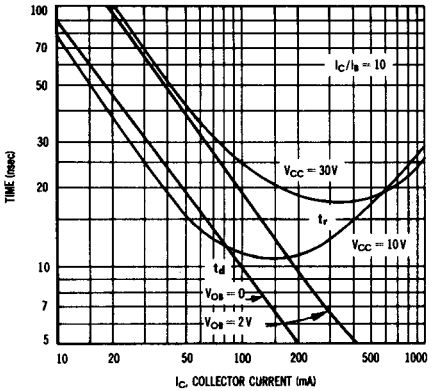


2N3734, 2N3735, 2N3736, 2N3737 (continued)

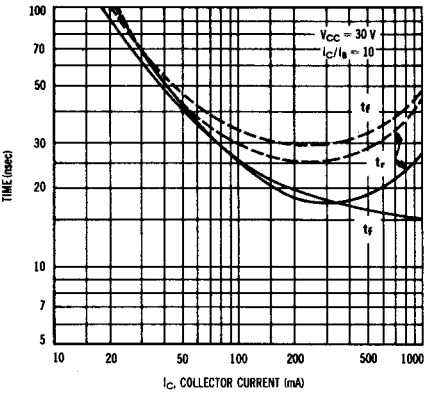
SWITCHING CHARACTERISTICS

— $T_J = 25°C$ -- $T_J = 150°C$

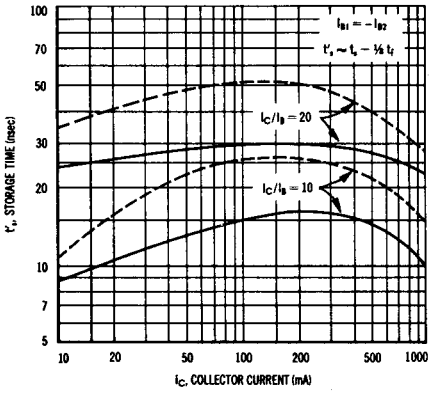
TURN-ON TIME



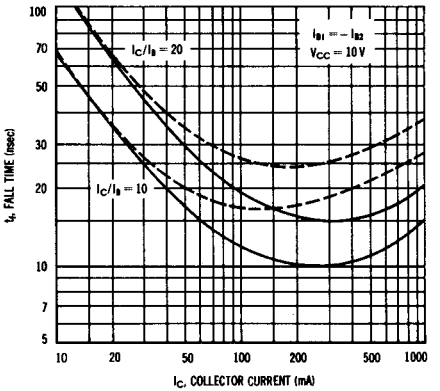
RISE AND FALL TIMES



STORAGE TIME

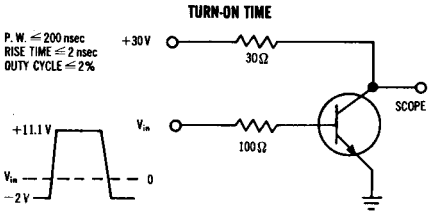


FALL TIME

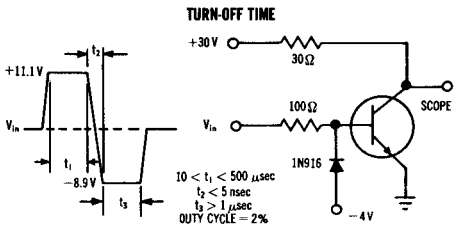


SWITCHING TIME EQUIVALENT TEST CIRCUITS

TURN-ON TIME

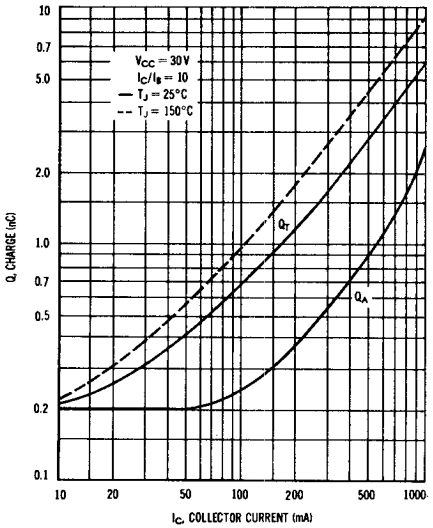


TURN-OFF TIME

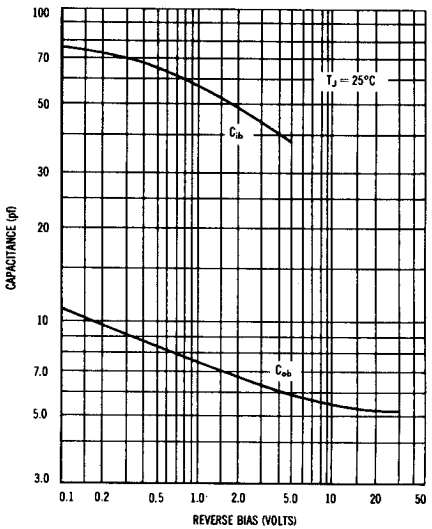


2N3734, 2N3735, 2N3736, 2N3737 (continued)

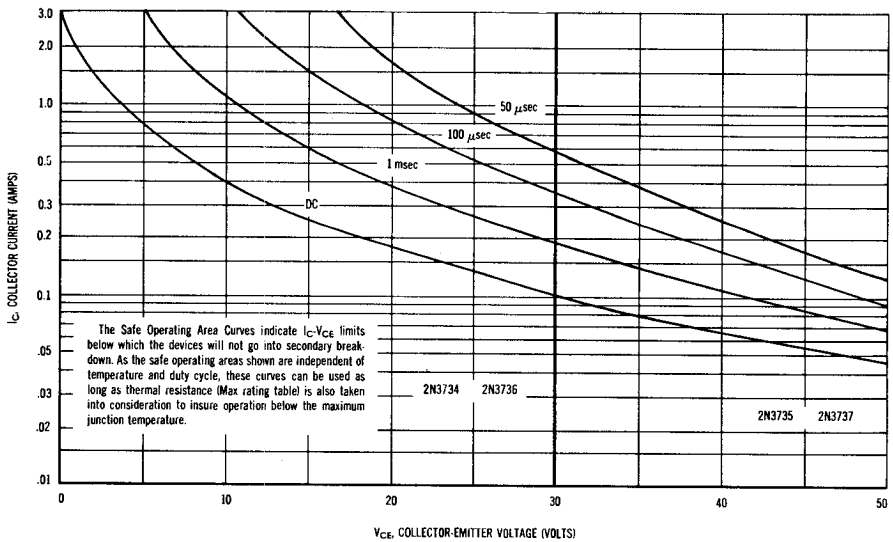
CHARGE DATA



CAPACITANCE



ACTIVE REGION SAFE OPERATING AREAS



2N3742 (SILICON)

$V_{CEO} = 300$ V
$I_C = 50$ mA
$f_T = 30$ Mc



CASE 31
(TO-5)

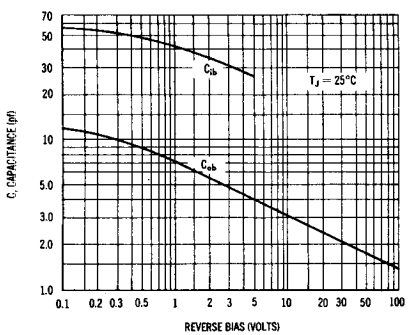
NPN silicon annular transistor for high voltage amplifier applications from DC to VHF.

Collector connected to case

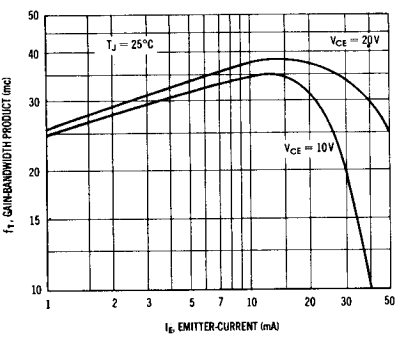
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	7	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derating Factor Above 25^oC	P_D	1.0 5.71	Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derating Factor Above 25^oC	P_D	5 28.6	Watts $mW/^oC$
Operating Junction Temperature	T_J	+200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



2N3742 (continued)

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

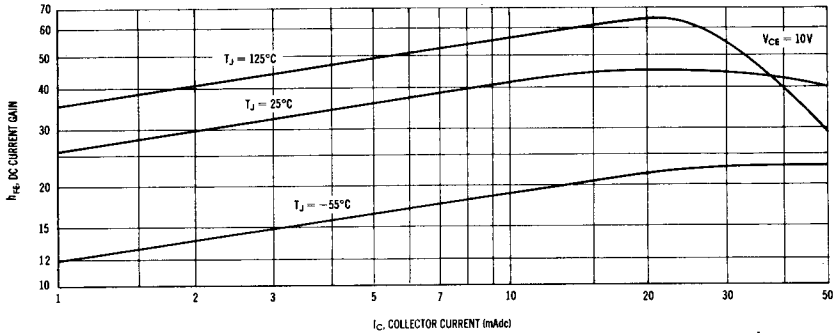
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μ Adc, I_E = 0)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100μAdc, I_C = 0)	BV_{EBO}	7	—	Vdc
Collector Saturation Voltage ** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$**	—	1	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	5	
Base-Emitter Saturation Voltage ** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$**	—	1.0	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	1.2	
DC Current Gain ** (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}**	10	—	—
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		15	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		20	200	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		20	—	
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.2	μ Adc
(V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)		—	20	
Emitter Cutoff Current V_{EB} = 6 Vdc, I_C = 0)	I_{EBO}	—	0.2	μAdc
Small Signal Current Gain (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 20 mc)	$\lvert h_{fe} \rvert$	1.5	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	—	6	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)	C_{ib}	—	80	pf
Small Signal Current Gain (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	h_{fe}	20	200	—
Voltage Feedback Ratio (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	h_{re}	—	1.0	$X10^{-4}$
Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	h_{ie}	—	0.5	Kohms
Output Admittance (I_C = 10 mA, V_{CE} = 10 V, f = 1 kc)	h_{oe}	5	50	μmhos
Real Part of Input Impedance (I_C = 10 mA, V_{CE} = 10 V, f = 5 mc)	$Re(h_{ie})$	—	40	ohms

*PW ≤ 30 μsec, Duty Cycle ≤ 1%

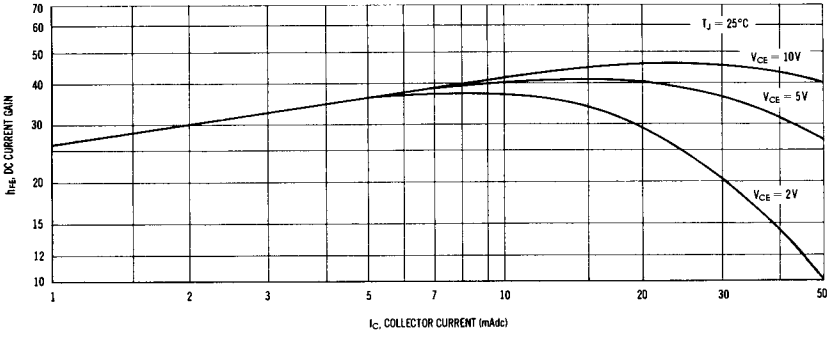
**PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N3742 (continued)

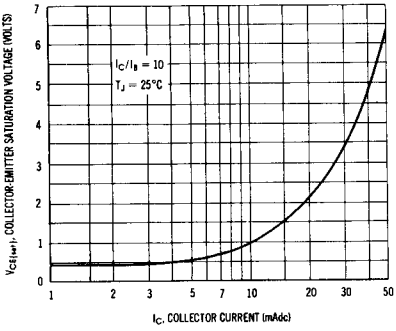
CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE



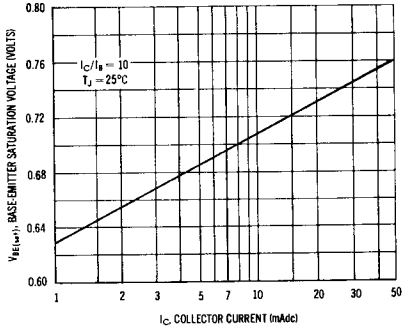
CURRENT GAIN CHARACTERISTICS versus COLLECTOR-EMITTER VOLTAGE



COLLECTOR-EMITTER SATURATION VOLTAGE



BASE -EMITTER SATURATION VOLTAGE

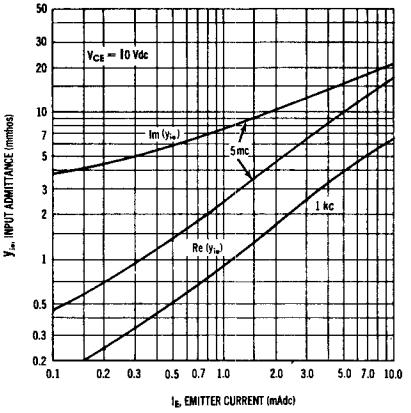


2N3742 (continued)

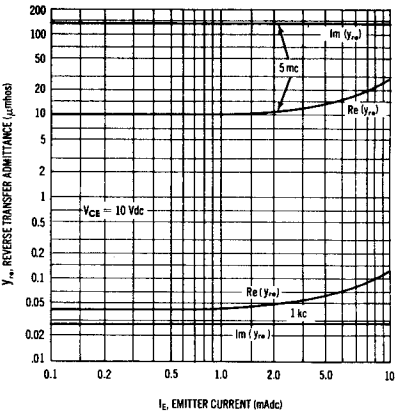
SMALL SIGNAL y PARAMETERS

$T_A = 25°C$

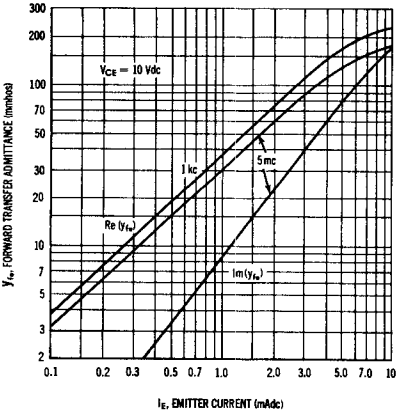
INPUT ADMITTANCE



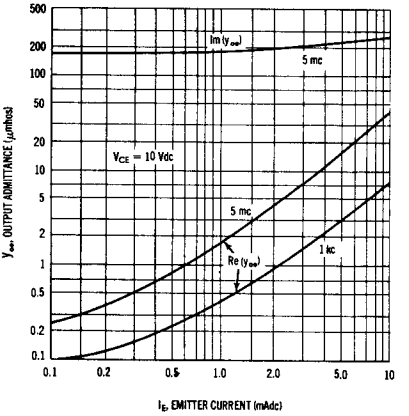
REVERSE TRANSFER ADMITTANCE



FORWARD TRANSFER ADMITTANCE



OUTPUT ADMITTANCE



2N3743 (SILICON)

$V_{CEO} = 300$ V
$I_C = 50$ mA
$f_T = 30$ Mc



PNP silicon annular transistor for high voltage amplifier applications from DC to VHF.

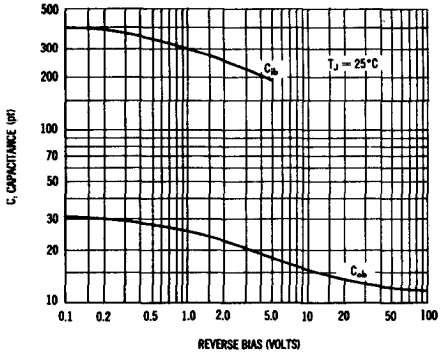
Collector connected to case

CASE 31
(TO-5)

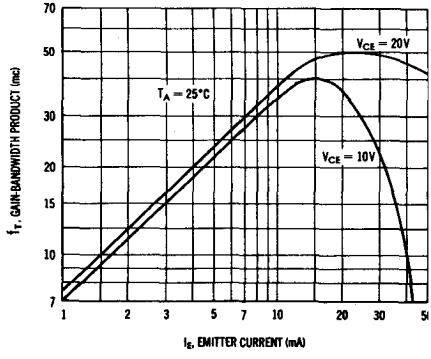
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	300	Vdc
Collector-Emitter Voltage	V_{CEO}	300	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate Above 25°C	P_D	1.0 5.7	Watt mW/°C
Total Device Dissipation@ $T_C = 25^oC$ Derate Above 25°C	P_D	5.0 28.6	Watts mW mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

JUNCTION CAPACITANCE



GAIN-BANDWIDTH PRODUCT



2N3743 (continued)

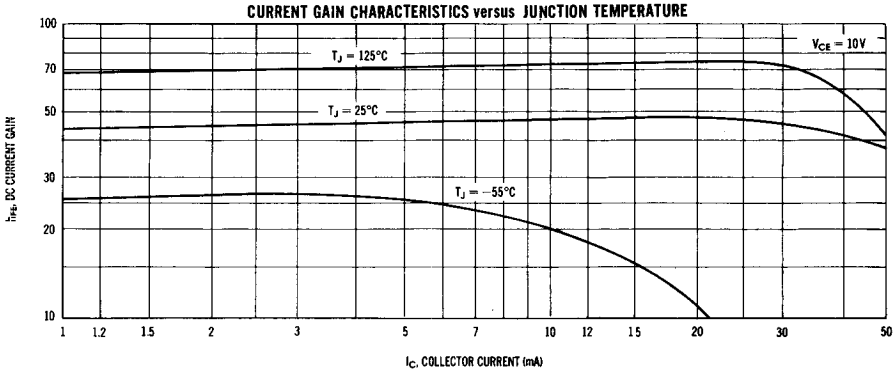
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise specified)

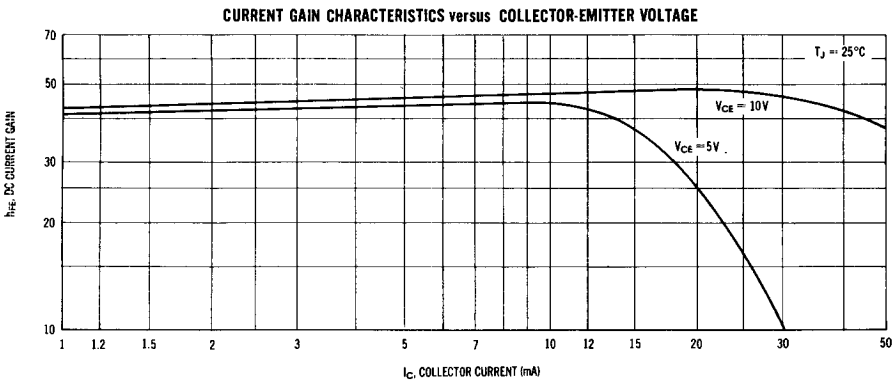
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	300	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	300	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Saturation Voltage** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$**	—	5	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	8	
Base-Emitter Saturation Voltage** (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$**	—	1.0	Vdc
(I_C = 30 mAdc, I_B = 3 mAdc)		—	1.2	
DC Forward Current Gain** (I_C = 100 μAdc, V_{CE} = 10 Vdc)	h_{FE}**	20	—	—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		25	—	
(I_C = 30 mAdc, V_{CE} = 10 Vdc)		25	250	
(I_C = 50 mAdc, V_{CE} = 20 Vdc)		25	—	
Collector Cutoff Current (V_{CB} = 200 Vdc, I_E = 0)	I_{CBO}	—	0.3	μAdc
(V_{CB} = 200 Vdc, I_E = 0, T_A = 100°C)		—	30	
Emitter-Base Leakage Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—	0.1	μAdc
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 20 mc)	$\|h_{fe}\|$	1.5	—	—
Output Capacitance (V_{CB} = 20 Vdc, I_E = 0, f = 100 kc)	C_{ob}	—	15	pf
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kc)	C_{ib}	—	400	pf
Small Signal Current Gain (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	h_{fe}	30	300	—
Voltage Feedback Ratio (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	h_{re}	—	4.0	$X10^{-4}$
Input Impedance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	h_{ie}	—	1.0	kohms
Output Admittance (V_{CE} = 10 V, I_C = 10 mA, f = 1 kc)	h_{oe}	—	200	μmhos
Real Part of Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 5 mc)	$Re(h_{ie})$	—	40	ohms

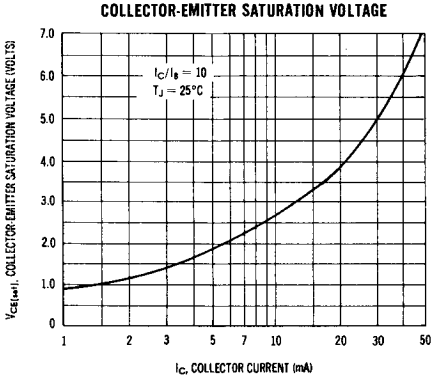
*PW ≤ 30 μsec, Duty Cycle ≤ 1%

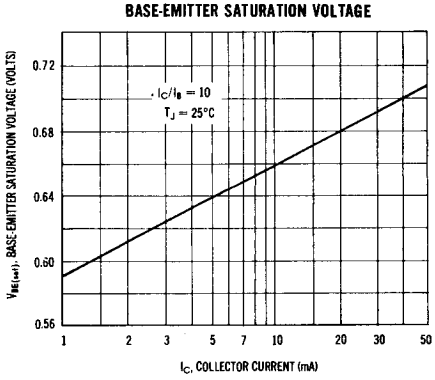
**PW ≤ 300 μsec, Duty Cycle ≤ 2%

2N3743 (continued)





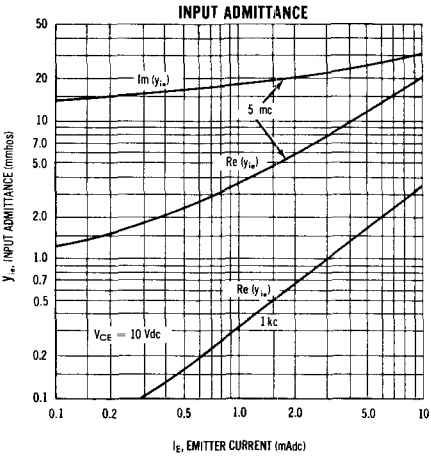


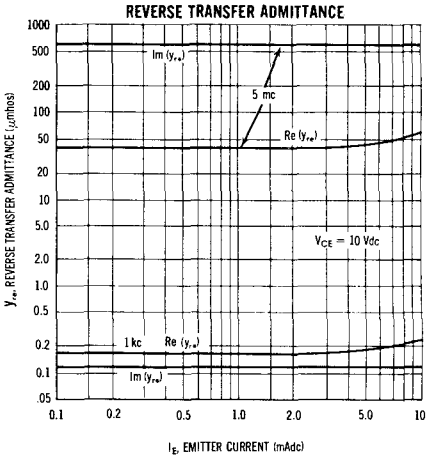


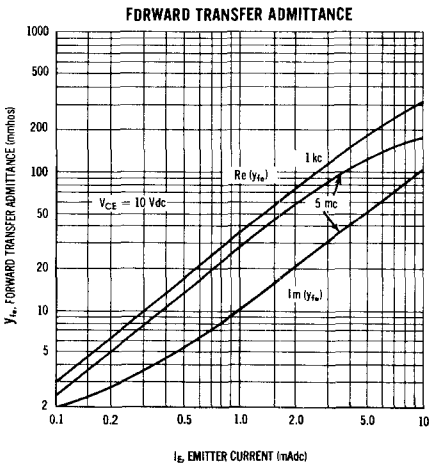
2N3743 (continued)

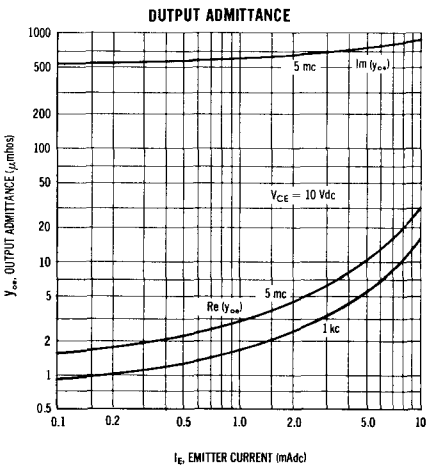
SMALL SIGNAL y PARAMETERS

$T_A = 25°C$



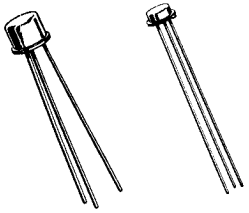






2N3762 (SILICON)
2N3763
2N3764
2N3765

V_{CBO} = 40-60 V
I_C = 1.5 A
C_{ob} = 15.0 pf (max)



CASE 31
(TO-5)
2N3762
2N3763

CASE 26
(TO-46)
2N3764
2N3765

Medium-current PNP silicon annular transistor, designed for high-speed switching and driver applications.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N3762 2N3764	2N3763 2N3765	Unit
Collector-Base Voltage	V_{CBO}	40	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	60	Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	1.5		Adc
		TO-5 2N3762 2N3763	TO-46 2N3764 2N3765	
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71	0.5 2.86	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Abovd 25°C	P_D	4.0 22.8	2.0 11.4	Watts mW/°C
Thermal Resistance Junction to Air Junction to Case	 θ_{JA} θ_{JC}	 0.175 0.044	 0.35 0.088	°C/mW
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

2N3762, 2N3763, 2N3764, 2N3765 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

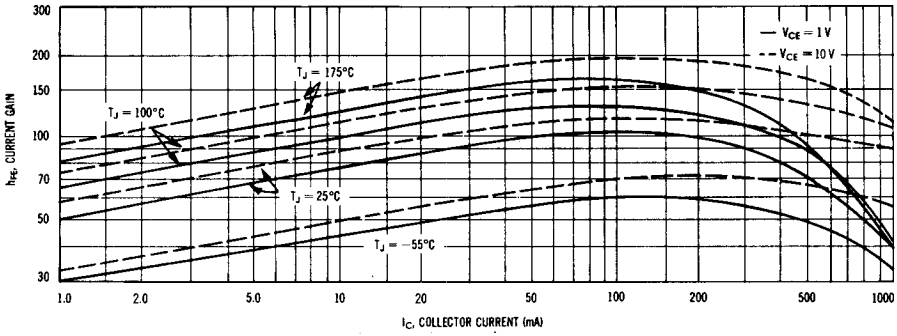
Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N3762, 2N3764	BV_{CBO}	40	—	Vdc
	2N3763, 2N3765		60	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	2N3762, 2N3764	BV_{CEO}*	40	—	Vdc
	2N3763, 2N3765		60	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2 Vdc)	2N3762, 2N3764	I_{CEX}	—	0.10	μAdc
(V_{CE} = 20 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	10	
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc)	2N3763, 2N3765		—	0.10	
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc, T_A = 100°C)			—	10	
Base Cutoff Current (V_{CE} = 20 Vdc, V_{EB} = 2 Vdc)	2N3762, 2N3764	I_{BL}	—	0.2	μAdc
(V_{CE} = 30 Vdc, V_{EB} = 2 Vdc)	2N3763, 2N3765		—	0.2	
ON CHARACTERISTICS					
DC Current Gain* (I_C = 10 mAdc, V_{CE} = 1 Vdc)		h_{FE}*	35	—	—
(I_C = 150 mAdc, V_{CE} = 1 Vdc)			40	—	
(I_C = 500 mAdc, V_{CE} = 1 Vdc)			35	—	
(I_C = 1 Adc, V_{CE} = 1.5 Vdc)	2N3762, 2N3764		30	120	
	2N3763, 2N3765		20	80	
(I_C = 1.5 Adc, V_{CE} = 5 Vdc)	2N3762, 2N3764		30	—	
	2N3763, 2N3765		20	—	
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$*	—	0.1	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	0.22	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	0.5	
(I_C = 1 Adc, I_B = 100 mAdc)			—	0.9	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$*	—	0.8	Vdc
(I_C = 150 mAdc, I_B = 15 mAdc)			—	1.0	
(I_C = 500 mAdc, I_B = 50 mAdc)			—	1.2	
(I_C = 1 Adc, I_B = 100 mAdc)			0.9	1.4	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	15	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	80	pf
High Frequency Current Gain (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3762, 2N3764	$\lvert h_{fe} \rvert$	1.8	—	—
	2N3763, 2N3765		1.5	—	
Delay Time	(V_{CC} = 30 V, $V_{BE(off)}$ = 2 V, I_C = 1 Amp, I_{B1} = 100 mA)	t_d	—	8	nsec
Rise Time		t_r	—	35	nsec
Storage Time	(V_{CC} = 30 V, I_C = 1 Amp, I_{B1} = $-I_{B2}$ = 100 mA)	t_s	—	80	nsec
Fall Time		t_f	—	35	nsec
Total Control Charge (I_C = 1 Amp, I_B = 100 mA, V_{CC} = 30 V)		Q_T	—	30	nC

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

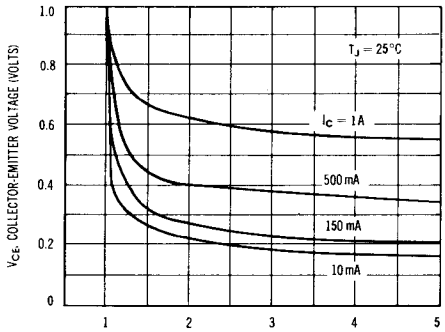
2N3762, 2N3763, 2N3764, 2N3765 (continued)

"ON" CONDITION CHARACTERISTICS

DC CURRENT GAIN



COLLECTOR SATURATION REGION

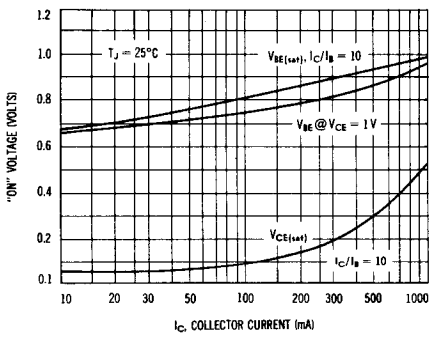


This graph shows the effect of base current on collector current. β_O (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_F (forced gain) is the ratio of I_C/I_{BF} in a circuit. EXAMPLE: For type 2N3734, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector of 500 mA.

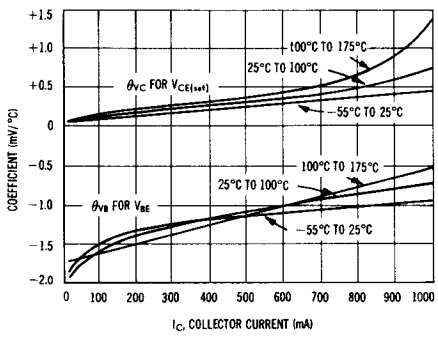
Observe that at I_C = 500 mA an overdrive factor of at least 2.0 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is typically 54 (guaranteed limits from the Table of Characteristics can be used for "worst-case" design).

$$\frac{\beta_O}{\beta_F} = \frac{h_{FE}\text{ @ 1 Volt}}{I_C/I_{BF}} \qquad 2 = \frac{54}{500\text{ mA}/I_{BF}} \qquad I_{BF} \approx 18.5\text{ mA typ}$$

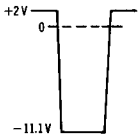
"ON" VOLTAGES



TEMPERATURE COEFFICIENTS

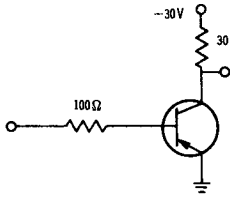


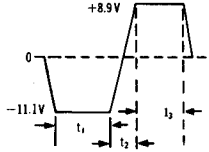
TURN-ON TIME



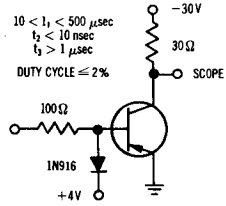
PW = 200 nsec
RISE TIME ≤ 2 nsec
DUTY CYCLE ≤ 2%

SWITCHING TIME EQUIVALENT TEST CIRCUITS





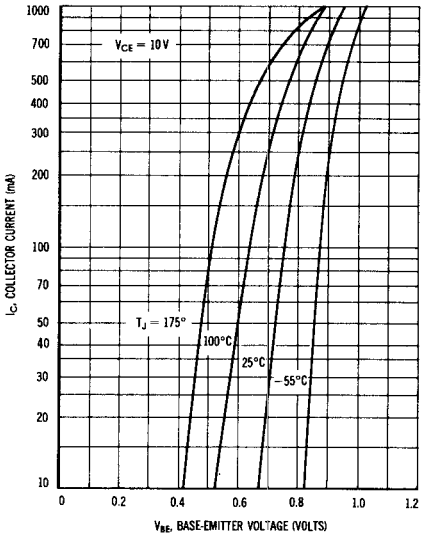
TURN-OFF TIME



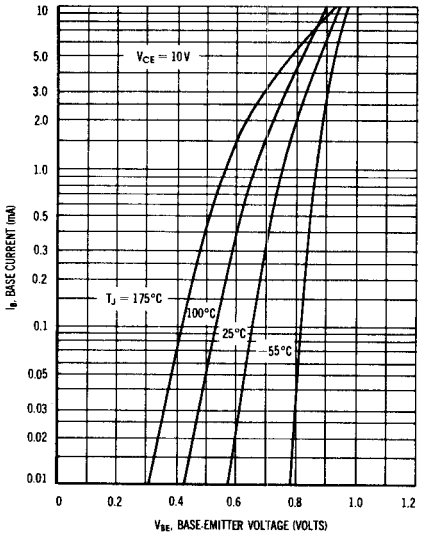
2N3762, 2N3763, 2N3764, 2N3765 (continued)

LARGE SIGNAL CHARACTERISTICS

TRANSCONDUCTANCE

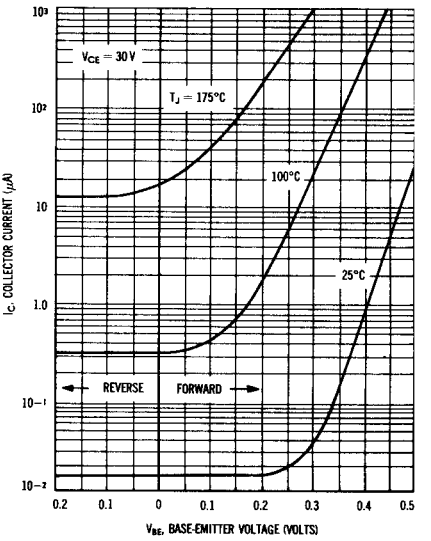


INPUT ADMITTANCE

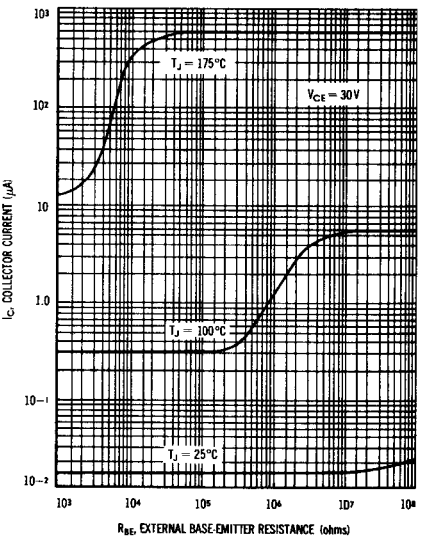


"OFF" CONDITION CHARACTERISTICS

TRANSCONDUCTANCE



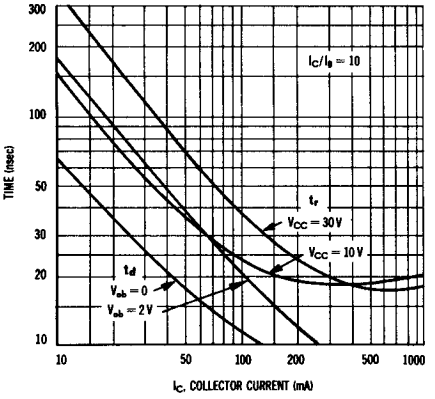
EFFECT OF BASE-EMITTER RESISTANCE



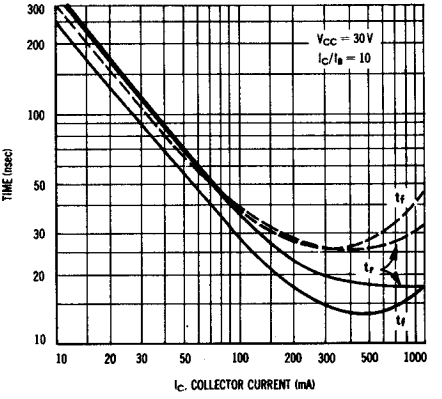
2N3762, 2N3763, 2N3764, 2N3765 (continued)

— $T_J = 25°C$ SWITCHING CHARACTERISTICS -- $T_J = 150°C$

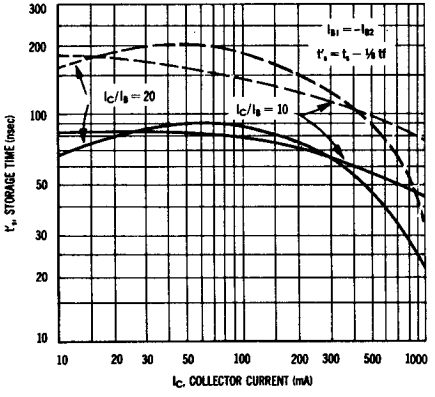
TURN-ON TIME



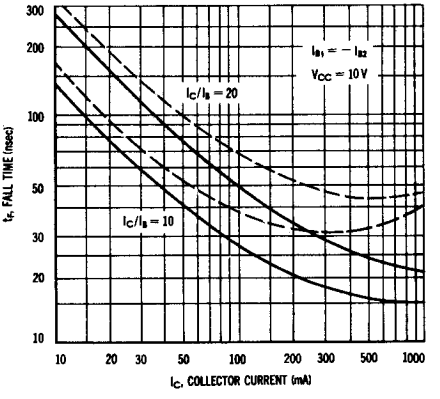
RISE AND FALL TIME



STORAGE TIME



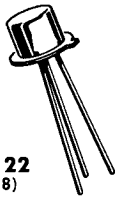
FALL TIME



2N3798 (SILICON)
2N3799



$V_{CEO} = 60$ V
$I_C = 50$ mA
$h_{FE} = 150$ and 300 Min @ 100 μA
NF = 1.5-2.5 db @ 10 kc



CASE 22
(TO-18)

PNP silicon annular transistors for low-level, low-noise amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristics	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	1.2 6.9	Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.36 2.06	Watt mW/°C
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

2N3798, 2N3799 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

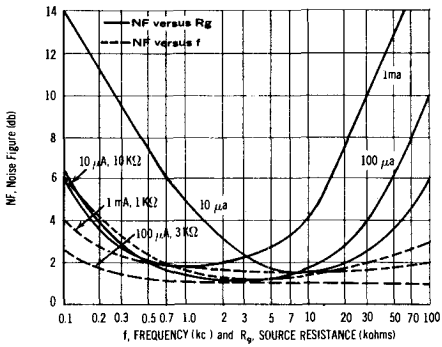
Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60	90	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)					10	
Emitter Cutoff Current (V_{OB} = 4 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
Collector-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	—	—	0.2	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			—	—	0.25	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	—	—	0.7	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			—	—	0.8	
DC Forward Current Transfer Ratio* (I_C = 1 μAdc, V_{CE} = 5 Vdc)	2N3799	h_{FE}*	75	—	—	—
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3798		100	—	—	
	2N3799		225	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N3798		75	—	—	
	2N3799		150	—	—	
(I_C = 500 μAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N3798		150	—	450	
	2N3799		300	—	900	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	2N3798		125	—	—	
	2N3799		250	—	—	
Base Emitter "ON" Voltage (I_C = 100 μAdc, V_{CE} = 5 V)		$V_{BE(ON)}$	—	—	0.7	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	—	4	pf
Input Capacitance (V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	—	8	pf
Small Signal Current Gain (I_C = 500 μA, V_{CE} = 5 V, f = 30 mc)		h_{fe}	1.0	—	—	—
(I_C = 1 mA, V_{CE} = 5 V, f = 100 mc)			1.0	—	5.0	
(I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)	2N3798		150	—	600	
	2N3799		300	—	900	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)		h_{re}	—	—	25	$X10^{-4}$
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3798	h_{ie}	3	—	15	k ohms
	2N3799		10	—	40	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)		h_{oe}	5	—	60	μmhos
Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_G = 3 KΩ)		NF				db
f = 100 cps	2N3798		—	4	7	
	2N3799		—	2.5	4	
f = 1 kc	2N3798		—	1.5	3	
	2N3799		—	0.8	1.5	
f = 10 kc	2N3798		—	1.0	2.5	
	2N3799		—	0.8	1.5	
Noise Bandwidth 10 cps to 15.7 kc	2N3798		—	2.5	3.5	
	2N3799		—	1.5	2.5	

* Pulse Test ≤ 300 μsec, duty cycle ≤ 2% V_{OB} - Base-Emitter Reverse Bias

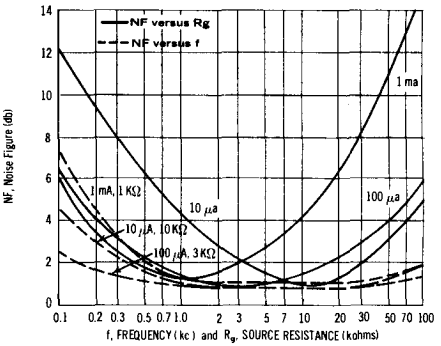
2N3798, 2N3799 (continued)

NOISE FIGURE versus FREQUENCY AND SOURCE RESISTANCE

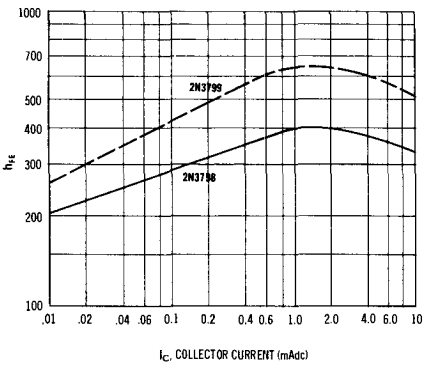
2N3798



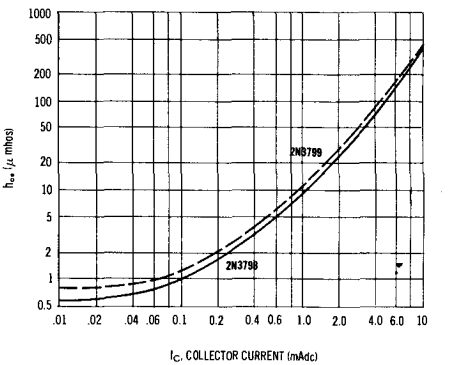
2N3799



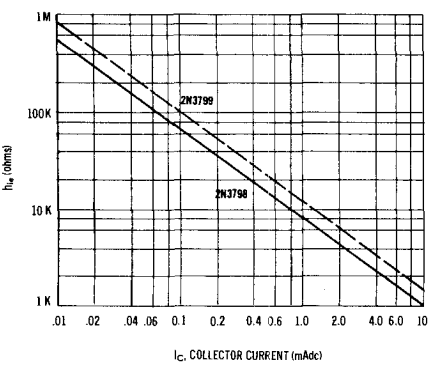
CURRENT GAIN



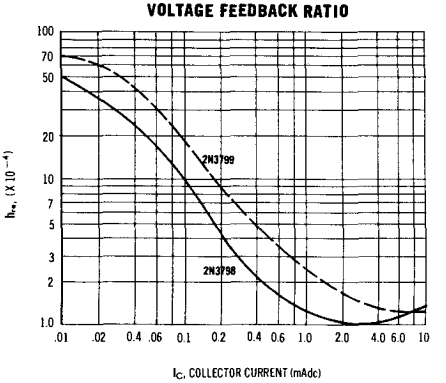
OUTPUT ADMITTANCE



INPUT IMPEDANCE

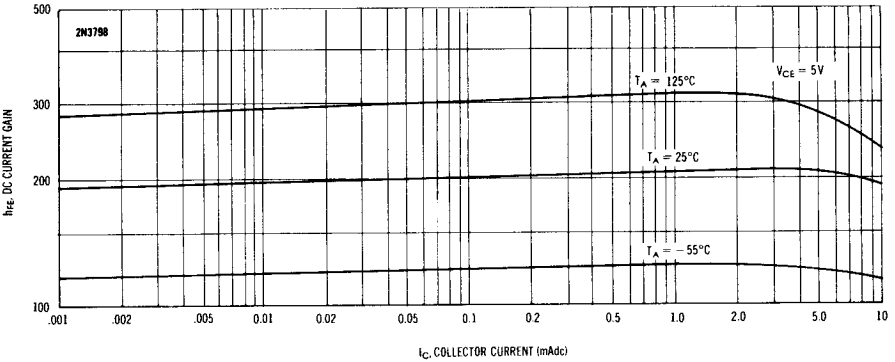


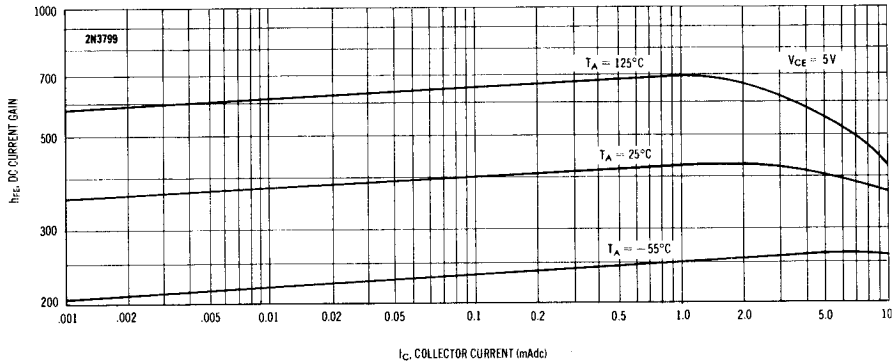
VOLTAGE FEEDBACK RATIO



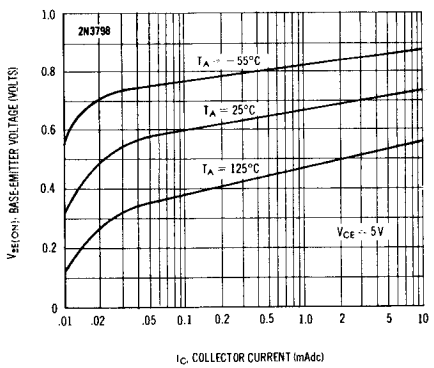
2N3798, 2N3799 (continued)

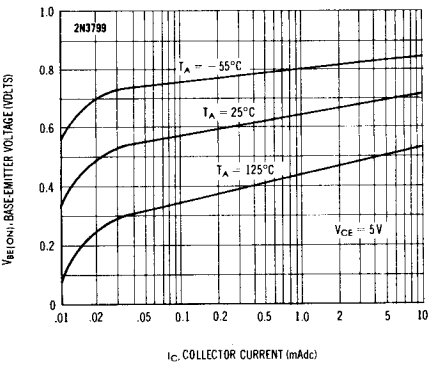
CURRENT GAIN CHARACTERISTICS





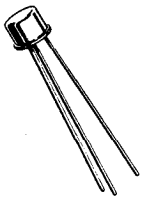
BASE-EMITTER "ON" VOLTAGE versus TEMPERATURE





2N3883 (GERMANIUM)

f_T = 300 Mc (typ)
I_C = 300 mA
P_D = 750 mW @ 25°C Case



Medium-current, germanium PNP high-speed switching transistor.

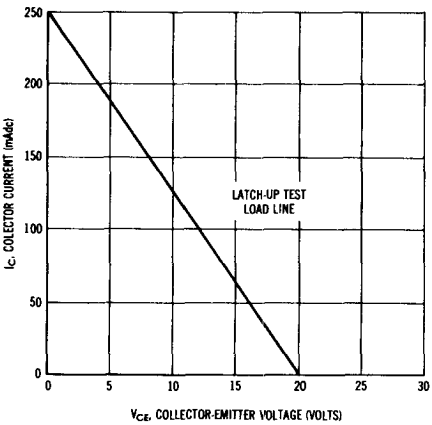
CASE 31
(TO-5)

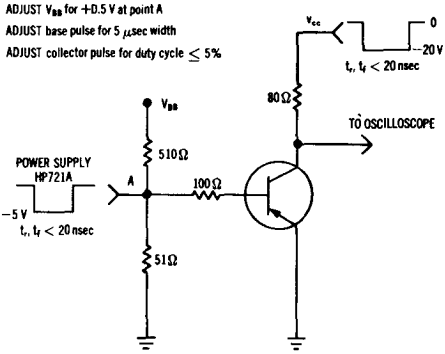
Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EBO}	3	Vdc
Collector Current (Continuous)	I_C	300	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ 25°C Case Temperature (Derate 10 mW/°C above 25°C)	P_D	750	mW
Device Dissipation @ 25°C Ambient (Derate 4 mW/°C)	P_D	300	mW

COLLECTOR LATCH-UP VOLTAGE AND TEST CIRCUIT



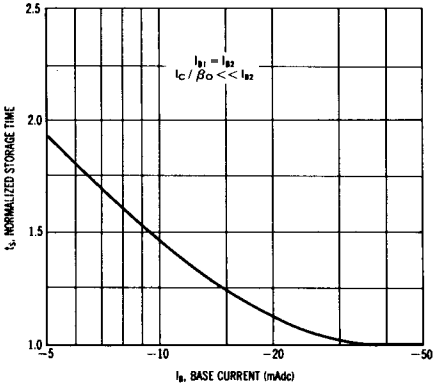


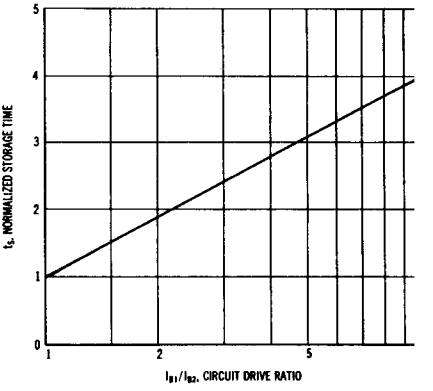
2N3883 (continued)

ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = -100μAdc, I_E = 0)	BV_{CBO}	—	—	-25	Vdc
Collector-Emitter Breakdown Voltage (I_C = -10mAdc, I_B = 0)	BV_{CEO}	—	—	-15	Vdc
Emitter-Base Breakdown Voltage (I_E = -100μAdc, I_C = 0)	BV_{EBO}	—	—	-3	Vdc
Latch-Up Voltage	LV_{CEX}	—	—	-20	Vdc
Collector-Emitter Leakage Current (V_{CE} = -15 Vdc, V_{EB} = 0)	I_{CES}	-100	—	—	μAdc
Base Cutoff Current (V_{CE} = -15 Vdc, V_{EB} = 0)	I_B	-100	—	—	μAdc
DC Current Gain (I_C = -200 mAdc, V_{CE} = -1.0 Vdc)	h_{FE}	—	—	30	—
Collector-Emitter Saturation Voltage (I_C = -200 mAdc, I_B = -40 mAdc	$V_{CE(sat)}$	-0.5	-0.35	—	Vdc
Base-Emitter Voltage (I_C = -200 mAdc, I_B = -40 mAdc)	V_{BE}	-0.9	-0.65	-0.4	Vdc
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	8	4.5	—	pf
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kc)	C_{ib}	25	10	—	pf
Current-Gain — Bandwidth Product (V_{CE} = -10 Vdc, I_C = -40 mAdc, f = 100 mc)	f_T	—	300	100	mc
Delay Time	t_d	15	8	—	nsec
Rise Time	t_r	40	28	—	nsec
Storage Time	t_s	70	40	—	nsec
Fall Time	t_f	40	28	—	nsec

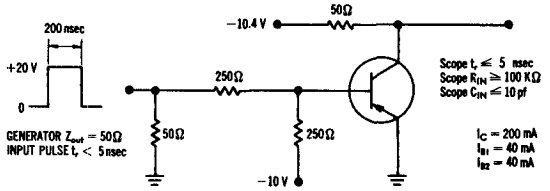
STORAGE TIME VARIATIONS



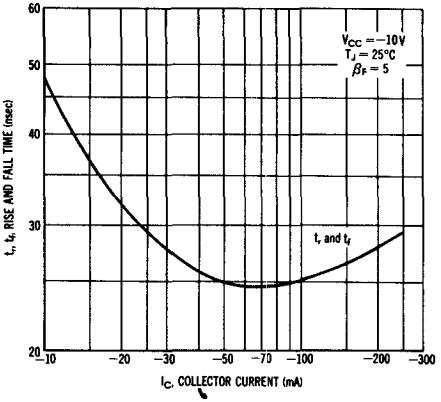


2N3883 (continued)

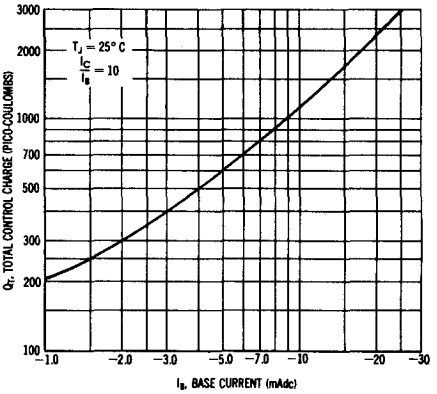
SWITCHING TIME TEST CIRCUIT



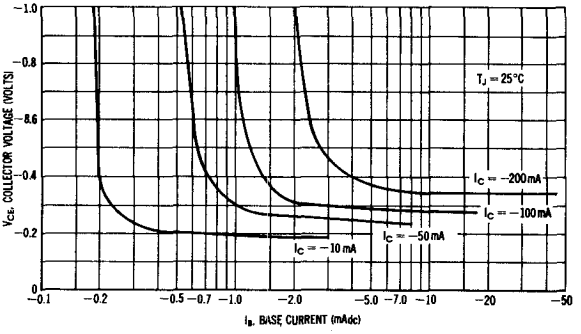
TYPICAL RISE AND FALL TIME BEHAVIOR



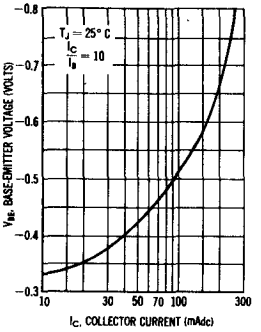
TOTAL CONTROL CHARGE



COLLECTOR-EMITTER SATURATION VOLTAGES versus BASE CURRENT

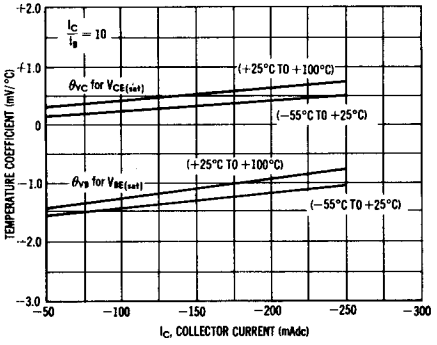


BASE-EMITTER VOLTAGE versus COLLECTOR CURRENT

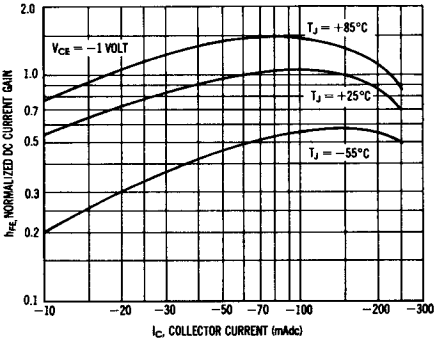


2N3883 (continued)

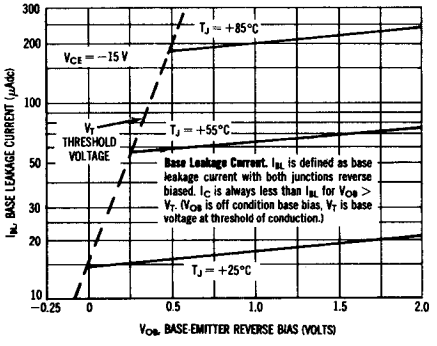
TEMPERATURE COEFFICIENTS



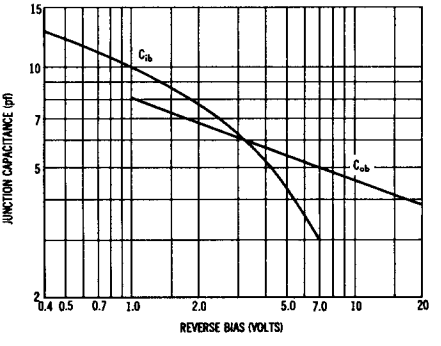
NORMALIZED CURRENT GAIN CHARACTERISTICS



LEAKAGE CHARACTERISTICS COMMON EMITTER

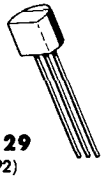


JUNCTION CAPACITANCE versus REVERSE VOLTAGE



2N3903 (SILICON)
2N3904

$V_{CB} = 60$ V
$I_C = 200$ mA
$C_{ob} = 4.0$ pf (max)



CASE 29
(TO-92)

NPN silicon annular transistors, designed for general purpose switching and amplifier applications, features one-piece, injection-molded plastic package for high reliability. The 2N3903 and 2N3904 are complementary with types 2N3905 and 2N3906, respectively.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 60°C$	P_D	210	mW
Total Device Dissipation @ $T_A = 25°C$ Derate above $25°C$	P_D	310 2.81	mW mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Operating Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage ($I_C = 10$ μAdc, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 1$ mAdc)	BV_{CEO}*	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10$ μAdc, $I_C = 0$)	BV_{EBO}	6	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{OB} = 3$ Vdc)	I_{CEX}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 40$ Vdc, $V_{OB} = 3$ Vdc)	I_{BL}	—	50	nAdc

*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2%. V_{OB} = Base Emitter Reverse Bias

2N3903, 2N3904 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain *		h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3903		20	—	
	2N3904		40	—	
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3903		35	—	
	2N3904		70	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3903		50	150	
	2N3904		100	300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3903		30	—	
	2N3904		60	—	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3903		15	—	
	2N3904		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.3	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.65	0.85	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.95	
SMALL SIGNAL CHARACTERISTICS					
High Frequency Current Gain	2N3903	$\|h_{fe}\|$	2.5	—	—
(I_C = 10 mA, V_{CE} = 20 V, f = 100 mc)	2N3904		3.0	—	
Current-Gain—Bandwidth Product	2N3903	f_T	250	—	mc
(I_C = 10 mA, V_{CE} = 20 V, f = 100 mc)	2N3904		300	—	
Output Capacitance		C_{ob}	—	4	pf
(V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)					
Input Capacitance		C_{ib}	—	6	pf
(V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)					
Small Signal Current Gain	2N3903	h_{fe}	50	200	—
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3904		100	400	
Voltage Feedback Ratio	2N3903	h_{re}	0.1	5.0	$X10^{-4}$
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3904		0.5	8.0	
Input Impedance	2N3903	h_{ie}	0.5	6	Kohms
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3904		1.0	10	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	Both Types		1.0	40	
Noise Figure		NF			db
(I_C = 100 μA, V_{CE} = 5 V, R_g = 1 Kohms,	2N3903		—	6	
Noise Bandwidth = 10 cps to 15.7 kc)	2N3904		—	5	
SWITCHING CHARACTERISTICS					
Delay Time	V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc,		t_d	—	35	nsec
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mA		t_r	—	35	nsec
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc,	2N3903	t_s	—	175	nsec
	I_{B1} = I_{B2} = 1 mAdc	2N3904		—	200	
Fall Time			t_f	—	50	nsec

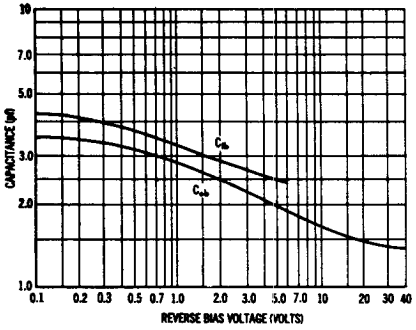
*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2% V_{OB} = Base Emitter Reverse Bias

2N3903, 2N3904 (continued)

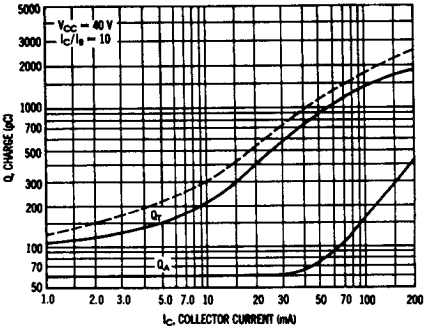
TRANSIENT CHARACTERISTICS

— $T_J = 25°C$ --- $T_J = 125°C$

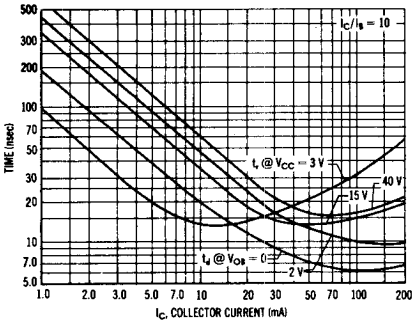
CAPACITANCE



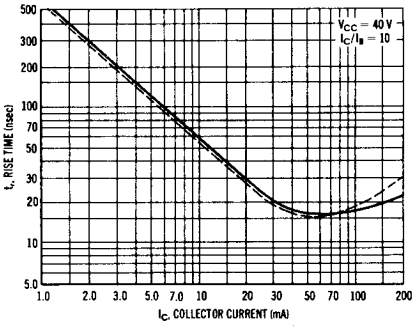
CHARGE DATA



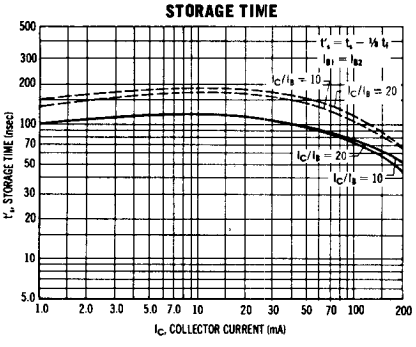
TURN-ON TIME



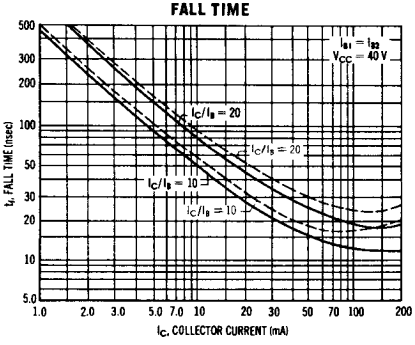
RISE TIME



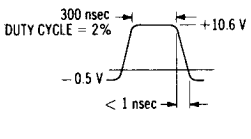
STORAGE TIME



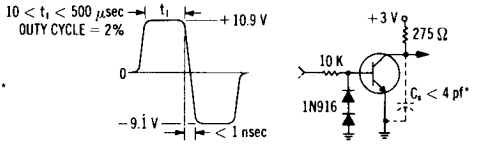
FALL TIME



DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



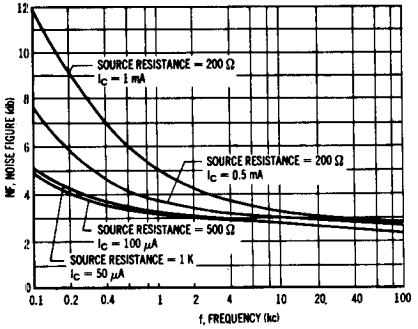
*Total shunt capacitance of test jig and connectors

2N3903, 2N3904 (continued)

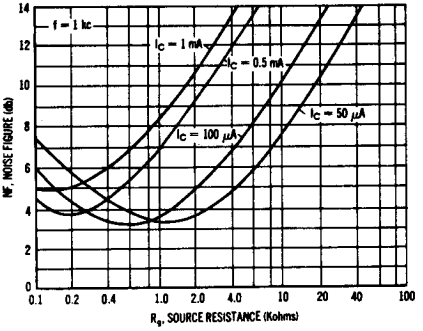
AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS
V_{CE} = 5 Vdc, T_A = 25°C

FREQUENCY VARIATION

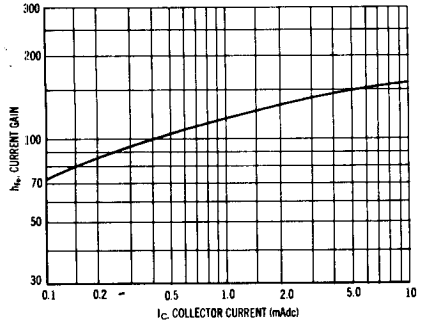


SOURCE RESISTANCE

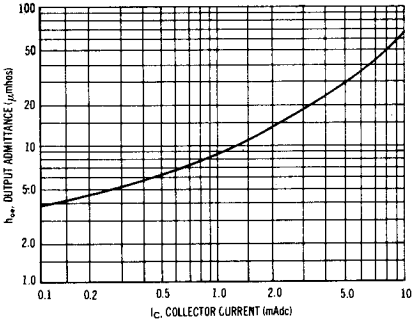


h PARAMETERS
(V_{CE} = 10 V, f = 1 kc, T_A = 25°C)

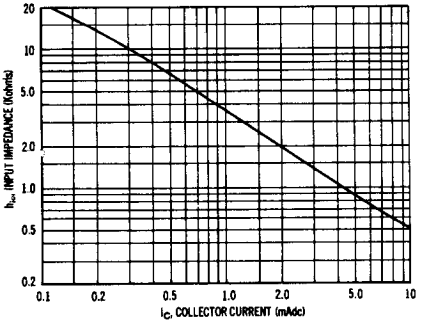
CURRENT GAIN



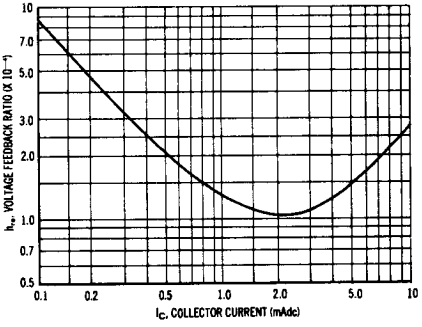
OUTPUT ADMITTANCE



INPUT IMPEDANCE



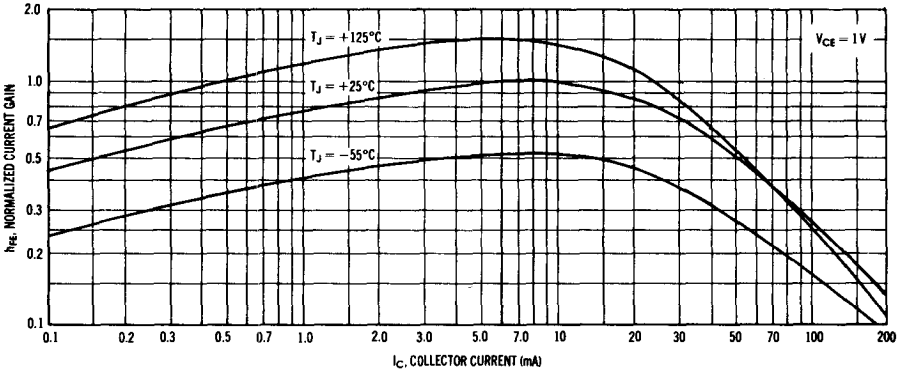
VOLTAGE FEEDBACK RATIO



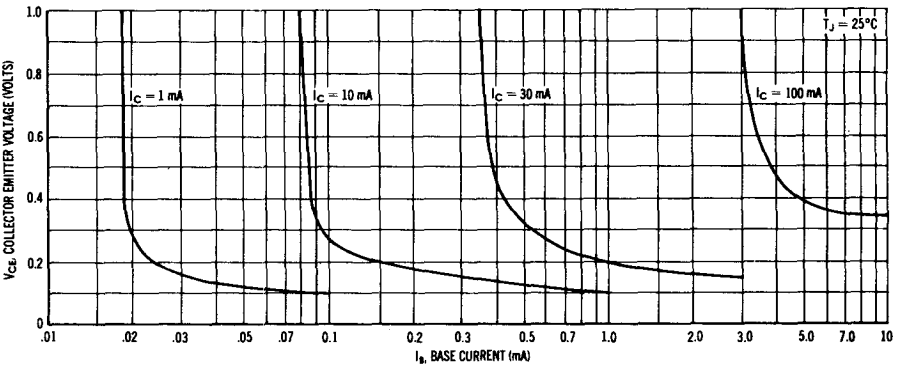
2N3903, 2N3904 (continued)

STATIC CHARACTERISTICS

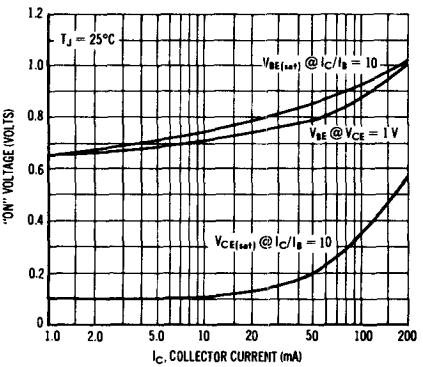
NORMALIZED CURRENT GAIN



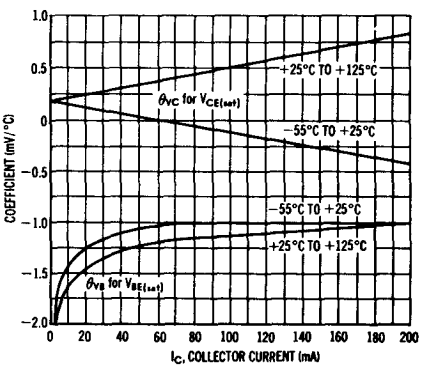
COLLECTOR SATURATION REGION



"ON" VOLTAGES



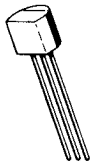
TEMPERATURE CO-EFFICIENTS



2N3905 (SILICON)
2N3906



$V_{CB} = 40$ V
$I_C = 200$ mA
$C_{ob} = 4.5$ pf (max)



CASE 29
(TO-92)

PNP silicon annular transistor, designed for general purpose switching and amplifier applications, features one-piece, injection-molded plastic package for high reliability. The 2N3905 and 2N3906 are complementary with types 2N3903 and 2N3904, respectively.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 60°C$	P_D	210	mW
Total Device Dissipation @ $T_A = 25°C$ Derate above $25°C$	P_D	310 2.81	mW mW/°C
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Operating Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage ($I_C = 10\ \mu$Adc, $I_E = 0$)	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage* ($I_C = 1$ mAdc)	BV_{CEO}*	40	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current ($V_{CE} = 40$ Vdc, $V_{OB} = 3$ Vdc)	I_{CEX}	—	50	nAdc
Base Cutoff Current ($V_{CE} = 40$ Vdc, $V_{OB} = 3$ Vdc)	I_{BL}	—	50	nAdc

*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2% V_{OB} = Base Emitter Reverse Bias

2N3905, 2N3906 (continued)

ELECTRICAL CHARACTERISTICS (continued)

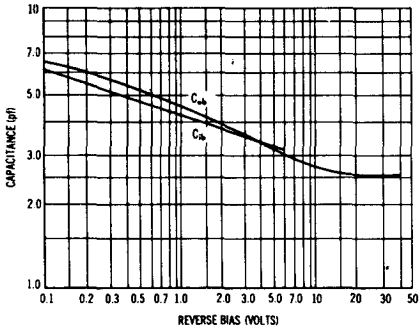
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3905		30	—	
	2N3906		60	—	
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3905		40	—	
	2N3906		80	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3905		50	150	
	2N3906		100	300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3905		30	—	
	2N3906		60	—	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N3905		15	—	
	2N3906		30	—	
Collector-Emitter Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.25	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.4	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.65	0.85	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.95	
SMALL SIGNAL CHARACTERISTICS					
High-Frequency Current Gain	2N3905	$\lvert h_{fe} \rvert$	2.0	—	—
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N3906		2.5	—	
Current-Gain—Bandwidth Product	2N3905	f_T	200	—	mc
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N3906		250	—	
Output Capacitance		C_{ob}			pf
(V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)			—	4.5	
Input Capacitance		C_{ib}			pf
(V_{OB} = 0.5 Vdc, I_C = 0, f = 100 kc)			—	10	
Small Signal Current Gain	2N3905	h_{fe}	50	200	—
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3906		100	400	
Voltage Feedback Ratio	2N3905	h_{re}	0.1	5	$X10^{-4}$
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3906		1.0	10	
Input Impedance	2N3905	h_{ie}	0.5	8	Kohms
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3906		2.0	12	
Output Admittance	2N3905	h_{oe}	1.0	40	μmhos
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3906		3.0	60	
Noise Figure		NF			db
(I_C = 100 μA, V_{CE} = 5 V, R_g = 1 Kohms, Noise Bandwidth = 10 cps to 15.7 kc)	2N3905		—	5.0	
	2N3906		—	4.0	
SWITCHING CHARACTERISTICS					
Delay Time	V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc, I_C = 10 mAdc, I_{B1} = 1 mA	t_d	—	35	nsec
Rise Time		t_r	—	35	nsec
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 1 mAdc 2N3905	t_s	—	200	nsec
	2N3906		—	225	
Fall Time	2N3905	t_f	—	60	nsec
	2N3906		—	75	

*Pulse Test: PW = 300 μsec, Duty Cycle = 2% V_{OB} = Base-Emitter Reverse Bias

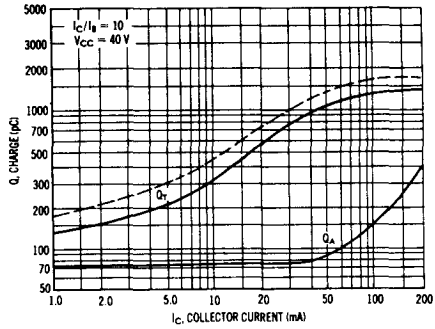
2N3905, 2N3906 (continued)

TRANSIENT CHARACTERISTICS
$T_J = 25°C$ ---- $T_J = 125°C$

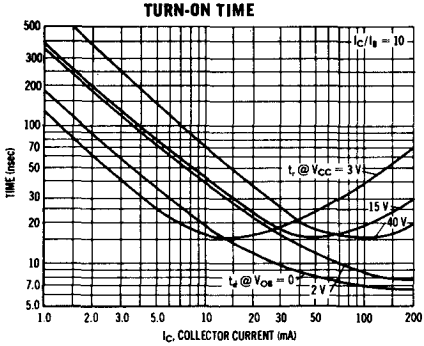
CAPACITANCE



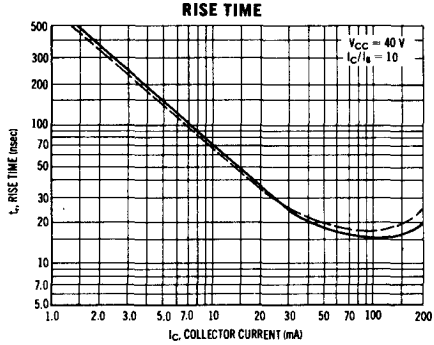
CHARGE DATA



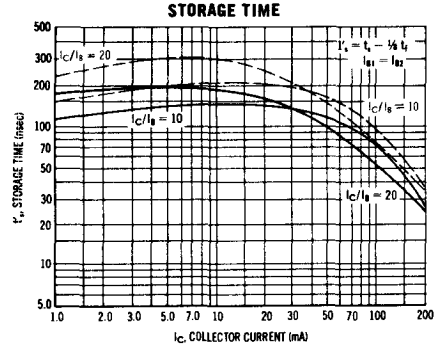
TURN-ON TIME



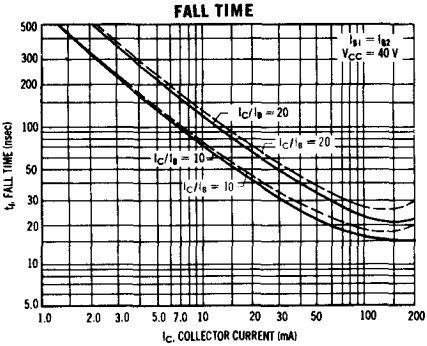
RISE TIME



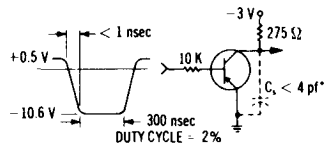
STORAGE TIME



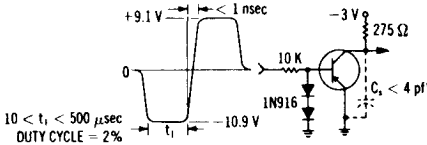
FALL TIME



DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



STORAGE AND FALL TIME EQUIVALENT TEST CIRCUIT



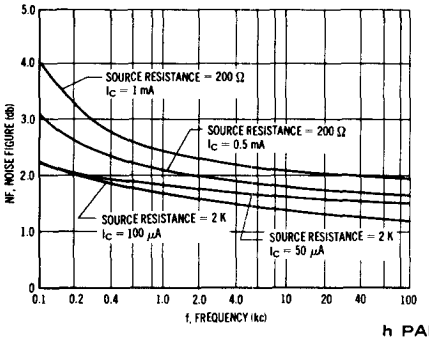
*Total shunt capacitance of test jig and connectors

2N3905, 2N3906 (continued)

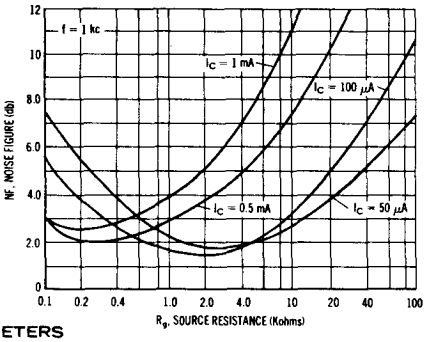
AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS
$V_{CE} = 5$ Vdc, $T_A = 25°C$

FREQUENCY VARIATION

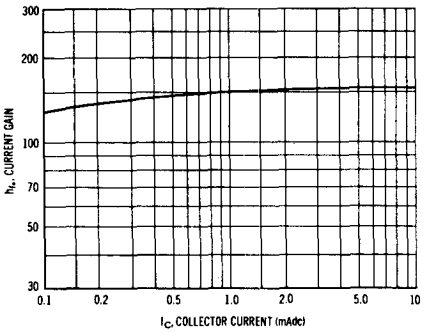


SOURCE RESISTANCE

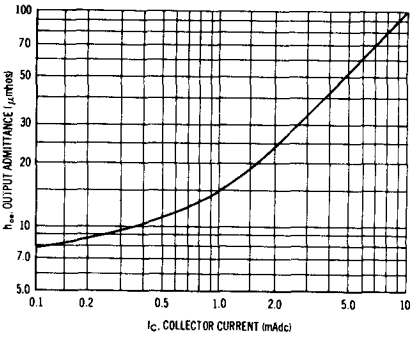


h PARAMETERS
(V_{CE} = 10 V, f = 1 kc, T_A = 25°C)

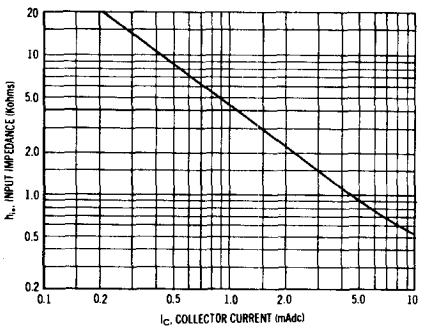
CURRENT GAIN



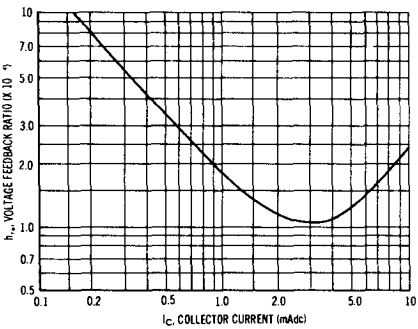
OUTPUT ADMITTANCE



INPUT IMPEDANCE



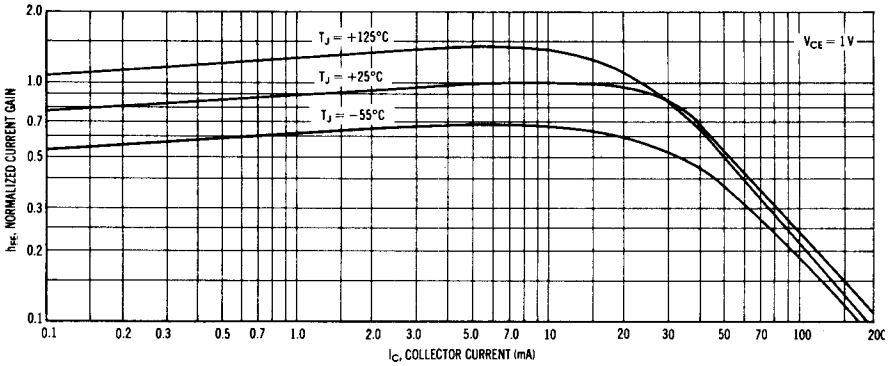
VOLTAGE FEEDBACK RATIO



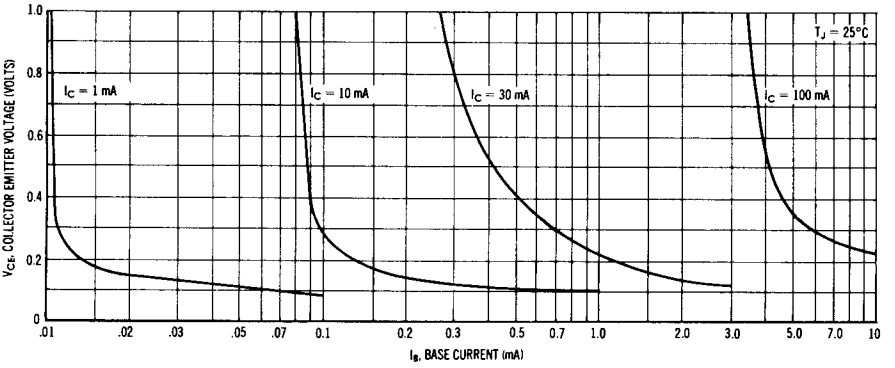
2N3905, 2N3906 (continued)

STATIC CHARACTERISTICS

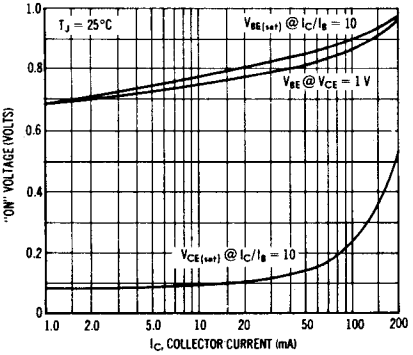
NORMALIZED CURRENT GAIN



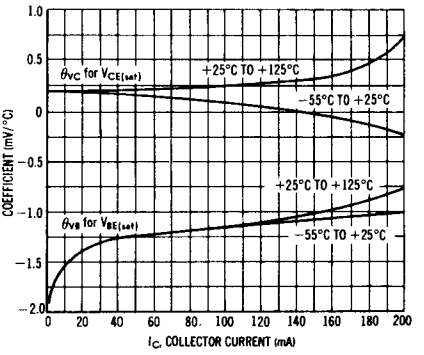
COLLECTOR SATURATION REGION



"ON" VOLTAGES



TEMPERATURE COEFFICIENTS



2N3946 (SILICON)
2N3947

V_{CEO} = 40 V (min)
I_C = 200 mA
f_T = 250-300 Mc (min)



CASE 22
(TO-18)

NPN silicon annular transistors, designed for general purpose switching and amplifier applications, The 2N3946 and 2N3947 are complementary with types 2N3250 and 2N3251, respectively.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	1.2 6.9	Watts mW/°C
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	0.36 2.06	Watt mW/°C
Thermal Resistance Junction to Air Junction to Case	 θ_{JA} θ_{JC}	 0.49 0.15	 °C/mW °C/mW
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	6	—	Vdc
Collector-Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc) (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc, T_A = 150°C)	I_{CEX}	— —	.010 15	μAdc
Base Cutoff Current (V_{CE} = 40 Vdc, V_{OB} = 3 Vdc)	I_{BL}	—	.025	μAdc

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

2N3946, 2N3947 (continued)

ELECTRICAL CHARACTERISTICS (continued)

(T_A = 25°C unless otherwise noted)

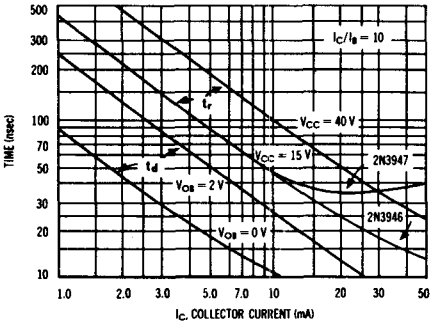
Characteristic		Symbol	Min	Max	Unit
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 1 Vdc)	2N3946		30	—	
	2N3947		60	—	
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)	2N3946		45	—	
	2N3947		90	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N3946		50	150	
	2N3947		100	300	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N3946		20	—	
	2N3947		40	—	
Collector Saturation Voltage*		$V_{CE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			—	0.2	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	0.3	
Base-Emitter Saturation Voltage*		$V_{BE(sat)}$*			Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)			0.6	0.9	
(I_C = 50 mAdc, I_B = 5 mAdc)			—	1.0	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	4	pf
Input Capacitance (V_{EB} = 1 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	8	pf
Current-Gain - Bandwidth Product		f_T			mc
(I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	2N3946		250	—	
	2N3947		300	—	
Delay Time	V_{CC} = 3 Vdc, V_{OB} = 0.5 Vdc	t_d	—	35	nsec
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mA	t_r	—	35	nsec
Storage Time	V_{CC} = 3 V, I_C = 10 mA, 2N3946	t_s	—	300	nsec
	2N3947		—	375	
Fall Time	I_{B1} = $-I_{B2}$ = 1 mAdc	t_f	—	75	nsec
SMALL SIGNAL CHARACTERISTICS					
Small-Signal Current Gain		h_{fe}			—
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3946		50	250	
	2N3947		100	700	
Voltage Feedback Ratio		h_{re}			X10-4
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3946		—	10	
	2N3947		—	20	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3946		0.5	6	
	2N3947		2	12	
Output Admittance		h_{oe}			μmhos
(I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3946		1	30	
	2N3947		5	50	
Collector-Base Time Constant (I_C = 10 mA, V_{CE} = 20 V, f = 31.8 mc)		r'_bC_C	—	200	psec
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 5 V, R_g = 1 kΩ, f = 10 cps to 15.7 kc)		NF	—	5	db

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2% V_{OB} = Base-Emitter Reverse Bias

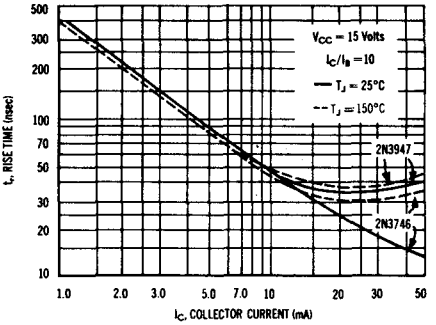
2N3946, 2N3947 (continued)

TYPICAL SWITCHING CHARACTERISTICS
($T_J = 25°C$ unless otherwise noted)

DELAY AND RISE TIME

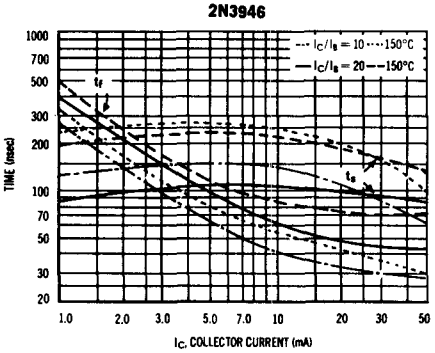


RISE TIME

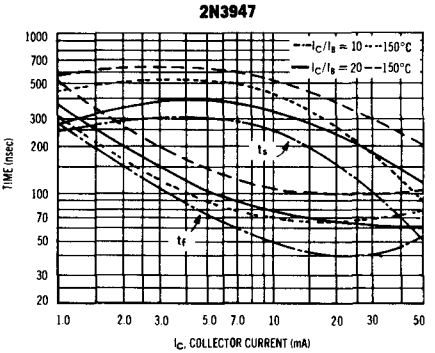


STORAGE AND FALL TIMES

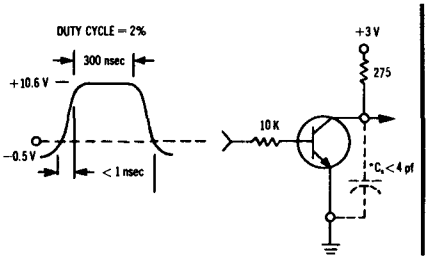
2N3946



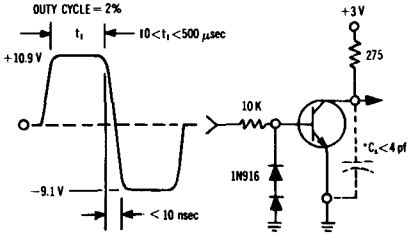
2N3947



TURN-ON TIME EQUIVALENT TEST CIRCUIT



TURN-OFF TIME EQUIVALENT TEST CIRCUIT



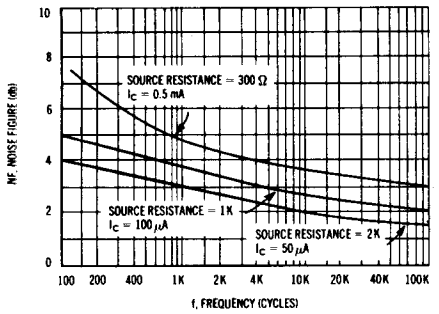
*TOTAL SHUNT CAPACITANCE OF TEST JIG AND CONNECTORS

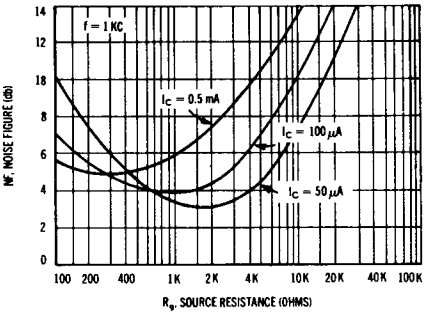
2N3946, 2N3947 (continued)

AUDIO SMALL-SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

V_{CE} = 5 V, T_A = 25°C

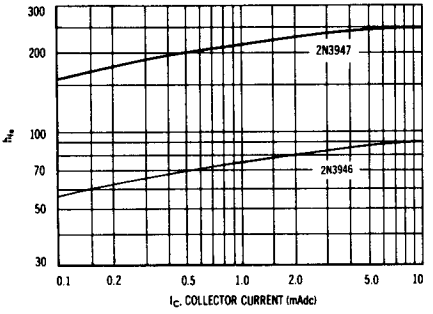




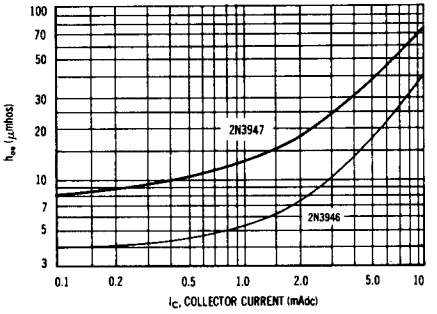
h PARAMETERS

V_{CE} = 10 V, T_A = 25°C, f = 1 Kc

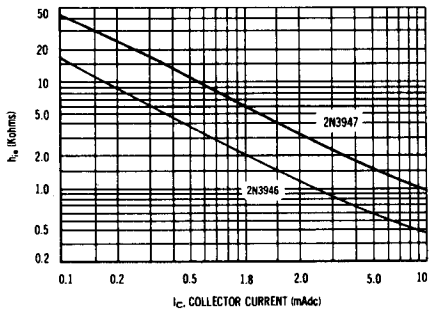
CURRENT GAIN



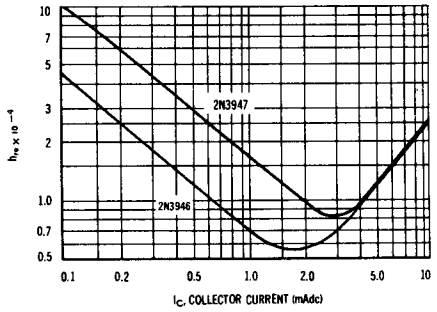
OUTPUT ADMITTANCE



INPUT IMPEDANCE

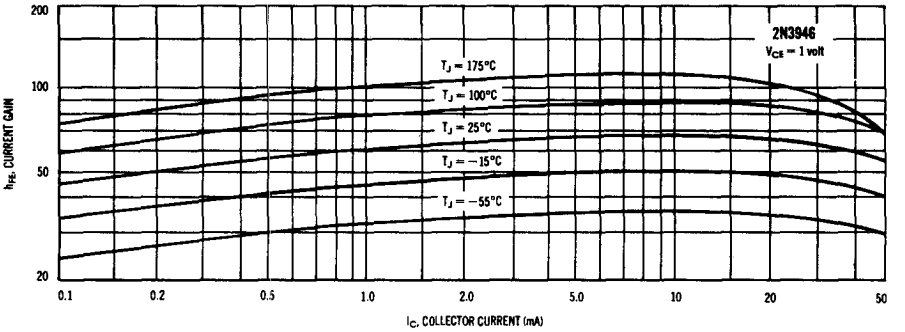


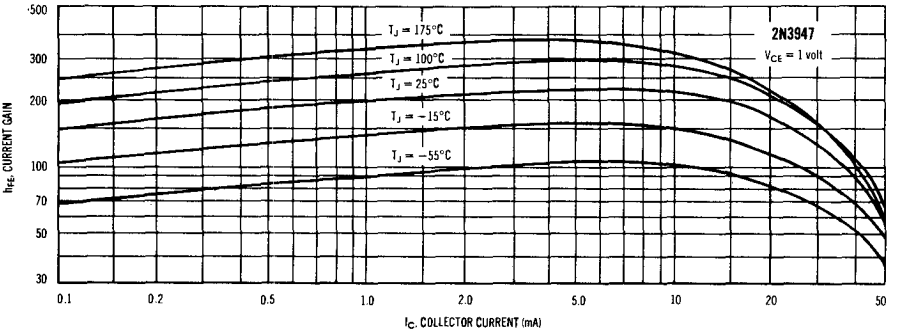
VOLTAGE FEEDBACK RATIO



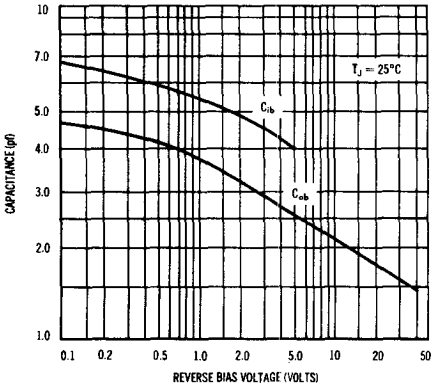
2N3946, 2N3947 (continued)

CURRENT GAIN CHARACTERISTICS

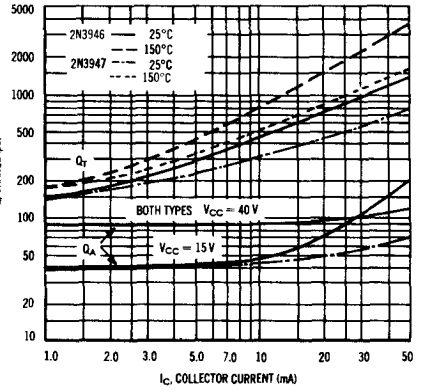




CAPACITANCE

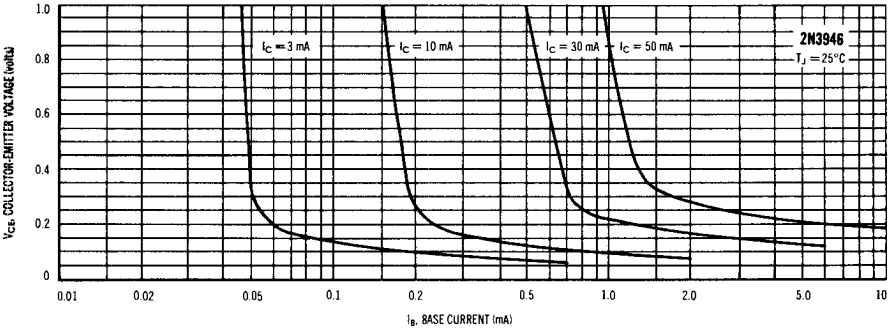


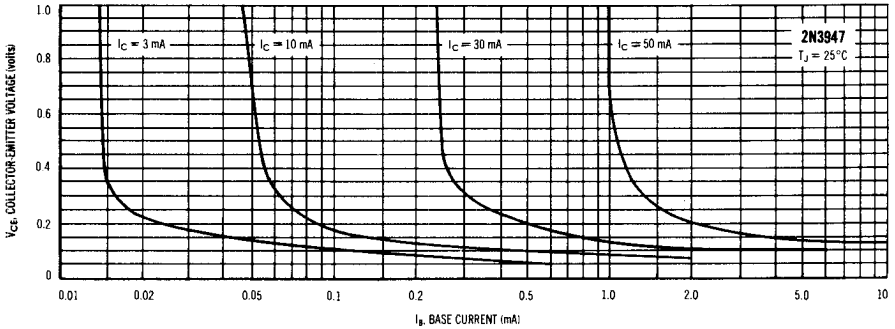
CHARGE DATA



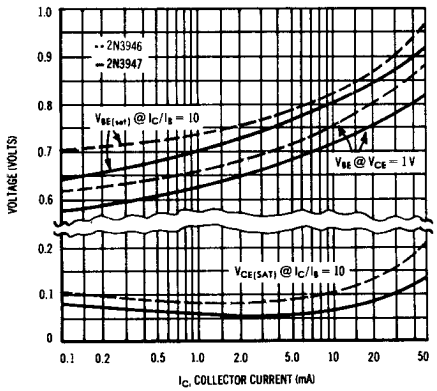
2N3946, 2N3947 (continued)

COLLECTOR SATURATION REGION

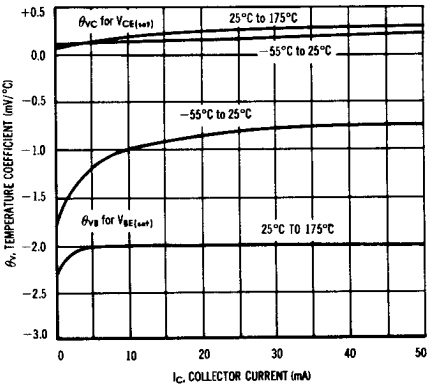




"ON" VOLTAGES



TEMPERATURE COEFFICIENTS



2N3959 (SILICON)
2N3960

f_T = 1800 Mc (typ) @ 10 mA and 10 V
C_{ob} and C_{ib} = 2.5 pf (max)
t_r = 1.7 nsec (typ) @ 30 mA



CASE 22
(TO-18)

NPN silicon annular transistor particularly well suited for high-speed current-mode logic switching applications.

Collector connected to case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	20	Vdc
Collector-Emitter Voltage (1 to 30 mA)	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	750 4.3	mW mW/°C
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.3	mW mW/°C
Thermal Resistance Junction to Case Junction to Ambient	 θ_{JC} θ_{JA}	 0.233 0.436	°C/mW
Junction Operating Temperature Range	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	20	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	12	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	4.5	—	Vdc
Collector Reverse Current (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc) (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc, T_A = 150°C)	9	I_{CEX}	— —	.005 5	μAdc
Base Cutoff Current (V_{CE} = 10 Vdc, V_{EB} = 2 Vdc)	9	I_{BL}	—	.005	μAdc
Collector Forward Current (V_{CE} = 5 Vdc, V_{BE} = 0.4 Vdc)	9	I_{CEX}	—	0.10	μAdc

2N3959, 2N3960 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
ON CHARACTERISTICS						
DC Current Gain		1	h_{FE}			—
(I_C = 1.0 mAdc, V_{CE} = 1 Vdc)				25	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)				40	200	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)				25	—	
Collector-Emitter Saturation Voltage		2, 3, 4	$V_{CE(sat)}$			Vdc
(I_C = 1.0 mAdc, I_B = 0.1 mAdc)				—	0.2	
(I_C = 30 mAdc, I_B = 3 mAdc)				—	0.3	
Base-Emitter "ON" Voltage		3,4	$V_{BE(ON)}$			Vdc
(I_C = 1.0 mAdc, V_{CE} = 1.0 Vdc)				—	0.8	
(I_C = 30 mAdc, V_{CE} = 1.0 Vdc)				—	1.0	
TRANSIENT CHARACTERISTICS						
Output Capacitance		8	C_{ob}			pf
(V_{CB} = 4 Vdc, I_E = 0, f = 1 kc)				—	2.5	
Input Capacitance		8	C_{ib}			pf
(V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)				—	2.5	
High-Frequency Current Gain			$\lvert h_{fe} \rvert$			—
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3959			13	—	
	2N3960			16	—	
Current-Gain - Bandwidth Product		5	f_T			mc
(I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 mc)	2N3959			1000	—	
	2N3960			1300	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	2N3959			1300	—	
	2N3960			1600	—	
(I_C = 30 mAdc, V_{CE} = 4 Vdc, f = 100 mc)	2N3959			1000	—	
	2N3960			1200	—	
Collector-Base Time Constant		6	$r'_b C_c$			psec
(I_C = 5 mAdc, V_{CE} = 4 Vdc)	2N3959			—	30	
	2N3960			—	50	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3959			—	25	
	2N3960			—	40	
(I_C = 30 mAdc, V_{CE} = 4 Vdc)	2N3959			—	30	
	2N3960			—	50	
TYPICAL SWITCHING TIMES				Typical Performance (v_{out} = 1 V)		
				@ 10 mA	@ 30 mA	
Turn-On Delay Time		7	$t_{on(delay)}$	2.4	2	nsec
Rise Time	2N3959		t_r	3	2.2	nsec
	2N3960			3	1.7	nsec
Turn-Off Delay Time		7	$t_{off(delay)}$	1.6	1.6	nsec
Fall-Time	2N3959		t_f	3.3	2.3	nsec
	2N3960			3.3	1.9	nsec

2N3959, 2N3960 (continued)

FIGURE 1

MINIMUM DC CURRENT GAIN

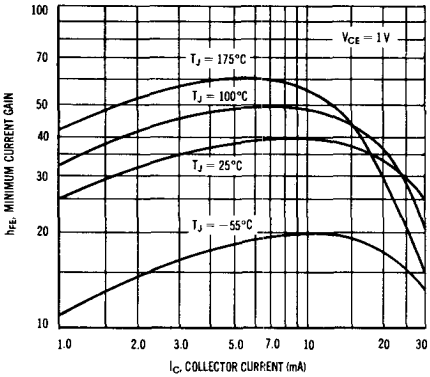


FIGURE 2

COLLECTOR SATURATION REGION

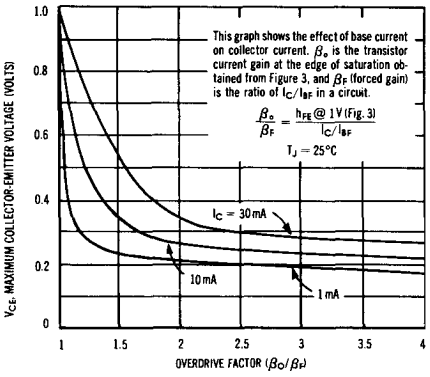


FIGURE 3

"ON" VOLTAGE LIMITS

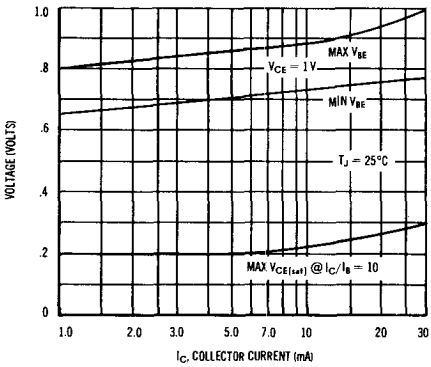


FIGURE 4

MAXIMUM COLLECTOR-BASE TIME CONSTANT

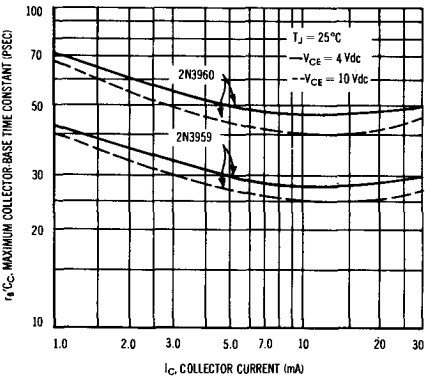


FIGURE 5

TYPICAL TEMPERATURE COEFFICIENTS

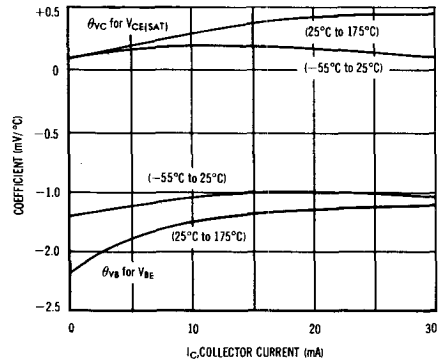
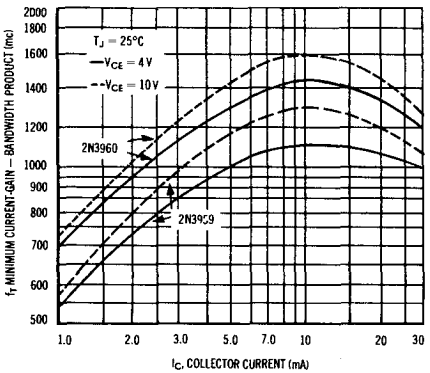


FIGURE 6

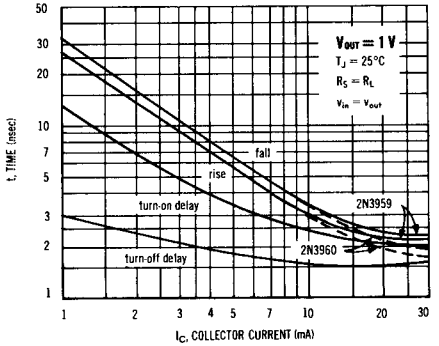
MINIMUM CURRENT GAIN-BANDWIDTH PRODUCT



2N3959, 2N3960 (continued)

FIGURE 7

TYPICAL SWITCHING TIMES



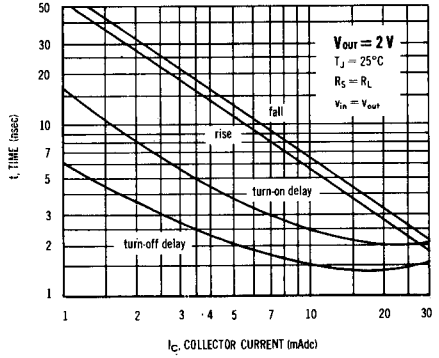


FIGURE 8

JUNCTION CAPACITANCE

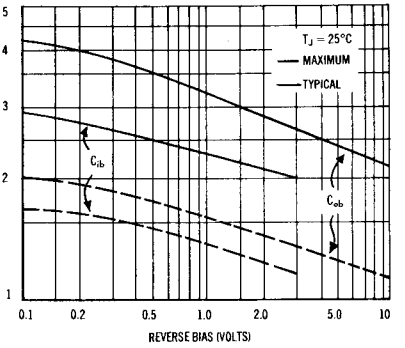
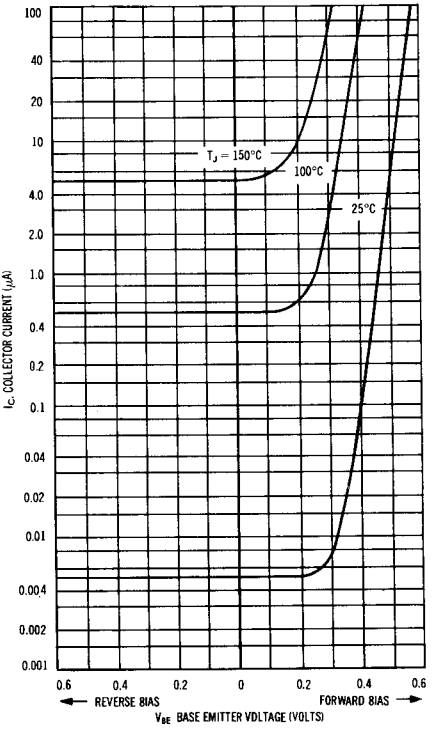
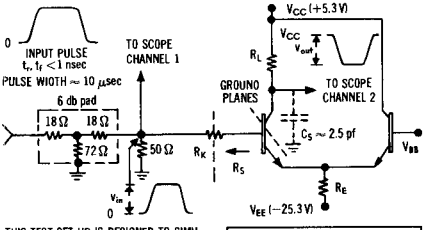


FIGURE 9

MAXIMUM CUT-OFF CHARACTERISTICS



TEST CIRCUIT



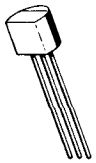
THIS TEST SET UP IS DESIGNED TO SIMULATE A CASCADE OF IDENTICAL STAGES. ∴ THE SOURCE RESISTANCE (R_S) EQUALS THE LOAD RESISTANCE (R_L). VALUES USED IN THE TEST ARE SHOWN IN THE TABLE.

FOR $V_{in} = V_{out} = 1$ V, $V_{BB} = +0.5$ V, R_L & R_K VALUES APPROPRIATELY REDUCED

$V_{in} = V_{out} = 2$ volts, $V_{BB} = +1.0$ V			
I_C (mA)	R_E (K Ω)	R_L (Ω)	R_K (Ω)
1.0	24.0	2 K	2 K
3.0	8.2	680	680
10	2.4	200	180
30	0.8	68	36

2N4123 (SILICON)
2N4124

V_{CEO} to 30V
I_C = 200 mAdc



CASE 29
(TO-92)

NPN silicon transistors designed for general purpose switching and amplifier applications and for complementary circuitry with PNP types 2N4125 and 2N4126. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Characteristic	Symbol	2N4123	2N4124	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	40	30	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210		mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — CAPACITANCE

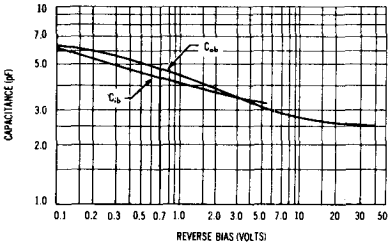
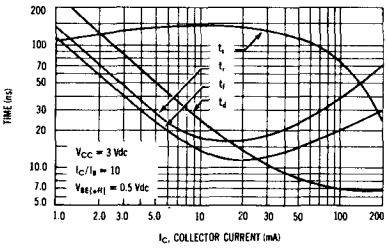


FIGURE 2 — SWITCHING TIMES



2N4123, 2N4124 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_E = 0)	2N4123 2N4124		BV_{CEO}*	30 25	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4123 2N4124		BV_{CBO}	40 30	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	5	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)			I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)			I_{EBO}	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4123 2N4124	9	h_{FE}*	50 120	150 360	–
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4123 2N4124			25 60	– –	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		10, 11	$V_{CE(sat)}$*	–	0.3	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		11	$V_{BE(sat)}$*	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS						
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124		$\lvert h_{fe} \rvert$	2.5 3.0	– –	–
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4123 2N4124		f_T	250 300	– –	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		1	C_{ob}	–	4	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		1	C_{ib}	–	8	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)	2N4123 2N4124	5	h_{fe}	50 120	200 480	–
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4123 2N4124	3, 4	NF	– –	6 5	dB

SWITCHING CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Typ	Unit
Delay Time	V_{CC} = 3 Vdc, $V_{EB(off)}$ = 0.5 Vdc,	2	t_d	24	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mAdc	2	t_r	13	ns
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc,	2	t_s	125	ns
Fall Time	I_{B1} = I_{B2} = 1 mAdc	2	t_f	11	ns

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

2N4123, 2N4124 (continued)

AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 3 — FREQUENCY VARIATIONS

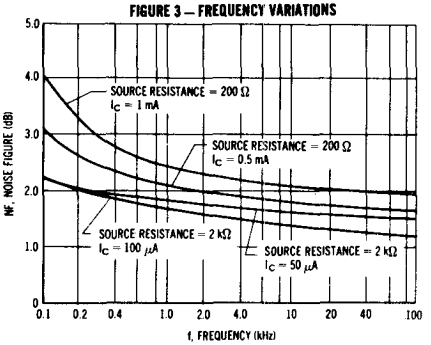
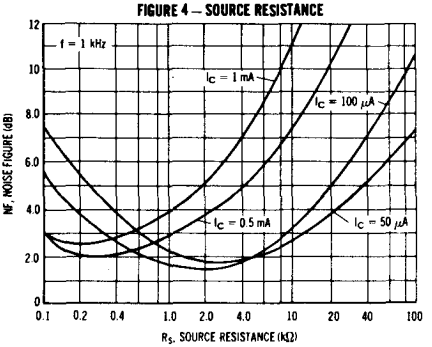


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

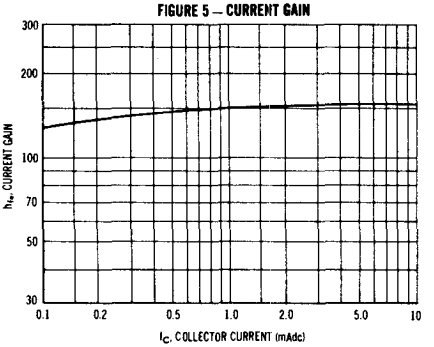


FIGURE 6 — OUTPUT ADMITTANCE

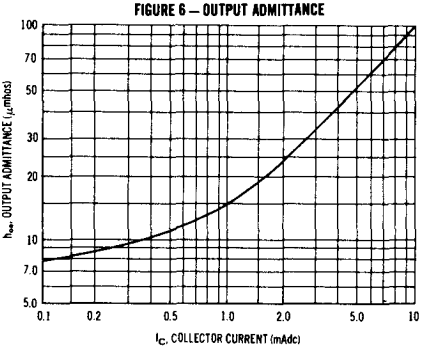


FIGURE 7 — INPUT IMPEDANCE

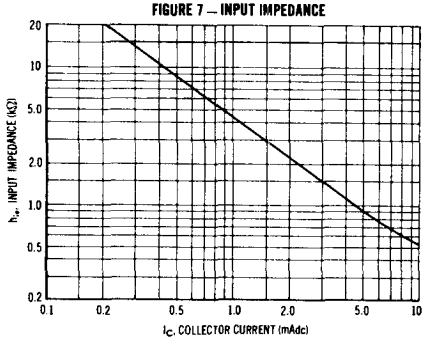
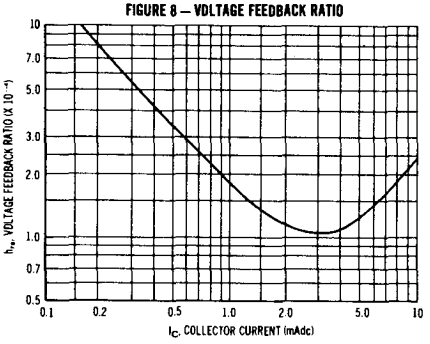


FIGURE 8 — VOLTAGE FEEDBACK RATIO



2N4123, 2N4124 (continued)

STATIC CHARACTERISTICS

FIGURE 9 — NORMALIZED CURRENT GAIN

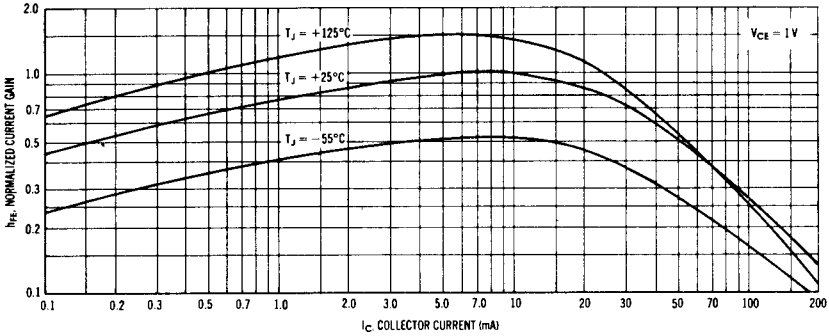


FIGURE 10 — COLLECTOR SATURATION REGION

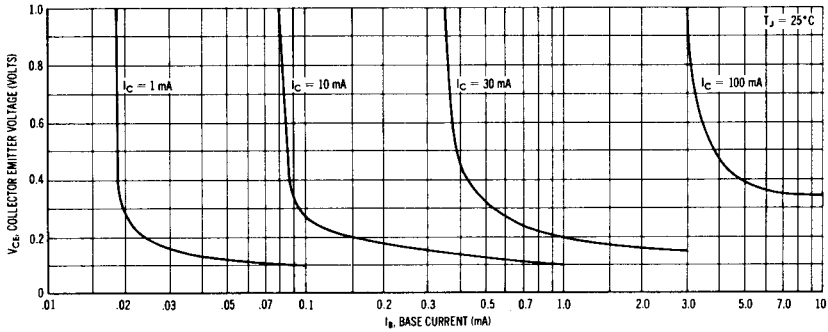


FIGURE 11 — "ON" VOLTAGES

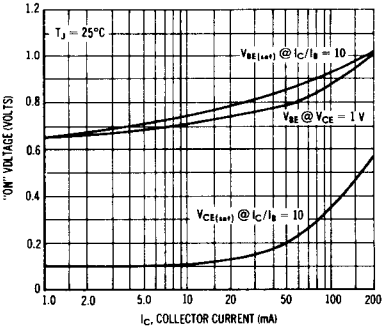
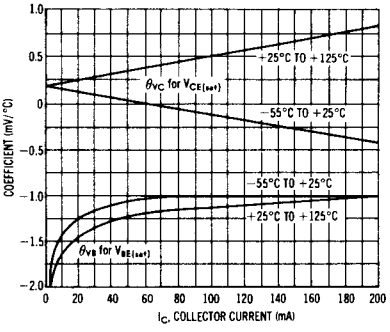
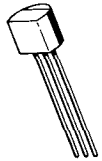


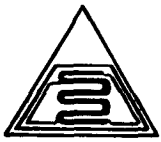
FIGURE 12 — TEMPERATURE COEFFICIENTS



2N4125 (SILICON)
2N4126

V_{CEO} to 30V
I_C = 200 mAdc





PNP silicon transistors designed for general purpose switching and amplifier applications and for complementary circuitry with NPN types 2N4123 and 2N4124. Features one-piece, injection-molded plastic package for high reliability.

CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	2N4125	2N4126	Unit
Collector-Emitter Voltage	V_{CEO}	30	25	Vdc
Collector-Base Voltage	V_{CB}	30	25	Vdc
Emitter-Base Voltage	V_{EB}	4		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210		mW
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — CAPACITANCE

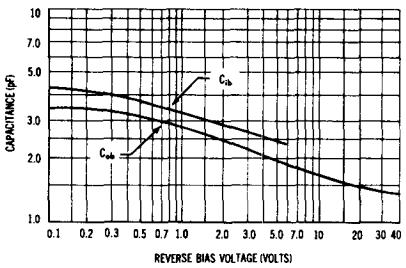
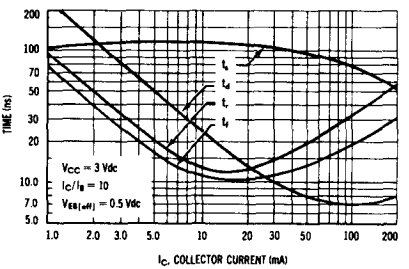


FIGURE 2 — SWITCHING TIMES



2N4125, 2N4126 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 1 mAdc, I_E = 0)	2N4125 2N4126		BV_{CEO}*	30 25	– –	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N4125 2N4126		BV_{CBO}	30 25	– –	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	4	–	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)			I_{CBO}	–	50	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)			I_{EBO}	–	50	nAdc
ON CHARACTERISTICS						
DC Current Gain* (I_C = 2 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126	9	h_{FE}*	50 120	150 360	–
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	2N4125 2N4126			25 60	– –	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		10, 11	$V_{CE(sat)}$*	–	0.4	Vdc
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		11	$V_{BE(sat)}$*	–	0.95	Vdc
SMALL SIGNAL CHARACTERISTICS						
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126		$\lvert h_{fe} \rvert$	2.0 2.5	– –	–
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 MHz)	2N4125 2N4126		f_T	200 250	– –	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		1	C_{ob}	–	4.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		1	C_{ib}	–	10	pF
Small-Signal Current Gain (I_C = 2 mAdc, V_{CE} = 1 Vdc, f = 1 kHz)	2N4125 2N4126	5	h_{fe}	50 120	200 480	–
Noise Figure (I_C = 100 μAdc, V_{CE} = 5 Vdc, R_S = 1 kohm, Noise Bandwidth = 10 Hz to 15.7 kHz)	2N4125 2N4126	3, 4	NF	– –	5.0 4.0	dB

SWITCHING CHARACTERISTICS

Characteristic		Fig. No.	Symbol	Typ	Unit
Delay Time	V_{CC} = 3 Vdc, $V_{BE(off)}$ = 0.5 Vdc,	2	t_d	25	ns
Rise Time	I_C = 10 mAdc, I_{B1} = 1 mAdc	2	t_r	18	ns
Storage Time	V_{CC} = 3 Vdc, I_C = 10 mAdc,	2	t_s	140	ns
Fall Time	$I_{B1} = I_{B2}$ = 1 mAdc	2	t_f	15	ns

*Pulse Test: Pulse Width = 300 μsec, Duty Cycle = 2%

2N4125, 2N4126 (continued)

AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE

V_{CE} = 5 Vdc, T_A = 25°C

FIGURE 3 — FREQUENCY VARIATIONS

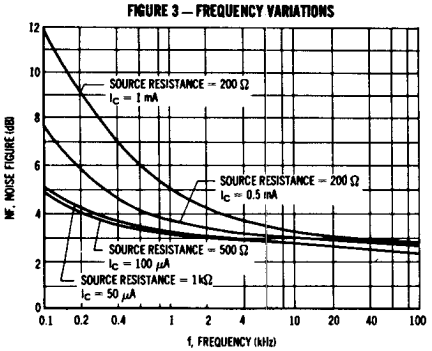
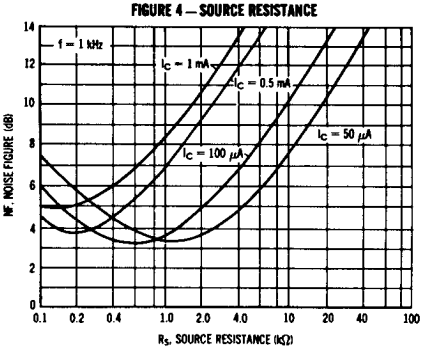


FIGURE 4 — SOURCE RESISTANCE



h PARAMETERS

V_{CE} = 10 V, f = 1 kHz, T_A = 25°C

FIGURE 5 — CURRENT GAIN

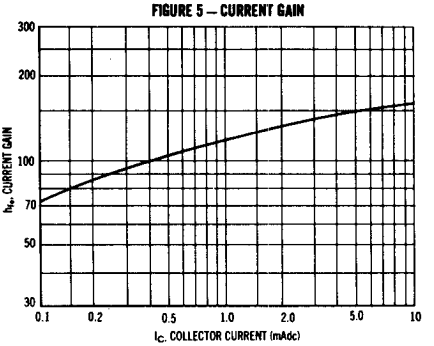


FIGURE 6 — OUTPUT ADMITTANCE

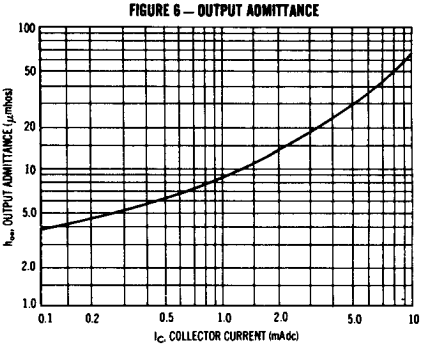


FIGURE 7 — INPUT IMPEDANCE

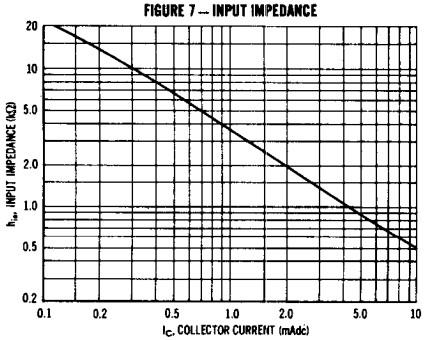
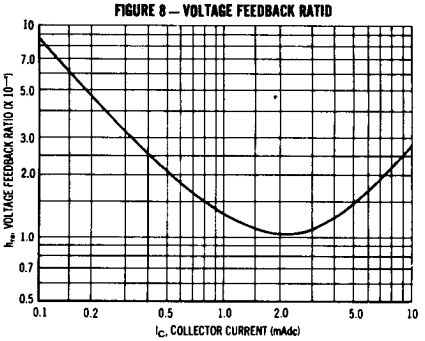


FIGURE 8 — VOLTAGE FEEDBACK RATIO



2N4125, 2N4126 (continued)

STATIC CHARACTERISTICS

FIGURE 9 — NORMALIZED CURRENT GAIN

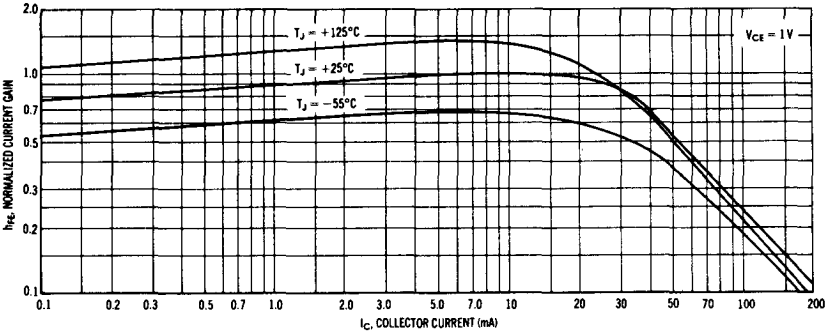


FIGURE 10 — COLLECTOR SATURATION REGION

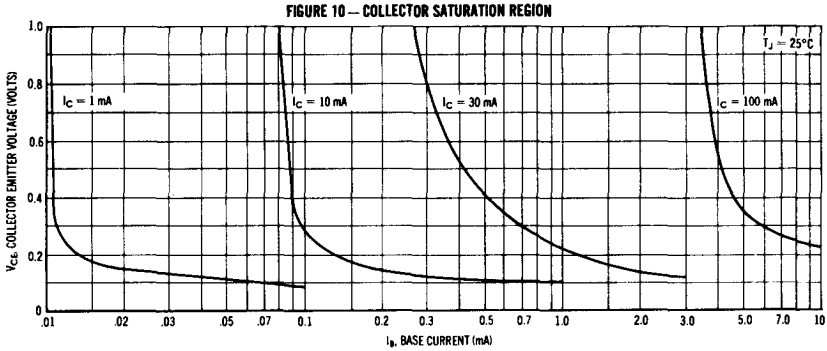


FIGURE 11 — "ON" VOLTAGES

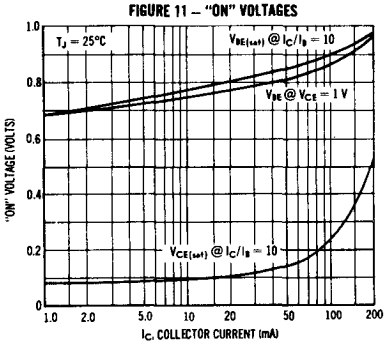
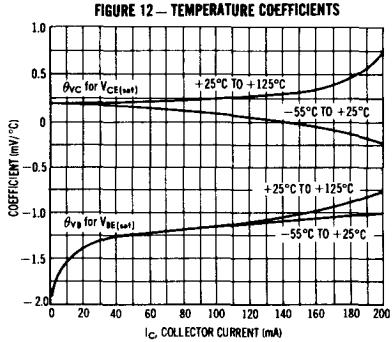


FIGURE 12 — TEMPERATURE COEFFICIENTS



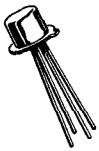
2N4260 (SILICON)

2N4261

$V_{CB} = 15$ V

$I_C = 30$ mA

$P_D = 200$ mW



CASE 20
(TO-72)

PNP silicon annular transistors, designed for high-speed current-mode logic switching applications and for complementary circuitry with NPN types 2N3959 and 2N3960.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	15	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4.5	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	200	mW
Derate above 25°C		1.14	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

2N4260, 2N4261 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_E = 0)			BV_{CEO}	15	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	4.5	-	Vdc
Collector Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc)			I_{CEX}	-	0.005	μAdc
(V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc, T_A = 150°C)				-	5.0	
(V_{CE} = 10 Vdc, $V_{EB(on)}$ = 0.4 Vdc)				-	0.05	
Base Cutoff Current (V_{CE} = 10 Vdc, $V_{BE(off)}$ = 2 Vdc)			I_{BL}	-	0.005	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 1 mAdc, V_{CE} = 1 Vdc)		1	h_{FE}	25	-	-
(I_C = 10 mAdc, V_{CE} = 1 Vdc)				30	150	
(I_C = 30 mAdc, V_{CE} = 2 Vdc)				20	-	
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 Adc)		2, 3, 4	$V_{CE(sat)}$	-	0.15	Vdc
(I_C = 10 mAdc, I_B = 1 mAdc)				-	0.35	
Base-Emitter On Voltage (I_C = 1 mAdc, V_{CE} = 1 Vdc)		3, 4	$V_{BE(on)}$	-	0.8	Vdc
(I_C = 10 mAdc, V_{CE} = 1 Vdc)				-	1.0	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 100 MHz)	2N4260	5	f_T	1200	-	MHz
	2N4261			1500	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4260			1800	-	
	2N4261			2000	-	
High-Frequency Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N4260		$\lvert h_{fe} \rvert$	16	-	-
	2N4261			20	-	
Output Capacitance (V_{CB} = 4 Vdc, I_E = 0, f = 100 kHz)		8	C_{ob}	-	2.5	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		8	C_{ib}	-	2.5	pF
Collector-Base Time Constant (I_C = 5 mAdc, V_{CE} = 4 Vdc, f = 31.8 MHz)	2N4260	6	$r_b'C_c$	-	35	ps
	2N4281			-	60	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 31.8 MHz)	2N4260			-	30	
	2N4281			-	50	

TYPICAL SWITCHING TIMES			Typical Performance (v_{out} = 1 V) @ 10 mA	@ 30 mA	
Turn-On Delay Time	Test Circuit Figure 7	$t_{on(delay)}$	1.0	1.2	ns
Rise Time		t_r	0.5	0.9	ns
Turn-Off Delay Time	Test Circuit Figure 7	$t_{off(delay)}$	1.0	1.2	ns
Fall-Time		t_f	1.0	1.2	ns

2N4260, 2N4261 (continued)

FIGURE 1 — DC CURRENT GAIN

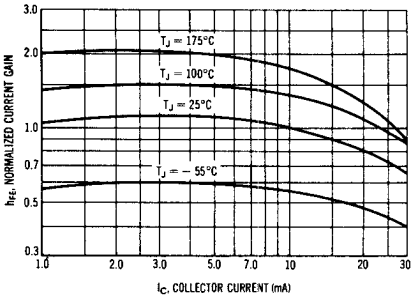


FIGURE 2 — COLLECTOR SATURATION REGION

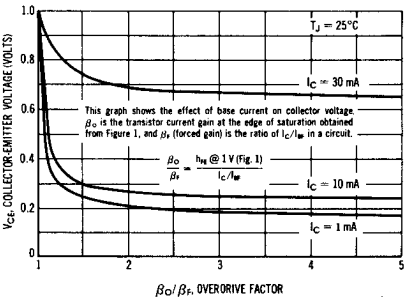


FIGURE 3 — "ON" VOLTAGES

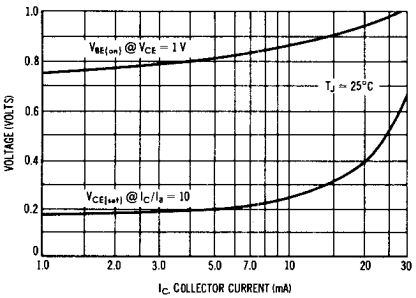


FIGURE 4 — TEMPERATURE COEFFICIENTS

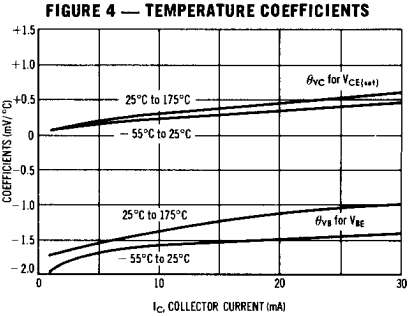


FIGURE 5 — CURRENT-GAIN — BANDWIDTH PRODUCT

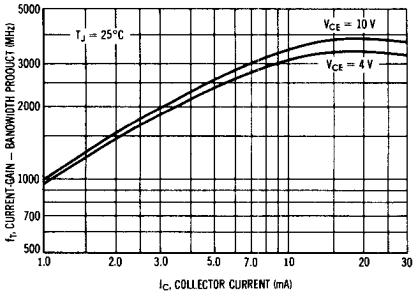
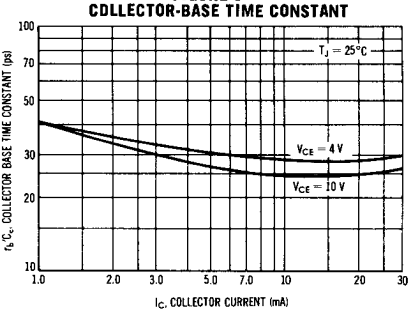
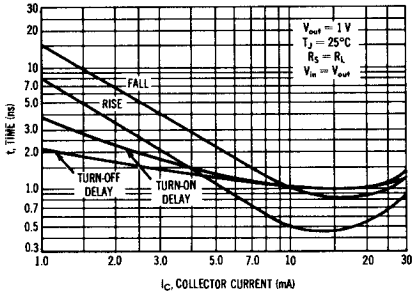


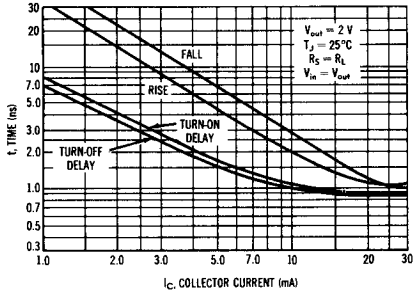
FIGURE 6 — CDLLECTOR-BASE TIME CONSTANT

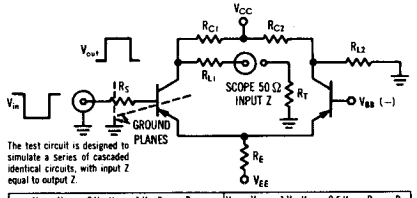


2N4260, 2N4261 (continued)

FIGURE 7 — SWITCHING TIMES







The test circuit is designed to simulate a series of cascaded identical circuits, with input Z equal to output Z.

$V_{in} = V_{out} = 2$ V $V_{BB} = 1$ V $R_{C1} = R_{C2}$								$V_{in} = V_{out} = 1$ V $V_{BB} = 0.5$ V $R_{C1} = R_{C2}$							
I_C mA	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{BB} volts	V_{CC} volts	R_S ohms	R_C ohms	R_{L1} ohms	R_{L2} ohms	R_E ohms	V_{EE} volts	V_{CC} volts
1	2 k	6 k	3 k	3 k	10 k	10	16	1 k	6 k	1.2 k	1.2 k	24 k	24	32
5	360	3.56 k	400	450	2 k	10	47	175	1 k	200	250	3 k	15	27
10	160	1 k	200	250	3 k	30	26.3	75	300	100	150	3 k	30	17
20	62	300	100	150	1 k	20	16	25	150	25	75	1 k	20	11
30	28	157	66	116	1 k	30	13	8	77	0	50	1 k	30	9

FIGURE 8 — CAPACITANCE

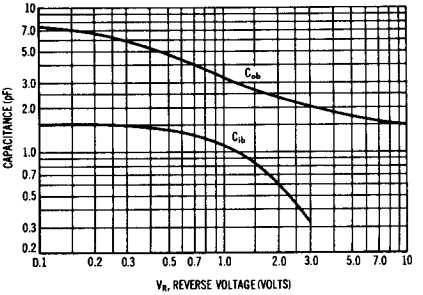
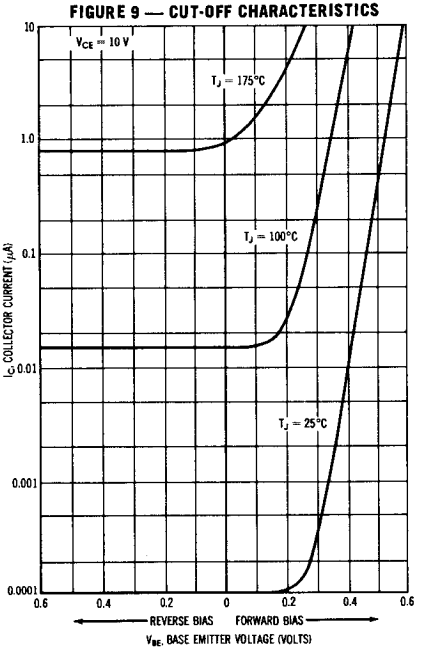


FIGURE 9 — CUT-OFF CHARACTERISTICS



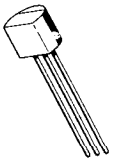
2N4264 (SILICON)

2N4265

$V_{CB} = 30$ V

$I_C = 200$ mA

$P_D = 310$ mW @ 25°C



CASE 29
(TO-92)

NPN silicon annular transistors, designed for low-level, saturated logic applications featuring one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

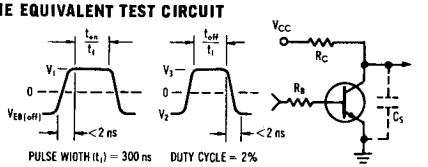
Characteristic	Symbol	2N4264	2N4265	Unit
Collector-Emitter Voltage	V_{CEO}	15	12	Vdc
Collector-Base Voltage	V_{CB}	30		Vdc
Emitter-Base Voltage	V_{EB}	6		Vdc
Collector Current	I_C	200		mAdc
Total Device Dissipation @ $T_A = 60°C$	P_D	210		mW
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1 — SWITCHING TIME EQUIVALENT TEST CIRCUIT

TEST CONDITION	I_C	V_{CC}	R_B	R_C	$C_{S(max)}$	$V_{EB(off)}$	V_1	V_3	V_2
	mA	V	Ω	Ω	pF	V	V	V	V
A	10	3	3300	270	4	−1.5	10.55	−4.15	10.70
B	10	10	560	960	4	—	—	−4.65	6.55
C	100	10	560	96	12	−2.0	6.35	−4.65	6.55



PULSE WIDTH (t_1) = 300 ns DUTY CYCLE = 2%

2N4264, 2N4265 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Fig. No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_E = 0)	2N4264		BV_{CEO}	15	—	Vdc
	2N4265			12	—	
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)			BV_{CBO}	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)			BV_{EBO}	6	—	Vdc
Collector Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)			I_{CEX}	—	100	nAdc
Base Cutoff Current (V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc)			I_{BL}	—	0.1	μAdc
(V_{CE} = 12 Vdc, $V_{EB(off)}$ = 0.25 Vdc, T_A = 100°C)				—	10	
ON CHARACTERISTICS						
DC Current Gain (I_C = 1 mAdc, V_{CE} = 1 Vdc)	2N4264	2	h_{FE}	25	—	—
	2N4265			50	—	
(I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N4264			40	160	
	2N4265			100	400	
(I_C = 10 mAdc, V_{CE} = 1 Vdc, T_A = -55°C)	2N4264			20	—	
	2N4265			45	—	
(I_C = 30 mAdc, V_{CE} = 1 Vdc)	2N4264			40	—	
	2N4265			90	—	
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	2N4264			30	—	
	2N4265			55	—	
(I_C = 200 mAdc, V_{CE} = 1 Vdc)	2N4264			20	—	
	2N4265			35	—	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		5, 6, 7	$V_{CE(sat)}$	—	0.22	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)				—	0.35	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		6, 7	$V_{BE(sat)}$	0.65	0.80	Vdc
(I_C = 100 mAdc, I_B = 10 mAdc)				0.75	0.95	
SMALL SIGNAL CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)			f_T	300	—	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)		12	C_{ob}	—	4	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 100 kHz)		12	C_{ib}	—	8	pF
SWITCHING CHARACTERISTICS						
Turn-On Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, $V_{EB(off)}$ = 1.5 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc	1	t_{on}	—	25	ns
Turn-Off Time	Figure 1, Test Condition A V_{CC} = 3 Vdc, I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1.5 mAdc	1	t_{off}	—	35	ns
Storage Time	Figure 1, Test Condition B V_{CC} = 10 Vdc, I_C = 10 mAdc, I_{B1} = I_{B2} = 10 mAdc	1	t_s	—	20	ns
Delay Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, $V_{EB(off)}$ = 2 Vdc, I_C = 100 mAdc, I_{B1} = 10 mAdc	1, 8	t_d	—	8	ns
Rise Time		1, 9	t_r	—	15	ns
Storage Time	Figure 1, Test Condition C V_{CC} = 10 Vdc, I_C = 100 mAdc, I_{B1} = I_{B2} = 10 mAdc	1, 10	t_s	—	20	ns
Fall Time		1, 11	t_f	—	15	ns
Total Control Charge	V_{CC} = 3 Vdc, I_C = 10 mAdc, I_B = mAdc	3, 13	Q_T	—	80	pC

2N4264, 2N4265 (continued)

CURRENT GAIN CHARACTERISTICS

FIGURE 2 — MINIMUM CURRENT GAIN

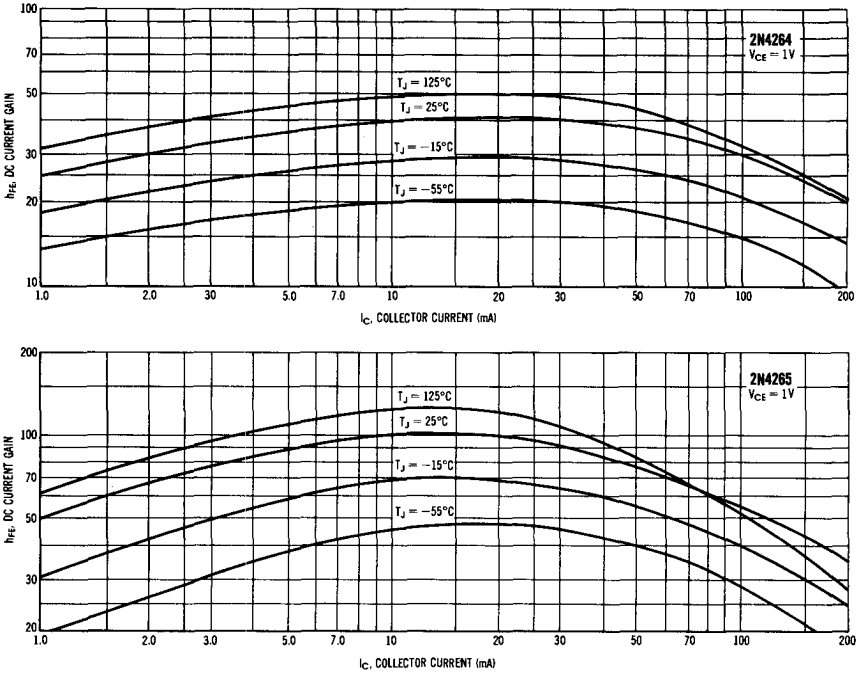


FIGURE 3 — Q_T TEST CIRCUIT

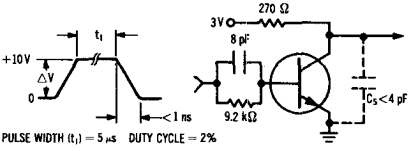
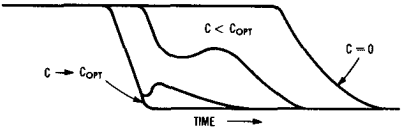


FIGURE 4 — TURN-OFF WAVEFORM



NOTE 1

When a transistor is held in a conductive state by a base current, I_B, a charge, Q_S, is developed or "stored" in the transistor. Q_S may be written: $Q_S = Q_i + Q_V + Q_X$.

Q_i is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to charge the collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i.e., operation in saturation.

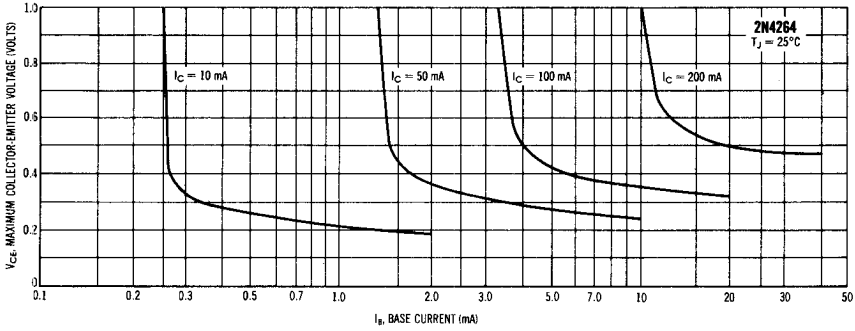
The charge required to turn a transistor "on" to the edge of saturation is the sum of Q_i and Q_V which is defined as the active region charge, Q_A. $Q_A = I_{B1}t$, when the transistor is driven by a constant current step (I_{B1}) and $I_{B1} << \frac{I_C}{h_{FE}}$.

If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, a charge, Q_T, of opposite polarity, equal in magnitude, can be stored on an external capacitor, C, to neutralize the internal charge and considerably reduce the turn-off time of the transistor. Figure 3 shows the test circuit and Figure 4 the turn-off waveform. Given Q_T from Figure 13, the external C for worst-case turn-off in any circuit is: $C = Q_T/\Delta V$, where ΔV is defined in Figure 3.

2N4264, 2N4265 (continued)

"ON" CONDITION CHARACTERISTICS

FIGURE 5 — COLLECTOR SATURATION REGION



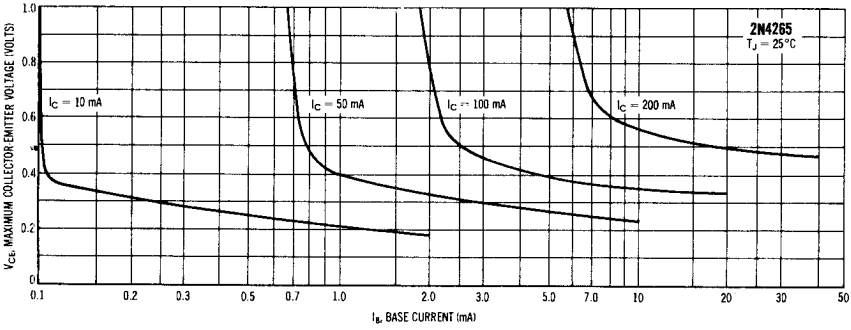


FIGURE 6 — SATURATION VOLTAGE LIMITS

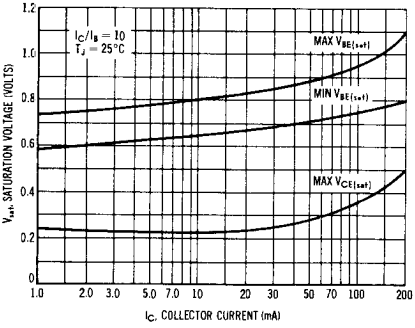
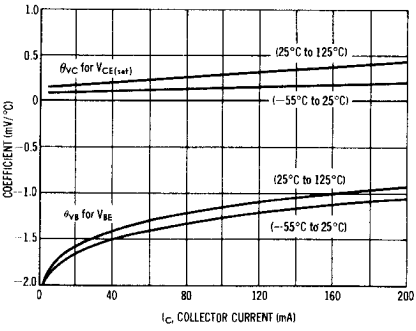


FIGURE 7 — TEMPERATURE COEFFICIENTS



2N4264, 2N4265 (continued)

DYNAMIC CHARACTERISTICS

FIGURE 8 — DELAY TIME

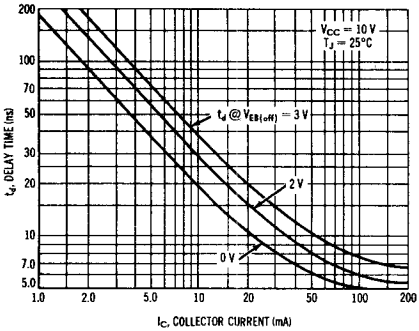


FIGURE 9 — RISE TIME

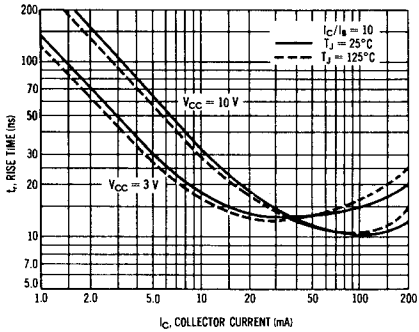


FIGURE 10 — STORAGE TIME

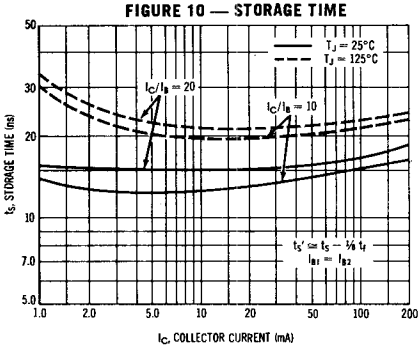


FIGURE 11 — FALL TIME

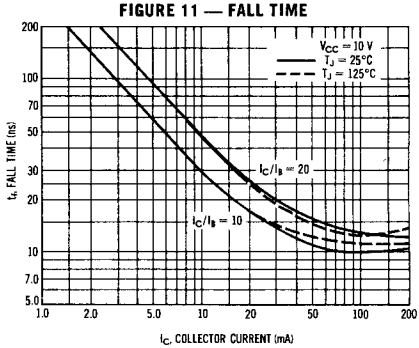


FIGURE 12 — JUNCTION CAPACITANCE

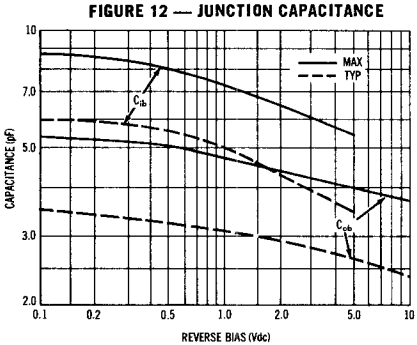
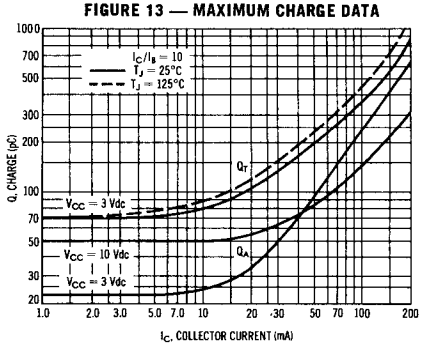
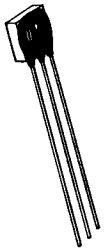


FIGURE 13 — MAXIMUM CHARGE DATA



MCS2135, MCS2136 (SILICON)

$V_{CEO} = 60$ V
$I_C = 50$ mA
$C_{ob} = 3$ pf
NF = 3-4 db @ 15.7 kc



CASE 37

NPN silicon annular transistors in a micro-ceramic package for general-purpose, low-current switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}	75	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	150	mW
Derating Factor Above 25°C		1.5	mW/°C
Junction Temperature, Operating	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +125	°C

MCS2135, MCS2136 (continued)

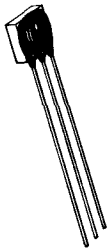
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	75	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	6	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	.010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 100°C)			-	2.0	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	20	nAdc
DC Current Gain*		h_{FE}*			-
(I_C = 1 μAdc, V_{CE} = 5 Vdc)	MCS2136		30	-	
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	MCS2135		40	-	
	MCS2136		100	-	
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	MCS2135		100	300	
	MCS2136		250	750	
(I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	MCS2135		50	-	
	MCS2136		125	-	
(I_C = 1.0 mAdc, V_{CE} = 5 Vdc)	MCS2135		150	-	
	MCS2136		250	-	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	MCS2135		150	-	
	MCS2136		250	-	
Collector-Emitter Saturation Voltage* (I_C = 10 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	-	0.3	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			-	0.5	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	-	0.7	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			-	1.0	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	0.7	Vdc
High-Frequency Current Gain (I_C = 500 μAdc, V_{CE} = 5 Vdc, f = 30 mc)		h_{fe}	1.0	-	-
(I_C = 1.0 mAdc, V_{CE} = 5 Vdc, f = 100 mc)			1.0	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kc)		C_{ob}	-	3.0	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	-	8.0	pf
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	MCS2135	h_{fe}	80	450	-
	MCS2136		150	900	
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	MCS2135	h_{ie}	3	20	kohms
	MCS2136		5	25	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)		h_{re}	-	25	$X10^{-4}$
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)		h_{oe}	-	50	μmhos
Noise Figure (Power Bandwidth = 15.7 kc)		NF			db
(I_C = 10 μAdc, V_{CE} = 5 Vdc, R_g = 10 kohms)	MCS2135		-	4	
	MCS2136		-	3	

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

MCS2137, MCS2138 (SILICON)

$V_{CEO} = 60$ V
$I_C = 50$ mA
$C_{ob} = 3$ pf
NF = 3-4 db @ 15.7 kc



PNP silicon annular transistors in a micro-ceramic package for general-purpose, low-current switching and amplifier applications.

CASE 37

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$	P_D	150	mW
Derating Factor Above 25°C		1.5	mW/°C
Junction Temperature, Operating	T_J	+125	°C
Storage Temperature Range	T_{stg}	-65 to +125	°C

MCS2137, MCS2138 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	60	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	.020	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 100°C)			-	2.0	
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	20	nAdc
DC Current Gain*		h_{FE}*			-
(I_C = 1 μAdc, V_{CE} = 5 Vdc)	MCS2138		50	-	
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	MCS2137		75	-	
	MCS2138		200	-	
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	MCS2137		100	300	
	MCS2138		250	750	
(I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	MCS2137		50	-	
	MCS2138		125	-	
(I_C = 1.0 mAdc, V_{CE} = 5 Vdc)	MCS2137		100	-	
	MCS2138		250	-	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	MCS2137		100	-	
	MCS2138		250	-	
Collector-Emitter Saturation Voltage* (I_C = 10 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	-	0.20	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			-	0.25	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	-	0.7	Vdc
(I_C = 1.0 mAdc, I_B = 100 μAdc)			-	0.8	
Base-Emitter On Voltage (I_C = 100 μAdc, V_{CE} = 5.0 Vdc)		$V_{BE(on)}$	-	0.7	Vdc
High-Frequency Current Gain (I_C = 500 μAdc, V_{CE} = 5 Vdc, f = 30 mc)		h_{fe}	1.0	-	-
(I_C = 1.0 mAdc, V_{CE} = 5 Vdc, f = 100 mc)			1.0	-	
Output Capacitance (V_{CB} = 5.0 Vdc, I_E = 0, f = 100 kc)		C_{ob}	-	3.0	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	-	8.0	pf
Small Signal Current Gain (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	MCS2137	h_{fe}	100	450	-
	MCS2138		300	900	
Input Impedance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	MCS2137	h_{ie}	3	15	kohms
	MCS2138		10	40	
Voltage Feedback Ratio (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)		h_{re}	-	25	$X10^{-4}$
Output Admittance (I_C = 1.0 mAdc, V_{CE} = 5.0 Vdc, f = 1 kc)	MCS2137	h_{oe}	-	60	μmhos
	MCS2138			60	
Noise Figure (Power Bandwidth = 15.7 kc) (I_C = 10 μAdc, V_{CE} = 5 Vdc, R_g = 10 kohms)	MCS2137	NF	-	4	db
	MCS2138		-	3	

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

MF3304

$V_{CEO} = 12$ V
$P_D = 300$ mW



CASE 20
(TO-72)

PNP silicon epitaxial transistor designed for low-level, high-speed switching applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	18	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	200 1.14	mW mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	300 1.71	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 100\ \mu A$, $I_B = 0$)	BV_{CBO}	-18	—	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu A$, $I_B = 0$)	BV_{CES}	-12	—	—	Vdc
Collector-Emitter Sustaining Voltage* ($I_C = 10$ mA, $I_B = 0$)	$V_{CEO(sus)}$*	-12	—	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu A$, $I_C = 0$)	BV_{EBO}	-5	—	—	Vdc

MF3304 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = -9 V, I_E = 0)	I_{CBO}	—	—	10	nA
Collector Reverse Current (V_{CE} = -6 V, V_{EB} = 0)	I_{CES}	—	—	10	nA
(V_{CE} = -6 V, V_{EB} = 0, 150°C)		—	—	10	μA
Collector-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{CE(sat)}$	—	—	-0.15	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		—	—	-0.16	
(I_C = 10 mA, I_B = 1.0 mA, 125°C)		—	—	-0.23	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	-0.50	
Base-Emitter Saturation Voltage (I_C = 1.0 mA, I_B = 0.1 mA)	$V_{BE(sat)}$	-0.7	—	-0.8	Vdc
(I_C = 10 mA, I_B = 1.0 mA)		-0.8	—	-0.9	
(I_C = 50 mA, I_B = 5.0 mA)		—	—	-1.2	
DC Current Gain (I_C = 1.0 mA, V_{CE} = -0.3 V)	h_{FE}	20	—	—	
(I_C = 10 mA, V_{CE} = -0.3 V)		30	—	120	
(I_C = 10 mA, V_{CE} = -0.3 V, -55°C)		15	—	—	
(I_C = 50 mA, V_{CE} = -1.0 V)		20	—	—	
High-Frequency Current Gain (I_C = 10 mA, V_{CE} = -5.0 V, f = 100 MHz)	h_{fe}	6.0	—	—	—
Output Capacitance** (V_{CB} = -5.0 V, I_E = 0, f = 140 kHz)	C_{ob}**	—	—	2.5	pF
Emitter Transition Capacitance (V_{EB} = -0.5 V, I_C = 0, f = 140 kHz)	C_{TE}	—	—	2.5	pF
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 10 mA, f = 31.8 MHz)	$r_b'C_c$	—	—	40	psec
Charge Storage Time ($I_C \approx I_{B1} \approx I_{B2} \approx$ -10 mA)	τ_s	—	—	30	nsec
Turn-On Time ($I_C \approx$ 10 mA, $I_{B1} \approx$ 0.5 mA)	t_{on}	—	—	60	nsec
Turn-Off Time ($I_C \approx$ 10 mA, $I_{B1} \approx I_{B2} \approx$ -0.5 mA)	t_{off}	—	—	60	nsec

TYPICAL AMPLIFIER PERFORMANCE

Noise Figure (V_{CE} = 10 V, I_C = 2 mA, f = 60 MHz, R_S = 200 ohms)	NF	—	2.7	—	dB
AC Current Gain (V_{CE} = 10 V, I_C = 2 mA, f = 1 kHz)	h_{fe}	—	70	—	—
Current Gain — Bandwidth Product (V_{CE} = 10 V, I_C = 2 mA, f = 100 MHz)	f_T	—	700	—	MHz
Collector-Base Time Constant (V_{CB} = 10 V, I_C = 2 mA)	$r_b'C_c$	—	15	—	psec

**Measured in guarded circuit
*Pulse Conditions: Length = 300 μsec, Duty Cycle ≤ 2%

MM709 (SILICON)

$V_{CEO} = 8$ V
$I_C = 100$ mAdc
$P_D = 400$ mW



Collector connected to case

CASE 27
(TO-52)

NPN silicon annular transistor designed for ultra-high speed switching and amplifier application.

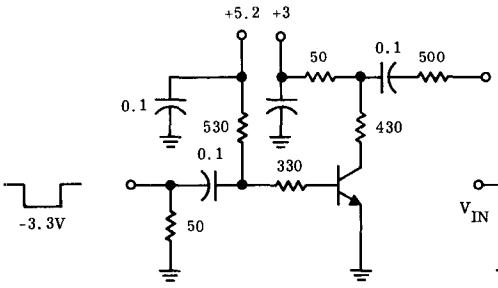
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage (1 to 30 mA)	V_{CEO}	8	Vdc
Collector-Base Voltage	V_{CB}	15	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	400 2.3	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 4.3	mW $mW/^oC$
Operating Junction Temperature Range	T_J	200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

THERMAL CHARACTERISTICS

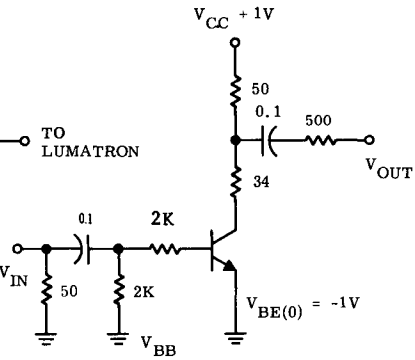
Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Case	θ_{JC}	0.233	$^oC/W$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.436	$^oC/W$

FIGURE 1 — CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



SKL
OR
EQUIVALENT
PW≥200 nsec

FIGURE 2 — t_{on} & t_{off} TEST CIRCUIT



MM709 (continued)

ELECTRICAL CHARACTERISTICS

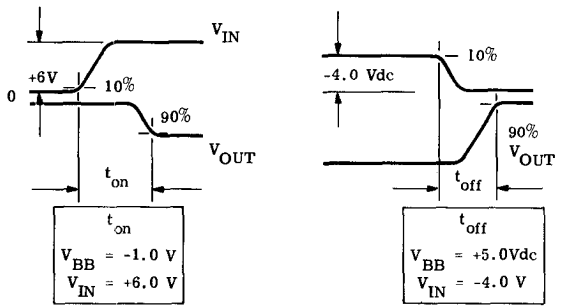
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	15	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	8	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4	-	Vdc
Collector Cutoff Current (V_{CB} = 5 Vdc)	I_{CBO}	-	.015	μAdc
(V_{CB} = 5 Vdc, T_A = 125°C)		-	20	
DC Forward Current Transfer Ratio* (I_C = 10 mAdc, V_{CE} = 0.5 V)	h_{FE}*	15	120	-
(I_C = 30 mAdc, V_{CE} = 1 V)		12	-	
(I_C = 10 mAdc, V_{CE} = 0.5 V, T_A = -55°C)		8	-	
Collector Saturation Voltage* (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{CE(sat)}$*	-	.35	Vdc
Base-Emitter Saturation Voltage* (I_C = 3 mAdc, I_B = 0.15 mAdc)	$V_{BE(sat)}$*	0.70	0.85	Vdc
Current Gain Bandwidth Product (I_C = 5 mAdc, V_{CE} = 4 Vdc)	f_T	300	-	MHz
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	3	pF
Input Capacitance (V_{OB} = 0.5 Vdc, I_E = 0, f = 100 kHz)	C_{ib}	-	2	pF

SWITCHING CHARACTERISTICS

Charge Storage Time - See Figure 1 (I_C = I_{B1} = -I_{B2} = 5.0 mAdc)	t_s	-	5	nsec
Turn-On Time - See Figure 2 (I_C = 10 mAdc, I_B = 2.0 mAdc, I_{B2} = 1.0 mAdc)	t_{on}	-	12	nsec
Turn-Off Time - See Figure 2 (I_C = 10 mAdc, I_{B1} = -I_{B2} = 1.0 mAdc)	t_{off}	-	10	nsec

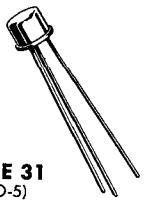
*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

INPUT & OUTPUT PULSE WAVEFORMS V_{in} RISE TIME ≦ 1 nsec



MM1812 SILICON

$V_{CEO} = 175$ V
$I_C = 100$ mA
$P_D = 1$ W



CASE 31
(TO-5)

NPN silicon transistor designed for audio power amplifier applications up to 1 watt output.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	175	Vdc
Collector-Emitter Voltage	V_{CEO}	175	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector-Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	1.0 5.71	Watt mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	5 28.6	Watts mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

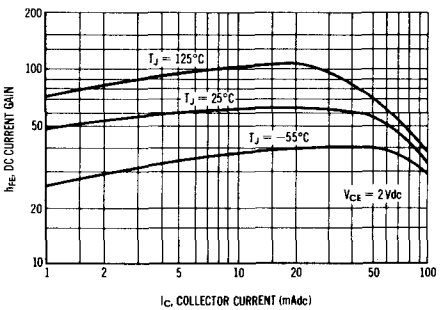
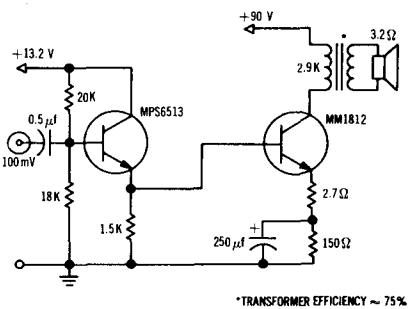


FIGURE 2 — 750 mW CLASS A AUDIO AMPLIFIER



MM1812 (continued)

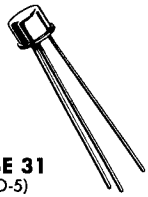
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0) (V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	— —		0.1 100	μAdc
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)	I_{EBO}	—		0.025	μAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	175		—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	175		—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	4		—	Vdc
Collector Saturation Voltage* (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 100 mAdc, I_B = 10 mAdc)	$V_{CE(sat)}$*	— —		0.3 0.6	Vdc
DC Current Gain * (I_C = 1.0 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc) (I_C = 100 mAdc, V_{CE} = 10 Vdc)	h_{FE}*	25 35 40		— 200 300	—
Small Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	h_{fe}	50		200	—
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	h_{re}	—		4	$X10^{-4}$
Input Impedance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	h_{ie}	0.2		1.25	k ohms
Output Admittance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1 kc)	h_{oe}	10		200	μmhos
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	—		10	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)	C_{ib}	—		100	pf
		Min	**Typ**	**Max**	
Power Gain (P_{out} = 1 W, V_{CE} = 85 Vdc, I_C = 30 mAdc, f = 1 kc, R_S = 400 ohms, R_L = 2.9 k ohms)	G_{pe}	36	44	—	db

*Pulse Test ≤ 300 μsec, duty cycle ≤ 2%

MM2258 SILICON
MM2259
MM2260

V_{CEO} = 120-175 V
I_C = 300-500 mA
P_D = 1 W



CASE 31
(TO-5)

NPN silicon transistors designed for video output circuitry in transistorized television receivers.

Collector connected to case

MAXIMUM RATINGS

Characteristics	Symbol	Rating		Unit
		MM2258	MM2259 MM2260	
Collector-Base Voltage	V_{CB}	120	175	Vdc
Collector-Emitter Voltage	V_{CEO}	120	175	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current	I_C	500	300	mAdc
Total Device Dissipation @ T_A = 25°C Derating Factor Above 25°C	P_D	1.0 5.71		Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derating Factor Above 25°C	P_D	5 28.6		Watt mW/°C
Junction Temperature, Operating	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C

THERMAL RESISTANCE

$\theta_{JA(air)}$ = 175°C/W
$\theta_{JC(case)}$ = 35°C/W

MM2258, MM2259, MM2260 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Collector Cutoff Current (V_{CB} = 75 Vdc, I_E = 0)		I_{CBO}	—	—	0.050	μAdc
(V_{CB} = 75 Vdc, I_E = 0, T_A = 150°C)			—	—	50	
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)		I_{EBO}	—	—	25	nAdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MM2258	BV_{CBO}	120	—	—	Vdc
	MM2259, MM2260		175	—	—	
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MM2258	BV_{CEO}*	120	—	—	Vdc
	MM2259, MM2260		175	—	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$	—	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 25 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$	—	—	1.0	Vdc
DC Current Gain* (I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MM2259	h_{FE}	25	—	—	—
	MM2258, MM2260		50	—	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MM2259		35	—	—	
	MM2258, MM2260		50	—	—	
(I_C = 50 mAdc, V_{CE} = 10 Vdc)	MM2259		35	—	—	
	MM2258, MM2260		50	—	—	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	MM2258	C_{ob}	—	—	9	pf
	MM2259, MM2260		—	—	8	
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	—	80	pf
Feedback (Miller) Capacitance (V_{CB} = 25 Vdc, I_C = 10 mAdc)	MM2258	C_{cb}	—	4.2	5.0	pf
	MM2259, MM2260		—	3.0	4.5	
Small Signal Current Gain (V_{CE} = 25 Vdc, I_C = 20 mAdc, f = 100 mc)		$\|h_{fe}\|$	1.5	—	—	—

*Pulse Test: PW ≤ 300 μsec, duty cycle ≤ 2%

FIGURE 1 — DC CURRENT GAIN CHARACTERISTICS versus JUNCTION TEMPERATURE

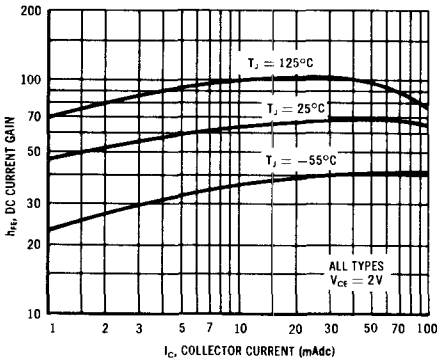
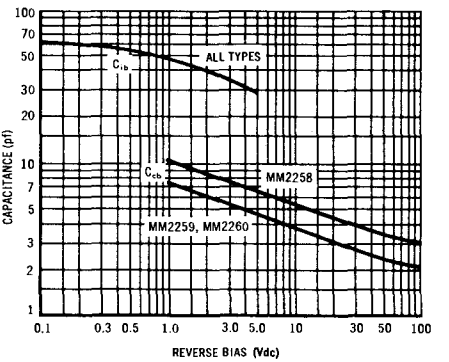


FIGURE 2 — JUNCTION CAPACITANCE VARIATIONS



MM2258, MM2259, MM2260 (continued)

SMALL SIGNAL h PARAMETER CHARACTERISTICS
(V_{CE} = 10 V, T_A = 25°C, f = 1 kc)

FIGURE 3 — CURRENT GAIN

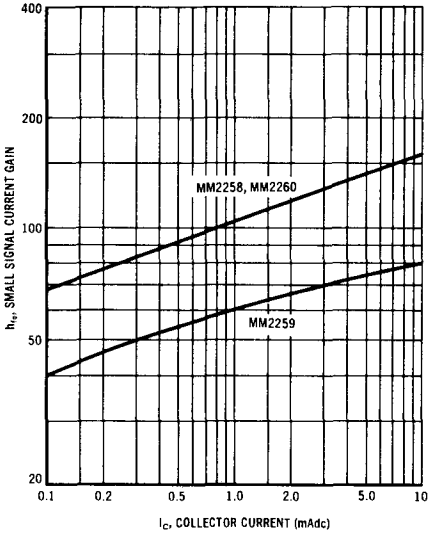


FIGURE 4 — OUTPUT ADMITTANCE

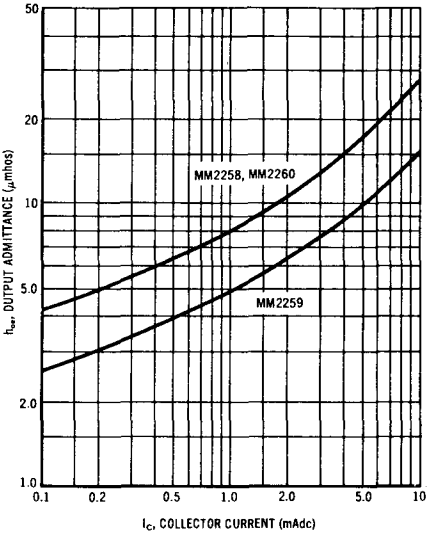


FIGURE 5 — INPUT IMPEDANCE

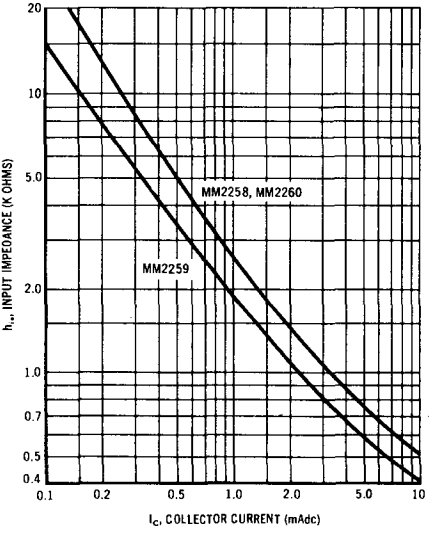
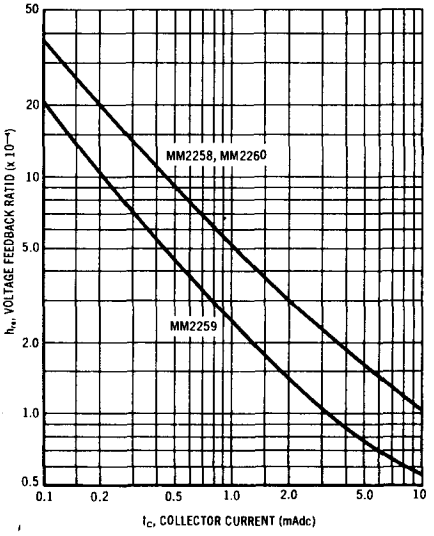
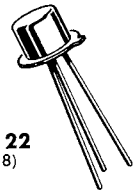


FIGURE 6 — VOLTAGE FEEDBACK RATIO



MM2483 SILICON
MM2484

$V_{CEO} = 60$ V
$I_C = 50$ mA
$P_D = 360$ mW



CASE 22
(TO-18)

NPN silicon epitaxial transistors designed for low-level, low-noise amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CEO}	60	Vdc
Emitter-Base Voltage	V_{EBO}	6	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derating Factor above 25°C	P_D	360 2.1	mW mW/°C
Total Device Dissipation @ $T_C = 25°C$ Derating Factor above 25°C	P_D	1.2 6.9	Watts mW/°C
Junction Temperature, Operating	T_J	+200	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C
Thermal Resistance: Junction-to-Air Junction-to-Case	 θ_{JA} θ_{JC}	 486 146	 °C/W °C/W

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = 10\ \mu A$, $I_E = 0$)	BV_{CBO}	60	—	V
Collector-Emitter Sustaining Voltage* ($I_C = 10$ mA, $I_B = 0$)	$V_{CEO(sus)}$	60	—	V
Emitter-Base Breakdown Voltage ($I_E = 10\ \mu A$, $I_C = 0$)	BV_{EBO}	6	—	V
Collector Cutoff Current ($V_{CB} = 45$ V, $I_E = 0$) ($V_{CB} = 45$ V, $I_E = 0$, $T_A = 150°C$)	I_{CBO}	— —	0.010 10	μA
Emitter Cutoff Current ($V_{EB} = 5.0$ V, $I_C = 0$)	I_{EBO}	—	0.010	μA
Collector-Emitter Saturation Voltage ($I_C = 1.0$ mA, $I_B = 0.1$ mA)	$V_{CE(sat)}$	—	0.35	V

MM2483, MM2484 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
DC Current Gain		h_{FE}			—
(I_C = 1.0 μA, V_{CE} = 5.0 V)	MM2484		30	—	
(I_C = 10 μA, V_{CE} = 5.0 V)	MM2483		40	120	
	MM2484		100	500	
(I_C = 10 μA, V_{CE} = 5.0 V, -55°C)	MM2483		10	—	
	MM2484		20	—	
(I_C = 100 μA, V_{CE} = 5.0 V)	MM2483		75	—	
	MM2484		175	—	
(I_C = 500 μA, V_{CE} = 5.0 V)	MM2483		100	—	
	MM2484		200	—	
(I_C = 1.0 mA, V_{CE} = 5.0 V)	MM2483		175	—	
	MM2484		250	—	
(I_C = 10 mA, V_{CE} = 5.0 V)*	MM2483		—	500	
	MM2484		—	800	
Emitter-Base On Voltage		$V_{BE(on)}$			V
(I_C = 100 μA, V_{CE} = 5.0 V)			0.5	0.7	
High-Frequency Current Gain		h_{fe}			—
(I_C = 50 μA, V_{CE} = 5.0 V, f = 5.0 MHz)	MM2483		2.4	—	
	MM2484		3.0		
(I_C = 500 μA, V_{CE} = 5.0 V, f = 30 MHz)			2.0	—	
Output Capacitance		C_{ob}			pF
(V_{CB} = 5.0 V, I_E = 0)			—	6.0	
Emitter Transition Capacitance		C_{TE}			pF
(V_{EB} = 0.5 V, I_C = 0)			—	6.0	
Small Signal Current Gain		h_{fe}			—
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)	MM2483		80	450	
	MM2484		150	900	
Input Impedance		h_{ie}			kohms
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)			3.5	24	
Output Conductance		h_{oe}			μmhos
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)			—	50	
Voltage Feedback Ratio		h_{re}			X10-6
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)			—	2500	
Common Base Input Impedance		h_{ib}			ohms
(I_C = 1.0 mA, V_{CE} = 5.0 V, f = 1 kHz)			25	32	
Wide Band Noise Figure		NF			dB
(I_C = 10 μA, V_{CE} = 5.0 V, R_S = 10 kohms	MM2483		—	4	
	MM2484		—	3	
Power Bandwidth of 15.7 kHz (3 dB points at 10 Hz and 10 kHz)					
Narrow Band Noise Figure		NF			dB
(I_C = 10 μA, V_{CE} = 5.0 V, f = 1 kHz	MM2483		—	4	
R_S = 10 kohms (Power Bandwidth = 200 Hz)	MM2484		—	3	
(I_C = 10 μA, V_{CE} = 5.0 V, f = 10 kHz,	MM2483		—	3	
R_S = 10 kohms (Power Bandwidth = 2 kHz)	MM2484		—	2	
(I_C = 10 μA, V_{CE} = 5 V, f = 10 kHz	MM2483		—	15	
R_S = 10 kohms (Power Bandwidth = 20 Hz)	MM2484		—	10	

*Pulse Conditions: Length ≤ 300 μsec, Duty Cycle ≤ 2%

MM2550 (GERMANIUM)

$V_{CEO} = 10$ V
$I_C = 100$ mA
$f_T = 1000$ Mc (min)
$t_{off} = 2.5$ nsec



CASE 22
(TO-18)

PNP germanium epitaxial mesa transistor for high-speed, low-power, current-mode switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-20	Vdc
Collector-Emitter Voltage	V_{CEO}	-10	Vdc
Emitter-Base Voltage	V_{EBO}	-0.5	Vdc
Collector Current	I_C	-100	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ T_C = 25°C Derating factor above 25°C	P_D	300 4	mW mW/°C
Device Dissipation @ T_A = 25°C Derating factor above 25°C	P_D	150 2	mW mW/°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

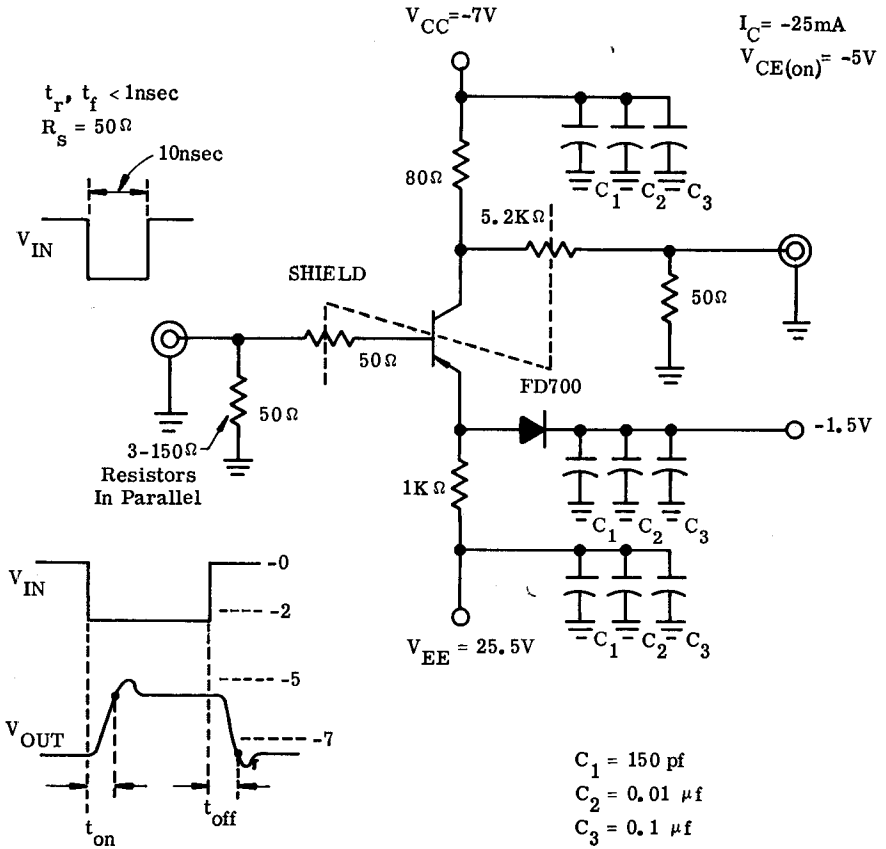
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = -100 μAdc, I_E = 0)	BV_{CBO}	-20	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = -10mAdc, I_B = 0)	BV_{CEO}	-10	-	Vdc
Emitter-Base Breakdown Voltage (I_E = -100 μAdc, I_C = 0)	BV_{EBO}	-0.5	-	Vdc
Collector Cutoff Current (V_{CB} = -10 Vdc, I_E = 0)	I_{CBO}	-	-10	μAdc
DC Current Gain (I_C = -10 mAdc, V_{CE} = -5 Vdc)	h_{FE}	20	-	-
Collector Saturation Voltage (I_C = -10 mAdc, I_B = -1.0 mAdc)	$V_{CE(sat)}$	-	-0.2	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1.0 mAdc)	$V_{BE(sat)}$	-0.3	-0.7	Vdc

MM2550 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Current Gain-Bandwidth Product (I_C = -5 mAdc, V_{CE} = -10 Vdc, f = 100 mc) (I_C = -10 mAdc, V_{CE} = -5 Vdc, f = 100 mc) (I_C = -15 mAdc, V_{CE} = -2 Vdc, f = 100 mc)	f_T	1000 1000 1000			mc mc mc
Collector Output Capacitance (V_{CB} = -5 Vdc, I_E = 0, f = 100 kc)	C_{ob}	Min -	Typ 	Max 3	pf
Collector-Base Time Constant (I_E = +10 mAdc, V_{CB} = -5 Vdc, f = 31.8 mc)	$r_b' C_c$	-	50	–	psec
Turn-on Time (I_C = -10 mAdc, $V_{CE(on)}$ = -5V)	t_{on}	–	1.8	2.5	nsec
Turn-off Time (I_C = -10 mAdc, $V_{CE(on)}$ = -5V)	t_{off}	–	1.8	2.5	nsec

CURRENT MODE SWITCHING TIME CIRCUIT



MM2552 (GERMANIUM)

$V_{CEO} = 10$ V
$I_C = 100$ mA
$f_T = 1000$ Mc (min)
$t_{off} = 2.5$ nsec



CASE 31
(TO-5)

PNP germanium epitaxial mesa transistor for high-speed, low-power, current-mode switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-20	Vdc
Collector-Emitter Voltage	V_{CEO}	-10	Vdc
Emitter-Base Voltage	V_{EBO}	-0.5	Vdc
Collector Current	I_C	-100	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ $T_C = 25$°C Derating factor above 25°C	P_D	600 8	mW mW/°C
Device Dissipation @ $T_C = 25$°C Derating factor above 25°C	P_D	300 4	mW mW/°C

ELECTRICAL CHARACTERISTICS ($T_C = 25$°C unless otherwise noted)

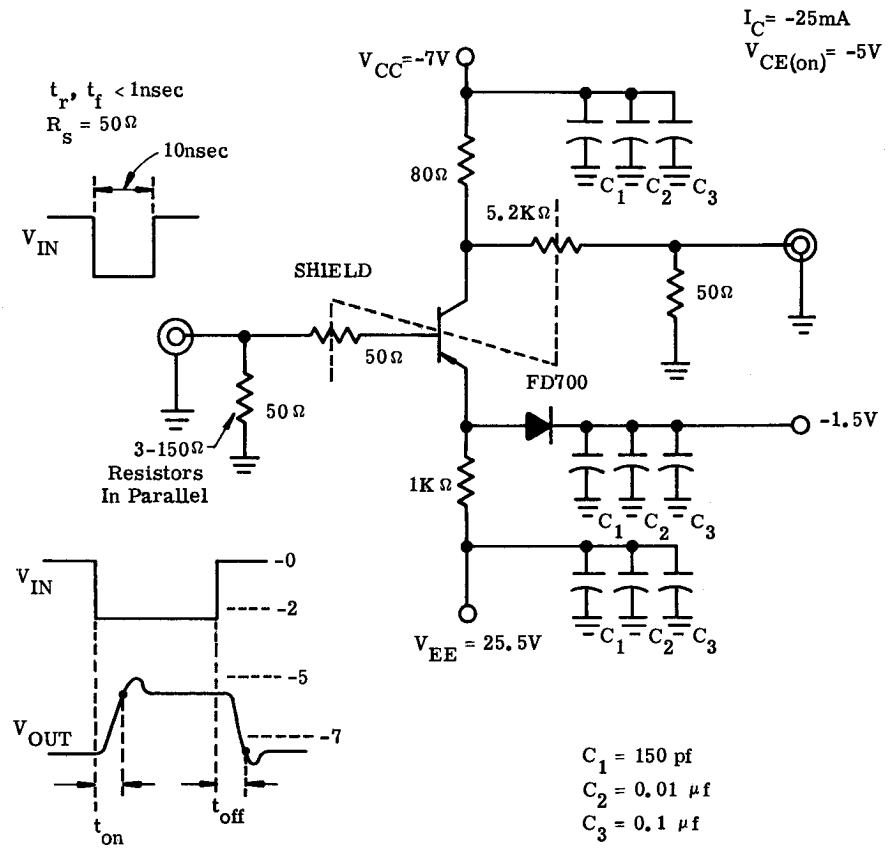
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = -100$ μAdc, $I_E = 0$)	BV_{CBO}	-20	–	Vdc
Collector-Emitter Breakdown Voltage ($I_C = -10$ mAdc, $I_B = 0$)	BV_{CEO}	-10	–	Vdc
Emitter-Base Breakdown Voltage ($I_E = -100$ μAdc, $I_C = 0$)	BV_{EBO}	-0.5	–	Vdc
Collector Cutoff Current ($V_{CB} = -10$ Vdc, $I_E = 0$)	I_{CBO}	–	-10	μAdc
DC Current Gain ($I_C = -25$ mAdc, $V_{CE} = -5$ Vdc)	h_{FE}	30	–	–
Collector Saturation Voltage ($I_C = -25$ mAdc, $I_B = -2.5$ mAdc)	$V_{CE(sat)}$	–	-0.2	Vdc
Base-Emitter Saturation Voltage ($I_C = -25$ mAdc, $I_B = -2.5$ mAdc)	$V_{BE(sat)}$	-0.3	-0.7	Vdc

MM2552 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Current-Gain, Bandwidth Product (I_C = -30 mAdc, V_{CE} = -2 Vdc, f = 100 mc) (I_C = -25 mAdc, V_{CE} = -5 Vdc, f = 100 mc) (I_C = -20 mAdc, V_{CE} = -10 Vdc, f = 100 mc)	f_τ	1000 1000 1000		mc mc mc
Collector Output Capacitance (V_{CB} = -5 Vdc, I_E = 0, f = 100 kc)	C_{ob}	–	3	pf
Collector-Base Time Constant (I_E = +25 mA, V_{CB} = -5V, f = 31.8 mc)	$r_b'C_c$	Min: – Typ: 50 Max: –		psec
Turn-on Time (I_C = -25 mAdc, $V_{CE(on)}$ = -5 Vdc)	t_{on}	–	2.2	3.5	nsec
Turn-off Time (I_C = -25 mAdc, $V_{CE(on)}$ = -5 Vdc)	t_{off}	–	1.8	2.5	nsec

CURRENT MODE SWITCHING TIME CIRCUIT



MM2554 (GERMANIUM)

$V_{CEO} = 10$ V
$I_C = 200$ mA
$f_T = 1000$ Mc (min)
$t_{off} = 2.5$ nsec



CASE 31
(TO-5)

PNP germanium epitaxial mesa transistor for high-speed, low-power, current-mode switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-20	Vdc
Collector-Emitter Voltage	V_{CEO}	-10	Vdc
Emitter-Base Voltage	V_{EBO}	-0.5	Vdc
Collector Current	I_C	-200	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Device Dissipation @ $T_C = 25°C$ Derating factor above 25°C	P_D	750 10	mW mW/°C
Device Dissipation @ $T_A = 25°C$ Derating factor above 25°C	P_D	300 4	mW mW/°C

ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

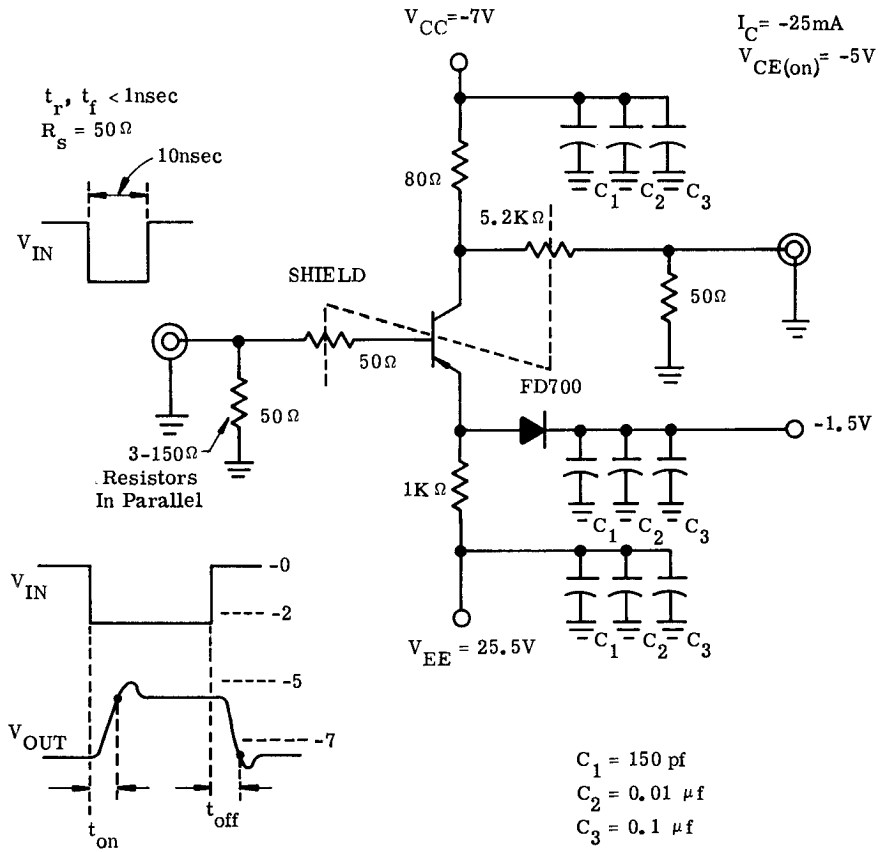
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage ($I_C = -100\ \mu$Adc, $I_E = 0$)	BV_{CBO}	-20		Vdc
Collector-Emitter Breakdown Voltage ($I_C = -10$mAdc, $I_B = 0$)	BV_{CEO}	-10		Vdc
Emitter-Base Breakdown Voltage ($I_E = -100\ \mu$Adc, $I_C = 0$)	BV_{EBO}	-0.5		Vdc
Collector Cutoff Current ($V_{CB} = -10$Vdc, $I_E = 0$)	I_{CBO}		-10	μAdc
DC Current Gain ($I_C = -40$mAdc, $V_{CE} = -5$ Vdc)	h_{FE}	20		
Collector Saturation Voltage ($I_C = -40$mAdc, $I_B = -4$mAdc)	$V_{CE(sat)}$		-0.25	Vdc
Base-Emitter Saturation Voltage ($I_C = -40$mAdc, $I_B = -4$mAdc)	$V_{BE(sat)}$	-0.4	-0.8	Vdc

MM2554 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Typ	Max	Unit
Current-Gain, Bandwidth Product (I_C = -35mAdc, V_{CE} = -10Vdc, f = 100MC) (I_C = -40mAdc, V_{CE} = -5Vdc, f = 100MC) (I_C = -45mAdc, V_{CE} = -2Vdc, f = 100MC)	f_τ	1000 1000 1000			mc mc mc
Collector Output Capacitance (V_{CB} = -5Vdc, I_E = 0, f = 100KC)	C_{ob}			4	pf
Collector-Base Time Constant (I_E = +40mAdc, V_{CB} = -5Vdc, f = 31.8MC)	$r_b'C_c$		50		psec
Turn-on Time (I_C = -40mAdc, $V_{CE(on)}$ = -5Vdc)	t_{on}		2.4	3.5	nsec
Turn-off Time (I_C = -40 mAdc, $V_{CE(on)}$ = -5Vdc)	t_{off}		1.6	2.5	nsec

CURRENT MODE SWITCHING TIME CIRCUIT



MM2894 (SILICON)

$V_{CEO} = 12$ V
$I_C = 100$ mA
$h_{FE} = 70$
$t_{OFF} = 60$ nsec



CASE 22
(TO-18)

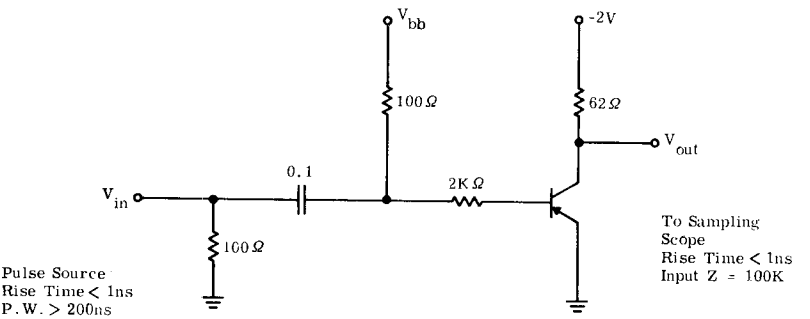
PNP silicon annular transistors for low-level, high-speed switching applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	15	Vdc
Collecto -Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4.5	Vdc
Total Device Dissipation @ 25° C Ambient Temperature Derate above 25° C	P_D	 0.36 2.06	 Watt mW/° C
Total Device Dissipation @ 25° C Case Temperature Derate above 25° C	P_D	 1.2 6.9	 Watts mW/° C
Operating Junction Temperature	T_J	200	° C
Storage Temperature	T_{stg}	-65 to 200	° C

SWITCHING TIME TEST CIRCUIT



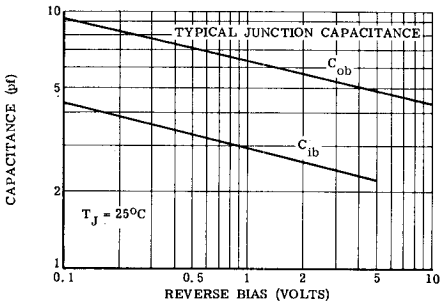
MM2894 (continued)

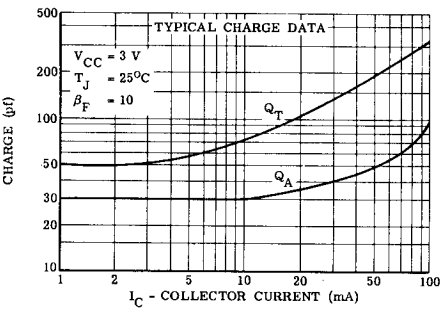
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

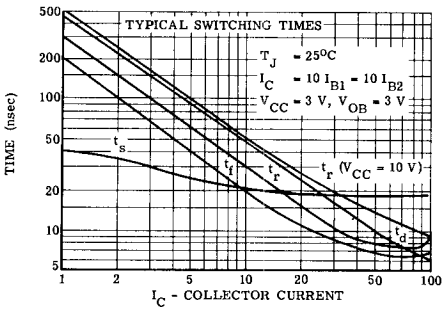
Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CB} = -6V, I_E = 0 V_{CB} = -6V, I_E = 0, T_A = 125° C	I_{CBO}			.08 10	μA
Collector-Base Breakdown Voltage I_C = 10μA, I_E = 0	BV_{CBO}	-15			Vdc
Collector-Emitter Sustaining Voltage* I_C = 10mA, I_B = 0	$V_{CEO(sust)}$	-12			Vdc
Emitter-Base Breakdown Voltage I_E = 100μA, I_C = 0	BV_{EBO}	-4.5			Vdc
Collector-Emitter Saturation Voltage I_C = 10mA, I_B = 1.0mA I_C = 30mA, I_B = 3.0mA I_C = 100mA, I_B = 10mA	$V_{CE(sat)}$		 -0.1	 -0.15 -0.2 -0.5	Vdc
Base-Emitter Saturation Voltage I_C = 10mA, I_B = 1.0mA I_C = 30mA, I_B = 3.0mA I_C = 100mA, I_B = 10mA	$V_{BE(sat)}$	 -0.68 -0.74		 -0.83 -0.89 -1.7	Vdc
DC Pulse Current Gain* I_C = 1mA V_{CE} = 0.3v I_C = 10mA V_{CE} = 0.3v I_C = 30mA, V_{CE} = 0.5v I_C = 30mA, V_{CE} = 0.5v (-55° C) I_C = 100mA, V_{CE} = 1.0V	h_{FE}*	 25 30 40 17 25	 70 	 150 	
High Frequency Current Gain (f = 100mc) VCE = 100 IC = 30mA	h_{fe}	4.0			
Output Capacitance V_{CB} = -5.0V, I_E = 0, f = 140KC	C_{ob}			6.0	pf
Emitter Transition Capacitance V_{EB} = -0.5V, I_C = 0, f = 140KC	C_{TE}			6.0	pf
Turn On Time I_C = 30mA, I_{B1} = 1.5mA	t_{on}		23	60	nsec
Turn Off Time I_C = 30mA, I_{B1} = I_{B2} = 1.5mA	t_{off}		34	60	nsec

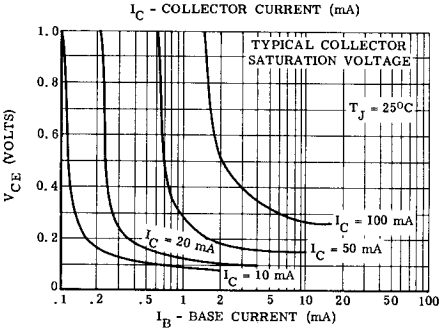
* Pulse Conditions; length = 300 μsec
duty cycle ≤ 2%

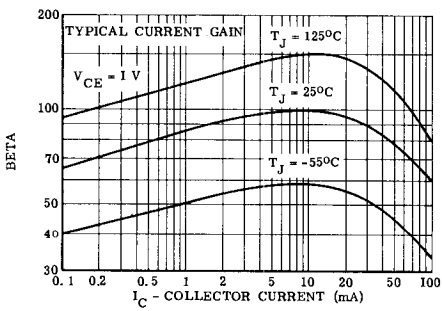
MM2894 (continued)

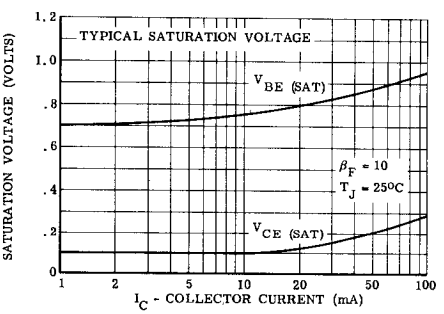


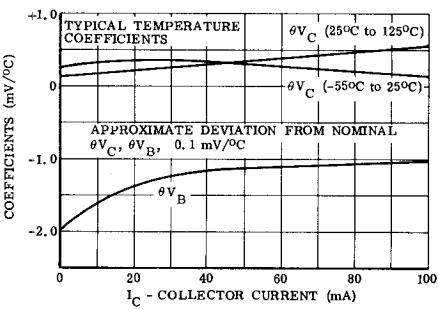






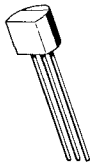






MPS706 (SILICON)

$V_{CEO} = 15$ V
$h_{FE} = 20$
$t_s = 60$ nsec



NPN silicon annular, plastic encapsulated transistor designed for low-cost, high-speed switching applications. For typical curves, see 2N706 data sheet.

CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CER}	20	Vdc
Emitter-Base Voltage	V_{EBO}	3	Vdc
Junction Temperature	T_J	125	°C
Storage Temperature	T_{stg}	-55 to +125	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 5 mW/°C above 25°C)	P_D	500	mW
Total Device Dissipation @ 25°C Ambient Temperature (Derate 3 mW/°C above 25°C)	P_D	300	mW

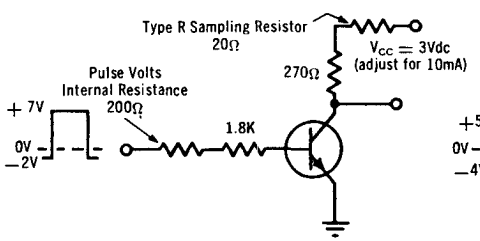
MPS706 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

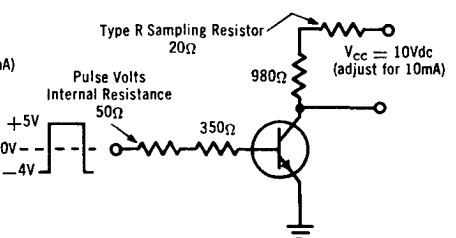
Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CB} = 15 V, I_E = 0	I_{CBO}	–	.005	0.5	μA
Emitter Cutoff Current V_{EB} = 3 V, I_C = 0	I_{EBO}	–	–	10	μA
Collector-Emitter Breakdown Voltage* I_C = 10 mA, I_B = 0	BV_{CEO}*	15	24	–	Vdc
Collector-Emitter Breakdown Voltage* I_C = 10 mA, R = 10Ω	BV_{CER}*	20	–	–	Vdc
Forward-Current Transfer Ratio* I_C = 10 mA, V_{CE} = 1 V	h_{FE}*	20	–	–	–
Base-Emitter Voltage* I_C = 10 mA, I_B = 1 mA	$V_{BE(sat)}$*	–	–	0.9	Vdc
Collector Saturation Voltage* I_C = 10 mA, I_B = 1 mA	$V_{CE(sat)}$*	–	–	0.6	Vdc
Collector Capacitance V_{CB} = 10 V, I_E = 0	C_{ob}	–	–	6	pf
Small-Signal Forward Current Transfer Ratio V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100mc	h_{fe}	2	4	–	–
Base Resistance V_{CE} = 15 Vdc, I_E = 10 mAdc, f = 100mc	r'_b	–	–	50	ohms
Charge Storage Time Constant	t_s**	–	–	60	nsec
Turn-on Time	t_{on}**	–	–	40	nsec
Turn-off Time	t_{off}**	–	–	75	nsec

* Pulse Test: PW ≤ 12 nsec, Duty Cycle ≤ 2%
**Switching Times Measured with Tektronix Type R Plug-In (50Ω Internal Impedance) and Circuits Shown

SWITCHING TIME TEST CIRCUIT

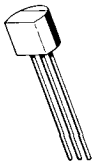


STORAGE TIME TEST CIRCUIT



MPS834 (SILICON)

$V_{CEO} = 30$ V
$I_C = 200$ mA
$t_{off} = 30$ nsec



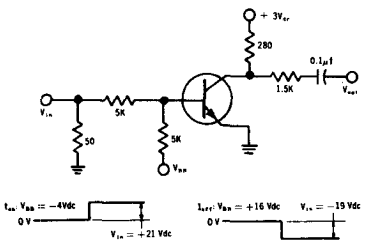
NPN silicon annular, plastic encapsulated transistor for low-cost, high-speed switching applications. For typical curves, see 2N834 data sheet.

CASE 29
(TO-92)

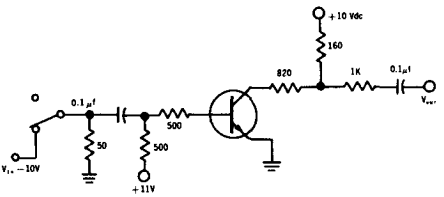
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
D.C. Collector Current	I_C	200	mAdc
Junction Temperature	T_J	+125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C
Total Device Dissipation @ 25°C Case Temperature (Derate 5.0 mW/°C above 25°C)	P_D	500	mW
Total Device Dissipation @ 25°C Ambient Temperature (Derate 3.0 mW/°C above 25°C)	P_D	300	mW

TURN-ON AND TURN-OFF TIME MEASUREMENT CIRCUIT



CHARGE STORAGE TIME CONSTANT MEASUREMENT CIRCUIT



NOTE: ALL SWITCHING TIMES MEASURED WITH LUMATRON MODEL 420 SWITCHING TIME TEST SET OR EQUIVALENT.

MPS834 (continued)

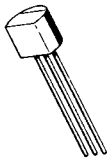
ELECTRICAL CHARACTERISTICS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage $I_E = 0$, $I_C = 10\ \mu Adc$	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage $I_C = 0$, $I_E = 10\ \mu Adc$	BV_{EBO}	5	-	-	Vdc
Collector Cutoff Current $V_{BE} = 0$, $V_{CE} = 30$ Vdc	I_{CES}	-	-	10	μAdc
Collector Cutoff Current $I_E = 0$, $V_{CB} = 20$ Vdc	I_{CBO}	-	-	0.5	μAdc
Forward Current Transfer Ratio* $I_C = 10$ mAdc, $V_{CE} = 1$ Vdc	h_{FE}*	25	-	-	-
Collector Saturation Voltage* $I_C = 10$ mA, $I_B = 1$ mA	$V_{CE(sat)}$*	-	-	0.25	Vdc
Collector Saturation Voltage* $I_C = 50$ mA, $I_B = 5$ mA	$V_{CE(sat)}$*	-	-	0.4	Vdc
Base-Emitter Saturation Voltage* $I_C = 10$ mAdc, $I_B = 1.0$ mAdc	$V_{BE(sat)}$*	-	-	0.9	Vdc
Collector Capacitance $I_E = 0$, $V_{CB} = 10$ Vdc, f = 100 kc	C_{ob}	-	-	4	pf
Small-Signal Forward Current Transfer Ratio $I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100mc	h_{fe}	3.5	-	-	-
Current Gain Bandwidth Product $I_C = 10$ mAdc, $V_{CE} = 20$ Vdc, f = 100mc	f_T	350	-	-	mc
Charge Storage Time Constant $I_C = 10$ mA, $I_{B1} = I_{B2} = 10$ mA	τ_s	-	-	25	nsec
Turn-on Time $I_C = 10$ mA, $I_{B1} = 3$ mA, $I_{B2} = 1$ mA	t_{on}	-	-	16	nsec
Turn-off Time $I_C = 10$ mA, $I_{B1} = 3$ mA, $I_{B2} = 1$ mA	t_{off}	-	-	30	nsec

* Pulse Test: PW ≤ 12 nsec, Duty Cycle ≤ 2%

MPS2711 (SILICON)
MPS2712
MPS 2715
MPS 2716

$V_{CEO} = 18$ V
$I_C = 25\text{-}100$ mA
$P_D = 300$ mW



NPN silicon epitaxial plastic encapsulated transistor designed for low-power, small-signal audio applications.

CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current MPS2711, 12 MPS2715, 16	I_C	 100 25	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/W$

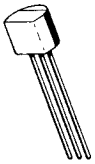
MPS2711, MPS2712, MPS2715, MPS2716 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 Vdc I_E = 0, T_A = 100°C)		I_{CBO}	- -	0.5 1.5	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.5	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS2711/15 MPS2712/16	h_{FE}	30 75	90 225	-
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)	MPS2711/12 MPS2715/16	C_{ob}	- -	4.0 3.5	pF
Small Signal Current Gain (V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kHz)	MPS2711/15 MPS2712/16	h_{fe}	30 80	120 200	-

MPS2713 (SILICON)
MPS2714

$V_{CE} = 18$ V
$I_C = 200$ mAdc
$C_{ob} = 2.5$ pF



CASE 29
(TO-92)

NPN Silicon annular transistor, designed for general purpose low-level switching applications. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	18	Vdc
Collector-Emitter Voltage	V_{CE}	18	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	200	mAdc
Total Device Dissipation @ $T_A = 60^oC$	P_D	210	mW
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	310 2.81	mW $mW/^oC$
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/mW$
Junction Operating Temperature	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0) (V_{CB} = 18 Vdc, I_E = 0, T_A = 100°C)	I_{CBO}	— —	— —	0.5 15	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	I_{EBO}	—	—	0.5	μAdc

MPS2713, MPS2714 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
ON CHARACTERISTICS						
DC Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc)	MPS2713	h_{FE}	30	60	90	—
	MPS2714		75	150	225	
Collector-Emttter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{CE(sat)}$	—	0.16	0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 3 mAdc)		$V_{BE(sat)}$	0.6	0.75	1.3	Vdc
SMALL SIGNAL CHARACTERISTICS						
Small Signal Current Gain (I_C = 2 mAdc, V_{CE} = 4.5 Vdc, f = 1 kc)	MPS2713	h_{fe}	30	—	120	—
	MPS2714		60	—	300	
Current-Gain – Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		f_T	—	250	—	mc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	2.5	—	pf
Input Impedance (I_C = 0.5 mAdc, V_{CE} = 1 Vdc, f = 1 kc)		h_{ie}	—	3000	—	ohms
SWITCHING CHARACTERISTICS						
Delay Time	I_C = 10 mA, I_{B1} = 3 mA, V_{CC} = 10 V	t_d	—	7	—	nsec
Rise Time		t_r	—	6	—	nsec
Storage Time	I_C = 10 mA, I_{B1} = 3 mA, I_{B2} = 1 mA, V_{CC} = 10 V	t_s	—	12	—	nsec
Fall Time		t_f	—	9	—	nsec

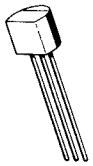
MPS2715 (SILICON)

MPS2716

For Specifications, See MPS2711 Data Sheet

MPS2894 (SILICON)

$V_{CEO} = 12$ V
$h_{FE} = 40$
$t_{OFF} = 90$ nsec



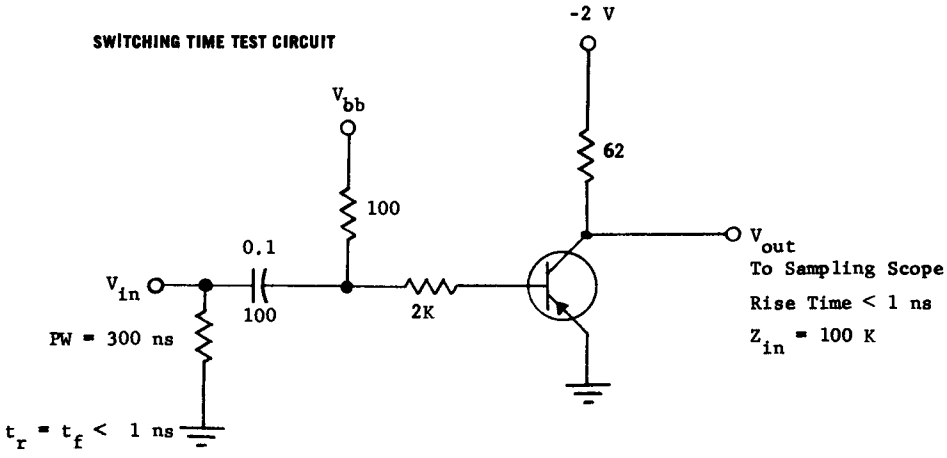
CASE 29
(TO-92)

PNP silicon annular, plastic encapsulated transistor for low-cost, low-level, high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	12	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ 25°C Ambient Temperature Derate above 25°C	P_D	 0.3 3	Watt mW/°C
Total Device Dissipation @ 25°C Case Temperature Derate above 25°C	P_D	 1.0 10	Watt mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

SWITCHING TIME TEST CIRCUIT



$Z_{in} = 50\ \Omega$

T_{on}; $V_{bb} = +3$, $V_{in} = -7$ V

T_{off}; $V_{bb} = -4$ V, $V_{in} = +6$ V

MPS2894 (continued)

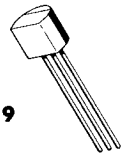
ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current V_{CB} = -6 V, I_E = 0 V_{CB} = -6 V, I_E = 0, T_A = 125°C	I_{CBO}			.08	μA
Collector-Base Breakdown Voltage I_C = 10 μA, I_E = 0	BV_{CBO}	-12			Vdc
Collector-Emitter Sustaining Voltage* I_C = 10 mA, I_B = 0	$V_{CEO(sust)}$	-12			Vdc
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BV_{EBO}	-4.0			Vdc
Collector-Emitter Saturation Voltage I_C = 10 mA, I_B = 1.0 mA I_C = 30 mA, I_B = 3.0 mA I_C = 100 mA, I_B = 10 mA	$V_{CE(sat)}$		 -0.1	 -0.15 -0.2 -0.5	Vdc
Base-Emitter Saturation Voltage I_C = 10 mA, I_B = 1.0 mA I_C = 30 mA, I_B = 3.0 mA I_C = 100 mA, I_B = 10 mA	$V_{BE(sat)}$	 -0.78 -0.85		 -0.98 -1.20 -1.7	Vdc
DC Pulse Current Gain* I_C = 1 mA, V_{CE} = 0.3 V I_C = 10 mA, V_{CE} = 0.3 V I_C = 30 mA, V_{CE} = 0.5 V I_C = 30 mA, V_{CE} = 0.5 V (-55°C) I_C = 100 mA, V_{CE} = 1.0 V	h_{FE}*	 25 30 40 17 25	 70 	 150 	-
High Frequency Current Gain (f = 100 mc) V_{CE} = 10 V, I_C = 30 mA	h_{fe}	4.0			-
Output Capacitance V_{CB} = -5.0 V, I_E = 0, f = 140 kc	C_{ob}			6.0	pf
Emitter Transition Capacitance V_{EB} = -0.5 V, I_C = 0, f = 140 kc	C_{TE}			6.0	pf
Turn-On Time I_C = 30 mA, I_{B1} = 1.5 mA	t_{on}		23	60	nsec
Turn-Off Time I_C = 30 mA, I_{B1} = I_{B2} = 1.5 mA	t_{off}		34	90	nsec

* Pulse Conditions: Length = 300 μsec
Duty Cycle ≤ 2%

MPS2923 thru MPS2925 (SILICON)

$V_{CEO} = 25$ V
$I_C = 100$ mA
$P_D = 200$ mW



CASE 29
(TO-92)

NPN silicon annular, plastic encapsulated transistors for low-cost, medium-speed, general-purpose amplifier and oscillator applications.

MAXIMUM RATINGS

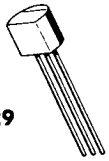
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector dc Current	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature Derating Factor above 25°C	P_D	200 2.67	mW mW/°C
Total Device Dissipation @ 55°C Ambient Temperature Derating Factor above 25°C	P_D	120 2.67	mW mW/°C
Junction Temperature-Operating	T_J	100	°C
Storage Temperature Range	T_{stg}	-30 to +125	°C

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CB} = 25$ V, $I_E = 0$	I_{CBO}	–	0.5	μA
$V_{CB} = 25$ V, $I_E = 0$, $T_A = 100$°C		–	15	μA
Emitter Cutoff Current $V_{EB} = 5$ V	I_{EBO}	–	0.5	μA
Small Signal Current Gain (f = 1 kc) $V_{CE} = 10$ V, $I_C = 2$ mA	h_{fe}			–
MPS2923		90	180	
MPS2924		150	300	
MPS2925		235	470	
Collector Capacitance $V_{CB} = 10$ V, $I_E = 0$, f = 1 mc	C_{ob}	–	12	pf

MPS2926 (SILICON)
MPS3721

$V_{CEO} = 18$ V
$I_C = 100$ mA
$P_D = 310$ mW



CASE 29
(TO-92)

NPN silicon epitaxial plastic encapsulated transistors designed for general-purpose applications.

MAXIMUM RATINGS

Characteristics	Symbol	Ratings	Unit
Collector-Emitter Voltage	V_{CEO}	18	Vdc
Collector-Base Voltage	V_{CB}	18	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ 25°C Ambient Temperature	P_D	310	mW
Total Device Dissipation @ 60°C Ambient Temperature	P_D	210	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Temperature, Operating	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25$°C unless otherwise noted)

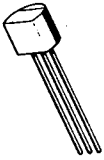
Characteristics	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current ($V_{CB} = 18$ Vdc, $I_E = 0$)	I_{CBO}	—	—	0.5	μA
($V_{CB} = 18$ Vdc, $I_E = 0$, $T_A = 100$°C)		—	—	15	
Emitter Cutoff Current ($V_{EB} = 5$ Vdc, $I_C = 0$)	I_{EBO}	—	—	0.5	μA
Current Gain — Bandwidth Product ($I_C = 4$ mA, $V_{CE} = 5$ V) MPS2926	f_T	—	300	—	MHz
Output Capacitance ($V_{CB} = 10$ V, $I_E = 0$, f = 1 MHz)	C_{ob}	—	—	3.5	pF
Small Signal Current Gain ($V_{CE} = 10$ V, $I_C = 2$ mA, f = 1 kHz)	h_{fe}				—
MPS2926		35	—	470	
MPS3721		60	—	660	

Each unit will be branded with the MPS2926 type and also by color code to identify the different A-C beta categories. A-C beta is broken down into five groups, though it is not a requirement of the JEDEC registration, and typical values of DC beta are listed for guidance only.

MPS2926 Color Code	h_{fe} ($V_{CE} = 10$ V, $I_C = 2$ mA, f = 1 kc)		h_{FE} ($V_{CE} = 4.5$ V, $I_C = 2$ mA)
	Min	Max	Typ
Brown	35	70	36
Red	55	110	62
Orange	90	180	115
Yellow	150	300	155
Green	235	470	215

MPS3392 thru MPS3398 (SILICON)

$V_{CEO} = 25$ V
$I_C = 100$ mA
$P_D = 310$ mW



NPN silicon annular plastic encapsulated transistors designed for small-signal, low-power audio applications.

CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

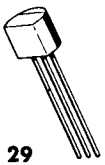
MPS3392 thru MPS3398 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	25	-	Vdc
Collector Cutoff Current (V_{CB} = 18 Vdc, I_E = 0)		I_{CBO}	-	0.1	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)		I_{EBO}	-	0.1	μAdc
DC Current Gain (V_{CE} = 4.5 Vdc, I_C = 2 mAdc)	MPS3392	h_{FE}	150	300	-
	MPS3393		90	180	
	MPS3394		55	110	
	MPS3395		150	500	
	MPS3396		90	500	
	MPS3397		55	500	
	MPS3398		55	800	
Output Capacitance (V_{CB} = 10 V, I_E = 0, f = 1 MHz)		C_{ob}	-	3.5	pF
Small Signal Current Gain (V_{CE} = 4.5 V, I_C = 2 mA, f = 1 kHz)	MPS3392	h_{fe}	150	500	-
	MPS3393		90	400	
	MPS3394		55	300	
	MPS3395		150	800	
	MPS3396		90	800	
	MPS3397		55	800	
	MPS3398		55	1250	

MPS3638 (SILICON)
MPS3638A

$V_{CE} = 25$ V
$I_C = 500$ mA
$t_{on} = 75$ ns
$t_{off} = 175$ ns



CASE 29
(TO-92)

PNP silicon epitaxial transistor designed for high-current digital applications. Features one-piece, injection-molded plastic package for high reliability.

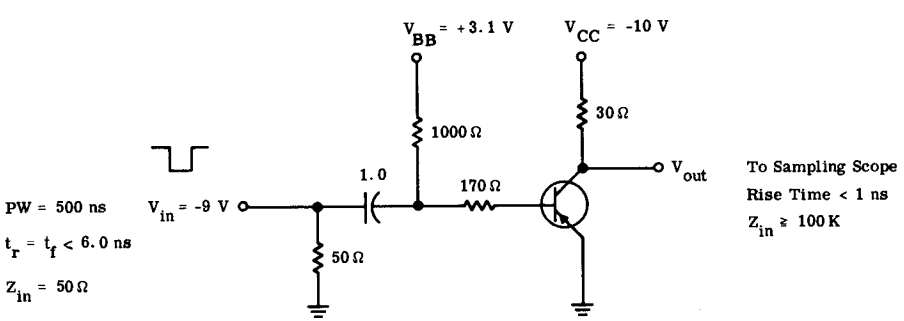
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Base Voltage	V_{CB}	25	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	500	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

FIGURE 1



MPS3638, MPS3638A (continued)

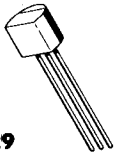
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	25	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	25	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	4	-	Vdc
Collector Reverse Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_{CES}	-	0.035	μAdc
(V_{CE} = 15 Vdc, V_{BE} = 0, T_A = +65°C)			-	2	
Base Current (V_{CE} = 15 Vdc, V_{BE} = 0)		I_B	-	0.035	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 10 Vdc)	MPS3638A	h_{FE}*	80	-	-
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS3638		20	-	
	MPS3638A		100	-	
(I_C = 50 mAdc, V_{CE} = 1 Vdc)	MPS3638		30	-	
	MPS3638A		100	-	
(I_C = 300 mAdc, V_{CE} = 2 Vdc)	MPS3638		20	-	
	MPS3638A		20	-	
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 2.5 mAdc)		$V_{CE(sat)}$*	-	0.25	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			-	1.0	
Base-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 2.5 mAdc)		$V_{BE(sat)}$*	-	1.1	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			0.80	2.0	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (V_{CE} = 3 Vdc, I_C = 50 mAdc, f = 100 MHz)	MPS3638	f_T	100	-	MHz
	MPS3638A		150	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	MPS3638	C_{ob}	-	20	pF
	MPS3638A		-	10	
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	MPS3638	C_{ib}	-	65	pF
	MPS3638A		-	25	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{fe}	25	180	-
	MPS3638A		100	-	
Output Conductance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)		h_{oe}	-	1.2	mmhos
Input Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{ie}	-	1500	Ohms
	MPS3638A		-	2000	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 1.0 kHz)	MPS3638	h_{re}	-	26	$X10^{-4}$
	MPS3638A		-	15	
SWITCHING CHARACTERISTICS					
Delay Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_d	-	20	ns
Rise Time	I_{B1} = 30 mAdc, $V_{BE(off)}$ = 3.1 Vdc	t_r	-	70	ns
Storage Time	V_{CC} = 10 Vdc, I_C = 300 mAdc,	t_s	-	140	ns
Fall Time	I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_f	-	70	ns
Turn-On Time	I_C = 300 mAdc, I_{B1} = 30 mAdc	t_{on}	-	75	ns
Turn-Off Time	I_C = 300 mAdc, I_{B1} = 30 mAdc, I_{B2} = 30 mAdc	t_{off}	-	170	ns

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 1%

MPS3639 (SILICON)

$V_{CEO} = 6$ V
$I_C = 80$ mA
$t_s = 20$ nsec



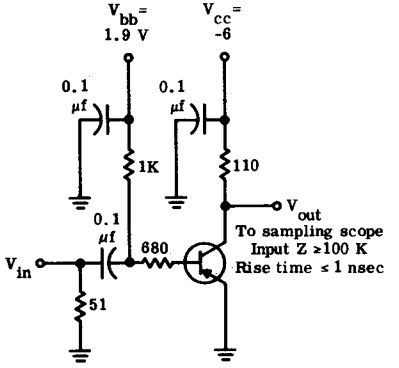
CASE 29
(TO-92)

PNP silicon annular, plastic encapsulated transistor for low-cost, low-level, high-speed switching applications.

MAXIMUM RATINGS

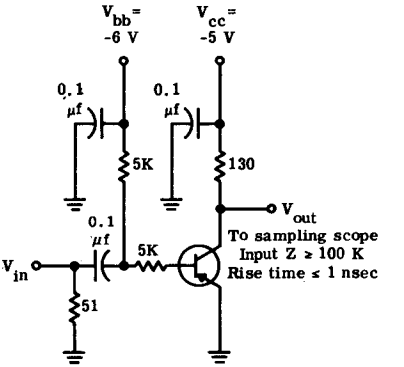
Characteristic	Symbol	Rating	Unit
D.C. Collector Current	I_C	80	mAdc
Collector-Base Voltage	V_{CBO}	-6	Vdc
Collector-Emitter Voltage	V_{CE}	-6	Vdc
Emitter-Base Voltage	V_{EBO}	-4	Vdc
Total Device Dissipation @ 25° Ambient Temperature	P_D	0.2	Watts
Derate above 25° C		2.0	mW/°C
Total Device Dissipation @ 25° C Case Temperature	P_D	0.5	Watts
Derate above 25° C		5.0	mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

SWITCHING TIME TEST CIRCUITS



PULSE SOURCE
Rise time ≤ 1 nsec
PW ≥100 nsec
Z_{in} = 50Ω
Fall time ≤1 nsec

NOTES: (1) Collector Current = 50 mA
(2) Turn-On and Turn-Off Base Currents = 5 mA



PULSE SOURCE
Rise time ≤ 1 nsec
PW ≥ 200 nsec
Z_{in} = 50Ω
Fall time ≤1 sec

NOTES: (1) Collector Current = 10 mA
(2) Turn-On and Turn-Off Base Currents = 0.5 mA

MPS3639 (continued)

ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current V_{CE} = 3 V, V_{EB} = 0 V_{CE} = 3 V, V_{EB} = 0, T_A = +65°C	I_{CES}	– –	.01 1	μA
Base Current V_{CE} = 3 V, V_{EB} = 0	I_B	–	10	nA
Collector-Emitter Breakdown Voltage I_C = 100 μA, V_{BE} = 0	BV_{CES}	6	–	V
Collector-Base Breakdown Voltage I_C = 100 μA, I_E = 0	BV_{CBO}	6	–	V
Emitter-Base Breakdown Voltage I_E = 100 μA, I_C = 0	BV_{EBO}	4	–	V
Collector-Emitter Sustaining Voltage I_B = 0, I_C = 10 mA, P.W. = 300 μsec D.C. = 1%	$V_{CEO(sus)}$	6	–	V
Collector-Emitter Saturation Voltage I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA, P.W. = 300 μsec D.C. = 1% I_C = 10 mA, I_B = 1 mA	$V_{CE(sat)}$	– – –	0.16 0.5 0.23	V
Base-Emitter Saturation Voltage I_C = 10 mA, I_B = 0.5 mA I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA, P.W. = 300 μsec, D.C. = 1%	$V_{BE(sat)}$	0.75 0.8 –	0.95 1 1.5	V
Forward Current Transfer Ratio V_{CE} = 0.3 V, I_C = 10 mA, P.W. = 300 μsec, D.C. = 1% V_{CE} = 1.0 V, I_C = 50 mA, P.W. = 300 μsec, D.C. = 1%	h_{FE}	 30 20	 120 –	–

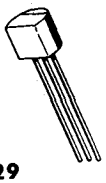
MPS3639 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Small-Signal Current Transfer Ratio V_{CE} = 5 V, I_C = 10 mA, f = 100 mc V_{CB} = 0, I_C = 10 mA, f = 100 mc	h_{fe}	5 3	– –	–
Output Capacitance I_E = 0, V_{CB} = 5 V, f = 140 kc	C_{ob}	–	3.5	pf
Input Capacitance V_{EB} = 0.5 V, I_C = 0, f = 140 kc	C_{ib}	–	3.5	pf
Delay Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA V_{OB} = 1.9 V	t_d	–	10	nsec
Rise Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V	t_r	–	30	nsec
Storage Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_s	–	20	nsec
Fall Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_f	–	12	nsec
Turn-On Time I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V I_C = 10 mA, I_{B1} = 0.5 mA	t_{on}	– –	25 60	nsec
Turn-Off Time I_C = 50 mA, V_{OB} = 1.9 V, I_{B1} = I_{B2} = 5 mA I_C = 10 mA, I_{B1} = I_{B2} = 0.5 mA	t_{off}	– –	25 60	nsec

MPS3640 (SILICON)

$V_{CEO} = 12$ V
$I_C = 80$ mA
$t_S = 20$ nsec



CASE 29
(TO-92)

PNP silicon annular, plastic encapsulated transistor for low-cost, low-level, high-speed switching applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
D.C. Collector Current	I_C	80	mAdc
Collector-Base Voltage	V_{CBO}	12	Vdc
Collector-Emitter Voltage	V_{CEO}	12	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Total Device Dissipation @ 25°C Ambient Temperature	P_D	0.2	Watts
Derate above 25°C		2.0	mW/°C
Total Device Dissipation @ 25° Case Temperature	P_D	0.5	Watts
Derate above 25°C		5.0	mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector Cutoff Current $V_{CE} = 6$ V, $V_{EB} = 0$ $V_{CE} = 6$ V, $V_{EB} = 0$, $T_A = +65°C$	I_{CES}	– –	.01 1	μA
Base Current $V_{CE} = 6$ V, $V_{EB} = 0$	I_B	–	10	nA
Collector-Emitter Breakdown Voltage $I_C = 100$ μA, $V_{BE} = 0$	BV_{CES}	12	–	V
Collector-Base Breakdown Voltage $I_C = 100$ μA, $I_E = 0$	BV_{CBO}	12	–	V
Emitter-Base Breakdown Voltage $I_E = 100$ μA, $I_C = 0$	BV_{EBO}	4	–	V
Collector-Emitter Sustaining Voltage $I_B = 0$, $I_C = 10$ mA, P.W. = 300 μsec, D.C. = 1%	$V_{CEO(sus)}$	12	–	V

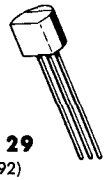
MPS3640 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA, P.W. = 300 μsec, D.C. = 1% I_C = 10 mA, I_B = 1 mA, T_A = +65°C	$V_{CE(sat)}$	– –	0.2 0.6	V
Base-Emitter Saturation Voltage I_C = 10 mA, I_B = 0.5 mA I_C = 10 mA, I_B = 1 mA I_C = 50 mA, I_B = 5 mA, P.W. = 300 μsec, D.C. = 1%	$V_{BE(sat)}$	0.75 0.8 –	0.95 1 1.5	V
Forward Current Transfer Ratio V_{CE} = 0.3 V, I_C = 10 mA, P.W. = 300 μsec, D.C. = 1% V_{CE} = 1.0 V, I_C = 50 mA, P.W. = 300 μsec, D.C. = 1%	h_{FE}	 30 20	 120 –	–
Small-Signal Current Transfer Ratio V_{CE} = 5 V, I_C = 10 mA, f = 100 mc V_{CB} = 0, I_C = 10 mA, f = 100 mc	h_{fe}	5 3	– –	–
Output Capacitiance I_E = 0, V_{CB} = 5 V, f = 140 kc	C_{ob}	–	3.5	pf
Input Capacitance V_{EB} = 0,5 V, I_C = 0, f = 140 kc	C_{ib}	–	3.5	pf
Delay Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V	t_d	–	10	nsec
Rise Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V	t_r	–	30	nsec
Storage Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_s	–	20	nsec
Fall Time V_{CC} = 6 V, I_C = 50 mA, I_{B1} = I_{B2} = 5 mA	t_f	–	12	nsec
Turn-On Time I_C = 50 mA, I_{B1} = 5 mA, V_{OB} = 1.9 V I_C = 10 mA, I_{B1} = 0.5 mA	t_{on}	 – –	 25 60	nsec
Turn-Off Time I_C = 50 mA, V_{OB} = 1.9 V, I_{B1} = I_{B2} = 5 mA I_C = 10 mA, I_{B1} = I_{B2} = 0.5 mA	t_{off}	 – –	 35 75	nsec

MPS3646 (SILICON)

V_{CES} = 40 V
I_C = 200 mA



CASE 29
(TO-92)

NPN silicon annular transistor designed for high-speed saturated switching applications. Features one-piece, injection-molded plastic package for high reliability.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Collector-Emitter Voltage Applicable 0.01-200 mA	V_{CEO}	15	Vdc
Emitter-Base Voltage	V_{EB}	5.0	Vdc
DC Collector Current	I_C	200	mA
Collector Current (10 μsec pulse)	I_C	500	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	200 2.0	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	500 5.0	mW mW/°C
Operating Junction Temperature	T_J	125	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

FIGURE 1 – t_{on} and t_{off} TEST CIRCUIT

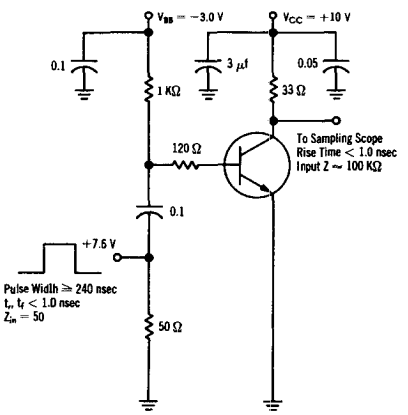
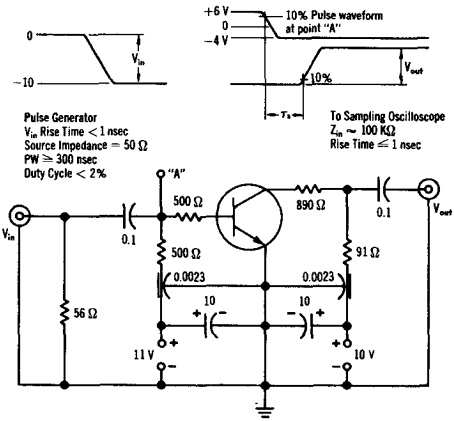


FIGURE 2 – CHARGE STORAGE TIME MEASUREMENT CIRCUIT



MPS3646 (continued)

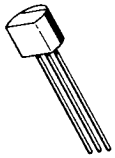
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise specified.)

Characteristic	Conditions	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage	I_C = 100 μAdc, I_E = 0	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage	I_C = 100 μAdc, V_{BE} = 0	BV_{CES}	40	—	Vdc
Collector-Emitter Sustaining Voltage*	I_C = 10 mAdc	$V_{CEO(sus)}$	15	—	Vdc
Emitter-Base Breakdown Voltage	I_E = 100 μAdc, I_C = 0	BV_{EBO}	5.0	—	Vdc
Collector-Emitter Saturation Voltage*	I_C = 30 mAdc, I_B = 3.0 mAdc I_C = 30 mAdc, I_B = 3.0 mAdc, T_A = +65 C I_C = 100 mAdc, I_B = 10 mAdc I_C = 300 mAdc, I_B = 30 mAdc	$V_{CE(sat)}$	— — — —	0.2 0.3 0.28 0.5	Vdc
Base-Emitter Saturation Voltage*	I_C = 30 mAdc, I_B = 3.0 mAdc I_C = 100 mAdc, I_B = 10 mAdc I_C = 300 mAdc, I_B = 30 mAdc	$V_{BE(sat)}$	0.75 — —	0.95 1.2 1.7	Vdc
DC Current Gain*	I_C = 30 mAdc, V_{CE} = 0.4 Vdc I_C = 100 mAdc, V_{CE} = 0.5 Vdc I_C = 300 mAdc, V_{CE} = 1.0 Vdc	h_{FE}*	30 25 15	120 — —	—
Collector Reverse Current	V_{CE} = 20 Vdc, V_{EB} = 0 V_{CE} = 20 Vdc, V_{EB} = 0, T_A = +65 C	I_{CES}	— —	0.5 3.0	μAdc
Base Current	V_{CE} = 20 Vdc, V_{EB} = 0	I_B	—	0.5	μAdc
Output Capacitance	V_{CB} = 5.0 V, I_E = 0, f = 140 kc	C_{ob}	—	5.0	pf
Input Capacitance	V_{EB} = 0.5 V, I_C = 0, f = 140 kc	C_{ib}	—	8.0	pf
Small-Signal Current Gain	I_C = 30 mA, V_{CE} = 10 V, f = 100 mc	h_{fe}	3.5	—	—
Turn-On Delay Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ = -3.0 V	t_d	—	10	nsec
Rise Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ = -3.0 V	t_r	—	15	nsec
Turn-On Time (Figure 1)	I_C 300 mA, I_{B1} 30 mA, $V_{BE(off)}$ -3.0 V	t_{on}	—	18	nsec
Storage Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_s	—	20	nsec
Fall Time (Figure 1)	V_{CC} = +10 V, I_{CS} 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_f	—	15	nsec
Turn-Off Time (Figure 1)	I_C 300 mA, I_{B1} 30 mA, I_{B2} -30 mA	t_{off}	—	28	nsec
Charge Storage Time Constant (Figure 2)	I_C 10 mA, I_{B1} 10 mA, I_{B2} -10 mA	τ_s	—	18	nsec

*Pulse Conditions: PW ≤ 300 sec: Duty Cycle ≤1%

MPS3707 (SILICON)
MPS3708
MPS3709
MPS3710
MPS3711

$V_{CEO} = 30$ V
$I_C = 30$ mAdc



CASE 29
(TO-92)

NPN silicon epitaxial plastic encapsulated transistor designed for general-purpose low-level amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	30	Vdc
Emitter-Base Voltage	V_{EB}	6	Vdc
Collector Current	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	310	mW
Total Device Dissipation @ $T_C = 60^oC$	P_D	210	mW
Operating Junction Temperature Range	T_J	135	^oC
Storage Temperature Range	T_{stg}	-55 to +135	^oC

THERMAL CHARACTERISTICS

Characteristic	Symbol	Rating	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	$^oC/W$

MPS3707, MPS3708, MPS3709, MPS3710, MPS3711 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)		BV_{CEO}	30	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{EB} = 6 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
DC Current Gain		h_{FE}			-
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MPS3707		100	400	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MPS3708		45	660	
	MPS3709		45	165	
	MPS3710		90	330	
	MPS3711		180	660	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 0.5 mAdc)		$V_{CE(sat)}$	-	1.0	Vdc
Base-Emitter Voltage (I_C = 1 mAdc, V_{CE} = 5 Vdc)		V_{BE}	0.5	1.0	Vdc
Small Signal Current Gain		h_{FE}			-
(I_C = 100 μAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3707		100	550	
(I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	MPS3708		45	800	
	MPS3709		45	250	
	MPS3710		90	450	
	MPS3711		180	800	
Noise Figure (V_{CE} = 5 V, I_C = 100 μA, R_G = 5 kΩ, Noise Bandwidth = 15.7 kHz) Note 1	MPS3707	NF	-	5	dB

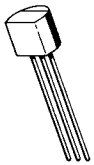
Note 1 Average Noise Figure is measured in an amplifier with low frequency response down 3 dB at 10 Hz.

MPS3721 (SILICON)

For Specifications, See MPS2926 Data Sheet

MPS6512 thru MPS6515 (SILICON)
MPS6520
MPS6521

V_{CEO} = 25-30 V
I_C = 100 mA
P_D = 310 mW



CASE 29
(TO-92)

NPN silicon transistors designed for use in general purpose audio and low-frequency amplifier applications. Types MPS6520 and MPS6521 are particularly suited for low-noise applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	MPS6512 MPS6513	MPS6514 MPS6515 MPS6520 MPS6521	Unit
Collector-Base Voltage	V_{CB}	40	40	Volts
Collector-Emitter Voltage	V_{CEO}	30	25	Volts
Emitter-Base Voltage	V_{EB}	4		Volts
Collector Current	I_C	100		mA
Total Device Dissipation @ T_A = 60°C @ T_A = 25°C	P_D	210 310		mW
Junction Temperature	T_J	135		°C

THERMAL RESISTANCE $\theta_{JA(air)}$ = 0.357°C/mW

MPS6512 thru MPS6515, MPS6520, MPS6521 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 0.5 mAdc, I_B = 0)	MPS6512, MPS6513	BV_{CEO}	30	—	—	Vdc
	MPS6514, MPS6515		25	—	—	
	MPS6520, MPS6521		25	—	—	
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	4	—	—	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0)		I_{CBO}	—	—	0.05	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)			—	—	1.0	
DC Current Gain (I_C = 100 μAdc, V_{CE} = 10 Vdc)	MPS6520	h_{FE}	100	—	—	—
	MPS6521		150	—	—	
(I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6512		50	—	100	
	MPS6513		90	—	180	
	MPS6514		150	—	300	
	MPS6515		250	—	500	
	MPS6520		200	—	400	
	MPS6521		300	—	600	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)*	MPS6512		30	—	—	
	MPS6513		60	—	—	
	MPS6514		90	—	—	
	MPS6515		150	—	—	
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$	—	—	0.5	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	—	3.5	pf
Current Gain - Bandwidth Product (I_C = 2 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513	f_T	—	250	—	mc
	MPS6514, MPS6515		—	390	—	
	MPS6520, MPS6521		—	390	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MPS6512, MPS6513		—	330	—	
	MPS6514, MPS6515		—	480	—	
	MPS6520, MPS6521		—	480	—	
Wideband Noise Figure (V_{CE} = 5 Vdc, I_C = 10 μAdc, R_G = 10 k ohms, Power Bandwidth = 15.7 kc, 3 db points @ 10 cps and 10 kc)	MPS6520, MPS6521	NF	—	1.8	3.0	db

*Pulse Test: PW ≤ 30 μsec, duty cycle ≤ 2%

WIDEBAND NOISE FIGURE versus SOURCE IMPEDANCE

FIGURE 1 — MPS6512 thru MPS6515

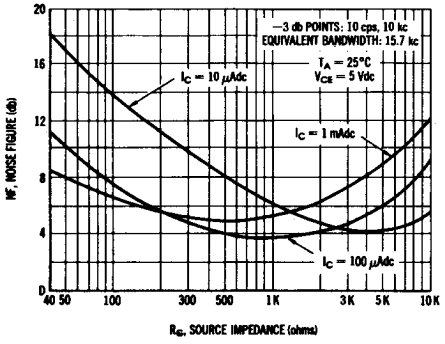
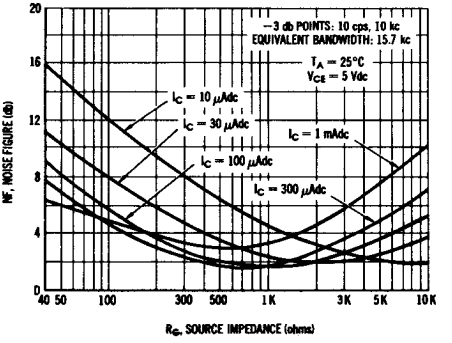


FIGURE 2 — MPS6520, MPS6521



MPS6512 thru MPS6515, MPS6520, MPS6521 (continued)

COLLECTOR CHARACTERISTICS — COMMON EMITTER

FIGURE 3 — MPS6512

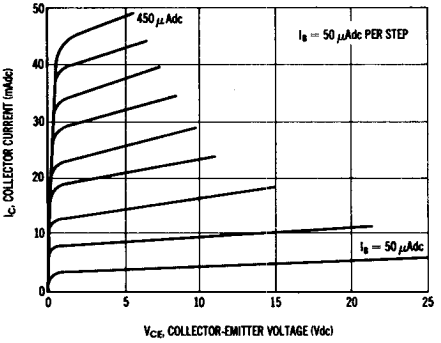


FIGURE 4 — MPS6513

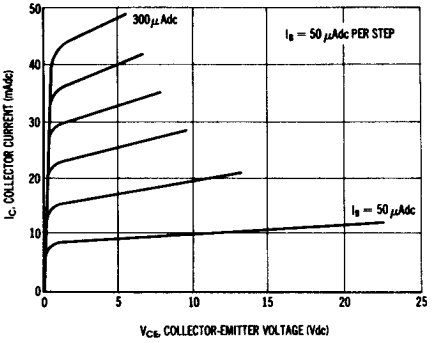


FIGURE 5 — MPS6514, MPS6520

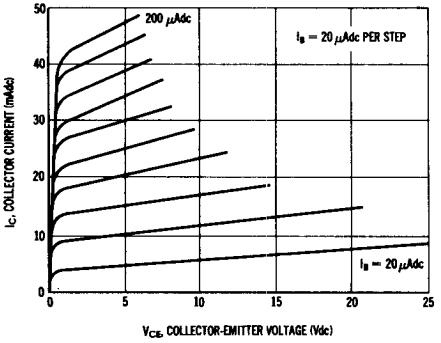


FIGURE 6 — MPS6515, MPS6521

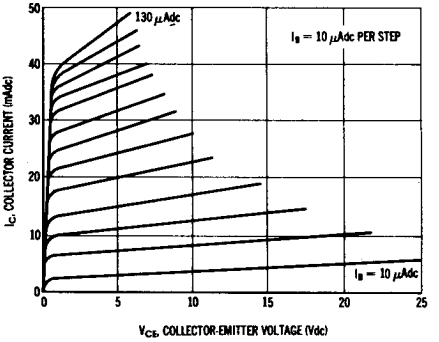


FIGURE 7 — SPOT NOISE FIGURE versus FREQUENCY

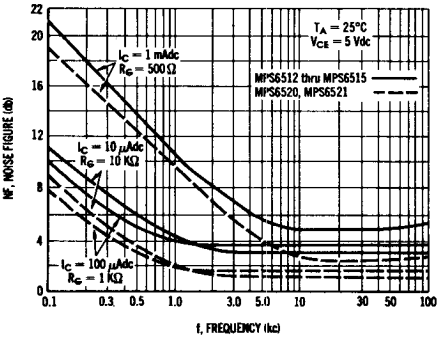
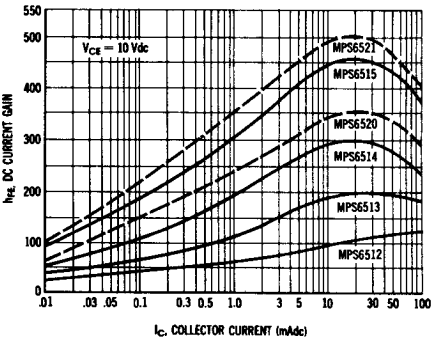


FIGURE 8 — DC CURRENT GAIN versus COLLECTOR CURRENT



MPS6512 thru MPS6515, MPS6520, MPS6521 (continued)

h PARAMETER VARIATIONS
(f = 1 kc, T_A = 25°C)

FIGURE 9 — INPUT IMPEDANCE versus COLLECTOR CURRENT

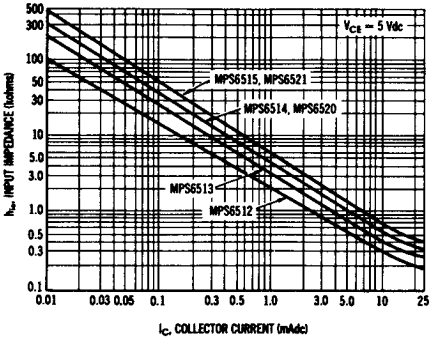


FIGURE 10 — REVERSE VOLTAGE TRANSFER RATIO versus COLLECTOR CURRENT

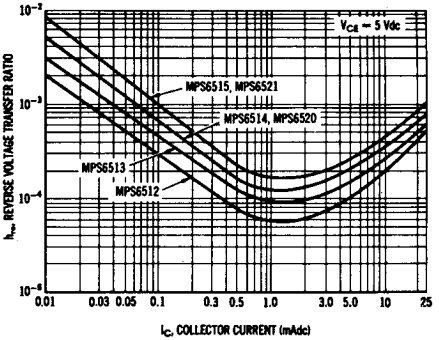


FIGURE 11 — SMALL SIGNAL CURRENT GAIN versus COLLECTOR CURRENT

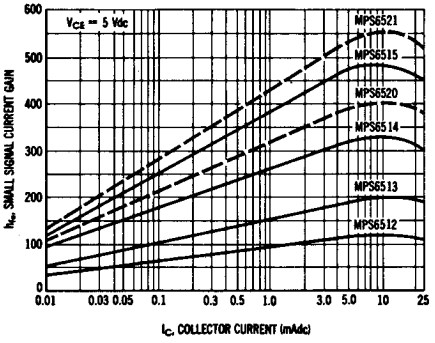


FIGURE 12 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

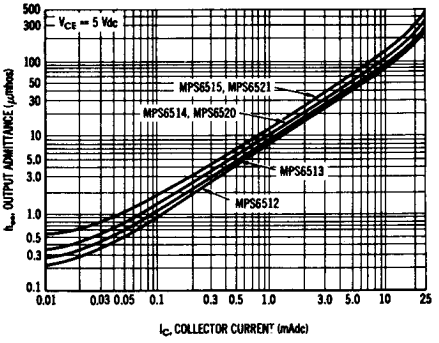


FIGURE 13 — GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

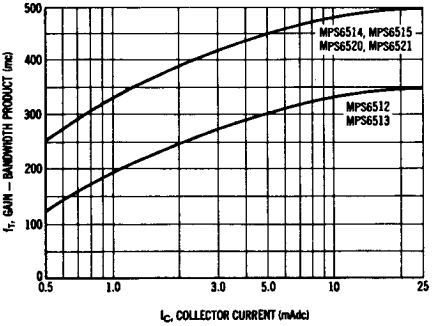
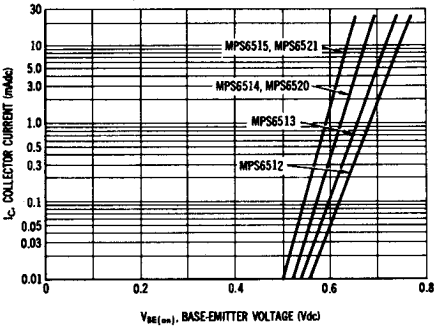
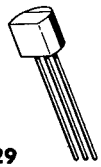


FIGURE 14 — COLLECTOR CURRENT versus BASE-EMITTER TURN-ON VOLTAGE



MPS6516 thru MPS6519 (SILICON)
MPS6522
MPS6523

V_{CEO} = 40V
f_T = 200 to 420 MHz
NF = 3.0 dB



CASE 29
(TO-92)

PNP silicon transistors designed for use in general purpose audio and low-frequency amplifier applications. Types MPS6522 and MPS6523 are particularly suited for low-noise applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	MPS6516 MPS6517 MPS6518	MPS6519 MPS6522 MPS6523	Unit
Collector-Emitter Voltage	V_{CEO}	40	25	Volts
Collector-Base Voltage	V_{CB}	40	25	Volts
Emitter Base Voltage	V_{EB}	4		Volts
Collector Current	I_C	100		mA
Total Device Dissipation @ T_A = 60°C @ T_A = 25°C	P_D	210 310		mW
Junction Temperature	T_J	135		°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

MPS6516 thru MPS6519, MPS6522, MPS6523 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = -0.5 mAdc, I_B = 0)	MPS6516 thru MPS6518 MPS6519, MPS6522, MPS6523	BV_{CEO}	-40 -25	— —	— —	Vdc
Emitter-Base Breakdown Voltage (I_B = -10 μAdc, I_C = 0)		BV_{EBO}	-4	—	—	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = -30 Vdc, I_E = 0)	MPS6516 thur MPS6518		—	—	-0.05	
(V_{CB} = -20 Vdc, I_E = 0)	MPS6519, MPS6522, MPS6523		—	—	-0.05	
(V_{CB} = -30 Vdc, I_E = 0, T_A = 60°C)	MPS6516 thru MPS 6518		—	—	-1.0	
(V_{CB} = -20 Vdc, I_E = 0, T_A = 60°C)	MPS6519, MPS6522, MPS6523		—	—	-1.0	
DC Current Gain		h_{FE}				—
(I_C = -100 μAdc, V_{CE} = -10 Vdc)	MPS6522		100	—	—	
	MPS6523		150	—	—	
(I_C = -2 mAdc, V_{CE} = -10 Vdc)	MPS6516		50	—	100	
	MPS6517		90	—	180	
	MPS6518		150	—	300	
	MPS6519		250	—	500	
	MPS6522		200	—	400	
	MPS6523		300	—	600	
(I_C = -100 mAdc, V_{CE} = -10 Vdc)	MPS6516		30	—	—	
	MPS6517		60	—	—	
	MPS8518		90	—	—	
	MPS6519		150	—	—	
Collector-Emitter Saturation Voltage (I_C = -50 mAdc, I_B = -5 mAdc)		$V_{CE(sat)}$	—	—	-0.5	Vdc
Current Gain — Bandwidth Product		f_T				MHz
(I_C = -2 mAdc, V_{CE} = -10 Vdc)	MPS6516, MPS6517		—	200	—	
	MPS6518, MPS6519		—	340	—	
	MPS6522, MPS6523		—	340	—	
(I_C = -10 mAdc, V_{CE} = -10 Vdc)	MPS6516, MPS6517		—	270	—	
	MPS6518, MPS6519		—	420	—	
	MPS6522, MPS6523		—	420	—	
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 100 kHz)	MPS6516 thru MPS6519	C_{ob}	—	—	4.0	pF
	MPS6522, MPS6523		—	—	4.0	
Wideband Noise Figure (V_{CE} = -5 Vdc, I_C = -10 μAdc, R_S = 10 kohms, Power Bandwidth = 15.7 kHz, 3 dB points @ 10 Hz and 10 kHz)	MPS6522, MPS6523	NF	—	1.8	3.0	dB

*Pulse Test: Pulse Width ≤ 30 μs, duty cycle ≤ 2%

WIDEBAND NOISE FIGURE versus SOURCE IMPEDANCE

FIGURE 1 — MPS6516 thru MPS6519

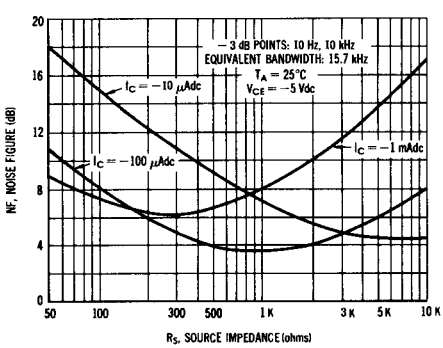
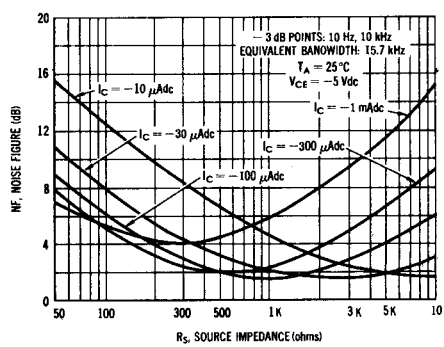


FIGURE 2 — MPS6522, MPS6523



MPS6516 thru MPS6519, MPS6522, MPS6523 (continued)

COLLECTOR CHARACTERISTICS — COMMON EMITTER

FIGURE 3 — MPS6516

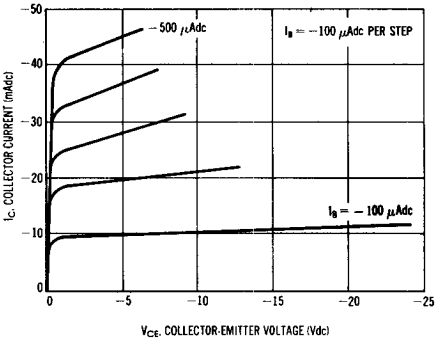


FIGURE 4 — MPS6517

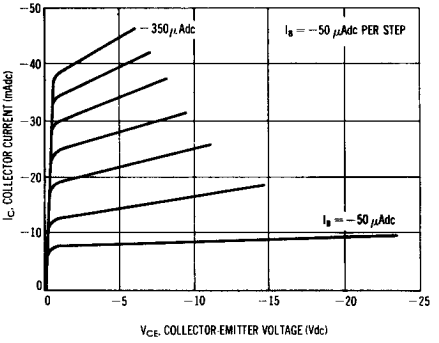


FIGURE 5 — MPS6518, MPS6522

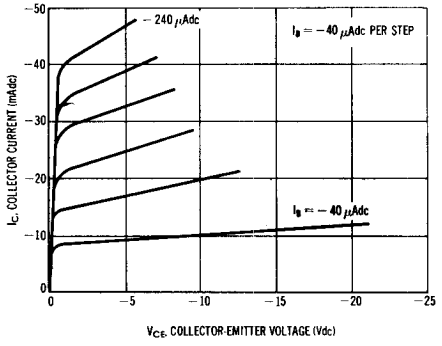


FIGURE 6 — MPS6519, MPS6523

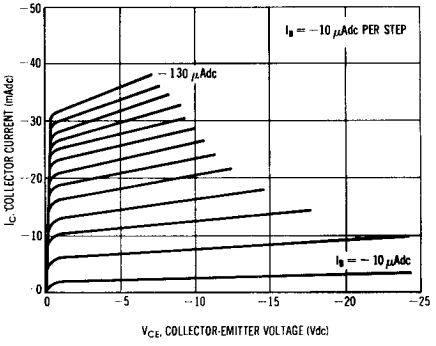


FIGURE 7 — SPOT NOISE FIGURE versus FREQUENCY

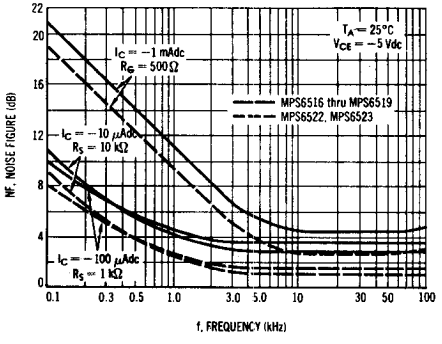
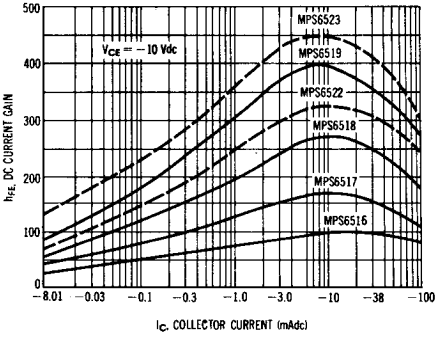


FIGURE 8 — DC CURRENT GAIN versus COLLECTOR CURRENT



MPS6516 thru MPS6519, MPS6522, MPS6523 (continued)

h PARAMETER VARIATIONS
($f = 1$ kHz, $T_A = 25°C$)

FIGURE 9 — INPUT IMPEDANCE versus COLLECTOR CURRENT

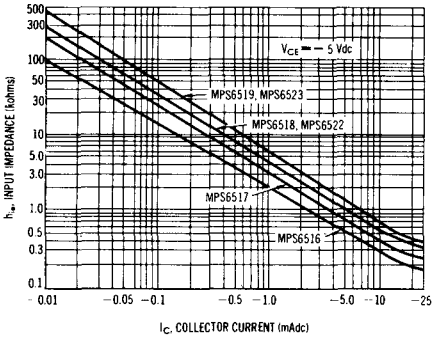


FIGURE 10 — REVERSE VOLTAGE TRANSFER RATIO versus COLLECTOR CURRENT

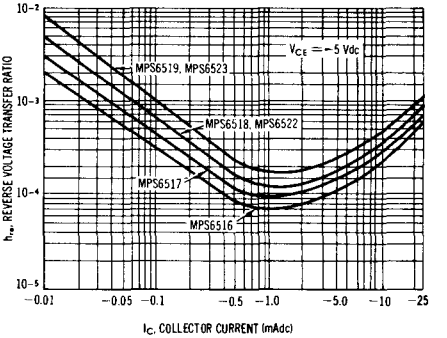


FIGURE 11 — SMALL-SIGNAL CURRENT GAIN versus COLLECTOR CURRENT

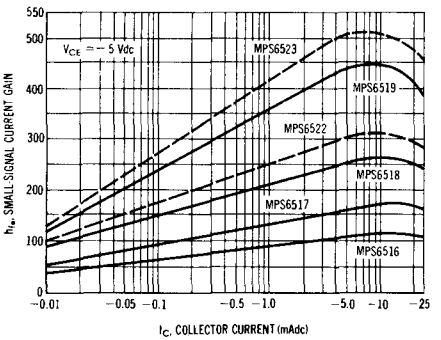


FIGURE 12 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

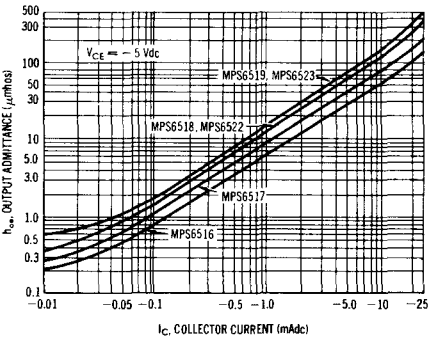


FIGURE 13 — GAIN — BANDWIDTH PRODUCT versus COLLECTOR CURRENT

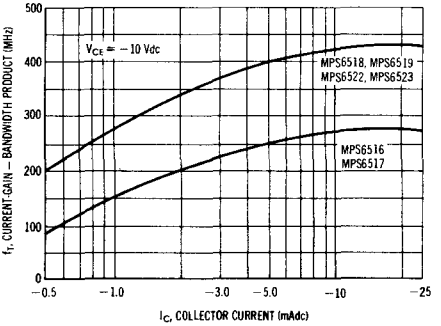
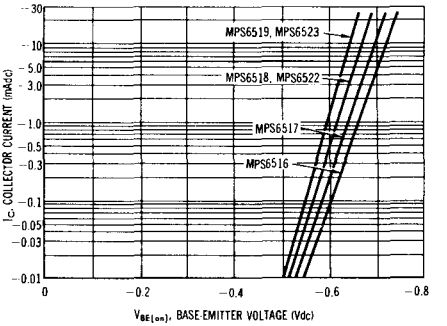


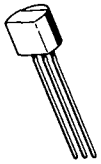
FIGURE 14 — COLLECTOR CURRENT versus BASE-EMITTER TURN-ON VOLTAGE



MPS6530
MPS6531
MPS6532
NPN (SILICON)

MPS6533
MPS6534
MPS6535
PNP

V_{CEO} = 30-40 V
I_C = 600 mA
P_D = 310 mW



CASE 29
(TO-92)

Silicon annular transistors designed for use in complementary amplifier circuits.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	NPN	PNP	Unit
Collector-Base Voltage	V_{CB}			Vdc
MPS6530, MPS6531 MPS6532		60 50		
MPS6533, MPS6534 MPS6535			40 30	
Collector-Emitter Voltage	V_{CEO}			Vdc
MPS6530, MPS6531 MPS6532		40 30		
MPS6533, MPS6534 MPS6535			40 30	
Emitter-Base Voltage	V_{EB}	5	4	Vdc
Collector Current	I_C	600	600	mAdc
Total Device Dissipation @ T_A = 60°C	P_D	210	210	mW
@ T_A = 25°C		310	310	
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	0.357	°C/mW
Junction Temperature	T_J	135	135	°C

MPS6530 thru MPS6535 (continued)

MPS6530 thru MPS6532 (NPN)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6530, MPS6531 MPS6532	BV_{CBO}	60 50	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6530, MPS6531 MPS6532	BV_{CEO}	40 30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 40 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0)	 MPS6530, MPS6531 MPS6532	I_{CBO}	 - -	 - -	 0.05 0.1	μAdc
(V_{CB} = 40 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C)	MPS6530, MPS6531 MPS6532		- -	- -	2.0 5.0	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	 MPS6530 MPS6531	h_{FE}	 30 60	 75 120	 - -	-
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MPS6530 MPS6531 MPS6532		40 90 30	85 150 -	120 270 -	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS6530 MPS6531		25 50	60 80	- -	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6532 MPS6531	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6530, MPS6531 MPS6532	$V_{BE(sat)}$	- -	0.82 0.85	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	All Types	C_{ob}	-	3.5	5.0	pf
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)	All Types	f_T	-	390	-	mc

MPS6533 thru MPS6535 (PNP)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MPS6533, MPS6534 MPS6535	BV_{CBO}	40 30	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)	MPS6533, MPS6534 MPS6535	BV_{CEO}	40 30	-	-	Vdc
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CB} = 30 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0)	 MPS6533, MPS6534 MPS6535	I_{CBO}	 - -	 - -	 0.05 0.1	μAdc
(V_{CB} = 30 Vdc, I_E = 0, T_A = 60°C) (V_{CB} = 20 Vdc, I_E = 0, T_A = 60°C)	MPS6533, MPS6534 MPS6535		- -	- -	2.0 5.0	
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	 MPS6533 MPS6534	h_{FE}	 30 60	 70 110	 - -	-
(I_C = 100 mAdc, V_{CE} = 1 Vdc)	MPS6533 MPS6534 MPS6535		40 90 30	85 140 -	120 270 -	
(I_C = 500 mAdc, V_{CE} = 10 Vdc)	MPS6533 MPS6534		25 50	55 70	- -	
Collector-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6535 MPS6534	$V_{CE(sat)}$	- -	0.2 0.13	0.5 0.3	Vdc
Base-Emitter Saturation Voltage (I_C = 100 mAdc, I_B = 10 mAdc)	MPS6533, MPS6534 MPS6535	$V_{BE(sat)}$	- -	0.84 0.67	1.0 1.2	Vdc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	All Types	C_{ob}	-	4.8	6.0	pf
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 10 Vdc)	All Types	f_T	-	260	-	mc

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

RF TRANSISTORS



RF TRANSISTORS

Transistors in this section are designed specifically for RF applications in VHF/UHF receivers and transmitters. Both silicon and germanium devices are included, and the accompanying selection guides permit a rapid pin-pointing of devices for specific circuit functions.

The following table lists a number of semiconductor devices that comply with the terms of military specifications, the applicable military specifications and the appropriate page in the data sections of this manual. For additional information, military-type data sheets are available.

USA 2N700A	MIL-S-19500/123	9-9
JAN 2N918	MIL-S-19500/301	9-15
USN 2N1142	MIL-S-19500/87	9-16
USN 2N1195	MIL-S-19500/71C	9-16
JAN 2N2273	MIL-S-19500/244B	9-24

For case outline dimensions, see page 1-186.

RF TRANSISTOR SELECTOR GUIDE

These tables and graphs are intended to permit rapid comparison and selection of transistors for transmitter and receiver designs. The devices included are suitable for application as RF and IF amplifiers, oscillators, mixers, multipliers, power oscillators, drivers, output and harmonic generator stages.

SMALL SIGNAL RF APPLICATIONS SELECTOR GUIDE

Frequency Range	Polarity and Material	RF and IF Amplifiers, Mixers and Converters	Low-Level Oscillators $P_o < 100$ mW	High-Level Oscillators $.1W < P_o < 2W$	Low-Level Wide-Band Amplifiers
2 Mc to 70 Mc	PNP Ge	2N700 2N700A 2N1141 2N1142 2N1143 2N1195 2N2273 2N2929 2N3279 2N3280 2N3281 2N3282 2N3283 2N3284 2N3285 2N3286 2N3323 2N3324 2N3325	2N700 2N700A 2N1141 2N1142 2N1143 2N1195 2N2273 2N2929 2N3127 2N3279 2N3280 2N3281 2N3282 2N3285 2N3323 2N3324 2N3325	2N1141 2N1142 2N1143 2N1195 2N1561 2N1562 2N1692 2N1693 2N2929	2N700 2N700A 2N1141 2N1142 2N1143 2N1195 2N2273 2N2929 2N3127 2N3279 2N3280 2N3281 2N3282 2N3283 2N3284 2N3285 2N3286 2N3323 2N3324 2N3325
	NPN Si	2N918 2N3287 2N3288 2N3289 2N3290 2N3291 2N3292 2N3293 2N3294	2N918 2N3287 2N3288 2N3289 2N3290 2N3293 2N3298	2N2949 2N2951 2N2952 2N3309A	2N918 2N3287 2N3288 2N3289 2N3290 2N3291 2N3292 2N3293 2N3294
	PNP Si	2N3250 2N3251 2N3307 2N3308	2N3250 2N3251 2N3307 2N3308	–	2N3307 2N3308

SMALL SIGNAL RF APPLICATIONS SELECTOR GUIDE (continued)

Frequency Range	Polarity and Material	RF and IF Amplifiers, Mixers and Converters	Low-Level Oscillators $P_o < 100$ mW	High-Level Oscillators $.1W < P_o < 2W$	Low-Level Wide-Band Amplifiers
70 Mc to 400 Mc	PNP Ge	2N1141 2N1142 2N1143 2N1195 2N2273 2N2929 2N3279 2N3280 2N3281 2N3282 2N3283 2N3284 2N3285 2N3286 2N3323 2N3783 2N3784 2N3785 MM2503	2N700 2N700A 2N1141 2N1142 2N1143 2N1195 2N2929 2N3127 2N3279 2N3280 2N3281 2N3282 2N3285 2N3323 2N3783 2N3784 2N3785 MM2503	2N1141 2N1142 2N1143 2N1195 2N1561 2N1562 2N1692 2N1693 2N2929	2N1141 2N1142 2N1143 2N1195 2N2929 2N3127 2N3279 2N3280 2N3281 2N3282 2N3783 2N3784 2N3785 MM2503
	NPN Si	2N918 2N3287 2N3288 2N3289 2N3290 2N3291 2N3292 2N3293 2N3294	2N918 2N3287 2N3288 2N3289 2N3290 2N3293 2N3298	2N2949 2N2951 2N3137 2N3309A	2N918 2N3287 2N3288 2N3289 2N3290
	PNP Si	2N3307 2N3308	2N3307 2N3308	—	2N3307 2N3308
400 Mc to 1 Gc	NPN Si	2N918 2N3287 2N3288 2N3289 2N3290 2N3291 2N3292 2N3293 2N3294 2N3544	2N918 2N3287 2N3288 2N3289 2N3290 2N3293 2N3544	2N3309A	2N918
	PNP Si	2N3307 2N3308	2N3307 2N3308	—	2N3307 2N3308
	PNP Ge	2N3783 2N3784 2N3785 MM2503	2N3783 2N3784 2N3785 MM2503	—	2N3783 2N3784 2N3785 MM2503
1 Gc Up	NPN Si	—	—	2N3309A 2N3664	—
	PNP Ge	2N3783 2N3784 2N3785	2N3783 2N3784 2N3785	—	2N3783 2N3784 2N3785 MM2503

LARGE SIGNAL RF APPLICATIONS SELECTOR GUIDE

Frequency Range	Polarity and Material	Power Amplifier Transistors			
		$P_o < 1W$	$1W < P_o < 5W$	$5W < P_o < 15W$	$15W < P_o < 50W$
30 Mc to 100 Mc	NPN Si	2N2949 2N2951 2N3295 2N3298 2N3309A	2N2949 2N2950 2N3296 2N3309A 2N3664 2N3553	2N2947 2N2948 2N3297 2N3961 2N3632 2N3925 2N3927 2N3375	2N2947 2N3632 2N3927
100 Mc to 400 Mc	NPN Si	2N3137 2N3866 2N3309A 2N4072 2N4073	2N3309A 2N3553 2N3664 2N3961 2N3375 2N3924 2N3925 2N3866	2N3375 2N3632 2N3926 2N3927	2N3632 2N3927
400 Mc Up	NPN Si	2N3309A 2N3866 2N4072 2N4073	2N3309A 2N3664 2N3866 2N3961 2N3375 2N4012	2N3632 2N3927	

Varactors		
Frequency Range	$2W < P_o < 20W$	$20W < P_o < 100W$
50 Mc to 300 Mc	1N4386 1N4387 1N4388	1N4386 1N4387
300 Mc to 1000 Mc	1N4387 1N4388 1N5149	1N5150
1000 Mc to 2000 Mc	1N5149 1N4388 1N5151 1N5152 1N5153	1N5150
2 Gc Up	1N5151 1N5152 1N5153 1N5154 1N5155	

ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

2N700, A (GERMANIUM)

2N700A USA/JAN

$V_{CBO} = 25$ V
$G_e = 20$ db @ 70 Mc
NF = 10 db @ 70 Mc



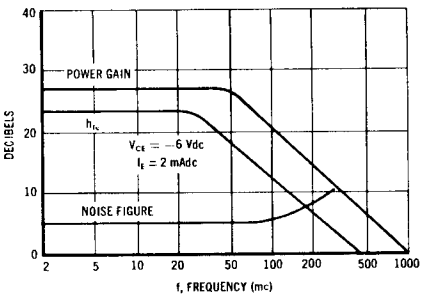
CASE 21
(TO-17)

PNP germanium mesa transistors for oscillator, frequency multiplier, wide-band mixer and wide-band amplifier applications.

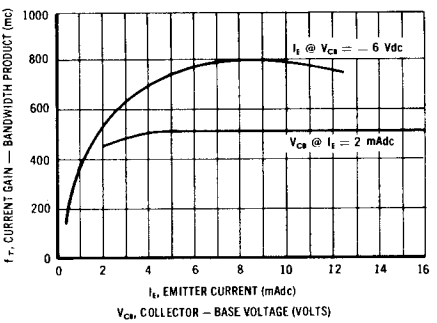
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage 2N700 2N700A	V_{CEO}	 20 25	Vdc
Emitter-Base Voltage	V_{EB}	0.2	Vdc
Collector DC Current	I_C	50	mAdc
Junction Temperature	T_J	100	°C
Storage Temperature	T_{stg}	-65 to +100	°C
Total Device Dissipation at 25°C Ambient (Derate 1 mW/°C above 25°C)	P_D	75	mW

POWER GAIN, CURRENT GAIN, & NOISE FIGURE versus FREQUENCY



CURRENT-GAIN-BANDWIDTH PRODUCT versus CURRENT AND VOLTAGE



2N700,A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Sym	Test Conditions	Types	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	All Types	25	32	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 100 μAdc, I_B = 0	2N700 2N700A	20 25	— —	— —	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 100 μAdc, I_C = 0	All Types	0.2	0.5	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 6 Vdc, I_E = 0 V_{CB} = 6 Vdc, I_E = 0, T_A = 85°C	All Types 2N700 2N700A	— — —	0.4 60 —	2 150 50	μAdc
Small Signal Forward Current Transfer Ratio	h_{fe}	I_E = 2 mAdc, V_{CE} = 6 Vdc, f = 1 kc I_E = 5 mAdc, V_{CE} = 6 Vdc, f = 1 kc I_E = 2 mAdc, V_{CE} = 6 Vdc, f = 200 mc	All Types 2N700A 2N700 2N700A	4 — 2.5 5	10 — 7 —	— 50 — —	— — db db
Input Impedance	h_{ib}	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 1 kc	All Types	—	17	30	Ohms
Base Resistance	r'_b	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 300 mc	All Types	—	55	100	Ohms
Collector-Base Output Capacitance (case grounded)	C_{ob}	V_{CB} = 6 Vdc, I_E = 0, f = 100 kc	2N700 2N700A	— —	1.1 —	1.5 1.4	pf
Power Gain	G_e	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 70 mc (neutralized)	2N700 2N700A	20 22	23 —	— —	db
Noise Figure	NF		All Types	—	6	10	db
Power Gain	G_e	I_E = 2 mAdc, V_{CB} = 6 Vdc, f = 30 mc (neutralized)	2N700A	26	—	—	

2N707, A (SILICON)

$f_{max} = 600$ Mc
$P_o = 200\text{-}400$ mW Min @ 100 Mc



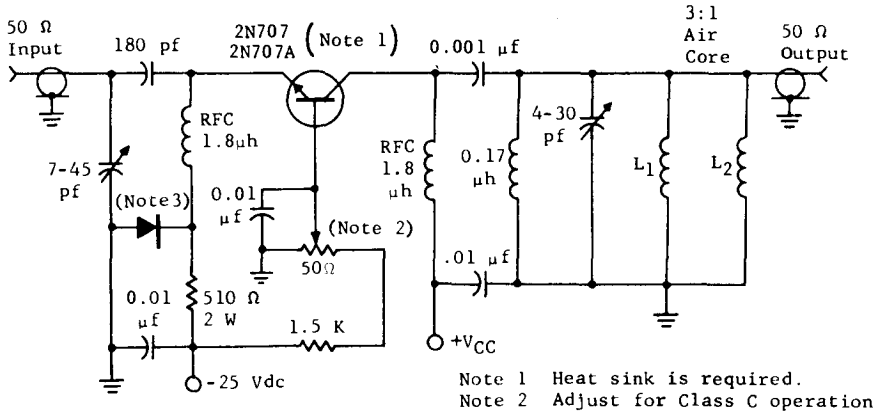
CASE 22
(TO-18)

Collector connected to case

NPN silicon epitaxial mesa transistors for VHF oscillator and class C amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N707	2N707A	Unit
Collector-Emitter Voltage	V_{CEO}	-	40	Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10$ ohms)	V_{CER}	28	-	Vdc
Collector-Base Voltage	V_{CB}	56	70	Vdc
Emitter-Base Voltage	V_{EB}	4	5	Vdc
Total Device Dissipation @ $T_A = 25^oC$	P_D	0.3	0.5	Watt
Derate above 25^oC		2	3.33	$mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$	P_D	1.0	1.2	Watts
Derate above 25^oC		6.67	8	$mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175		^oC



L_1 5 turns #14 wire wound on 1/2" diameter.

L_2 2 turns #14 wire wound on L_1.

Note 1 Heat sink is required.
Note 2 Adjust for Class C operation.
Note 3 Very High conductance silicon diode.
Note 4 Adjust V_{CC} for proper V_{CE}

FIGURE 1 — 100 MC, CLASS C, COMMON BASE AMPLIFIER

2N707,A (continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise specified)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_B = 0)	2N707A	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, R_{BE} = 10 ohms)	2N707	BV_{CER}	28	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N707 2N707A	BV_{CBO}	56 70	- -	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N707A	BV_{EBO}	5	-	-	Vdc
Collector Cutoff Current		I_{CBO}				μAdc
(V_{CB} = 15 Vdc, I_E = 0)	2N707		-	0.005	5.0	
(V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	2N707		-	3.0	-	
(V_{CB} = 30 Vdc, I_E = 0)	2N707A		-	0.01	1.0	
(V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C)	2N707A		-	5.0	100	
Emitter Cutoff Current		I_{EBO}				μAdc
(V_{BE} = 4 Vdc, I_C = 0)	2N707		-	-	10	
(V_{BE} = 5 Vdc, I_C = 0)	2N707A		-	-	100	
ON CHARACTERISTICS						
DC Current Gain (I_C = 10 mAdc, V_{CE} = 1 Vdc)	2N707 2N707A	h_{FE}	9 9	12 -	- 50	-
Collector Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	-	0.18	0.6	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	-	0.75	0.9	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 15 mAdc, V_{CE} = 10 Vdc)		f_T	70	350	-	MHz
Maximum Frequency of Oscillation		f_{max}	-	600	-	MHz
Output Capacitance		C_{ob}				pF
(V_{CB} = 10 Vdc, I_E = 0)	2N707		-	4.0	10.0	
(V_{CB} = 5 Vdc, I_E = 0)	2N707A		-	4.0	6.0	
Collector-Base Time Constant (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 4 MHz)		$r'_b C_c$	-	80	-	ps
FUNCTIONAL TEST						
Power Output (Figure 1)		P_{out}				mW
(V_{CE} = 20 Vdc, P_{in} = 50 mW)	All Types		200	300	-	
(V_{CE} = 40 Vdc, P_{in} = 175 mW)	2N707A		400	-	-	
100-MHz Oscillator Efficiency (V_{CE} = 28 Vdc, I_C = 40 mAdc)		η	-	38	-	%

*Pulse Test 300 μs, 2% duty cycle

2N741, A (GERMANIUM)

V_{CBO} = 15-20 V
G_e = 16 db @ 30 Mc
NF = 7 db @ 30 Mc



CASE 22
(TO-18)

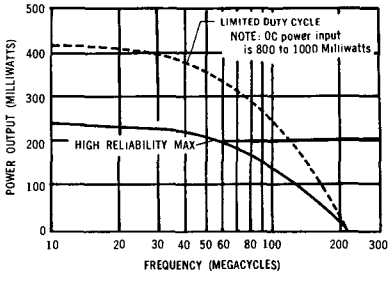
PNP germanium mesa transistors for oscillator, frequency multiplier and amplifier applications.

Collector connected to case

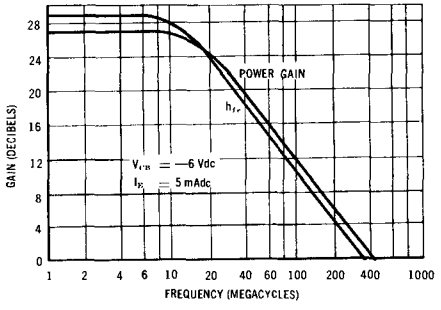
MAXIMUM RATINGS

Characteristic	Symbol	2N741	2N741A	Unit
Collector-Emitter Voltage	V_{CE}	15	20	Vdc
Collector-Base Voltage	V_{CB}	15	20	Vdc
Emitter-Base Voltage	V_{EB}	1.0		Vdc
Collector Current	I_C	100		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	150 2		mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	300 4		mW $mW/^oC$
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100		^oC

POWER OUTPUT versus FREQUENCY, CLASS C AMPLIFIER



POWER GAIN AND COMMON EMITTER CURRENT GAIN versus FREQUENCY



2N741,A (continued)

ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N741	BV_{CBO}	15	-	-	Vdc
	2N741A		20	-	-	
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	1.0	-	-	Vdc
Collector Cutoff Current (V_{CE} = 15 Vdc, V_{BE} = 0)	2N741	I_{CES}	-	-	100	μAdc
(V_{CE} = 20 Vdc, V_{BE} = 0)	2N741A		-	-	100	
Collector Cutoff Current (V_{CB} = 6 Vdc, I_E = 0)		I_{CBO}	-	0.2	3	μAdc
ON CHARACTERISTICS						
DC Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc)		h_{FE}	10	25	-	-
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 100 MHz)	2N741	f_T	-	360	-	MHz
	2N741A		300	360	-	
Output Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	6	10	pF
Collector Capacitance (V_{CB} = 6 Vdc, I_E = 0, f = 100 kHz)		C_c	-	3	-	pF
Small-Signal Current Gain (I_C = 5 mAdc, V_{CE} = 6 Vdc, f = 1 kHz)		h_{fe}	20	-	-	-
Output Admittance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 1 kHz)		h_{ob}	-	45	-	μmhos
Input Impedance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 1 kHz)		h_{ib}	-	8	15	Ohms
Base Resistance (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 300 MHz)	2N741	r'_b	-	75	-	Ohms
	2N741A		-	65	-	
Noise Figure (I_E = 5 mAdc, V_{CB} = 6 Vdc, f = 30 MHz)		NF	-	7	-	dB
Power Gain, Matched, Neutralized (V_{CB} = 6 Vdc, I_E = 5 mAdc, f = 30 MHz)		G_{pe}	16	22	-	dB
Power Output (I_C = 60 mAdc, V_{CB} = 6 Vdc,		P_{out}	-	200	-	mW
G_{pe} = 8 dB, f = 30 MHz)			-	250	-	
Power Output (I_C = 60 mAdc, V_{CB} = 6 Vdc, G_{pe} = 5 dB, f = 70 MHz)		P_{out}	-	200	-	mW

2N918 (SILICON)

G_e = 15 db @ 200 Mc
NF = 6 db @ 60 Mc max
P_o = 30 mW @ 500 Mc min



CASE 20
(TO-72)

NPN silicon annular transistor for ultra-high frequency oscillator and amplifier applications.

MAXIMUM RATINGS

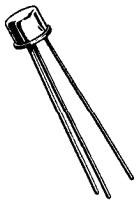
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	30	Volts
Collector-Emitter Voltage	V_{CEO}	15	Volts
Emitter-Base Voltage	V_{EBO}	3.0	Volts
Total Dissipation at 25°C Case Temperature at 25°C Ambient Temperature	P_D	0.3 0.2	Watt Watt
Operating Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +300	°C

ELECTRICAL CHARACTERISTICS (at 25°C unless otherwise specified)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 V, I_E = 0 V_{CB} = 15V, 150 C, I_E = 0	- -	- -	10 1.0	nA μA
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 1.0 μA, I_E = 0	30	-	-	Volts
Emitter-Base Breakdown Voltage	BV_{EBO}	I_C = 10 μA, I_C = 0	3	-	-	Volts
Collector-Emitter Voltage	BV_{CEO}	I_C = 3 mA	15	-	-	Volts
DC Current Gain	h_{FE}	V_{CE} = 1.0 V, I_C = 3.0 mA	20	50	-	-
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	-	-	0.4	Volt
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 10 mA, I_B = 1.0 mA	-	-	1.0	Volt
Output Capacitance	C_{ob}	V_{CB} = 10 V I_E = 0, f = 140 kc V_{CB} = 0, f = 140 kc I_E = 0	- -	- -	1.7 3.0	pf pf
Input Capacitance	C_{ib}	V_{EB} = 0.5 V I_C = 0	-	-	2.0	pf
Small Signal Current Gain	h_{fe}	I_C = 4.0 mA V_{CE} = 10 V f = 100 mc	6.0	9.0	-	-
Amplifier Power Gain	G_e	I_C = 6.0 mA V_{CB} = 12 V f = 200 mc R_G = R_L = 50 Ω	15	-	-	db
Power Output	P_{out}	I_C = 8.0 mA V_{CB} = 15 V f = 500 mc	30	-	-	mW
Collector Efficiency	eff	V_{CB} = 15 V f = 500 mc I_C = 8.0 mA	25	-	-	%
Noise Figure	NF	I_C = 1.0 mA V_{CE} = 6.0 V f = 60 mc R_G = 400 Ω	-	3	6	db

2N1141 thru 2N1143 (GERMANIUM)
2N1142 USN/JAN
2N1195
2N1195 JAN

G_e = 25 db @ 70 Mc
NF = 4-5 db @ 100 Mc
P_D = 300 mW



CASE 31
(TO-5)

PNP germanium mesa transistors for amplifier, driver, oscillator and doubler applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N1141	2N1142	2N1143	2N1195	Unit
Collector-Base Voltage	V_{CB}	35	30	25	30	Vdc
Emitter-Base Voltage	V_{EB}	1.0	0.7	0.5	1.0	Vdc
Collector Current-Continuous	I_C	100	100	100	40	mAdc
Base Current	I_B	50	50	50	-	mAdc
Emitter Current-Continuous	I_E	100	100	100	-	mAdc
Total Device Dissipation @ T_A = 25°C	P_D	300	300	300	-	mW
Derate above 25°C		4	4	4	-	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	750	750	750	-	mW
Derate above 25°C		10	10	10	-	mW/°C
Collector Dissipation @ T_A = 25°C	P_C	-	-	-	225	mW
Derate above 25°C		-	-	-	3	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +100				°C

2N1141-2N1143, 2N1195 (continued)

TRANSISTOR SELECTION CHART

TYPE	Minimum BV_{CBO} @ $I_C = -100\mu Adc$, $I_E = 0$			Typical 100mc Noise Figure @ $V_{CE} = -10Vdc$, $I_E = 1mAdc$ $R_S = 75\Omega$			Minimum h_{fe} @ $I_C = -10mAdc$, $V_{CE} = -10Vdc$, f = 100mc		
	35 Vdc	30 Vdc	25 Vdc	4.0 db	4.5 db	5.0 db	12 db	10 db	8 db
2N1141	✓			✓			✓		
2N1142		✓			✓			✓	
2N1143			✓			✓			✓
2N1195		✓		✓			✓		

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

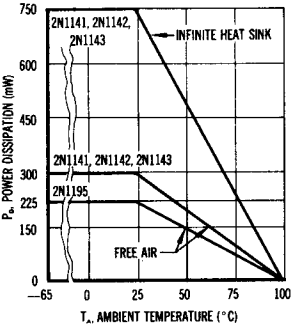
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage ($I_C = 100\mu Adc$, $I_E = 0$)	2N1141	BV_{CBO}	35	45	-	Vdc
	2N1142		30	45	-	
	2N1143		25	45	-	
	2N1195		30	45	-	
Emitter-Base Breakdown Voltage ($I_E = 100\mu Adc$, $I_C = 0$)	2N1141	BV_{EBO}	1.0	1.3	-	Vdc
	2N1142		0.7	1.3	-	
	2N1143		0.5	1.3	-	
	2N1195		1.0	1.3	-	
Collector Cutoff Current ($V_{CB} = 15$ Vdc, $I_E = 0$)		I_{CBO}	-	0.5	5	μAdc
($V_{CB} = 20$ Vdc, $I_E = 0$)			-	0.5	5	
Emitter Cutoff Current ($V_{BE} = 0.5$ Vdc, $I_C = 0$)		I_{EBO}	-	0.2	-	μAdc
ON CHARACTERISTICS						
DC Current Gain ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N1141, 2N1142, 2N1143	h_{FE}	10	25	-	-
($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	2N1195		-	25	-	
Collector-Emitter Saturation Voltage ($I_C = 50$ mAdc, $I_B = 10$ mAdc)	2N1141, 2N1142, 2N1143	$V_{CE(sat)}$	-	0.185	2	Vdc
($I_C = 50$ mAdc, $I_B = 10$ mAdc)	2N1195		-	0.185	-	

2N1141-2N1143, 2N1195 (continued)

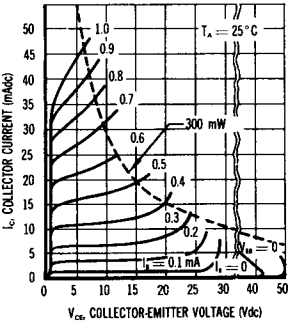
Characteristic	Symbol	Min	Typ	Max	Unit
DYNAMIC CHARACTERISTICS					
Common-Base Cutoff Frequency (I_C = 10 mAdc, V_{CE} = 10 Vdc) All Types	$f_{\alpha b}$	-	1000	-	MHz
Collector Transition Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz) 2N1141	C_{Tc}	-	1.1	1.5	pF
2N1142, 2N1143, 2N1195		-	1.1	-	
Emitter Transition Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 1 MHz) All Types	C_{Te}	-	2.5	-	pF
Small-Signal Current Gain (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	h_{fe}				dB
2N1141, 2N1195		12	18	-	
2N1142		10	18	-	
2N1143		8	18	-	
Small-Signal Current Gain (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{fb}				-
2N1141, 2N1142, 2N1143		-	0.98	-	
2N1195		0.96	0.98	0.995	
Output Admittance (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{ob}				μmhos
2N1141, 2N1142, 2N1143		-	10	-	
2N1195		-	10	20	
Input Impedance (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{ib}				Ohms
2N1141, 2N1142, 2N1143		-	3.6	-	
2N1195		-	3.6	10	
Voltage Feedback Ratio (I_C = 10 mAdc, V_{CB} = 10 Vdc, f = 1 kHz)	h_{rb}				-
2N1141, 2N1142, 2N1143		-	0.0013	-	
2N1195		-	0.0013	0.003	
Collector-Base Time Constant (I_E = 3 mAdc, V_{CB} = 10 Vdc, f = 30 MHz)	$r'_b C_c$				ps
All Types		-	23	-	
Extrinsic Base Resistance (I_C = 10 mAdc, V_{CE} = 10 Vdc, f = 250 MHz)	r'_b				Ohms
2N1141		-	65	70	
2N1142		-	80	-	
2N1143		-	110	-	
2N1195		-	65	80	
Collector Series Resistance (I_E = 10 mAdc, V_{CB} = 10 Vdc) All Types	r'_c	-	2	-	Ohms
Noise Figure	NF				dB
(I_E = 0.8 mAdc, V_{CE} = 5 Vdc, R_S = 300 ohms, f = 4.5 MHz)					
2N1141, 2N1195		-	3.0	-	
2N1142		-	3.5	-	
2N1143		-	4.0	-	
(I_E = 1 mAdc, V_{CE} = 10 Vdc, R_S = 75 ohms, f = 100 MHz)					
2N1141		-	4.0	-	
2N1142, 2N1195		-	4.5	-	
2N1143		-	5.0	-	
(I_E = 1 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)					
2N1141		-	5.5	-	
2N1142, 2N1195		-	6.0	-	
2N1143		-	6.5	-	
Oscillator Efficiency (V_{CE} = 20 Vdc, I_C = 10 mAdc, f = 400 MHz)	η				%
2N1141		-	20	-	
2N1142		-	18	-	
2N1143		-	12	-	
2N1195		-	18	-	

2N1141-2N1143, 2N1195 (continued)

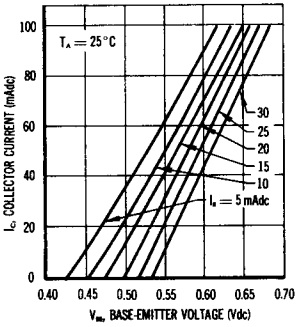
POWER-TEMPERATURE DERATING CURVE



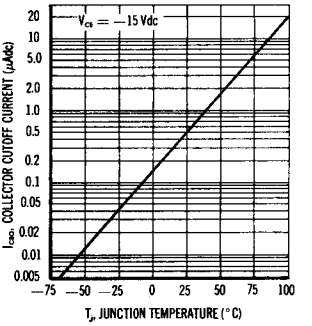
COLLECTOR CHARACTERISTICS, COMMON EMITTER



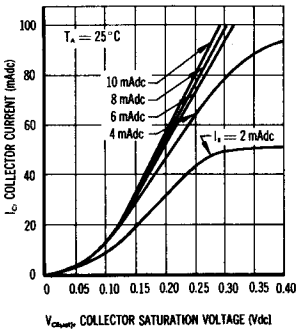
BASE CHARACTERISTICS, COMMON EMITTER



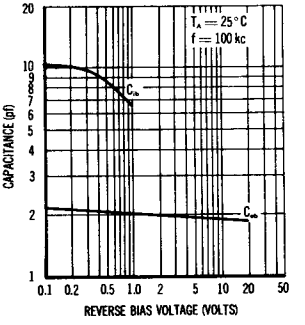
COLLECTOR CUTOFF CURRENT versus JUNCTION TEMPERATURE



COLLECTOR SATURATION CHARACTERISTICS

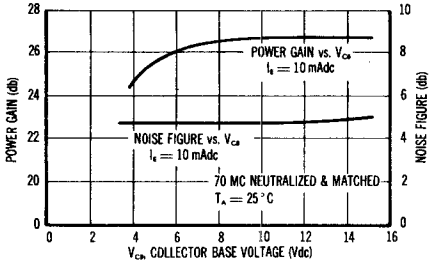


COLLECTOR INPUT AND OUTPUT CAPACITANCE versus VOLTAGE

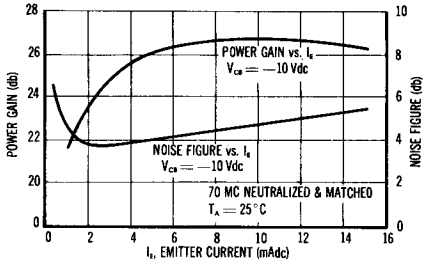


2N1141-2N1143, 2N1195 (continued)

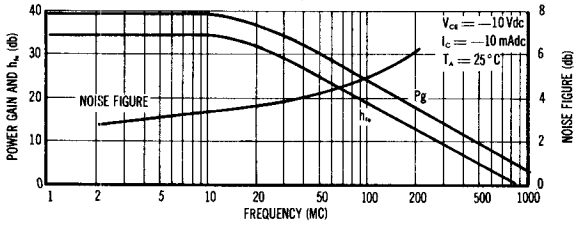
POWER GAIN AND NOISE FIGURE versus COLLECTOR-BASE VOLTAGE



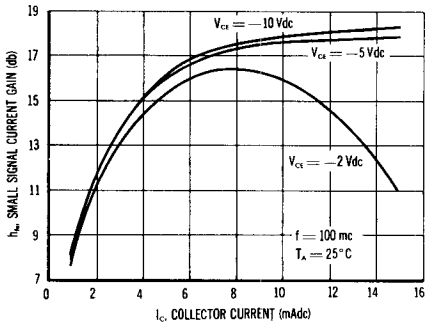
POWER GAIN AND NOISE FIGURE versus EMITTER CURRENT



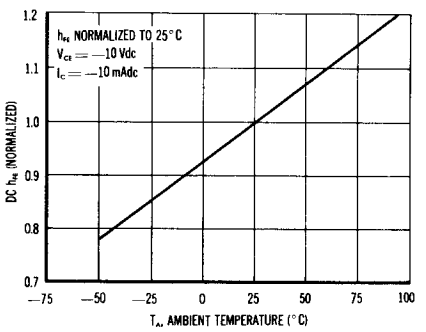
COMMON EMITTER POWER GAIN, h_{fe}, AND NOISE FIGURE versus FREQUENCY



SMALL SIGNAL CURRENT GAIN (h_{fe}) versus COLLECTOR CURRENT

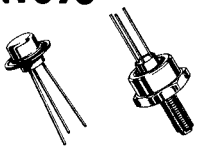


NORMALIZED h_{FE} versus AMBIENT TEMPERATURE



2N1561 (GERMANIUM)
2N1562
2N1692
2N1693

G_e = 5-6 db @ 160 Mc
P_o = 0.4-0.5 W @ 160 Mc



PNP germanium mesa transistors for VHF power amplifier applications.

Collector connected to case; stud isolated from case

CASE 23
2N1561
2N1562

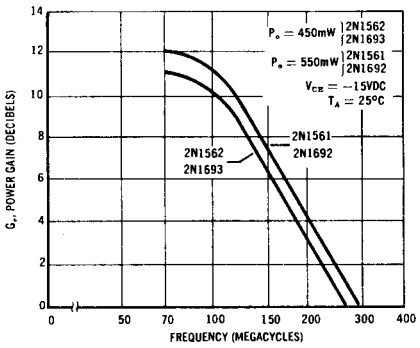
CASE 24
(TO-102)
2N1692
2N1693

MAXIMUM RATINGS

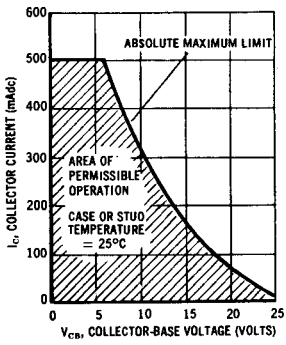
Characteristic	Symbol	2N1561	2N1562	2N1692	2N1693	Unit
Collector-Emitter Voltage	V_{CE}	25	25	25	25	Vdc
Collector-Base Voltage	V_{CB}	25	25	25	25	Vdc
Emitter-Base Voltage*	V_{EB}*	3	2	3	2	Vdc
Collector Current-Continuous Peak	I_C	250 500	250 500	250 500	250 500	mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	250 3.33	250 3.33	350 4.67	350 4.67	Watts mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	3 40	3 40	3 40	3 40	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to 100				°C

*May be exceeded provided total rated device dissipation is not exceeded.

POWER GAIN versus FREQUENCY



SAFE OPERATING AREA



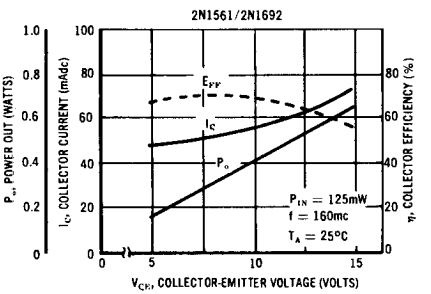
2N1561, 2N1562, 2N1692, 2N1693 (continued)

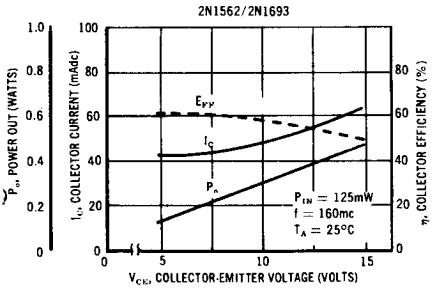
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)		BV_{CES}	25	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)		BV_{CBO}	25	-	-	Adc
Collector Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)		I_{CBO}	-	1.5	10	μAdc
Emitter Cutoff Current		I_{EBO}				mAdc
(V_{BE} = 0.4 Vdc, I_C = 0)	2N1562, 2N1693		-	5.0	-	
(V_{BE} = 1.0 Vdc, I_C = 0)	2N1561, 2N1692		-	5.0	-	
ON CHARACTERISTICS						
Collector-Emitter Saturation Voltage		$V_{CE(sat)}$				Vdc
(I_C = 200 mAdc, I_B = 40 mAdc)	2N1561, 2N1692		-	-	3.0	
(I_C = 200 mAdc, I_B = 40 mAdc)	2N1562, 2N1693		-	-	4.0	
DYNAMIC CHARACTERISTICS						
Current-Gain — Bandwidth Product		f_T				MHz
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N1561, 2N1692		-	500	-	
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	2N1562, 2N1693		-	450	-	
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kHz)		C_{ob}	-	7	10	pF
Small-Signal Current Gain		h_{fe}				dB
(I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 160 MHz)	2N1561, 2N1692		-	10	-	
	2N1562, 2N1693		-	9	-	
Extrinsic Base Resistance (I_E = 20 mAdc, V_{CB} = 10 Vdc, f = 300 MHz)		r'_b	-	25	-	Ohms
FUNCTIONAL TEST						
Power Gain		G_{pe}				dB
(I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{out} = 0.5 W, f = 160 MHz)	2N1561, 2N1692		6	-	-	
(I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{out} = 0.4 W, f = 160 MHz)	2N1562, 2N1693		5	-	-	
Power Output		P_{out}				Watt
(I_C = 100 mAdc, V_{CE} = 15 Vdc, P_{in} = 125 mW, f = 160 MHz)						
	2N1561, 2N1692		0.5	-	-	
	2N1562, 2N1693		0.4	-	-	

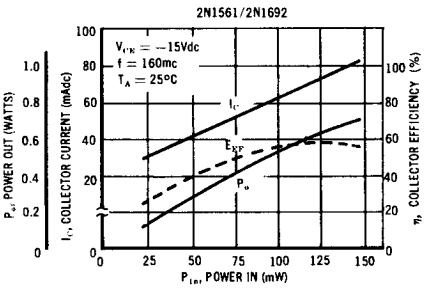
2N1561, 2N1562, 2N1692, 2N1693 (continued)

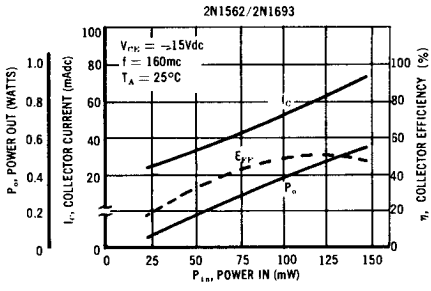
POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus COLLECTOR-EMITTER VOLTAGE



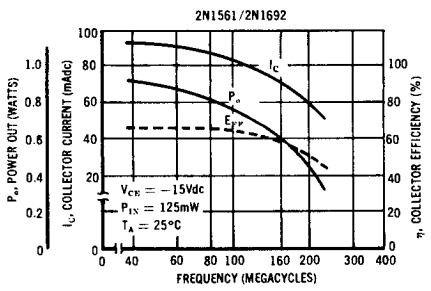


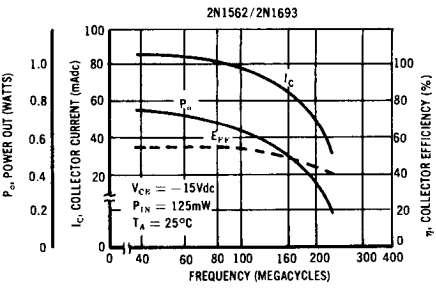
POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus POWER IN



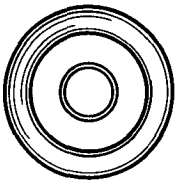


POWER OUT, COLLECTOR CURRENT AND COLLECTOR EFFICIENCY versus FREQUENCY

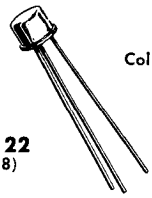




2N2273 (GERMANIUM)
JAN 2N2273



f_T = 250 mc min
I_C = 100 mA
P_D = 150 mW @ 25°C Ambient



Collector connected to case

CASE 22
(TO-18)

High-frequency germanium PNP transistor, designed for military and high-reliability industrial as well as commercial VHF amplifier applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Volts
Collector-Emitter Voltage	V_{CES}	25	Volts
Collector-Emitter Voltage	V_{CEO}	15	Volts
Emitter-Base Voltage	V_{EBO}	1.0	Volt
Collector Current	I_C	100	mA
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2	mW mW/°C
Junction Operating & Storage Temperature Range	T_J, T_{stg}	-65 to +100	°C

TABLE I — GROUP A INSPECTION (T_A = 25°C unless otherwise noted)

BOTH TYPES (LTPD applies to JAN 2N2273 only)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Visual and Mechanical Examination	2071	—	—	—	—	5
SUBGROUP 2						
Collector-Base Cutoff Current (V_{CB} = -12 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	-10	μAdc	5
Collector-Base Breakdown Voltage (I_C = -100 μAdc, I_E = 0)	3001 Condition D	BV_{CBO}	-25	—	Vdc	
Emitter-Base Breakdown Voltage (I_E = -100 μAdc, I_C = 0)	3026 Condition D	BV_{EBO}	-1.0	—	Vdc	
Forward Current Transfer Ratio* (I_C = -1 mAdc, V_{CE} = -10 Vdc)	3076	h_{FE}*	20	75	—	
Collector-Emitter Breakdown Voltage (I_C = -200 μAdc, V_{BE} = 0)	3011 Condition C	BV_{CES}	-25	—	Vdc	
Small-Signal Forward Current Transfer Ratio (I_C = -1 mAdc, V_{CE} = -6 Vdc, f = 10 mc)	3306	h_{fe}	20	28	(db)	

2N2273 (continued)

TABLE I — GROUP A INSPECTION (continued) *

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 3						
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 1 mc)	3236	C_{ob}	—	3.5	pf	10
Base Spreading Resistance (I_C = -1 mAdc, V_{CE} = -10 Vdc, f = 250 mc)	3266	r_b'	—	250	ohms	
Small-Signal Forward Current Transfer Ratio* (I_C = -1 mAdc, V_{CE} = -6 Vdc, f = 100 mc)	3306	h_{fe}*	2.5	—	—	
Noise Figure* (V_{CB} = -10 Vdc, I_C = -1 mAdc, f = 10 mc, R_G = 50 ohms)	3246	NF*	—	12	db	

STANDARD UNIT ONLY

Emitter-Base Leakage Current (V_{EB} = -0.5 Vdc, I_C = 0)	I_{EBO}	—	-100	μAdc	
Collector-Emitter Breakdown Voltage (I_C = -100 μAdc, I_E = 0)	BV_{CEO}	-15	—	Vdc	
Forward Current Transfer Ratio (I_C = -1 mAdc, V_{CE} = -10 Vdc)	h_{FE}	20	150	—	—
Real Part of Small-Signal Short-Circuit Input Impedance (V_{CE} = -10 Vdc, I_C = -1 mAdc, f = 250 mc)	$Re(h_{ie})$	50	250	ohms	
Power Gain (See Figure 1) (V_{CE} = -9 Vdc, I_C = -1 mAdc, f = 30 mc)	G_{PE}	10	30	db	

* Applies to MIL unit only

TABLE II — GROUP B INSPECTION — JAN 2N2273 only

(T_A = 25°C unless otherwise noted)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 1						
Physical Dimensions	2066	—	—	—	—	10
SUBGROUP 2						
Solderability	2026	—	—	—	—	10
Temperature Cycling (T_{high} = 100^{+3}_{-0}°C; 10 cycles)	1051 Condition B	—	—	—	—	
Thermal Shock (Glass Strain)	1056 Condition A	—	—	—	—	
Moisture Resistance	1021	—	—	—	—	
End Points: (Subgroups 2, 3, 5, 6, 7)						
Collector-Base Cutoff Current (V_{CB} = -12 Vdc, I_E = 0)	3036 Condition D	I_{CBO}	—	-20	μAdc	
DC Forward Current Transfer Ratio (I_C = -1 mAdc, V_{CE} = -10 Vdc)	3076	h_{FE}	15	—	—	

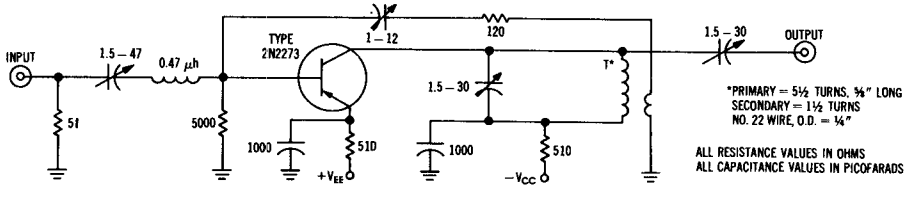
2N2273 (continued)

TABLE II — GROUP B INSPECTION (continued)

Examination or Test	MIL-STD-750 Method	Symbol	Limits Min	Limits Max	Unit	LTPD
SUBGROUP 3						
Shock (500 G, 1 msec, 5 blows each orientation: Y_1, Y_2, X_1 and Z_1)	2016 Nonoperating	—	—	—	—	10
Vibration, Variable Frequency (10 G)	2056	—	—	—	—	
Constant Accelerating (10,000 G)	2006	—	—	—	—	
End Points: Same as Subgroup 2						
SUBGROUP 4						
Lead Fatigue (Note 1)	2036 Condition E	--	—	—	—	10
SUBGROUP 5						
High Temperature Operation (Note 2) ($T_A = 70^{+3}_{-0}°C$)		—	—	—	—	10
Collector-Base Cutoff Current (V_{CB} = -12 Vdc, I_E = 0)	3036	I_{CBO}	—	-100	μAdc	
Low Temperature Operation (Note 2) (T_A = -55±3°C)		—	—	—	—	
Forward Current Transfer Ratio (V_{CE} = -10 Vdc, I_C = -1 mAdc)	3076	h_{FE}	8	—	—	
Salt Atmosphere (Corrosion)	1041	—	—	—	—	
End Points: Same as Subgroup 2						
SUBGROUP 6						
High Temperature Life ($T_A = 100^{+5}_{-0}°C$)	1031 (Nonoperating)	—	—	—	—	λ = 10
End Points: Same as Subgroup 2						
SUBGROUP 7						
Steady State Operation Life (V_{CB} = -10 Vdc, P_C = 60 mW, $T_A = 55^{+3}_{-0}°C$)	1026	—	—	—	—	λ = 10
End Points: Same as Subgroup 2						

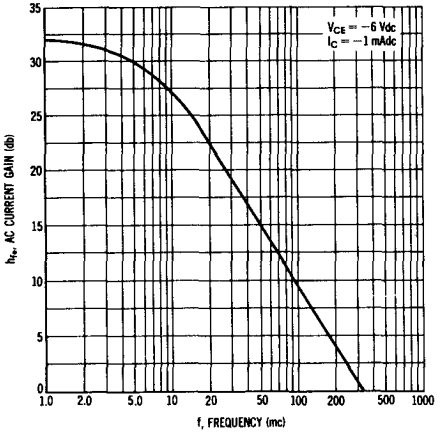
Note 1. Rejects from prior electrical tests from the same lot may be used for this test.
Note 2. Test measurement shall be made after thermal equilibrium has been reached at the temperature specified.

FIGURE 1 — 30 mc POWER GAIN TEST CIRCUIT

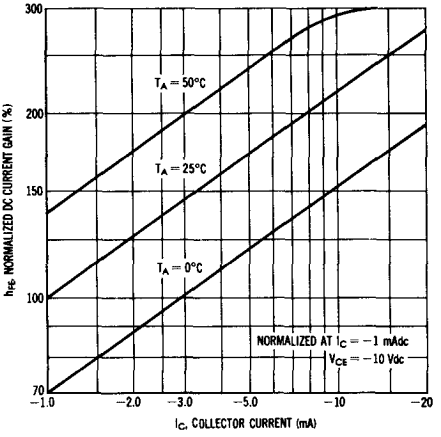


2N2273 (continued)

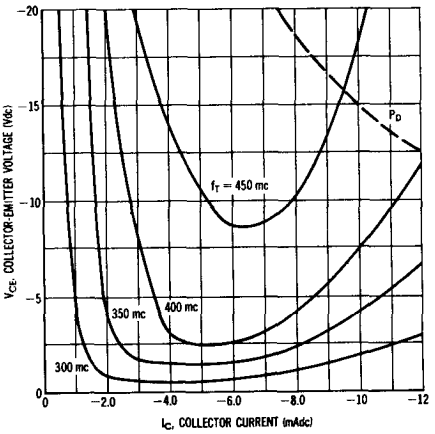
AC CURRENT GAIN versus FREQUENCY



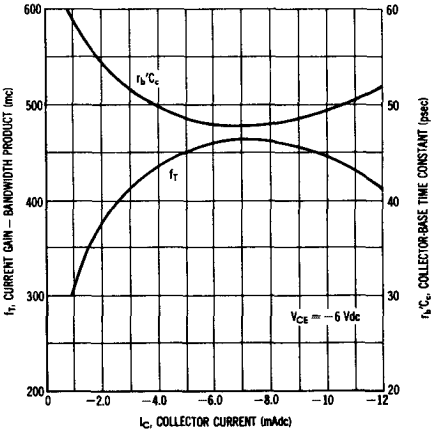
VARIATION IN DC GAIN versus COLLECTOR CURRENT



CONTOURS OF CURRENT GAIN — BANDWIDTH PRODUCT



f_T AND $r_b'C_c$ versus COLLECTOR CURRENT



2N2929 (GERMANIUM)

$V_{CBO} = 25$ V
$G_e = 26$ db @ 60 Mc
NF = 5.5 db @ 200 Mc
$P_D = 300$ mW



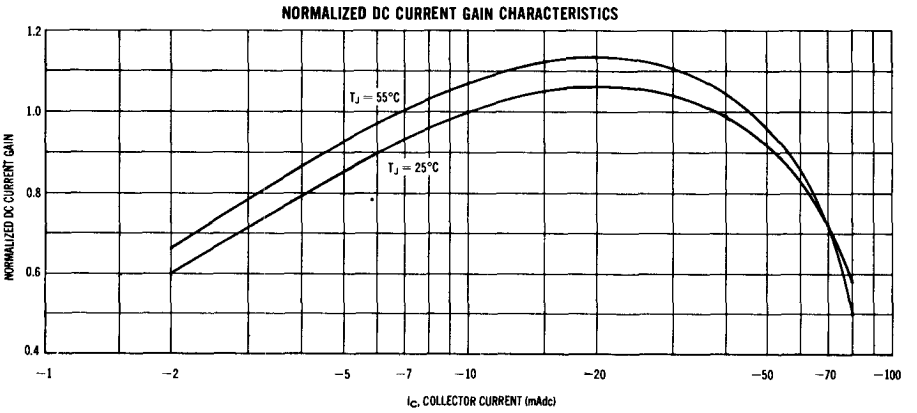
CASE 31
(TO-5)

PNP germanium epitaxial mesa transistor for low noise, broadband, power and driver amplifier applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-25	Volts
Collector-Emitter Voltage	V_{CES}	-25	Volts
Collector-Emitter Voltage	V_{CEO}	-10	Volts
Emitter-Base Voltage	V_{EBO}	-0.75	Volts
Collector Current	I_C	-100	mA
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	300 4	mW $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	750 10	mW $mW/^oC$
Junction Temperature	T_J	100	^oC
Storage Temperature	T_{stg}	-65 to +100	^oC

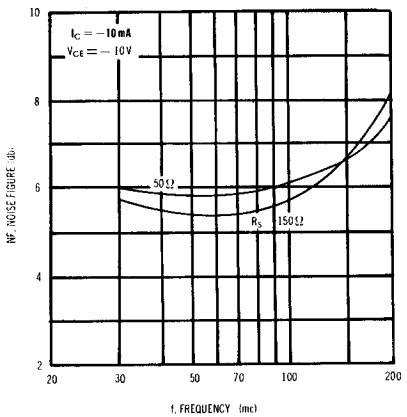


2N2929 (Continued)

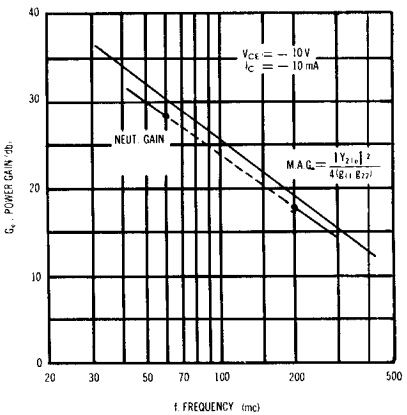
ELECTRICAL CHARACTERISTICS

Characteristic	Sym	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C =-100 μAdc, I_E = 0	-25	-45	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C =-100 μAdc, V_{EB} = 0	-25	-45	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C =-10 mAdc, I_B = 0	-10	-20	—	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E =-1 mAdc, I_C = 0	-0.75	-1.5	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} =-10 Vdc, I_E = 0	—	-0.15	-5	μAdc
		V_{CB} =-10 Vdc, I_E = 0, T_A =+55°C	—	—	-50	
Emitter Cutoff Current	I_{EBO}	V_{EB} =-0.5 Vdc, I_C = 0	—	-1	-100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} =-10 Vdc, I_C =-10 mAdc	10	30	100	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C =-50 mAdc, I_B =-10 mAdc	—	-0.15	-0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C =-50 mAdc, I_B =-10 mAdc	—	-0.55	-1.0	Vdc
Small-Signal Forward Current Transfer Ratio	h_{fe}	I_C =-10 mAdc, V_{CE} =-10 Vdc, f = 1 kc	10	35	120	—
Current Gain - Bandwidth Product	f_T	I_C =-10 mAdc, V_{CE} =-10 Vdc, f = 100 mc	800	1100	1400	mc
		I_C =-20 mAdc, V_{CE} =-10 Vdc, f = 100 mc	1000	1250	1600	
		I_C =-40 mAdc, V_{CE} =-10 Vdc, f = 100 mc	700	1200	—	
Collector-Base Time Constant	$r_b' C_c$	V_{CB} =-10 Vdc, I_E =+20 mAdc, f = 31.8 mc	10	25	40	psec
Real Part of Small-Signal Short Circuit Input Impedance	$Re(h_{ie})$	I_C =-10 mA, V_{CE} =-10 V, f = 1000 mc	—	45	75	ohms
Collector-Base Capacitance	C_{ob}	V_{CB} =-10 Vdc, I_E = 0, f = 100 kc	—	1.75	2.5	pf
Power Gain	G_e	V_{CE} =-10 Vdc, I_C =-10 mAdc, f = 60 mc	26	28	—	db
		V_{CE} =-10 Vdc, I_C =-10 mAdc, f = 200 mc	—	16	—	
Noise Figure	NF	V_{CE} =-10 Vdc, I_C =-2 Adc, f = 200 mc R_G = 50 Ω	—	5.5	—	db

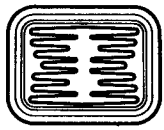
NOISE FIGURE versus FREQUENCY



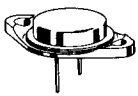
MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N2947 (SILICON)
2N2948



$G_o = 10$ db @ 50 Mc
$P_o = 15$ W @ 50 Mc



NPN silicon annular transistors for power amplifier applications to 100 Mc.

CASE 1
(TO-3)

Collector connected to case

MAXIMUM RATINGS*

Characteristic	Symbol	2N2947	2N2948	Unit
Collector-Base Voltage	V_{CBO}	60	40	Vdc
Collector-Emitter Voltage	V_{CES}	60	40	Vdc
Emitter - Base Voltage	V_{EB}	3	2	Vdc
Collector-Current (continuous)	I_C	1.5		Adc
Base-Current (continuous)	I_B	500		mAdc
Power Input (Nominal)	P_{in}	5.0		Watts
Power Output (Nominal)	P_{out}	20.0		Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0		Watts
Derating Factor above 25°C		167		mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature	T_{stg}	-65 to + 175		°C

*The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See electrical characteristics.

2N2947 (Continued)

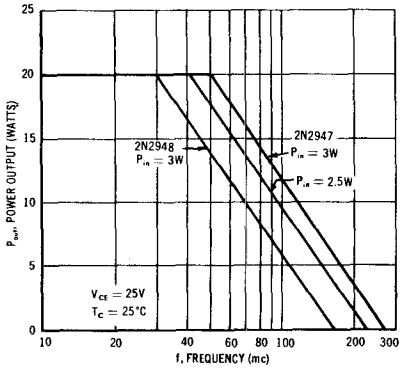
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	2N2947: I_C = 0.250 A, R_{BE} = 0	90	120	--	Volts
		2N2948: I_C = 0.250A, R_{BE} = 0	80	100	--	
Collector-Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$*	2N2947: I_C = 0.250A, I_B = 0	40	--	--	Volts
		2N2948: I_C = 0.250A, I_B = 0	20	--	--	
Collector-Emitter Current	I_{CES}	2N2947: V_{CE} = 60 Vdc, V_{BE} = 0	--	--	0.5	mAdc
		V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
		2N2948: V_{CE} = 40 Vdc, V_{BE} = 0	--	--	0.5	
		V_{CE} = 30 Vdc, V_{BE} = 0, T_C = 175°C	--	--	1.0	
Collector Cutoff Current	I_{CBO}	2N2947: V_{CB} = 50 Vdc, I_E = 0	--	--	1	μAdc
		2N2948: V_{CB} = 30 Vdc, I_E = 0	--	--	1	
Emitter Cutoff Current	I_{EBO}	2N2947: V_{EB} = 3 Vdc, I_C = 0	--	--	100	μAdc
		2N2948: V_{EB} = 2 Vdc, I_C = 0	--	--	100	
DC Current Gain	h_{FE}	2N2947: I_C = 400 mAdc, V_{CE} = 2Vdc	2.5	--	35	
		2N2948: I_C = 400 mAdc, V_{CE} = 2 Vdc	2.5	--	100	
		Both Types: I_C = 1 Adc, V_{CE} = 2 Vdc	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 1.0 Adc, I_B = 500 mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 2.0 Vdc, I_C = 400 mAdc, f = 50 mc	2.0	--	--	
Collector Output Capacitance	C_{ob}	V_{CB} = 25 Vdc, I_E=0, f = 100 kc	--	--	60	pf
Power Input	P_{in}	P_{out} = 15 W, f = 50 mc, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1A 2N2947	60	80	--	%
Power Input	P_{in}	P_{out} = 15 W, f = 30 mc, V_{CE} = 25 Vdc	--	2.0	3.0	Watts
Efficiency	η	$I_{C(max)}$ = 1.0 A 2N2948	60	70	--	%

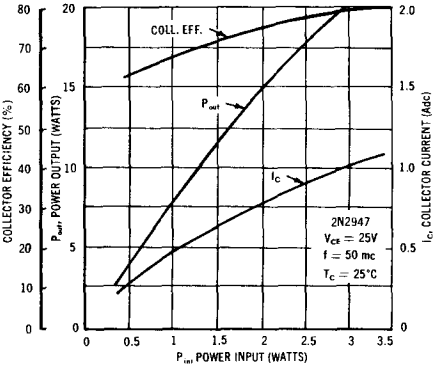
* Pulse Measurement: Pulse Width ≤ 100 μsec, Duty Cycle

2N2947 (continued)

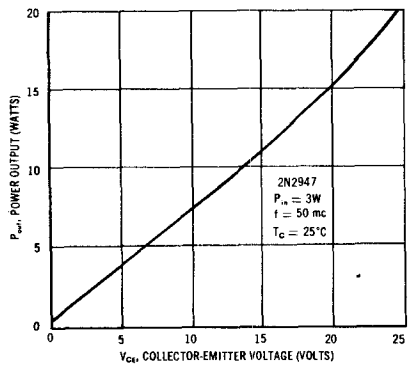
POWER OUTPUT versus FREQUENCY



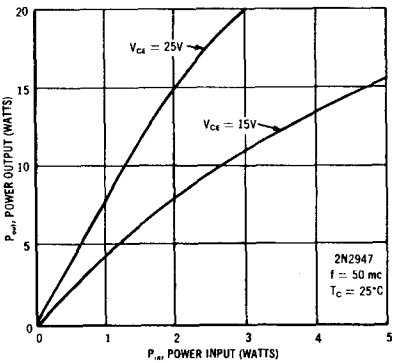
OUTPUT CHARACTERISTICS versus POWER INPUT



POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT

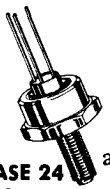


2N2949 (SILICON)
2N2950

G_e = 12 db @ 50 Mc
P_o = 3.5 W @ 50 Mc



CASE 23
2N2949



CASE 24
(TO-102)
2N2950

NPN silicon annular transistors for power amplifier and driver applications to 100 Mc.

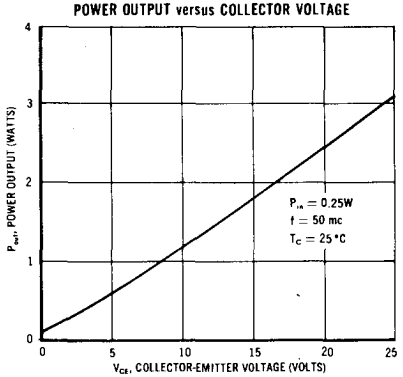
Collector connected to case; stud isolated from case

MAXIMUM RATINGS*

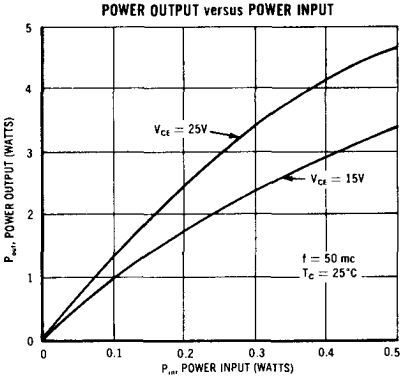
Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter - Base Voltage	V_{EB}	3.0		Vdc
Collector Current (Continuous)	I_C	0.7		Adc
Base Current (Continuous)	I_B	100		mAdc
RF Input Power (Nom)	P_{in}	1.0		Watt
RF Output Power (Nom)	P_{out}	5.0		Watts
Total Device Dissipation (25°C Case temperature) (Derating Factor above 25°C)	P_C	6.0 40		Watts mW/°C
Total Device Dissipation at 25° Ambient (Derating Factor above 25°C)	P_D	2N2949 0.5 3.33	2N2950 0.7 4.67	Watt mW/°C
Junction Temperature	T_J	175		°C
Storage Temperature	T_{stg}	-65 to + 175		°C

* The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See Electrical Characteristics.

POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT

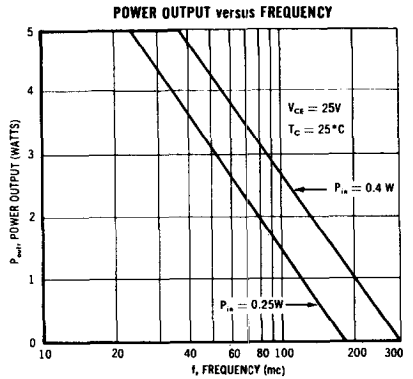


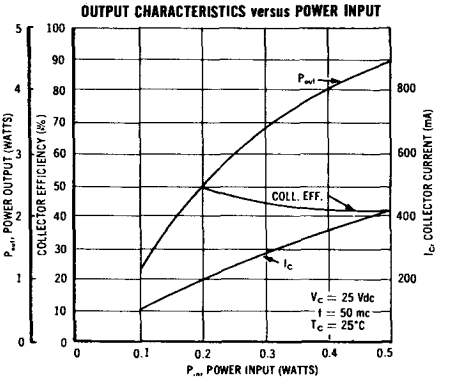
2N2949, 2N2950 (Continued)

ELECTRICAL CHARACTERISTICS $T_A = 25°C$ unless otherwise noted

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}^*$	I_C=0.250 A, R_{BE}= 0	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}^*$	I_C=0.250A, I_B=0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE}= 60 Vdc, V_{BE}=0	--	--	100	μAdc
		V_{CE}=50 Vdc, V_{BE}= 0 T_C= +175°C	--	--	500	
Collector - Cutoff Current	I_{CBO}	V_{CB}=50 Vdc, I_E=0	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB}= 3 Vdc, I_C=0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE}= 2.0 Vdc I_C= 40 mAdc	5.0	--	100	--
		V_{CE}=2.0 Vdc I_C= 400 mAdc	5.0	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C= 400 mAdc, I_B= 80 mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C=400 mAdc, I_B=80mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE}=2.0 Vdc I_C=40 mAdc, f=50 mc	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB}= 25 Vdc, I_E=0 f=100kc	--	--	20	pf
Power Input	P_{in}	P_{out}=3.5 watts, f=50 mc V_{CE}=25 Vdc, $I_{C(max)}$=325 mA,	--	--	0.35	Watt
Efficiency	η		43	--	--	%

* Pulse Width ≤ 100 μsec, Duty Cycle = 2%





2N2951 (SILICON)
2N2952



G_e = 9 db @ 50 Mc
P_o = 600 mW @ 50 Mc



CASE 31
(TO-5)
2N2951



CASE 22
(TO-18)
2N2952

NPN silicon annular Star transistors for power amplifier applications to 100 Mc.

Collector connected to case

MAXIMUM RATINGS*

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CES}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current (continuous)	I_C	250		mAdc
Base Current (continuous)	I_B	50		mAdc
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_C	2N2951 3 20	2N2952 1.8 12	Watts mW/°C
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	0.8 5.33	0.5 3.33	mW/°C
Junction Temperature	T_J	-65 to 175		°C
Storage Temperature	T_{stg}	-65 to 175		°C

* The maximum ratings as given for D.C. conditions can be exceeded on a pulse basis. See Electrical Characteristics.

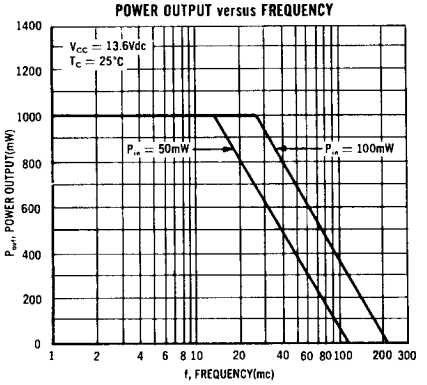
2N2951, 2N2952 (Continued)

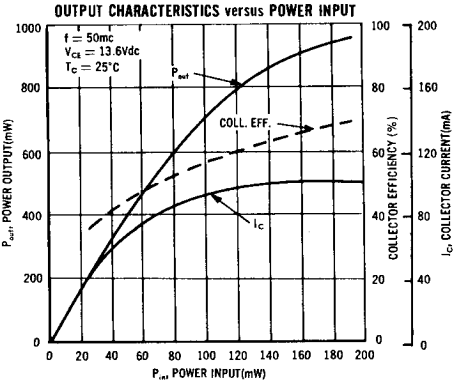
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

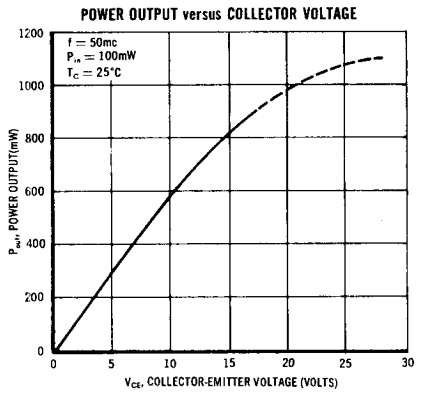
Characteristic	Symbol	Conditions	Min	Max	Unit
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	100	μAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = 175°C	--	500	μAdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 50 Vdc, I_E = 0	--	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5 Vdc, I_C = 0	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	20	150	--
		I_C = 150mAdc, V_{CE} = 10 Vdc*	20	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 150 mAdc, I_B = 15 mAdc	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE}(sat)$	I_C = 150 mAdc, I_B = 15 mAdc	--	2.0	Vdc
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 100 mA, R_{BE} = 0	30	--	Volts
Collector-Emitter Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 100 mA, I_B = 0	20	--	Volts
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 50 mc	4.0	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E=0 , f = 100kc	--	8	pf
Power Input	P_{in}	Test Circuit Fig. 1 P_{out} = 600 mW f = 50 mc V_{CE} = 13.6 Vdc $I_{C(max)}$ = 125 mA	--	100	mW
Efficiency	η		35	--	%

*Pulse Width = 100 μsec, Duty Cycle = 2%

2N2951, 2N2952 (Continued)







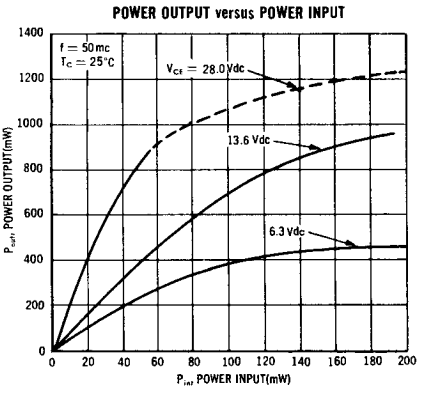
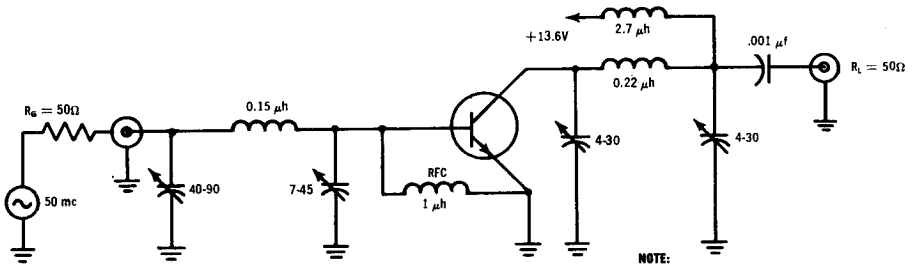


FIGURE 1 — POWER OUTPUT AND POWER GAIN CIRCUIT



NOTE:
GROUND POINT must be kept as close as possible to the transistor emitter lead. Transistor must be mounted with heat sink.

2N3127 (GERMANIUM)
2N3127 JAN

$V_{CEO} = 20$ V
$I_C = 50$ mA
$P_D = 100$ mA



CASE 20
(TO-72)

PNP germanium high frequency transistors designed for military and high-reliability industrial as well as commercial VHF amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Collector-Emitter Voltage	V_{CEO}	20	Vdc
Emitter-Base Voltage	V_{EBO}	0.75	Vdc
Collector Current	I_C	50	mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	100 1.33	mW mW/^oC
Junction Operating & Storage Temperature Range	T_J, T_{stg}	-65^oC to $+100^oC$	^oC

2N3127 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

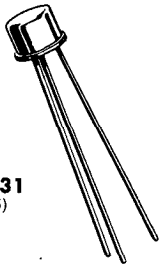
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	BV_{CBO}	25	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 2 mAdc, I_B = 0)	BV_{CEO}	20	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 100 μAdc, V_{BE} = 0)	BV_{CES}	25	-	Vdc
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0)	I_{CBO}	-	3	μAdc
Emitter-Base Cutoff Current (V_{BE} = 0.75 Vdc, I_C = 0)	I_{EBO}	-	100	μAdc
DC Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc)	h_{FE}	20	100	-
Base-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	-	0.6	Vdc
Collector-Emitter Saturation Voltage (I_C = 5 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.3	Vdc
Small-Signal Current Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc, f = 1 kHz)	h_{fe}	20	125	-
Current-Gain — Bandwidth Product (I_C = 2 mAdc, V_{CE} = 6 Vdc, f = 100 MHz)	f_T	400	-	MHz
Output Capacitance* (V_{CB} = 10 Vdc, I_E = 0, f ≥ 0.1 ≤ 1.0 MHz)	C_{ob}*	-	1.2	pF
Collector-Base Cutoff Current (V_{CB} = 10 Vdc, I_E = 0, T_A = 85°C)	I_{CBO}	-	50	μAdc
DC Current Gain† (I_C = 3 mAdc, V_{CE} = 10 Vdc, T_A = -55 $^{+0}_{-3}$ °C)	h_{FE}†	7	-	-
Power Gain (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	G_{pe}	17	25	dB
Noise Figure (I_C = 3 mAdc, V_{CE} = 10 Vdc, R_S = 50 ohms, f = 200 MHz)	NF	-	5	dB
Collector-Base Time Constant (I_C = 3 mAdc, V_{CB} = 10 Vdc, f = 31.8 MHz)	$r_b'C_c$	1	12	ps

*Measured in a guarded circuit, such that the can capacitance is not included.
†Applies to JAN unit only.

2N3137 (SILICON)
MM1803

G_{PE} = 7.7-8.5 db @ 250 Mc Typ

P_O = 600-700 mW @ 250 Mc Typ



CASE 31
(TO-5)

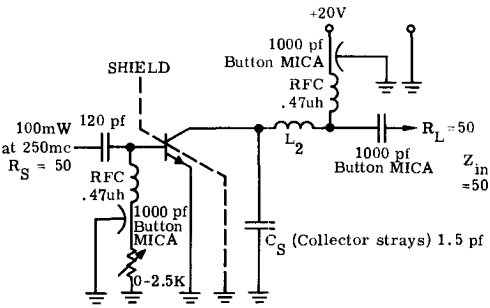
NPN silicon annular transistors for large signal VHF and UHF applications.

Collector connected to case

MAXIMUM RATINGS

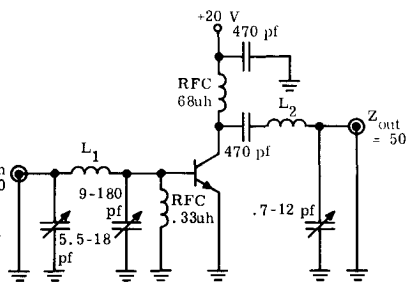
Characteristic	Symbol	2N3137	MM1803	Unit
Collector-Base Voltage	V_{CBO}	40	50	Vdc
Collector-Emitter Voltage	V_{CEO}	20	25	Vdc
Emitter-Base Voltage	V_{EBO}	4	5	Vdc
Collector Current (Continuous)	I_C	150	150	mAdc
Power Dissipation @25° C Case Temperature @25° C Ambient Temperature	P_D	2.0 0.8		Watts
Operating Junction Temperature Storage Temperature Range	T_J T_{stg}	200 -65 to +200		°C
Thermal Resistance-- Junction to Case	θ_{JC}	87.5		°C/ Watt
Thermal Resistance-- Junction to Air	θ_{JA}	153		°C/ Watt

250 MC POWER GAIN TEST CIRCUIT (2N3137)



L_2 = .075 uh (5.5 turns #18ga. ID = 3/16" length 1/2")

250 MC POWER GAIN TEST CIRCUIT (MM1803)



L_1 = 3/4 turn No. 14 tinned wire 3/8" ID
L_2 = 4 turns No. 18 tinned wire 1/4" ID 7/16" long

2N3137, MM1803 (Continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise specified)

Characteristic		Symbol	Min	Typical	Max	Unit
Collector-Base Breakdown Voltage I_C = 0.1mAdc, I_E = 0	2N3137 MM1803	V_{CBO}	40 50			Vdc
Collector-Emitter Open Base Sus. Voltage I_C = 15mAdc, I_B = 0	2N3137 MM1803	$V_{CEO(sus)}$	20 25			Vdc
Collector Cutoff Current V_{CB} = 20Vdc, I_E = 0, T_C = +150°C	Both Types	I_{CBO}			50	μAdc
Collector Cutoff Current V_{CB} = 20Vdc, I_E = 0	Both Types	I_{CBO}			.05	μAdc
Emitter-Base Breakdown Voltage I_E = 100μA, I_C = 0	2N3137 MM1803	V_{EBO}	4 5			Vdc
DC Current Gain V_{CE} = 5Vdc, I_C = 50mAdc	2N3137 MM1803	h_{FE}	20 40		120 160	
Collector-Emitter Saturation Voltage I_C = 50mAdc, I_E = 5mAdc	Both Types	$V_{CE(sat)}$			0.3	Vdc
Small Signal Current Gain V_{CE} = 10Vdc, I_C = 50mAdc, f = 100mc		$\|h_{fe}\|$	5.0			
Common-base Output Capacitance V_{CB} = 10Vdc, I_C = 0, f = 100kc		C_{ob}			3.5	pf
Power Output		P_{out}	400	600		mWatts
Power Gain P_{in} = 100mw, f = 250mc	2N3137	G_e	6.0	7.7		db
Efficiency V_{CE} = 20Vdc		η	40	65		%
Power Output		P_{out}	560	700		mWatts
Power Gain P_{in} = 100mw, f = 250mc	MM1803	G_e	7.5	8.5		db
Efficiency V_{CE} = 20V		η	45	60		%

*Pulse Width ≈ 300 μsec. Duty cycle = 1%

2N3279 thru 2N3282 (GERMANIUM)

V_{CBO} = 30 V
G_e = 16-17 db @ 200 Mc
NF = 3.5-5 db @ 200 Mc



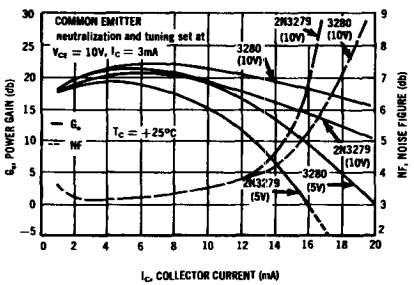
CASE 20
(TO-72)

PNP germanium epitaxial mesa transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

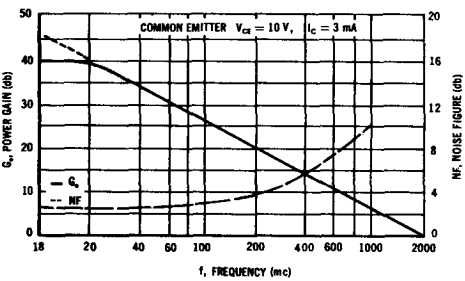
MAXIMUM RATINGS

Characteristic	Symbol	Rating 2N3279 2N3280	Rating 2N3281 2N3282	Unit
Collector-Base Voltage	V_{CBO}	30	30	Volts
Collector-Emitter Voltage	V_{CES}	30	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	15	Volts
Emitter-Base Voltage	V_{EBO}	1.0	0.5	Volts
Collector Current	I_C	50	50	mA
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	100 1.33	100 1.33	mW mW/°C
Junction Temperature	T_j	+100	+100	°C
Storage Temperature	T_{stg}	-65 to +100	-65 to +100	°C

POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT
200mc



NEUTRALIZED POWER GAIN AND NOISE FIGURE versus FREQUENCY



2N3279 thru 2N3282 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

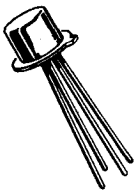
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0 All Types	30	—	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 100 μAdc, V_{EB} = 0 All Types	30	—	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = 2.0 mAdc, I_B = 0 2N3279, 2N3280 2N3281, 2N3282	20 15	— —	— —	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0 All Types V_{CB} = 10 Vdc, I_E = 0, T_A = +55°C 2N3279, 2N3280	— —	1 —	5 50	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.75 Vdc, I_C = 0 2N3279, 2N3280 V_{EB} = 0.5 Vdc, I_C = 0 2N3281, 2N3282	— —	— —	100 100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc 2N3279, 2N3280 2N3281, 2N3282	10 10	— —	70 100	—
Collector-Emitter Saturation Voltage	$V_{CE\ (sat)}$	I_C = 5 mAdc, I_B = 1.0 mAdc 2N3279, 2N3280 2N3281, 2N3282	— —	— —	0.3 0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE\ (sat)}$	I_C = 5 mAdc, I_B = 1.0 mAdc 2N3279, 2N3280 2N3281, 2N3282	— —	— —	1.0 1.5	Vdc
Small Signal Forward Current Transfer Ratio	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 1 kc 2N3279, 2N3280 2N3281, 2N3282	10 10	— —	100 150	—
Collector-Base Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kc (Note 1) 2N3279 2N3280 thru 2N3282	— —	0.9 1.0	1.0 1.2	pf
Collector-Base Time Constant	$r_b{}'C_c$	V_{CB} = 10 Vdc, I_C = 3 mAdc, f = 31.8 mc 2N3279, 2N3280 2N3281, 2N3282	3 3	5 5	10 15	psec
Current Gain - Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 3 mAdc 2N3279, 2N3280 2N3281, 2N3282	400 300	500 400	800 800	mc
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 3 mAdc All Types	—	2000	—	mc
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 200 mc 2N3279, 2N3280 2N3281, 2N3282	17 16	— —	23 23	db
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 200 mc 2N3279, 2N3280 2N3281, 2N3282	— —	2.9 4.0	3.5 5.0	db
Power Gain (AGC)	G_e	V_{CE} = 5 Vdc, I_C = 20 mAdc, f = 200 mc (Note 2) 2N3279, 2N3281 (Note 2) 2N3280, 2N3282	— —	— 0	0 —	db

Note 1. C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc and I_C = 3 mAdc operation.

2N3283 thru 2N3286 (GERMANIUM)

V_{CBO} = 20-25 V
G_e = 14-16 db @ 200 Mc
NF = 4-5 db @ 200 Mc



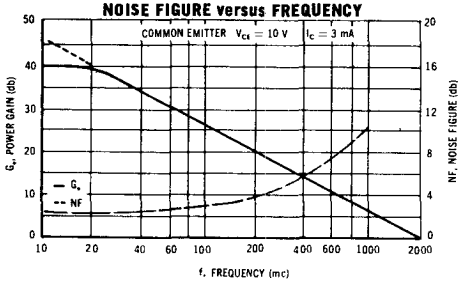
CASE 20
(TO-72)

PNP germanium epitaxial mesa transistors for TV and FM, RF and IF amplifier, oscillator and general purpose high-gain, low-noise amplifier applications.

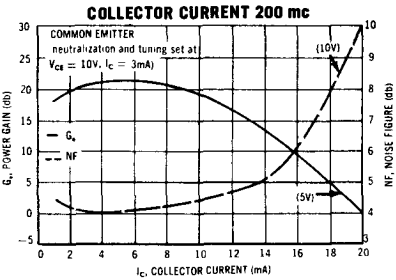
MAXIMUM RATINGS

Characteristic	Symbol	2N3283 2N3284	2N3285 2N3286	Unit
Collector-Base Voltage	V_{CBO}	25	20	Volts
Collector-Emitter Voltage	V_{CES}	25	20	Volts
Emitter-Base Voltage	V_{EB}	0.5	0.5	Volt
Collector Current	I_C	50	50	mA
Total Device Dissipation at T_A = 25°C Derate above 25°C	P_D	100 1.33	100 1.33	mW mW/°C
Junction Temperature	T_J	+100	+100	°C
Storage Temperature Range	T_{stg}	←——— -65 to +100 ———→		°C

NEUTRALIZED POWER GAIN AND NOISE FIGURE versus FREQUENCY



POWER GAIN AND NOISE FIGURE versus COLLECTOR CURRENT 200 mc



2N3283 thru 2N3286 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Sym	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 100 μAdc, V_{BE} = 0 2N3283, 2N3284	25	30	—	Vdc
		2N3285, 2N3286	20	25	—	
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	—	2.0	10	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc 2N3283, 2N3284	10	30	—	—
		2N3285, 2N3286	5	15	—	—
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc, 2N3283, 2N3284	10	—	200	—
		f = 1 kc 2N3285, 2N3286	5	—	200	
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kc Note 1	—	1.0	1.5	pf
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 mc	2.5	4.0	8.0	—
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 3 mAdc, f = 31.8 mc	—	10	25	psec
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 3 mAdc	—	2000	—	mc

2N3283

Power Gain	G_e		16	20	23	db
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 200 mc	—	4	5	db
Power Gain (AGC)	G_e	Circuit Fig. 1 - Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc, f = 200 mc	—	—	0	db

2N3284

Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 200 mc	16	20	23	db
Noise Figure	NF		—	5	6	db
Power Gain (AGC)	G_e	V_{CE} = 5 Vdc, I_C = 20 mAdc, f = 200 mc	—	0	—	db

2N3285

Power Output	P_{out}	V_{EE} = +12 Vdc, f = 257 mc	2	—	—	mW

2N3286

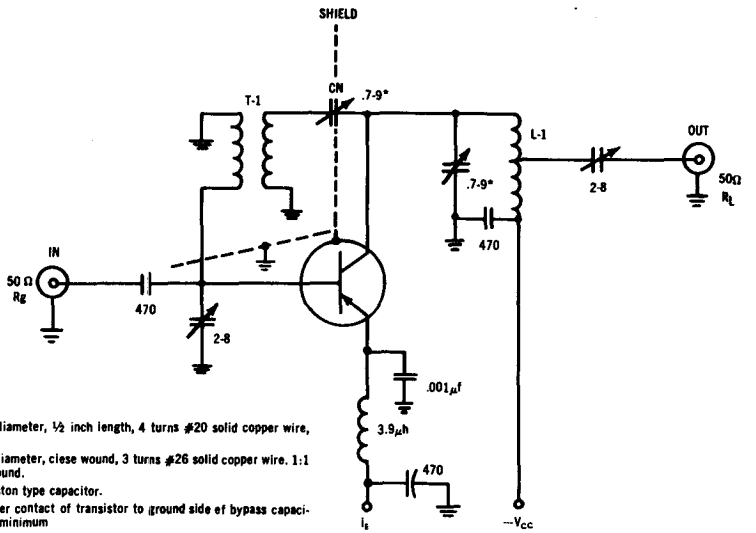
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 3 mAdc f = 200 mc	14	—	—	db
Noise Figure	NF		—	5	—	db

Note 1. C_{ob} is measured in a guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc and I_C = 3 mAdc operation.

2N3283 thru 2N3286 (Continued)

FIGURE 1 — 200 MC POWER GAIN AND NOISE FIGURE TEST CIRCUIT



NOTES:

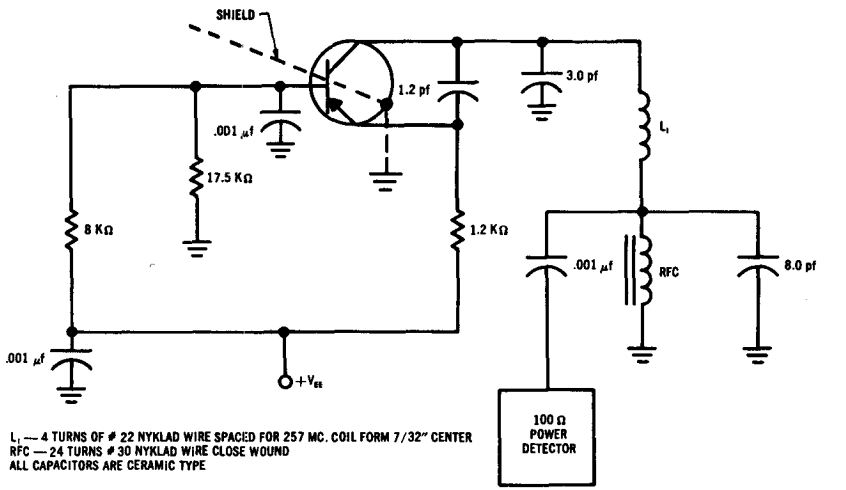
L-1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.

T-1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bi-filler wound.

* High Quality piston type capacitor.

Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum

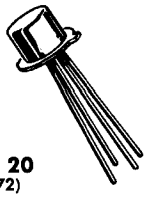
FIGURE 2 — 257 MC OSCILLATOR POWER OUTPUT TEST CIRCUIT



L_1 — 4 TURNS OF # 22 NYKLAD WIRE SPACED FOR 257 MC. COIL FORM 7/32" CENTER
RFC — 24 TURNS # 30 NYKLAD WIRE CLOSE WOUND
ALL CAPACITORS ARE CERAMIC TYPE

2N3287 thru 2N3290 (SILICON)

V_{CBO} = 30-40 V
G_e = 17 db @ 200 Mc
NF = 6-7 db @ 200 Mc



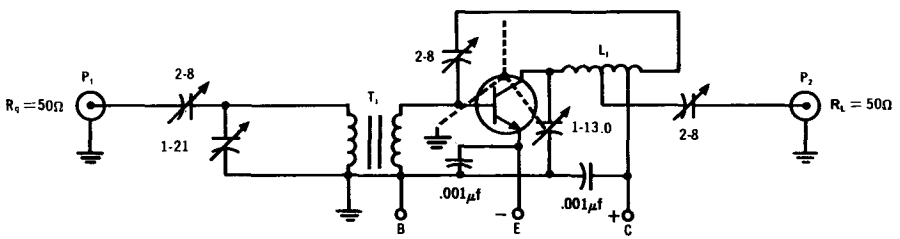
CASE 20
(TO-72)

NPN silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N3287 2N3288	2N3289 2N3290	Unit
Collector - Base Voltage	V_{CBO}	40	30	Volts
Collector - Emitter Voltage	V_{CES}	40	30	Volts
Collector - Emitter Voltage	V_{CEO}	20	15	Volts
Emitter - Base Voltage	V_{EBO}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_C	300	300	mW
Power Dissipation at 25° C amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_j	+200	+200	°C
Storage Temperature	T_{stg}	-65 to +200	-65 to +200	°C

200 MC TEST CIRCUIT: POWER GAIN, NOISE FIGURE, & AGC



L_1-6 turns of #16 tinned wire; 3/8" ID; Air wound; winding length 3/4"; V_{CC} feeds tap 4 3/4 turns from collector end; output tap 3 1/2 turns from collector end.

T_1-3 turns primary and secondary Bifilar wound (close wound) on 1/4" ceramic form (cambion type) with brass slug. #22 enameled wire.

P_1-General Radio 874 G6 Pad (6 db)
P_2-General Radio 874 G6 Pad (6 db)

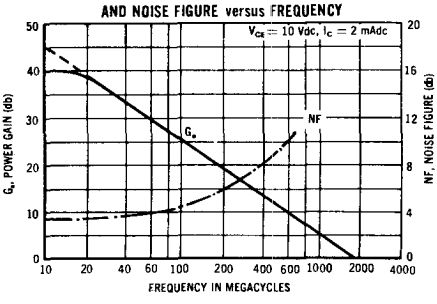
2N3287 thru 2N3290 (Continued)

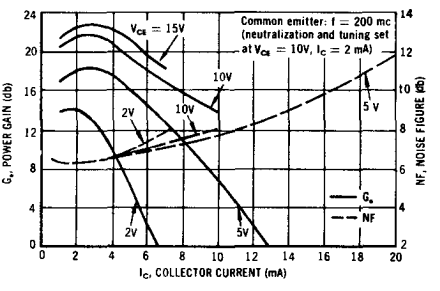
ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0				Vdc
		2N3287, 2N3288	40	—	—	
		2N3289, 2N3290	30	—	—	
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μAdc, V_{BE} = 0				Vdc
		2N3287, 2N3288	40	—	—	
		2N3289, 2N3290	30	—	—	
Collector-Emitter Breakdown Voltage	BVCEO	I_C = 2.0 mAdc, I_B = 0				Vdc
		2N3287, 2N3288	20	—	—	
		2N3289, 2N3290	15	—	—	
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = 10 μAdc, I_C = 0	3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc All Types	—	—	.010	μAdc
		V_{CB} = 15 Vdc, T = 150°C 2N3287, 2N3288	—	—	3.0	
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc				—
		2N3287, 2N3288	15	—	100	
		2N3289, 2N3290	10	—	150	
Collector-Emitter Saturation Voltage	$V_{CE\ (sat)}$	I_C = 5 mAdc, I_B = 0.5 mAdc				Vdc
		2N3287, 2N3288	—	—	0.3	
		2N3289, 2N3290	—	—	0.4	
Base-Emitter Saturation Voltage	$V_{BE\ (sat)}$	I_C = 5 mAdc, I_B = 0.5 mAdc				Vdc
		2N3287, 2N3288	—	—	0.9	
		2N3288, 2N3290	—	—	1.0	
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kc				—
		2N3287, 2N3288	15	—	150	
		2N3289, 2N3290	10	—	200	
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 0.1 mc (Note 1)				pf
		2N3287	—	0.9	1.1	
		2N3288 thru 2N3290	—	1.2	1.5	
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc, f = 31.8 mc				psec
		2N3287, 2N3288	3	8	15	
		2N3289, 2N3290	3	8	20	
Current Gain - Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 2 mAdc				mc
		2N3287, 2N3288	350	600	1200	
		2N3289, 2N3290	300	500	1200	
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mAdc	—	2000	—	mc
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 mc				db
		All Types	17	—	24	
Noise Figure	NF	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 mc				db
		2N3287, 2N3288	—	4.9	6.0	
		2N3289, 2N3290	—	6.0	7.0	
Power Gain (AGC)	G_e	V_{CE} = 5.0 Vdc, I_C = 20 mAdc, f = 200 mc (Note 2)				db
		2N3287	—	—	0	
		2N3289	—	—	+5	
		2N3288, 2N3290	—	0	—	

Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.





2N3291 thru 2N3294 (SILICON)

V_{CBO} = 20-25 V
G_e = 14-16 db @ 200 Mc
NF = 8 db @ 200 Mc

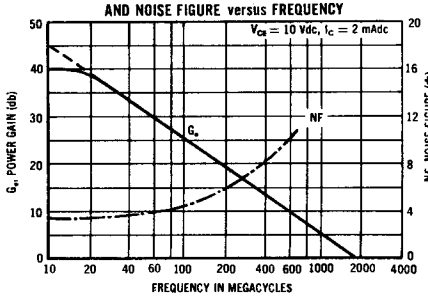
NPN silicon annular transistor for TV and FM mixer, RF and IF amplifier and general-purpose, low-noise, high-gain amplifier applications.

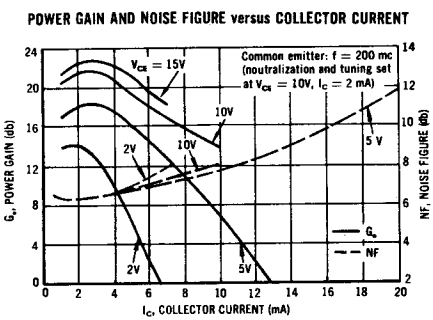


CASE 20
(TO-72)

MAXIMUM RATINGS

Characteristic	Symbol	2N3291 2N3292	2N3293 2N3294	Unit
Collector - Base Voltage	V_{CBO}	25	20	Volts
Collector - Emitter Voltage	V_{CES}	25	20	Volts
Emitter - Base Voltage	V_{EBO}	3.0	3.0	Volts
Collector Current	I_C	50	50	mA
Power Dissipation at 25°C Case Above 25°C derate 1.71 mW/°C	P_C	300	300	mW
Power Dissipation at 25°C Amb. Above 25°C derate 1.14 mW/°C	P_D	200	200	mW
Junction Temperature	T_J	+200	+200	°C
Storage Temperature	T_{stg}	← -65 to +200 →		°C





2N3291 thru 2N3294 (Continued)

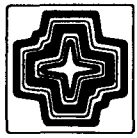
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 25 μAdc, V_{BE} = 0 2N3291, 2N3292 2N3293, 2N3294	 25 20	 35 30	 — —	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	—	.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 0.5 Vdc, I_C = 0	—	—	100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = 10 Vdc, I_C = 2 mAdc	10	—	—	—
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 1 kc	10	—	200	—
Output Capacitance	C_{ob}	V_{CB} = 10 Vdc, I_E = 0, f = 100 kc, Note 1	—	1.0	2.0	pf
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 100 mc	2.5	6.0	12	—
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 2 mAdc f = 31.8 mc	—	15	30	psec
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 2 mA	—	2000	—	mc
2N3291						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc, f = 200 mc	16	20	24	db
Noise Figure	NF		—	6	8	db
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 mc	—	—	0	db
2N3292						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 mc	16	20	24	db
Noise Figure	NF		—	7	9	db
Power Gain (AGC)	G_e	Note 2 V_{CE} = 5 Vdc, I_C = 20 mAdc f = 200 mc	—	0	—	db
2N3293						
Power Output	P_{out}	V_{EE} = -11 Vdc, f = 257 mc	2	—	—	mW
2N3294						
Power Gain	G_e	V_{CE} = 10 Vdc, I_C = 2 mAdc f = 200 mc	14	—	—	db
Noise Figure.	NF		—	7	—	db

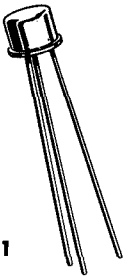
Note 1. C_{ob} is measured in guarded circuit such that the can capacitance is not included.

Note 2. AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = 10 Vdc, I_C = 2 mAdc operation.

2N3295 (SILICON)



G_{PE} = 17 db @ 30 Mc Typ
P_o = 0.3 W PEP @ 30 Mc
I_m = 32 db @ 30 Mc



CASE 31
(TO-5)

NPN silicon annular Star transistor for linear amplifier applications from 2 to 100 Mc.

Collector connected to case

MAXIMUM RATINGS*

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EBO}	5	Vdc
Collector Current (Continuous)	I_C	250	mAdc
Base Current (Continuous)	I_B	50	mAdc
Total Device Dissipation (25°C Case Temperature) Derate above 25°C	P_C	2 13.3	Watts mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	0.8 5.33	Watts mW/°C
Junction Temperature Range	T_J	-65 to 175	°C
Storage Temperature Range	T_{stg}	-65 to 175	°C

* The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See Electrical Characteristics.

2N3295 (Continued)

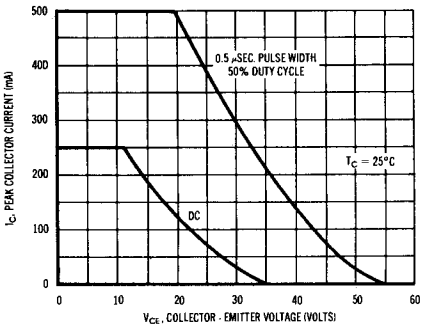
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Min	Typ	Max	Unit
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	100	μ Adc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = 175°C	--	--	500	μ Adc
Collector Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	0.1	μ Adc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 5 Vdc, I_C = 0	--	--	100	μ Adc
DC Current Gain	h_{FE}	I_C = 10mAdc, V_{CE} = 10Vdc	20	--	60	--
		I_C = 150mAdc, V_{CE} = 10Vdc *	20	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 150mAdc, I_B = 15mAdc	--	--	0.5	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = 150mAdc, I_B = 15mAdc	--	--	2.0	Vdc
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 100mA, R_{BE} = 0	30	--	--	Volts
Collector-Emitter Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 100mA, I_B = 0	20	--	--	Volts
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 10Vdc, I_C = 10mAdc, f=50mc	4.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 10Vdc, I_E = 0, f = 100kc	--	--	8	pf
Power Input (PEP) (Note 1)	P_{in}	P_{out} = 0.3 Watts PEP (0.15 W rms) f = 30mc, V_{CE} = 15.0Vdc $I_{C(max)}$ = 40mA	--	--	12	mW
Power Gain	G_e		14	17	--	db
Intermodulation Distortion Ratio	I_m		30	32	--	db
Efficiency	η		25	30	--	%

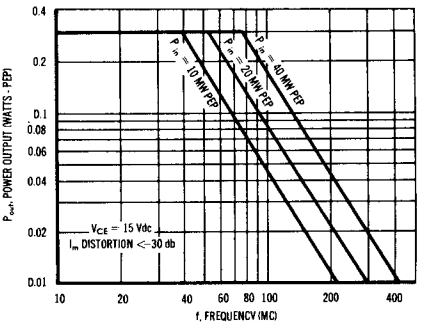
* Pulse = 100 μsec, Duty Cycle = 2%
Note 1. PEP. Peak Envelope Power

2N3295 (Continued)

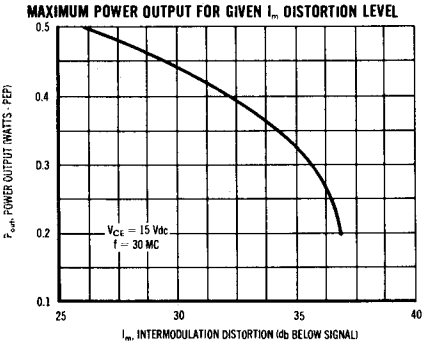
SAFE OPERATING AREA



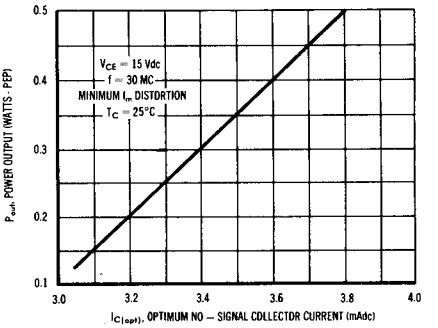
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

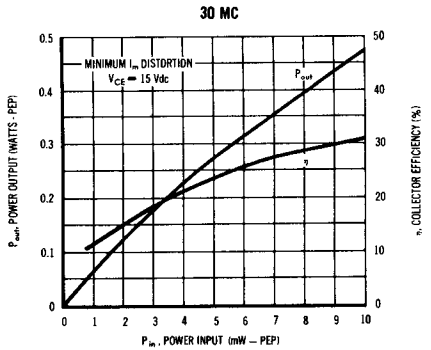


POWER OUTPUT versus OPTIMUM BIAS

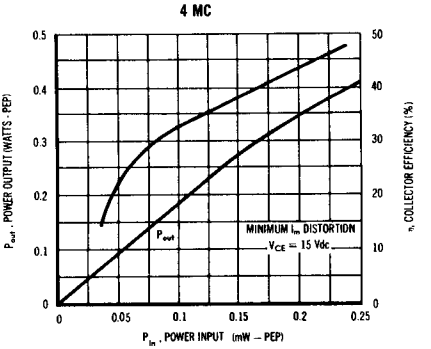


OUTPUT CHARACTERISTICS versus POWER INPUT

30 MC

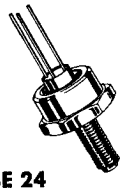


4 MC



2N3296 (SILICON)

G_{PE} = 19 db @ 30 Mc Typ
P_o = 3 W PEP @ 30 MC
I_m = 35 db @ 30 Mc Typ



CASE 24
(TO-102)
Collector connected to case; stud isolated from case

NPN silicon annular transistor for linear amplifier applications from 2 to 100 Mc.

MAXIMUM RATINGS (Note 1)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Collector Current (Continuous)	I_C	700	mAdc
Base Current (Continuous)	I_B	100	mAdc
RF Input Power (Note 2)	P_{in}	1.0	Watt (PEP)
RF Output Power (Note 2)	P_{out}	5.0	Watts (PEP)
Total Device Dissipation (25°C Case Temperature) Derating Factor above 25°C	P_C	6.0 40	Watts mW/°C
Total Device Dissipation at (25°C Ambient Temperature) Derating Factor above 25°C	P_D	0.7 4.67	Watts mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

Note 1: The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See Electrical Characteristics.
Note 2: PEP = Peak Envelope Power.

2N3296 (Continued)

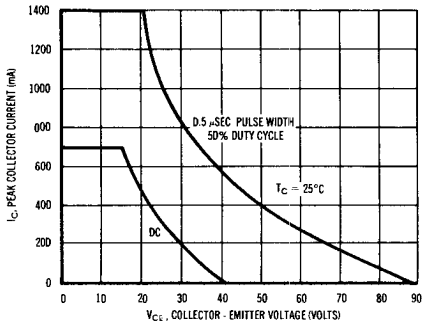
ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 0.200A, R_{BE} = 0	85	120	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 0.200A, I_B = 0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	100	μAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = +175°C	--	--	500	
Collector-Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	0.1	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 3Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE} = 2.0Vdc, I_C = 40mAdc	5.0	--	50	--
		V_{CE} = 2.0Vdc, I_C = 400mAdc	5.0	--	--	--
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 400mAdc, I_B = 80mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 400mAdc, I_B = 80mAdc	--	--	2.0	Vdc
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 2.0Vdc, I_C = 40mAdc, f = 50mc	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CB} = 25Vdc, I_E = 0, f = 100kc	--	--	20	pf
Power Input (PEP) (Note 2)	P_{in}	P_{out} = 3.0 Watts (PEP) (1.5 W rms) V_{CE} = 30 Volts, f = 30mc $I_{C(max)}$ = 125mA	--	--	75	mW
Power Gain	G_e		16	19	--	db
Intermodulation Distortion Ratio	I_m		30	35	--	db
Efficiency	η		40	48	--	%

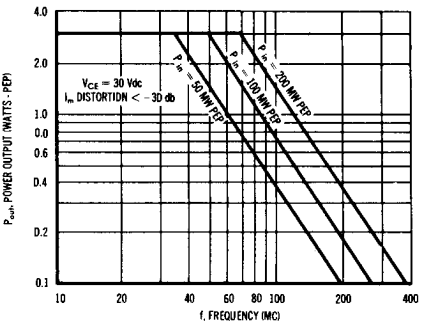
*Pulse Test. Pulse Width = 100 μsec. Duty Cycle = 2%.
Note 2 PEP. Peak Envelope Power.

2N3296 (Continued)

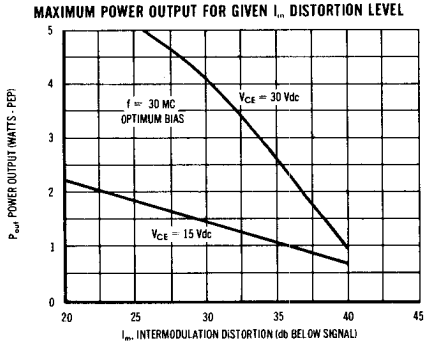
SAFE OPERATING AREA



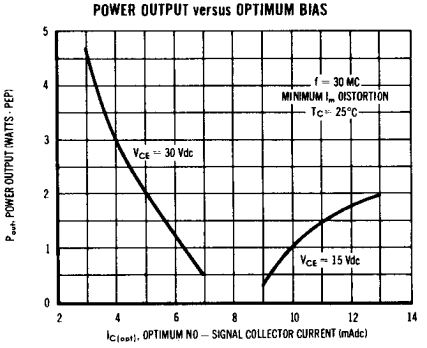
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

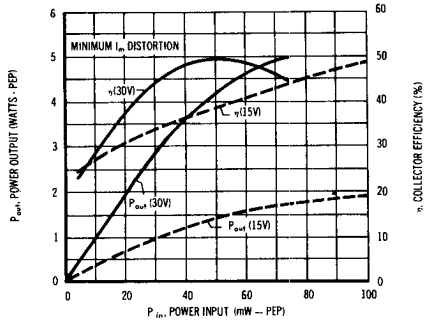


POWER OUTPUT versus OPTIMUM BIAS

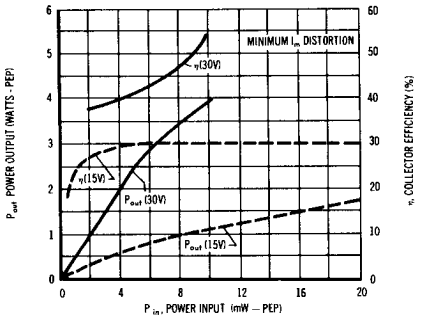


OUTPUT CHARACTERISTICS versus POWER INPUT

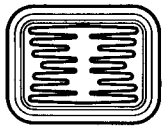
30 MC



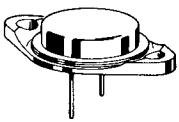
4 MC



2N3297 (SILICON)



G_{PE} = 13 db @ 30 Mc Typ
P_o = 12 W PEP @ 30 Mc
I_m = 33 db @ 30 Mc Typ



CASE 1
(TO-3)

NPN silicon annular transistor for linear amplifier applications for 2 to 100 Mc.

Collector connected to case

MAXIMUM RATINGS *

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	3	Vdc
Collector Current (Continuous)	I_C	1.5	Adc
Base-Current (Continuous)	I_B	500	mAdc
Power Input (PEP)	P_{in}	5.0	Watts (PEP)
Power Output (PEP)	P_{out}	20.0	Watts (PEP)
Total Device Dissipation @ 25°C Case Temperature Derating Factor above 25°C	P_D	 25.0 167	 Watts mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

* The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See electrical characteristics

2N3297 (Continued)

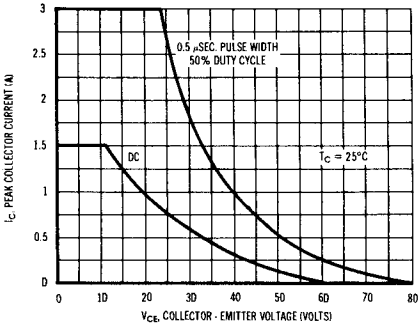
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 0.250A, R_{BE} = 0	80	100	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus)}$*	I_C = 0.250A, I_B = 0	40	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE} = 60Vdc, V_{BE} = 0	--	--	0.5	mAdc
		V_{CE} = 50Vdc, V_{BE} = 0, T_C = +175°C	--	--	1.0	
Collector-Cutoff Current	I_{CBO}	V_{CB} = 50Vdc, I_E = 0	--	--	1.0	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 3Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 400mAdc, V_{CE} = 2Vdc	2.5	--	35	--
		I_C = 1Adc, V_{CE} = 2Vdc	2.5	--	--	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 1Adc, I_B = 500mAdc	--	--	2.0	Vdc
AC Current Gain	$\lvert h_{fe} \rvert$	V_{CE} = 2Vdc, I_C = 400mAdc, f = 50mc	2.0	--	--	--
Collector Output Capacitance	C_{ob}	V_{CE} = 25Vdc, I_E = 0, f = 100kc	--	--	60	pf
Power Input (PEP) Note 2	P_{in}	P_{out} = 12 Watts PEP (6.0W rms)	--	--	1.2	Watts PEP
Power Gain	G_e	V_{CE} = 30 Volts, f = 30mc	10	13	--	db
Intermodulation Distortion Ratio	I_m	$I_{C(max)}$ = 0.50 Amp	30	33	--	db
Efficiency	η		40	45	--	%

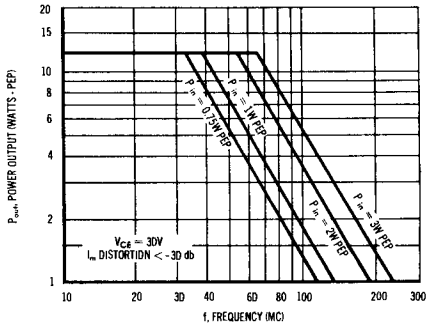
* Pulse Test: Pulse Width = 100 μsec, Duty Cycle = 2 %
Note 2. PEP. Peak Envelope Power

2N3297 (Continued)

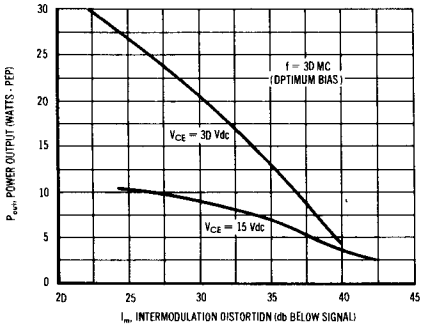
SAFE OPERATING AREA



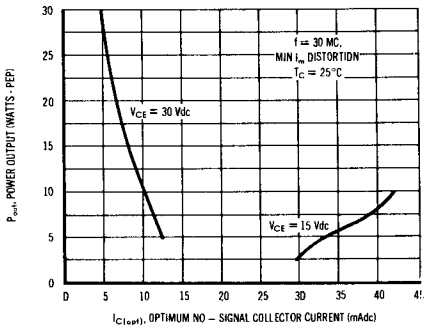
POWER OUTPUT versus FREQUENCY



MAXIMUM POWER OUTPUT FOR GIVEN I_m DISTORTION LEVEL

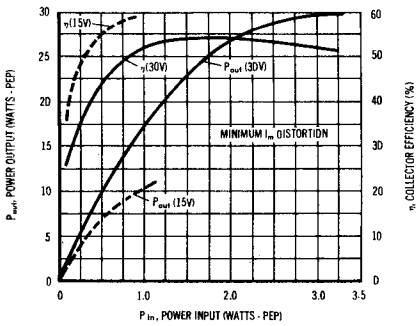


POWER OUTPUT versus OPTIMUM BIAS

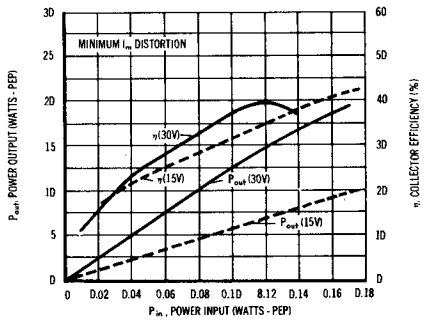


OUTPUT CHARACTERISTICS versus POWER INPUT

30 MC

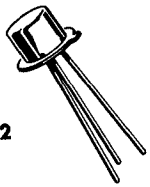


4 MC



2N3298 (SILICON)

$V_{CES} = 25$ V
$P_o = 60$-100 mW @ 80 Mc



CASE 22
(TO-18)

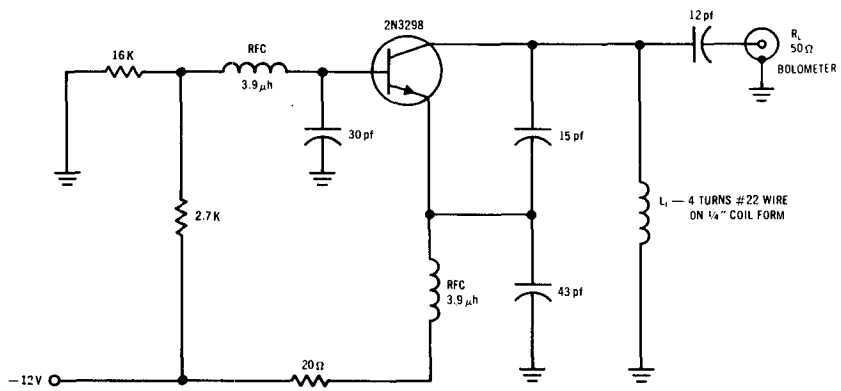
NPN silicon annular transistor for power oscillator applications to 150 Mc.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Vdc
Collector-Emitter Voltage	V_{CES}	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0	Vdc
Collector Current	I_C	100	mA
Total Device Dissipation (25°C Case Temperature) Derate Above 25°C	P_C	1.0 6.67	Watt mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate Above 25°C 2mW/°C	P_D	0.3 2	Watt mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

80 MC OSCILLATOR POWER OUTPUT TEST CIRCUIT



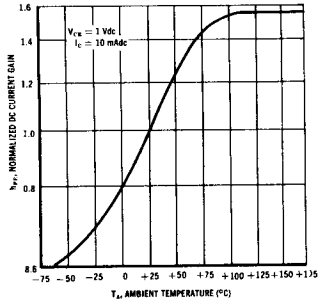
2N3298 (Continued)

ELECTRICAL CHARACTERISTICS (At 25°C Ambient unless otherwise noted)

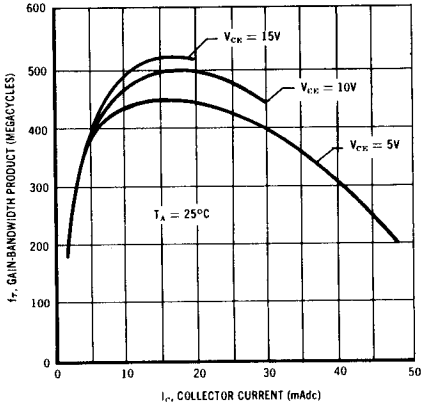
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C=25 μAdc, V_{BE}=0	25	35	-	Vdc
Collector-Emitter Open Base Sustaining Voltage	$BV_{CEO(sus)}$*	I_C=10mA, I_B=0	15	24	-	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB}=10 Vdc, I_E=0 V_{CB}=10 Vdc, I_E=0, T_A=150°C	- -	0.01 10	0.5 50	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB}=3 Vdc, I_C=0	-	-	10	μAdc
DC Current Gain	h_{FE}	V_{CE}=1 Vdc, I_C=10 mAdc	60	90	120	-
AC Current Gain	$\|h_{fe}\|$	V_{CE}=10 Vdc, I_C=10mAdc, f=100mc	2	-	-	-
Collector Output Capacitance	C_{ob}	V_{CB}=10 Vdc, I_E=0, f=100 kc	-	5	6	pf
Power Output	P_{out}	f=80 mc V_{CC}=12 Vdc $I_{C(max)}$=20 mA	60	-	100	mW
Efficiency	η		25	40	-	%

*Pulse Width = 300 μsec, Duty Cycle = 2%

NORMALIZED DC CURRENT GAIN versus AMBIENT TEMPERATURE



f_T versus COLLECTOR CURRENT



2N3307 (SILICON)
2N3308

G_{PE} = 17 db @ 200 Mc
NF = 4-5db @ 200 Mc Typ



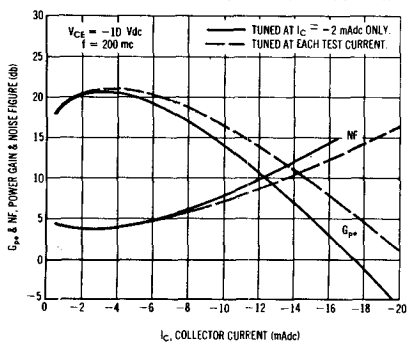
CASE 20
(TO-72)

PNP silicon annular transistors for high-gain, low-noise amplifier, oscillator, mixer and frequency multiplier applications.

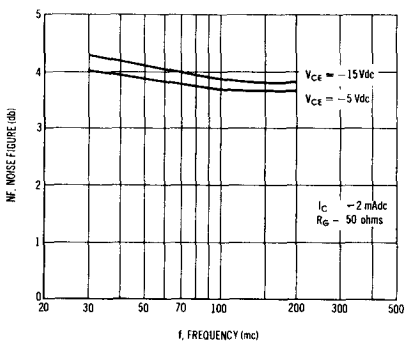
MAXIMUM RATINGS

Characteristic	Symbol	Rating		Unit
		2N3307	2N3308	
Collector-Base Voltage	V_{CBO}	40	30	Vdc
Collector-Emitter Voltage	V_{CES}	40	30	Vdc
Collector-Emitter Voltage	V_{CEO}	35	25	Vdc
Emitter-Base Voltage	V_{EBO}	3.0		Vdc
Collector Current	I_C	50		mAdc
Power Dissipation at T_C = 25°C Above 25°C derate	P_C	300 1.71		mW mW/°C
Power Dissipation at T_A = 25°C Above 25°C derate	P_D	200 1.14		mW mW/°C
Junction Temperature	T_j	200		°C
Storage Temperature	T_{stg}	-65 to +200		°C

COMMON EMITTER AVERAGE SMALL POWER GAIN & NOISE FIGURE versus COLLECTOR CURRENT



NOISE FIGURE versus FREQUENCY



2N3307, 2N3308 (Continued)

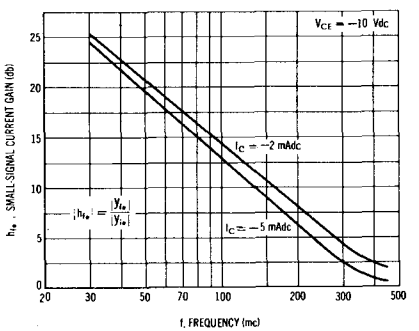
ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = -10 μAdc, I_E = 0	2N3307 2N3308	-40 -30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = -10 μAdc, V_{BE} = 0	2N3307 2N3308	-40 -30	— —	— —	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = -2.0 mAdc, I_B = 0	2N3307 2N3308	-35 -25	— —	— —	Vdc
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = -10 μAdc, I_C = 0	Both Types	-3.0	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = -15 Vdc V_{CB} = -15 Vdc, T = 150 °C	Both Types 2N3307	— —	-0.001 -0.5	-0.010 -3.0	μAdc
DC Current Gain	h_{FE}	V_{CE} = -10 Vdc, I_C = -2 mAdc	2N3307 2N3308	40 25	— —	250 250	—
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = -3 mAdc, I_B = -0.6 mAdc	Both Types	—	—	-0.4	Vdc
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = -3 mAdc, I_B = -0.6 mAdc	Both Types	—	—	-1.0	Vdc
AC Current Gain	h_{fe}	V_{CE} = -10 Vdc, I_C = -2 mAdc, f = 1 kc	2N3307 2N3308	40 25	— —	250 250	—
Output Capacitance *	C_{ob}	V_{CB} = -10 Vdc, I_E = 0, f = 0.1 mc	2N3307 2N3308	— —	1.0 1.2	1.3 1.6	pf
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = -10 Vdc, I_C = -2 mAdc, f = 31.8 mc	2N3307 2N3308	2 2	— —	15 20	psec
Current Gain-Bandwidth Product	f_T	V_{CE} = -10 Vdc, I_C = -2 mAdc, f = 100 mc	Both Types	300	—	1200	mc
Maximum Frequency of Oscillation	f_{max}	V_{CE} = -10 Vdc, I_C = -2 mAdc	Both Types	—	2000	—	mc
Power Gain	G_e	V_{CE} = -10 Vdc, I_C = -2 mAdc, f = 200 mc	Both Types	17	—	24	db
Noise Figure	NF	V_{CE} = -10 Vdc, I_C = -2 mAdc, f = 200 mc	2N3307 2N3308	— —	4.0 5.0	4.5 6.0	db
Power Gain (AGC) **	G_e	V_{CE} = -5.0 Vdc, I_C = -20 mAdc, f = 200 mc	2N3307 2N3308	— —	— 0	0 —	db

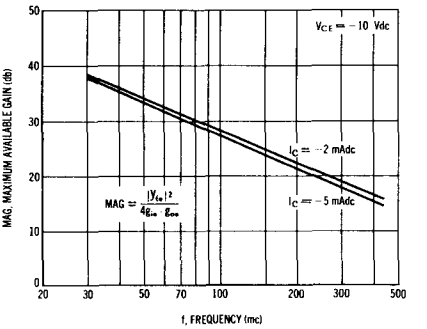
* C_{ob} is measured in guarded circuit such that the can capacitance is not included.

** AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = -10 Vdc, I_C = -2 mAdc operation.

SMALL SIGNAL CURRENT GAIN versus FREQUENCY

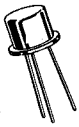


MAXIMUM AVAILABLE GAIN versus FREQUENCY



2N3309A (SILICON)

G_{PE} = 7.4 db @ 250 Mc
P_o = 2.2 W @ 250 Mc



CASE 79
(TO-39)

NPN silicon annular transistor for power amplifier and driver applications to 500 Mc.

Collector connected to case

MAXIMUM RATINGS*

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-EmitterVoltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EBO}	4	Vdc
Collector Current (Continuous)	I_C	0.5	Adc
Base Current (Continuous)	I_B	0.1	Adc
RF Input Power (Nom)	P_{in}	0.5	Watt
RF Output Power (Nom)	P_{out}	2.5	Watts
Total Device Dissipation (25° C Case Temperature) (Derating Factor Above 25 C)	P_C	5 28.6	Watts mW/ C
Total Device Dissipation at 25° Ambient (Derating Factor Above 25 C)	P_D	1.0 5.7	Watt mW/ C
Junction Temperature	T_J	200	C
Storage Temperature Range	T_{stg}	-65 to +200	C

*The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See Electrical Characteristics.

2N3309A (Continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	TEST CONDITIONS	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus^*)}$	I_C = 50mA, R_{BE} = 0	60	--	--	Volts
Collector Emitter-Open Base Sustain Voltage	$V_{CEO(sus^*)}$	I_C = 100mA, I_B = 0	30	--	--	Volts
Collector-Emitter Current	I_{CES}	V_{CE} = 50 Vdc, V_{BE} = 0	--	--	100	μAdc
		V_{CE} = 25 Vdc, V_{BE} = 0	--	--	500	μAdc
		T_C = +150°C				
Collector-Cutoff Current	I_{CBO}	V_{CB} = 25 Vdc, I_E = 0	--	--	0.5	μAdc
Emitter-Cutoff Current	I_{EBO}	V_{EB} = 4 Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	I_C = 50 mAdc,	8	--	80	--
		V_{CE} = 2.0 Vdc				
		I_C = 250 mAdc,	8	--	--	--
		V_{CE} = 2.0 Vdc				
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = 250 mAdc, IB = 50 mAdc	--	--	0.5	Vdc
Emitter-Base Saturation Voltage	$V_{BE(sat)}$	I_C = 250 mAdc, I_B = 50 mAdc	--	--	1.2	Vdc
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 15 Vdc	3	--	--	--
		I_C = 30 mAdc, f = 100 mc				
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0,	--	--	6	pf
		f = 100 kc				
Power Output	P_{out}	P_{in} = 400 mW max, f = 250 mc	2.2	--	--	Watts
Power Gain	G_e	V_{CE} = 25 Vdc, $I_{C(max)}$ = 176 mA	7.4	--	--	db
Efficiency	η		50	--	--	%

*Pulse Width = 100 μsec, Duty Cycle = 2%

2N3323 (GERMANIUM)
2N3324
2N3325

V_{CBO} = 35 V
G_e = 11 db @ 100 Mc



CASE 22
(TO-18)

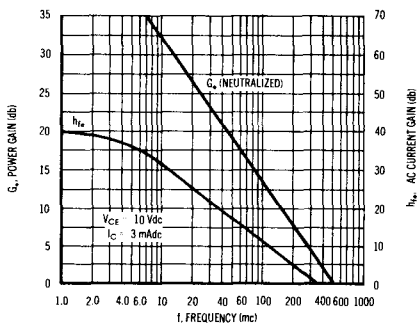
Collector connected to case

PNP germanium epitaxial transistors for FM RF, IF, mixer and oscillator and AM RF, IF and converter applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	35	Volts
Collector-Emitter Voltage	V_{CES}	35	Volts
Emitter-Base Voltage	V_{EBO}	3.0	Volts
Collector Current	I_C	100	mA
Total Device Dissipation 25°C Case Temperature Derate Above 25°C	P_C	300 4	mW mW/°C
Total Device Dissipation 25°C Ambient Temperature Derate Above 25°C	P_D	150 2	mW mW/°C
Junction Temperature	T_J	+100	°C
Storage Temperature Range	T_{stg}	-65 to +100	°C

POWER GAIN AND AC CURRENT GAIN versus FREQUENCY



2N3323 thru 2N3325 (Continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage	BV_{CER}	I_C = 100 μAdc, R_{BE} = 10K	35	40	--	Vdc
Collector-Emitter Current	I_{CES}	V_{CE} = 35 Vdc, V_{BE} = 0	--	--	100	μAdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 10 Vdc, I_E = 0	--	0.5	10	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 2 Vdc, I_C = 0	--	--	100	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 3 mAdc	30	--	200	--
AC Current Gain	h_{fe}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 1 kc	30	--	225	--
Current-Gain — Bandwidth Product	f_T	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 mc	200	--	600	mc
Collector-Base Time Constant	$r_b'C_C$	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 31.8 mc	--	50	100	psec
Output Capacitance	C_{ob}	V_{CE} = 10 Vdc, I_E = 0, f = 100 kc	--	2.2	3.0	pf
Maximum Frequency of Oscillation	f_{max}	V_{CE} = 10 Vdc, I_C = 3mAdc	--	500	--	mc
Input Resistance, Parallel Equivalent	R_{ie}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 10 mc	--	1200	--	ohms
Output Resistance, Parallel Equivalent	R_{oe}		--	11	--	kohms
Input Resistance, Parallel Equivalent	R_{ie}	V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 mc	--	100	--	ohms
Output Resistance, Parallel Equivalent	R_{oe}		--	1.0	--	kohms

2N3323

Power Gain	G_e	Test Circuit Figure 1, V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 100 mc	11	--	15	db

2N3324

Power Gain	G_e	Test Circuit Figure 2, V_{CE} = 10 Vdc, I_C = 3 mAdc, f = 10 mc	24	--	31	db

2N3323 thru 2N3325 (Continued)

FIGURE 1: 100MC POWER GAIN TEST CIRCUIT – 2N3323

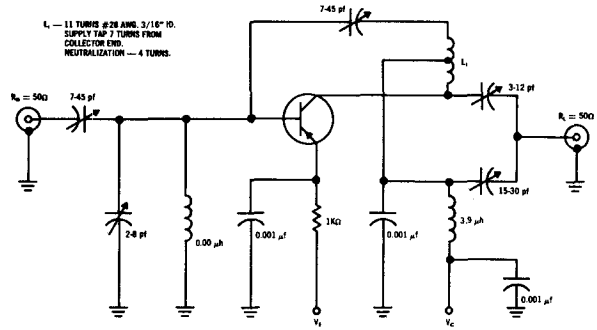
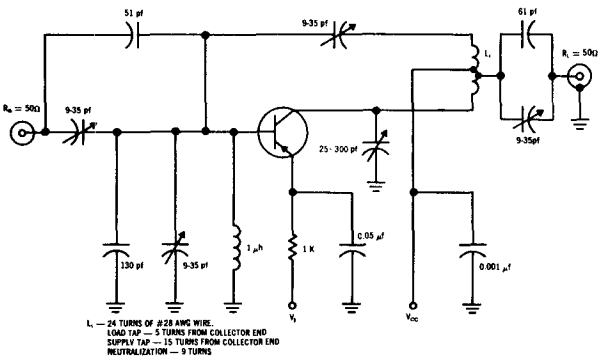


FIGURE 2: 10MC POWER GAIN TEST CIRCUIT – 2N3324



2N3375

2N3553

2N3632

2N3961

$V_{CB} = 65$ V
$I_C = 1.0\text{-}3.0$ A
$P_D = 7\text{-}23$ W



*CASE 79
(TO-39)

2N3553



*CASE 24
(TO-102)

2N3961



**CASE 36
(TO-60)

2N3375
2N3632

*Collector connected to case; stud isolated from case

**Emitter connected to case; stud isolated from case

NPN silicon RF Power transistors, optimized for large-signal power amplifier and driver applications to 400 Mc, provide wide choice of power levels and guaranteed safe operating areas.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	2N3375	2N3553	2N3632	2N3961	Unit
Collector-Base Voltage	V_{CB}	65	65	65	65	Vdc
Emitter-Base Voltage	V_{EB}	4	4	4	4	Vdc
Collector-Emitter Voltage	V_{CEC}	40	40	40	40	Vdc
Collector Current	I_C	1.5	1.0	3.0	1.0	Adc
Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	11.6 66.4	7.0 40	23 131	10 57.2	Watts mW/°C
Junction Temperature	T_J	← 200 →				°C
Storage Temperature Range	T_{stg}	← -65 to +200 →				°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
STATIC CHARACTERISTICS						
Collector Cutoff Current	$V_{CE} = 65$ Vdc, $V_{BE} = -1.5$ Vdc 2N3375, 2N3553 2N3632	I_{CEX}	- -	- -	1.0 5.0	mAdc
	$V_{CE} = 30$ Vdc, $V_{BE} = -1.5$ Vdc, $T_C = 200°C$ 2N3375, 2N3553 2N3632		- -	- -	5 10	
Collector Cutoff Current	$V_{CE} = 30$ Vdc, $I_B = 0$ 2N3375, 2N3553 2N3632	I_{CEO}	- -	- -	0.1 0.25	mAdc

2N3375, 2N3553, 2N3632, 2N3961 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Collector Cutoff Current	V_{CB} = 65 Vdc, I_E = 0 2N3632	I_{CBO}	-	-	0.5	mAdc
	2N3961		-	-	1.0	
	V_{CB} = 28 Vdc, I_E = 0, T_A = 150°C 2N3961		-	-	5.0	
Emitter Cutoff Current	V_{EB} = 4.0 Vdc, I_C = 0 2N3375, 2N3553	I_{EBO}	-	-	0.1	mAdc
	2N3632		-	-	0.25	
Collector-Emitter Open-Base Sustaining Voltage*	I_C = 200 mAdc, I_B = 0 2N3375, 2N3553, 2N3632	$BV_{CEO(sus)}$*	40	-	-	Vdc
	I_C = 400 mAdc, I_B = 0 2N3961		40	-	-	
Emitter-Base Breakdown Voltage	I_E = 0.1 mAdc, I_C = 0 2N3375, 2N3553	BV_{EBO}	4	-	-	Vdc
	I_E = 0.25 mAdc, I_C = 0 2N3632		4	-	-	
	I_E = 1.0 mAdc, I_C = 0 2N3961		4	-	-	
DC Current Gain	I_C = 250 mAdc, V_{CE} = 5 Vdc 2N3375, 2N3553, 2N3632	h_{FE}	10	-	-	-
	I_C = 1.0 Adc, V_{CE} = 5 Vdc 2N3632		5	-	-	
Collector-Emitter Saturation Voltage	I_C = 250 mAdc, I_B = 50 mAdc 2N3553	$V_{CE(sat)}$	-	-	1.0	Vdc
	I_C = 500 mAdc, I_B = 100 mAdc 2N3375, 2N3632		-	-	1.0	
Base-Emitter Saturation Voltage	I_C = 1.0 Adc, V_{CE} = 5 Vdc 2N3632	$V_{BE(sat)}$	-	-	1.5	Vdc
DYNAMIC CHARACTERISTICS						
Current-Gain—Bandwidth Product	I_C = 100 mAdc, V_{CE} = 28 Vdc, f = 100 mc 2N3553	f_T	400	500	-	mc
	2N3961		-	500	-	
	I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 mc 2N3375		400	500	-	
	2N3632		-	400	-	
Output Capacitance	V_{CB} = 28 Vdc, I_E = 0, f = 100 kc 2N3961	C_{ob}	-	8	10	pf
	V_{CB} = 30 Vdc, I_E = 0, f = 100 kc 2N3375, 2N3553		-	8	10	
	2N3632		-	16	20	

FUNCTIONAL TEST

2N3375						
Common-Emitter Amplifier Power Gain	Test Circuit Figure 7	G_{pe}	8.75	-	-	db
Power Input	V_{CE} = 28 Vdc, P_{out} = 7.5 watts, f = 100 mc	P_{in}	-	-	1.0	Watt
Collector Efficiency		η	65	-	-	%
Common-Emitter Amplifier Power Gain	Test Circuit Figure 8	G_{pe}	4.77	-	-	db
Power Input	V_{CE} = 28 Vdc, P_{out} = 3 watts, f = 400 mc	P_{in}	-	-	1.0	Watt
Collector Efficiency		η	40	-	-	%
2N3553						
Common-Emitter Amplifier Power Gain	Test Circuit Figure 9	G_{pe}	10	-	-	db
Power Input	V_{CE} = 28 Vdc, P_{out} = 2.5 watts, f = 175 mc	P_{in}	-	-	0.25	Watt
Collector Efficiency		η	50	-	-	%
2N3632						
Common-Emitter Amplifier Power Gain	Test Circuit Figure 10	G_{pe}	5.86	-	-	db
Power Input	V_{CE} = 28 Vdc, P_{out} = 13.5 watts, f = 175 mc	P_{in}	-	-	3.5	Watts
Collector Efficiency		η	70	-	-	%
2N3961						
Common-Emitter Amplifier Power Gain	Test Circuit Figure 11	G_{pe}	6	-	-	db
Power Input	V_{CE} = 12.5 Vdc, P_{out} = 2 watts,	P_{in}	-	-	0.5	Watt
Collector-Efficiency	R_S = 50 ohms, R_L = 50 ohms, f = 135 mc	η	69	-	-	%
Common-Emitter Amplifier Power Gain	Test Circuit Figure 12	G_{pe}	9	-	-	db
Power Input	V_{CE} = 28 Vdc, P_{out} = 4 watts,	P_{in}	-	-	0.5	Watt
Collector-Efficiency	R_S = 50 ohms, R_L = 50 ohms, f = 175 mc	η	60	-	-	%

2N3375, 2N3553, 2N3632, 2N3961 (continued)

POWER OUTPUT versus FREQUENCY

COMMON EMITTER — V_{CE} = 28 Vdc, T_C = 25°C

FIGURE 1 — 2N3375

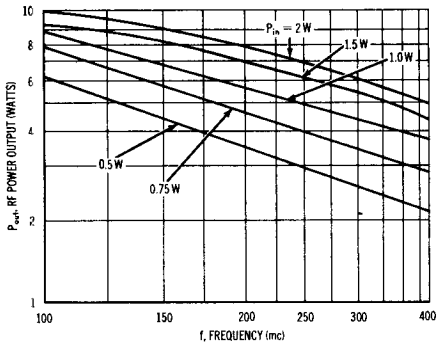


FIGURE 2 — 2N3553

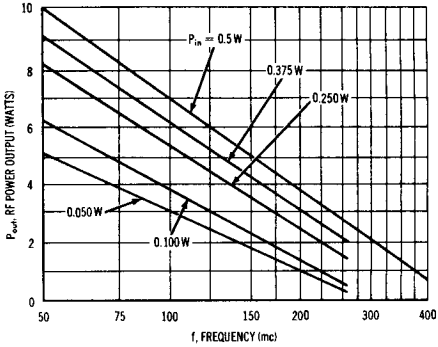


FIGURE 3 — 2N3632

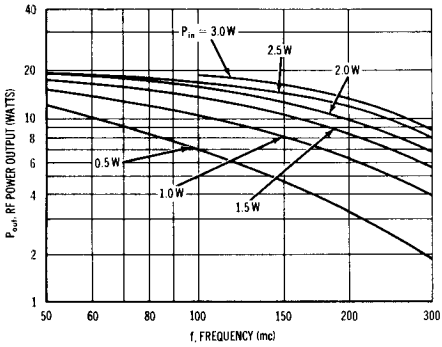
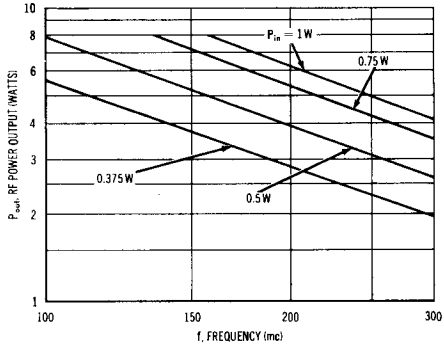


FIGURE 4 — 2N3961



$BV_{CEO(sus)}$ PULSE TEST CIRCUITS

FIGURE 5 — 2N3375, 2N3553, 2N3632

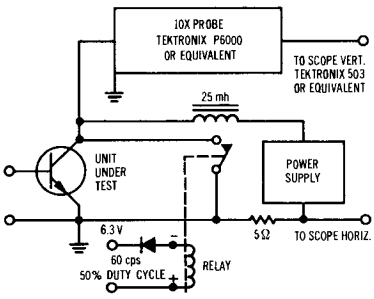
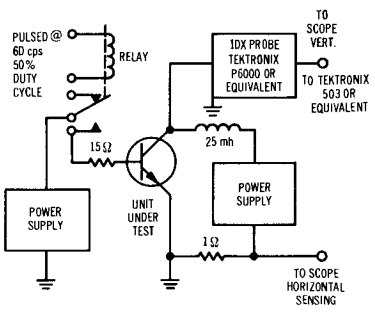


FIGURE 6 — 2N3961

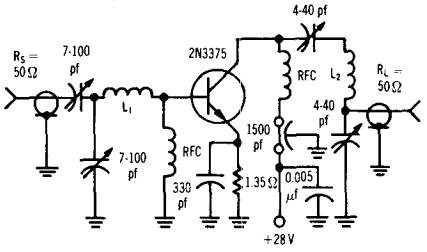


2N3375, 2N3553, 2N3632, 2N3961 (continued)

TEST CIRCUITS

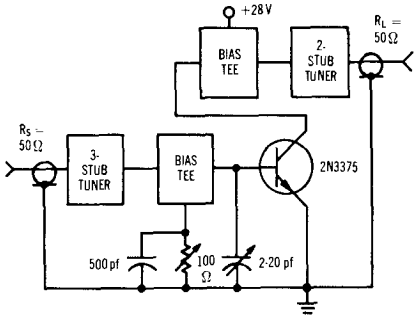
2N3375

FIGURE 7 — 100 mc



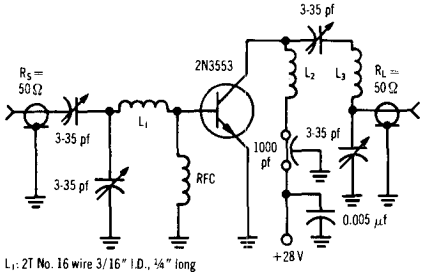
L_1: 3T No. 16 wire ¼" I.D., 5/16" long
L_2: 5T No. 16 wire 5/16" I.D., 7/16" long

FIGURE 8 — 400 mc



2N3553

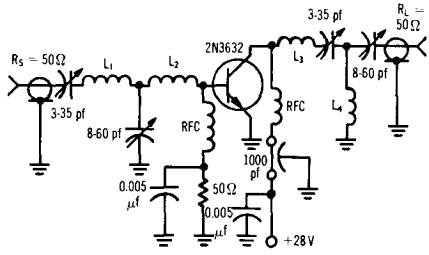
FIGURE 9 — 175 mc



L_1: 2T No. 16 wire 3/16" I.D., ¼" long
L_2: 2T No. 16 wire 3/16" I.D., ¼" long
L_3: 3T No. 16 wire ⅜" I.D., ⅜" long

2N3632

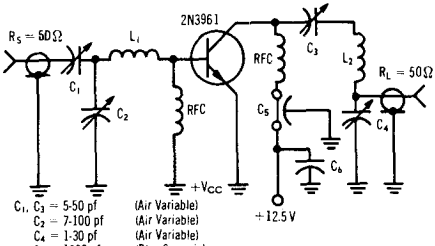
FIGURE 10 — 175 mc



L_1, L_3: 4T No. 18 wire ¼" I.D., 3/16" long
L_2: 1T No. 16 wire ¼" I.D., 3/16" long
L_4: 2½T No. 16 wire ¼" I.D., ¼" long

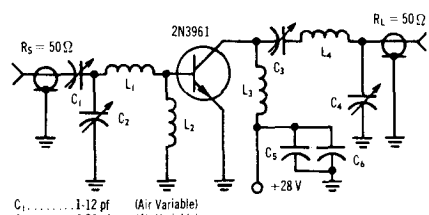
2N3961

FIGURE 11 — 135 mc



C_1, C_3 = 5-50 pf (Air Variable)
C_2 = 7-100 pf (Air Variable)
C_4 = 1-30 pf (Air Variable)
C_5 = 1000 pf (Disc Ceramic)
C_6 = 0.02 μf (Disc Ceramic)
L_1 = 3T No. 16 wire, 5/16" I.D., 5/16" long
L_2 = 5T No. 16 wire, 7/16" I.D., ⅝" long

FIGURE 12 — 175 mc



C_1 ..... 1-12 pf (Air Variable)
C_2 ..... 1-30 pf (Air Variable)
C_3 ..... 5-50 pf (Air Variable)
C_4 ..... 7-75 pf (Air Variable)
C_5 ..... 470 pf (Disc Ceramic)
C_6 ..... 0.001 μf (Disc Ceramic)
L_1, L_3, L_4 ..... 2T No. 18 enameled wire ¼" I.D., air wound 3/16" long
L_2 ..... RFC, Q_U < 1

2N3544 (SILICON)

V_{CBO} = 25 V
P_o = 10 mW @ 1000 Mc



CASE 22
(TO-18)

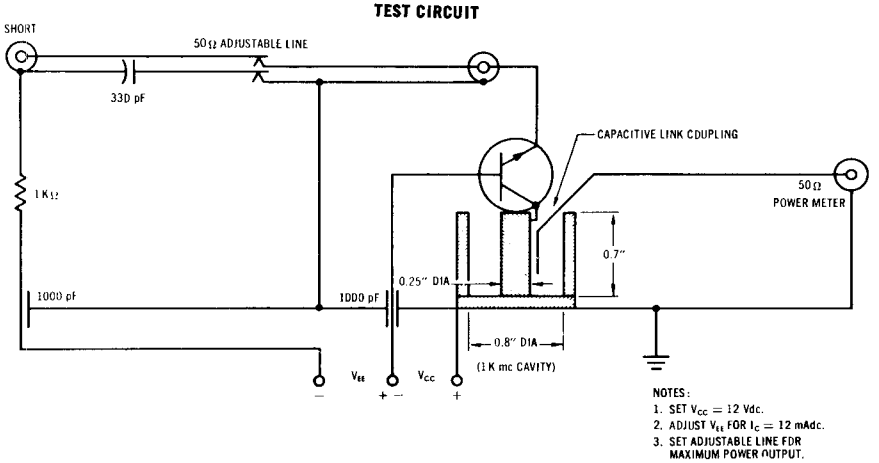
NPN silicon annular transistor for VHF and UHF oscillator applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	25	Volts
Collector-Emitter Voltage	V_{CES}	25	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Collector Current	I_C	100	mA
Power Dissipation @ T_C = 25°C Derate above 25°C	P_C	400 2.67	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2.0	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

TEST CIRCUIT



NOTES:
1. SET V_{cc} = 12 Vdc.
2. ADJUST V_{ee} FOR I_c = 12 mAdc.
3. SET ADJUSTABLE LINE FOR MAXIMUM POWER OUTPUT.

2N3544 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

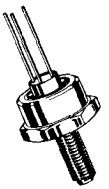
Characteristic	Symbol	Conditions	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 10 μAdc, I_E = 0	25	30	--	Vdc
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = 10 μA, V_{BE} = 0	25	30	--	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0	--	0.01	0.1	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	--	0.1	10	μAdc
DC Current Gain	h_{FE}	V_{CE} = 10 Vdc, I_C = 10 mAdc	25	50	--	--
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc, f = 100 mc	6	9	15	--
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kc	--	--	2.5	pF
Collector-Base Time Constant	$r_b'C_c$	V_{CB} = 10 Vdc, I_C = 10 mAdc, f = 31.8 mc	--	--	10	psec
Oscillator Power Output	P_{out}	f = 1000 mc, V_C = 12 Vdc, I_C = 12 mAdc	10	16	--	mW

2N3553 (SILICON)
2N3632

For Specifications, See 2N3375 Data Sheet

2N3664 (SILICON)

G_{PE} = 7.4 db @ 250 Mc
P_o = 2.2 W @ 250 Mc



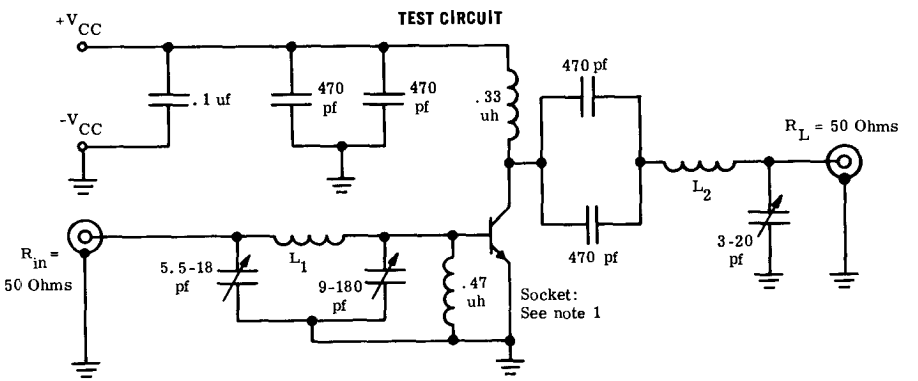
CASE 24
(TO-102)

NPN silicon annular transistor for power amplifier and driver applications to 500 Mc.

Collector connected to case; stud isolated from case

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector Base Voltage	V_{CBO}	60	Vdc
Collector Emitter Voltage	V_{CES}	60	Vdc
Collector Emitter Voltage	V_{CEO}	40	Vdc
Emitter Base Voltage	V_{EBO}	4	Vdc
Collector Current (Continuous)	I_C	0.5	Adc
Base Current (Continuous)	I_B	0.1	Adc
Power Dissipation @ 25°C Case Temperature @ 25°C Ambient Temperature	P_D	 5.0 1.0	 Watts Watts
Operating Junction Temperature Storage Temperature Range	T_j T_{stg}	200 -65 to +200	°C



L_1: 2T No. 14 tinned wire 5/16" ID, 1/4" long
L_2: 2T No. 14 tinned wire 3/8" ID, 3/16" long

Note 1: Use a 0.100" pin circle teflon socket with the emitter grounded to the chassis at the top of the socket.

When making RF power test, the device must be provided with an adequate heat sink.

2N3664 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Sustain Voltage I_C = 30mAdc, R_{BE} = 0 ohms		$V_{CES(sus)}$*	60		Vdc
Collector-Emitter Open Base Sustain Voltage I_C = 30mAdc, I_B = 0		$V_{CEO(sus)}$*	40		Vdc
Collector-Emitter Cutoff Current V_{CE} = 25Vdc, V_{BE} = 0, T_C = +150°C		I_{CES}		50	μAdc
Collector-Emitter Cutoff Current V_{CE} = 25Vdc, V_{BE} = 0		I_{CES}		0.05	μAdc
Collector-Emitter Cutoff Current V_{CE} = 50Vdc, V_{BE} = 0		I_{CES}		I0	μAdc
Emitter Cutoff Current V_{EB} = 4Vdc, I_C = 0		I_{EBO}		100	μAdc
DC Current Gain V_{CE} = 2Vdc, I_C = 250mAdc V_{CE} = 2Vdc, I_C = 50mAdc		h_{FE}	8 8	 80	
Collector-Emitter Saturation Voltage I_C = 250mAdc, I_B = 50mAdc		$V_{CE(sat)}$		0.75	Vdc
Base-Emitter Saturation Voltage I_C = 250mAdc, I_B = 50mAdc		$V_{BE(sat)}$		1.2	Vdc
Small Signal Current Gain V_{CE} = I5Vdc, I_C = 100mAdc, f = 100mc		$\lvert h_{fe} \rvert$	3		
Common Base Output Capacitance V_{CB} = 15Vdc, I_E = 0, f = 100kc		C_{ob}		6.0	pf
Power Output	P_{in} = 400 mW, f = 250 mc V_{CE} = 25 Vdc	P_{out}**	2.2		Watts
Power Gain		G_{PE}	7.4		db
Efficiency		η	50		%

*Pulse width ≤ 200 μsec Duty cycle ≤ 2%

**In functional test P_{out} is fixed at 2.2 watts and P_{in} is monitored to be ≤ 400 mW.

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance - Junction to Case	θ_{JC}	35	°C/W
Thermal Resistance - Junction to Air	θ_{JA}	175	°C/W

2N3733 (SILICON)

V_{CEO} = 40 Vdc
P_{out} = 10 W @ 400 mHz
η = 45 min @ 400 mHz



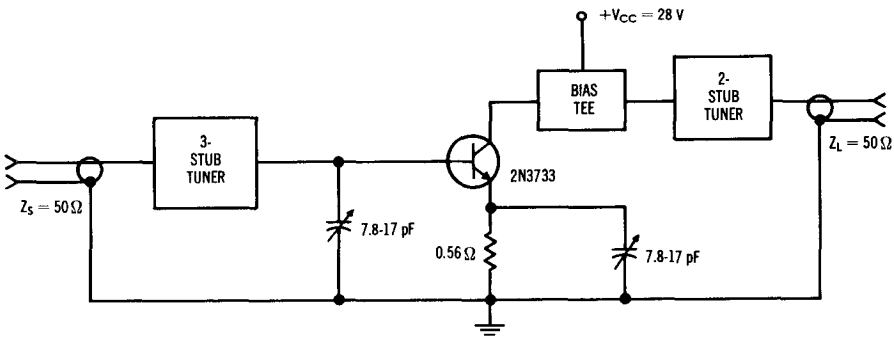
CASE 36
(TO-60)
stud isolated from case

NPN silicon transistor designed for amplifier, frequency multiplier, and oscillator applications.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)}$ = 1.5 Vdc)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	3	Amps
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	23 0.13	Watts W/°C
Operating and Storage Junction Temperature Range	T_J,T_{stg}	-65 to +200	°C

FIGURE 1 — 400-MHz TEST CIRCUIT



2N3733 (continued)

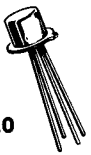
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, I_B = 0)	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, $V_{EB(off)}$ = 1.5 Vdc)	BV_{CEV}*	65	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.5 mAdc, I_E = 0)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.25 mAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	-	0.25	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	-	1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	-	400	-	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0)	C_{ob}	-	-	20	pF
Collector-Case Capacitance	C_s	-	-	6	pF
Base-Spreading Resistance (I_C = 250 mAdc, V_{CE} = 28 Vdc, f = 200 MHz)	$r_{bb'}$	-	6.5	-	Ohms
FUNCTIONAL TEST					
Power Output	V_{CE} = 28 Vdc, P_{in} = 4 W, f = 260 MHz	P_{out}	-	14.5	-	Watts
Efficiency		η	-	60	-	%
Power Output	V_{CE} = 28 Vdc, P_{in} = 4 W, f = 400 MHz (Figure 1)	P_{out}	10	-	-	Watts
Efficiency		η	45	-	-	%

*Pulsed through a 25 mH inductor; duty cycle = 50%

2N3783 thru 2N3785
(GERMANIUM)

V_{CBO} = 15-30 V
G_e = 18-20 db @ 200 Mc
NF = 2.2-2.9 db @ 200 Mc



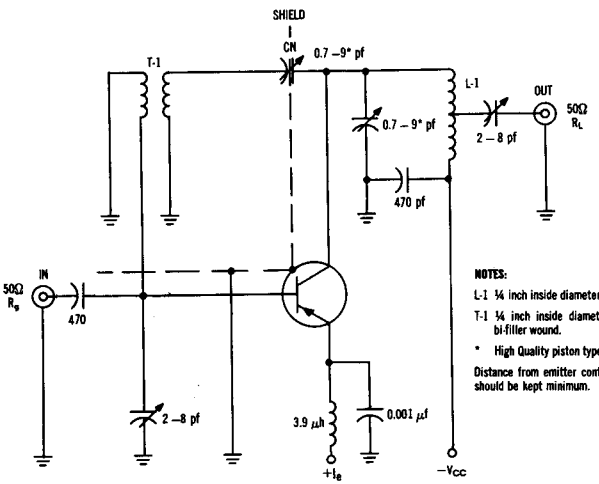
CASE 20
(TO-72)

PNP germanium epitaxial mesa transistors for high-gain, low-noise amplifier, oscillator and frequency multiplier applications.

MAXIMUM RATINGS

Characteristic	Symbol	2N3783 2N3784	2N3785	Unit
Collector-Base Voltage	V_{CBO}	30	15	Vdc
Collector-Emitter Voltage	V_{CES}	30	15	Vdc
Collector-Emitter Voltage	V_{CEO}	20	12	Vdc
Emitter-Base Voltage	V_{EBO}	0.5		Vdc
Collector Current	I_C	20		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	150 2		mW mW/°C
Junction Operating & Storage Temperature Range	T_J, T_{stg}	-65 to +100		°C

FIGURE 1 — 200 MC TEST CIRCUIT: POWER GAIN & NOISE FIGURE.



NOTES:
L-1 ¼ inch inside diameter, ½ inch length, 4 turns #20 solid copper wire, center tapped.
T-1 ¼ inch inside diameter, close wound, 3 turns #26 solid copper wire. 1:1 ratio bi-filler wound.
* High Quality piston type capacitor.
Distance from emitter contact of transistor to ground side of bypass capacitor should be kept minimum.

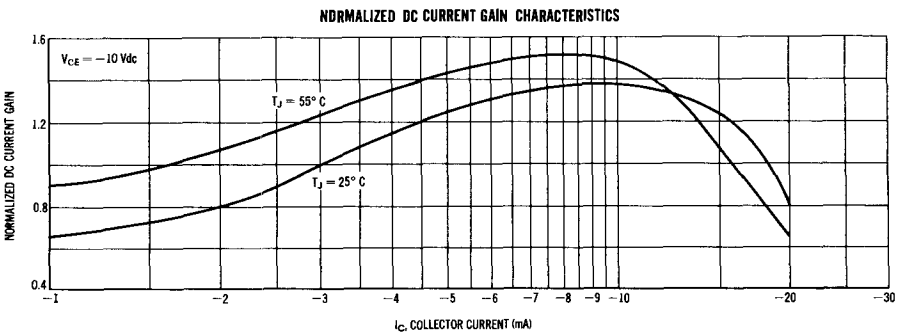
2N3783 thru 2N3785 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions		Min	Typ	Max	Unit
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = -100 μAdc, I_E = 0	2N3783, 2N3784	-30	—	—	Vdc
			2N3785	-15	—	—	
Collector-Emitter Breakdown Voltage	BV_{CES}	I_C = -100 μAdc, V_{EB} = 0	2N3783, 2N3784	-30	—	—	Vdc
			2N3785	-15	—	—	
Collector-Emitter Breakdown Voltage	BV_{CEO}	I_C = -2 mAdc, I_B = 0	2N3783, 2N3784	-20	—	—	Vdc
			2N3785	-12	—	—	
Emitter-Base Breakdown Voltage	BV_{EBO}	I_E = -100 μAdc, I_C = 0	All Types	-0.5	—	—	Vdc
Collector Cutoff Current	I_{CBO}	V_{CB} = -10 Vdc, I_E = 0	All Types	—	—	-5	μAdc
		V_{CB} = -10 Vdc, I_E = 0, T_A = +55°C	2N3783, 2N3784	—	—	-50	
Emitter Cutoff Current	I_{EBO}	V_{EB} = -0.5 Vdc, I_C = 0	All Types	—	—	-100	μAdc
DC Forward Current Transfer Ratio	h_{FE}	V_{CE} = -10 Vdc, I_C = -3 mAdc	2N3783, 2N3784	20	—	200	—
			2N3785	15	—	200	
Collector-Emitter Saturation Voltage	$V_{CE(sat)}$	I_C = -5.0 mAdc, I_B = -1.0 mAdc	2N3783, 2N3784	—	—	-0.25	Vdc
			2N3785	—	—	-0.35	
Base-Emitter Saturation Voltage	$V_{BE(sat)}$	I_C = -5.0 mAdc, I_B = -1.0 mAdc	2N3783, 2N3784	—	—	-0.55	Vdc
			2N3785	—	—	-0.65	
Small-Signal Forward Current Transfer Ratio	h_{fe}	I_C = -3 mAdc, V_{CE} = -10 Vdc, f = 1 kc	2N3783, 2N3784	20	—	200	—
			2N3785	15	—	200	
Current Gain - Bandwidth Product	f_T	I_C = -3 mAdc, V_{CE} = -10 Vdc, f = 200 mc	2N3783	800	—	1600	mc
			2N3784, 2N3785	700	—	1600	
Collector-Base Time Constant	$r'_b C_c$	V_{CB} = -10 Vdc, I_E = +3 mAdc, f = 31.8 mc	2N3783, 2N3784	1	—	6	psec
			2N3785	1	—	10	
Collector-Base Capacitance	C_{ob}	V_{CB} = -10 Vdc, I_E = 0, f = 100 kc	2N3783, 2N3784	—	—	1.0	pf
			2N3785	—	—	1.2	
Power Gain	G_e	V_{CE} = -10 Vdc, I_C = -3 mAdc, f = 200 mc	2N3783, 2N3784	20	—	33	db
			2N3785	18	—	33	
Noise Figure	NF	V_{CE} = -10 Vdc, I_C = -3 mAdc, f = 200 mc	2N3783	—	—	2.2	db
		R_G = 50 ohms	2N3784	—	—	2.5	
			2N3785	—	—	2.9	
Power Gain (AGC) Note 1	G_e(AGC)	V_{CE} = -10 Vdc, I_C = -15 mAdc, f = 200 mc	2N3783	—	—	0	db
			2N3784, 2N3785	—	0	—	
Noise Figure	NF	V_{CE} = -10 Vdc, I_C = -3 mAdc, f = 1000 mc	2N3783	—	—	6.5	db
		R_G = 50 ohms (Note 2)	2N3784	—	7.0	—	
			2N3785	—	7.5	—	

NOTE 1: AGC is obtained by increasing I_C. The circuit remains adjusted for V_{CE} = -10 Vdc and I_C = -3 mAdc.

NOTE 2: This Noise Figure was obtained using Hewlett-Packard Type 342A Noise Figure Meter and Type 349A Noise Source.

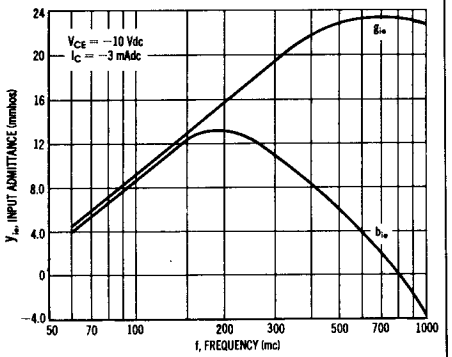


2N3783 thru 2N3785 (continued)

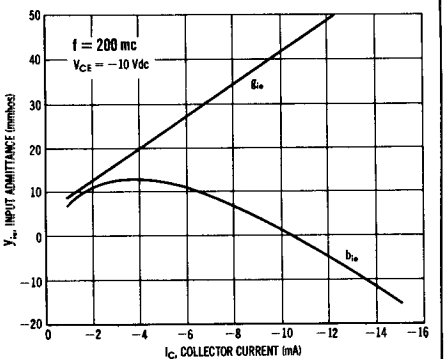
y_{ie}, INPUT ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

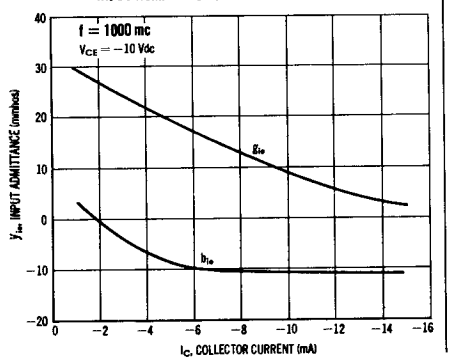
INPUT ADMITTANCE versus FREQUENCY



INPUT ADMITTANCE versus COLLECTOR CURRENT



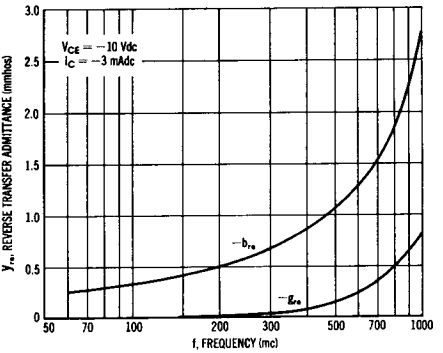
INPUT ADMITTANCE versus COLLECTOR CURRENT



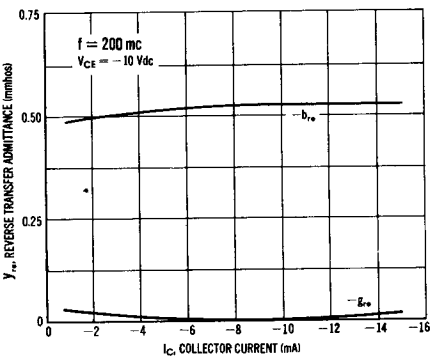
y_{re}, REVERSE TRANSFER ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

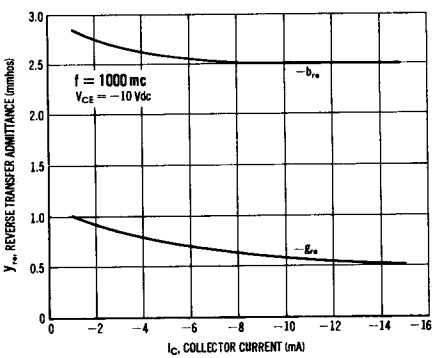
REVERSE TRANSFER ADMITTANCE versus FREQUENCY



REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

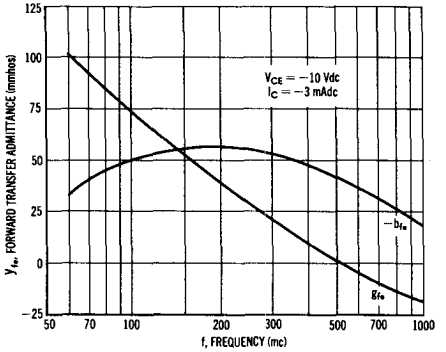


2N3783 thru 2N3785 (continued)

y_{fe}, FORWARD TRANSFER ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

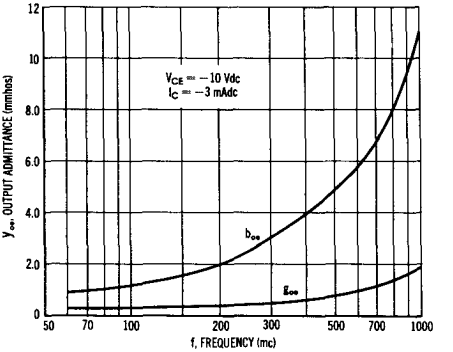
FORWARD TRANSFER ADMITTANCE versus FREQUENCY



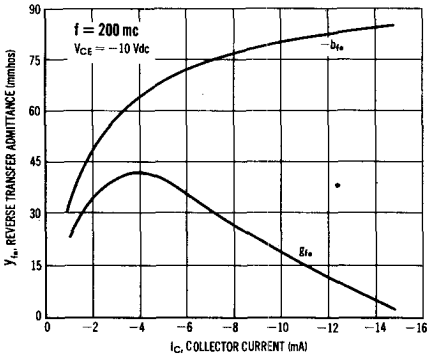
y_{oe}, OUTPUT ADMITTANCE CHARACTERISTICS

(T_A = 25° C unless otherwise noted)

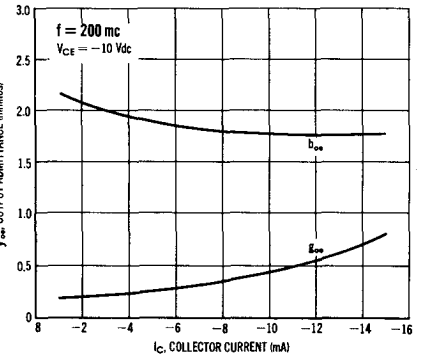
DUTPUT ADMITTANCE versus FREQUENCY



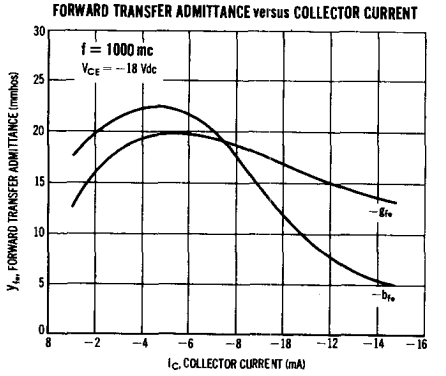
FDRWARD TRANSFER ADMITTANCE versus COLLECTDR CURRENT



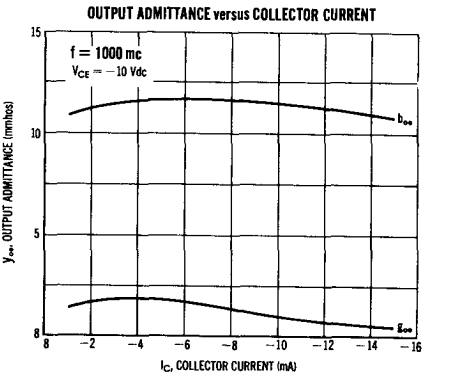
DUTPUT ADMITTANCE versus COLLECTOR CURRENT



FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

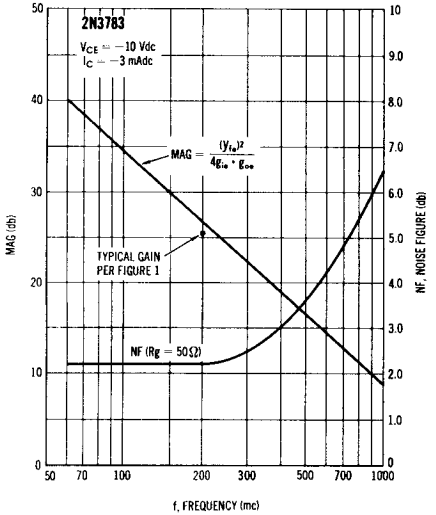


OUTPUT ADMITTANCE versus COLLECTOR CURRENT

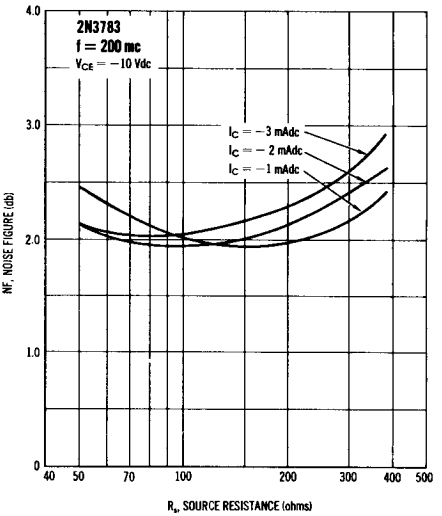


2N3783 thru 2N3785 (continued)

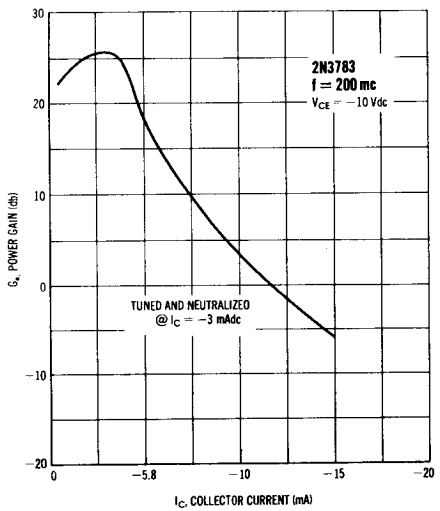
MAG & MAXIMUM NF versus FREQUENCY



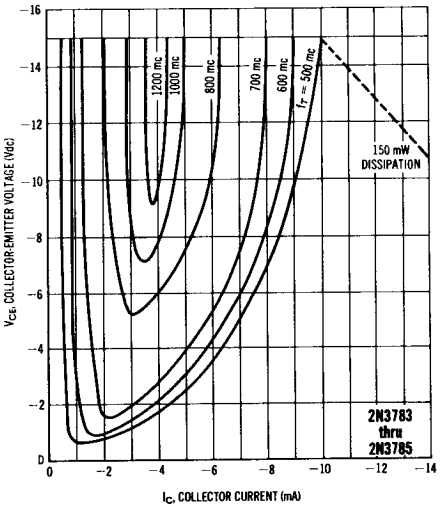
NOISE FIGURE versus SOURCE RESISTANCE



GAIN versus COLLECTOR CURRENT



CONTOURS OF CURRENT-GAIN — BANDWIDTH PRODUCT — f_T



2N3818 (SILICON)

G_{PE} = 7 db @ 100 Mc Typ
P_o = 15 W @ 100 Mc



NPN silicon annular transistor for high-frequency power applications to 150 Mc.

All leads isolated from case

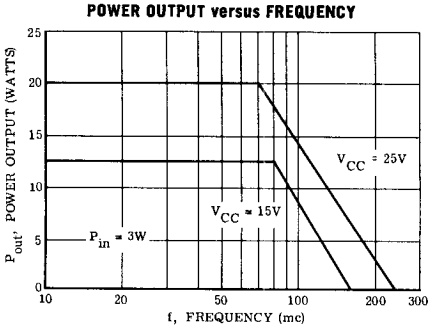
CASE 36
(TO-60)

MAXIMUM RATINGS *

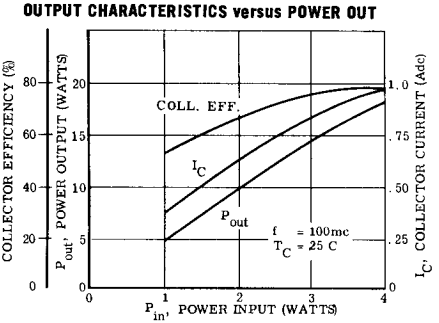
Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	60	Vdc
Collector-Emitter Voltage	V_{CES}	60	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector-Current (continuous)	I_C	2.0	Adc
Base-Current (continuous)	I_B	1.0	mAdc
Power Input (Nominal)	P_{in}	5.0	Watts
Power Output (Nominal)	P_{out}	20.0	Watts
Total Device Dissipation @ 25°C Case Temperature	P_D	25.0	Watts
Derating Factor above 25°C		167	mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

* The maximum ratings as given for DC conditions can be exceeded on a pulse basis. See electrical characteristics.

POWER OUTPUT versus FREQUENCY



OUTPUT CHARACTERISTICS versus POWER OUT



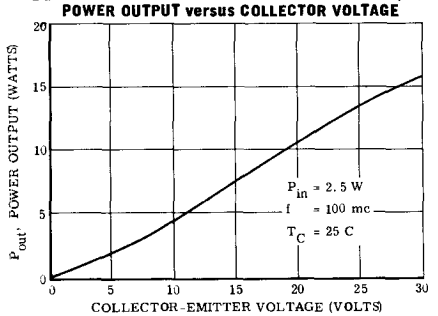
2N3818 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

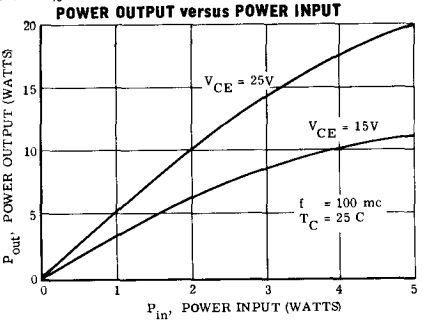
Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage I_C = 0.25 Adc, R_{BE} = 0	$V_{CES(sus)}$*	80	100	--	Vdc
Collector-Emitter-Open Base Sustain Voltage I_C = 0.25 Adc, I_B = 0	$V_{CEO(sus)}$*	40	--	--	Vdc
Collector-Emitter Current V_{CE} = 60 Vdc, V_{BE} = 0 V_{CE} = 50 Vdc, V_{BE} = 0, T_C = 175°C	I_{CES}	-- --	-- --	0.5 1.0	mAdc
Collector Cutoff Current V_{CB} = 50 Vdc, I_E = 0	I_{CBO}	--	--	1	μAdc
Emitter Cutoff Current V_{EB} = 4 Vdc, I_C = 0	I_{EBO}	--	--	100	μAdc
DC Current Gain I_C = 400 mAdc, V_{CE} = 2 Vdc I_C = 1 Adc, V_{CE} = 2 Vdc	h_{FE}	5.0 5.0	-- --	50 --	
Collector-Emitter Saturation Voltage I_C = 1.0 Adc, I_B = 250 mAdc	$V_{CE(sat)}$	--	--	0.5	Vdc
Base-Emitter Saturation Voltage I_C = 1.0 Adc, I_B = 250 mAdc	$V_{BE(sat)}$	--	--	2.0	Vdc
AC Current Gain V_{CE} = 2.0 Vdc, I_C = 400 mAdc, f = 50 mc	$\lvert h_{fe} \rvert$	3	--	--	
Collector Output Capacitance V_{CB} = 25 Vdc, I_E = 0, f = 100 kc	C_{ob}	--	--	40	pf
Power Input P_{out} = 15 W, f = 100 mc V_{CE} = 25 Vdc	P_{in}	--	3.0	3.75	Watts
Efficiency $I_{C(max.)}$ = 1 Adc	η	60	70	--	%

*Pulse Measurement: Pulse Width ≤ 100 μsec, Duty Cycle = 2%.

POWER OUTPUT versus COLLECTOR VOLTAGE



POWER OUTPUT versus POWER INPUT



2N3866 (SILICON)

$V_{CB} = 55$ V
$I_C = 0.4$ A
$P_D = 5.0$ W



CASE 79
(TO-39)

NPN silicon transistor, designed for amplifier, frequency-multiplier, or oscillator applications in military and industrial equipment. Suitable for uses as output, driver, or pre-driver stages in VHF and UHF equipment.

Collector connected to case

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	30	Vdc
Collector-Base Voltage	V_{CB}	55	Vdc
Emitter-Base Voltage	V_{EB}	3.5	Vdc
Collector Current	I_C	0.4	Amp
Total Device Dissipation @ $T_C = 25°C$	P_D	5	Watts
Derate above 25°C		28.6	mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 5 mAdc, I_B = 0)	$BV_{CEO(sus)}$	30	—	—	Vdc
Collector-Base Breakdown Voltage (I_E = 0, I_C = 0.1 mAdc)	BV_{CBO}	55	—	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	3.5	—	—	Vdc
Collector Cutoff Current (V_{CE} = 28 Vdc, I_B = 0)	I_{CEO}	—	—	20	μA
ON CHARACTERISTICS					
DC Current Gain (I_C = 0.36 Adc, V_{CE} = 5 Vdc)	h_{FE}	5	—	—	—
(I_C = 0.05 Adc, V_{CE} = 5 Vdc)		10	—	200	
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 25 mAdc, V_{CE} = 15 Vdc, f = 200 MHz)	f_T	—	800	—	MHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0, f = 1 MHz)	C_{ob}	—	2.0	3.0	pF
FUNCTIONAL TEST					
Power Gain	G_{pe}	10	—	—	dB
Power Output	P_{out}	1.0	—	—	Watts
Collector Efficiency	η	45	—	—	%

Test Circuit-Figure 1
P_{in} = 0.1 W, V_{CE} = 28 Vdc
f = 400 MHz, T_C = 25°C

2N3866 (continued)

FIGURE 1 — 400 MHz RF AMPLIFIER CIRCUIT FOR POWER-OUTPUT TEST

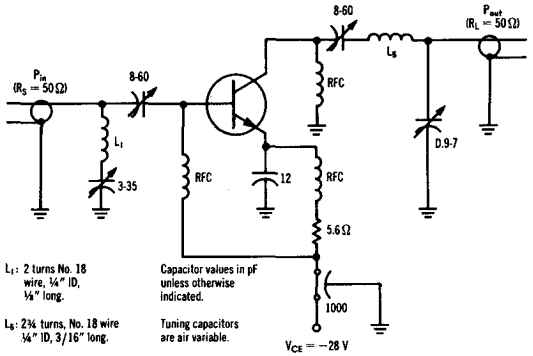


FIGURE 2 — POWER OUTPUT versus FREQUENCY (Class C)

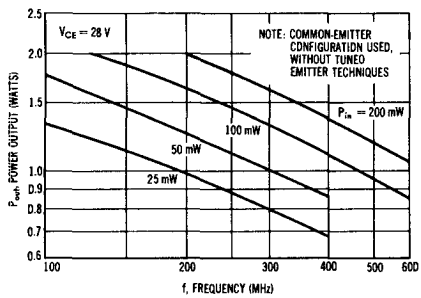


FIGURE 3 — POWER OUTPUT versus POWER INPUT (Class C)

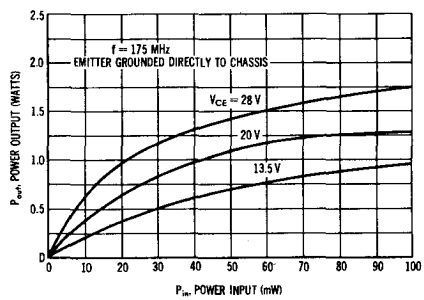


FIGURE 4 — PARALLEL INPUT RESISTANCE AND CAPACITANCE versus FREQUENCY (Class C)

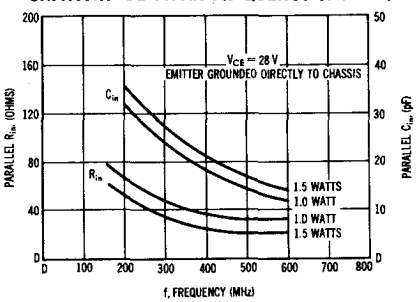
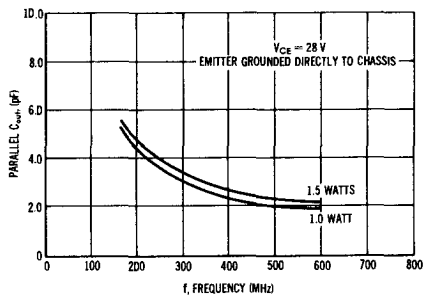


FIGURE 5 — PARALLEL OUTPUT CAPACITANCE versus FREQUENCY (Class C)



2N3866 (continued)

FIGURE 6 — SMALL-SIGNAL CURRENT GAIN versus FREQUENCY

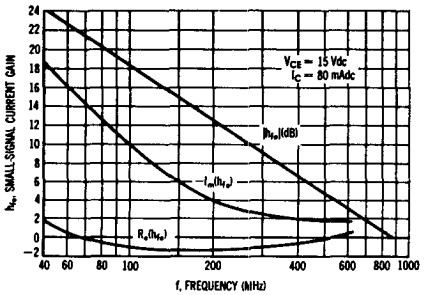


FIGURE 7 — OUTPUT CAPACITANCE versus COLLECTOR VOLTAGE

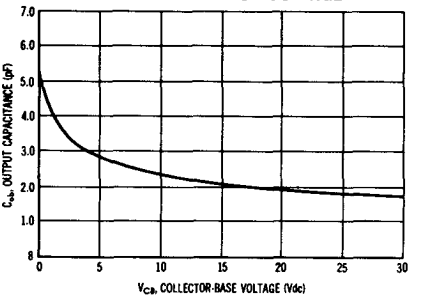


FIGURE 8 — f_T versus COLLECTOR CURRENT

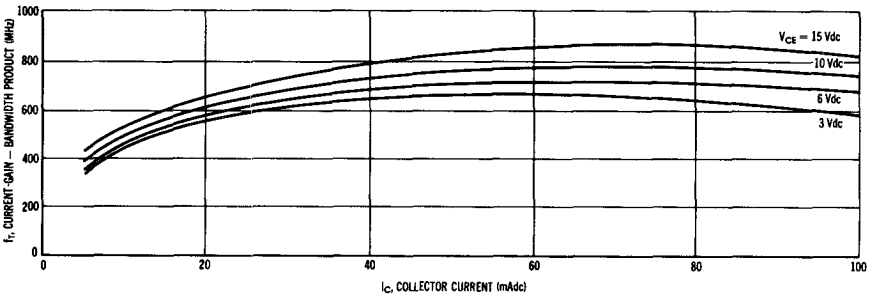


FIGURE 9 — $r_b' C_c$ versus COLLECTOR CURRENT

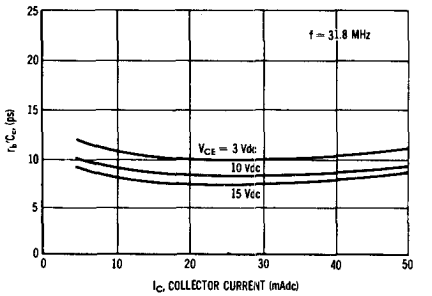
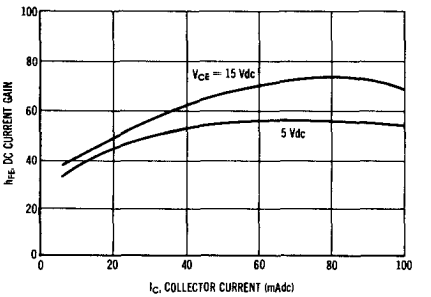


FIGURE 10 — DC CURRENT GAIN versus COLLECTOR CURRENT



2N3866 (continued)

y PARAMETER VARIATIONS

FIGURE 11 — SMALL-SIGNAL INPUT ADMITTANCE versus COLLECTOR CURRENT

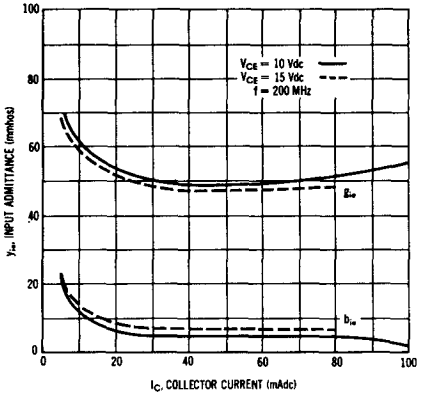


FIGURE 12 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT

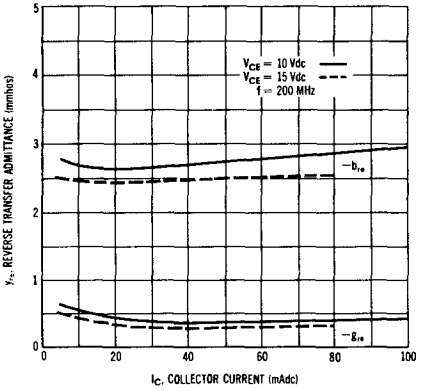


FIGURE 13 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

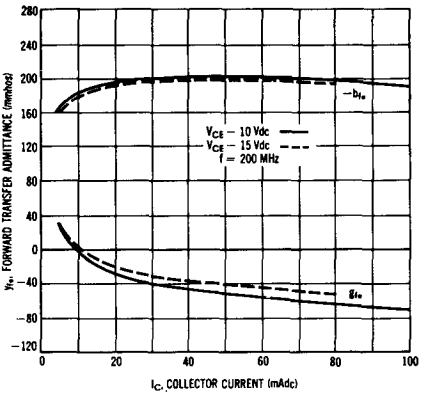
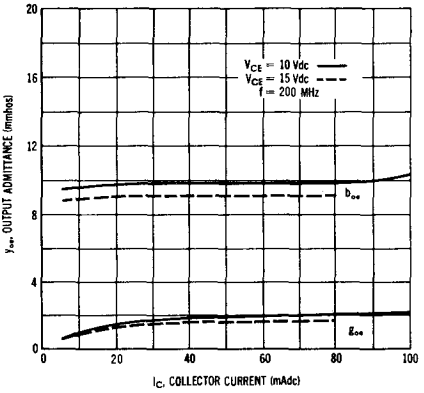


FIGURE 14 — SMALL-SIGNAL OUTPUT ADMITTANCE versus COLLECTOR CURRENT



DESIGN NOTE

Figures 11 through 18 show small-signal admittance-parameter data. This data can be used for Class A amplifier designs.

For Class C power-amplifier designs, the small-signal parameters are not applicable. Figures 4 and 5 give parallel output capacitance and the parallel input resistance and capacitance for Class C power-amplifier operation.

The parallel resistive portion of the collector load impedance for a power amplifier, R_L', may be computed by assuming a peak voltage swing equal to V_{CC}, and using the expression

$$R_L' = \frac{V_{CC}^2}{2P}$$

where P = RF power output. The computed R_L' may then be combined with the data in Figures 2 and 3 to comprise complete device impedance data for Class C power amplifier design.

2N3866 (continued)

y PARAMETER VARIATIONS

(V_{CE} = 15 Vdc, I_C = 80 mAdc, T_A = 25°C)

FIGURE 15 — SMALL-SIGNAL INPUT ADMITTANCE versus FREQUENCY

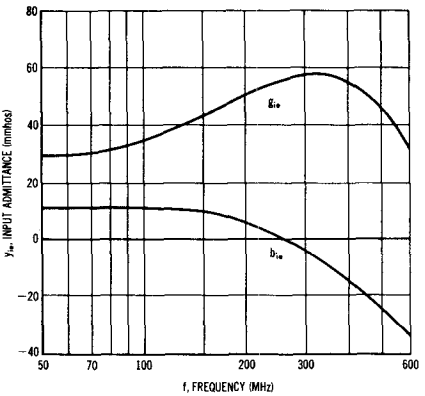


FIGURE 16 — SMALL-SIGNAL REVERSE TRANSFER ADMITTANCE versus FREQUENCY

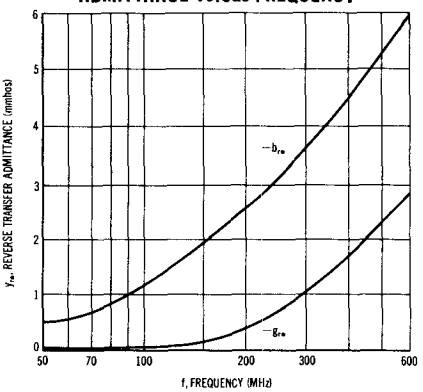


FIGURE 17 — SMALL-SIGNAL FORWARD TRANSFER ADMITTANCE versus FREQUENCY

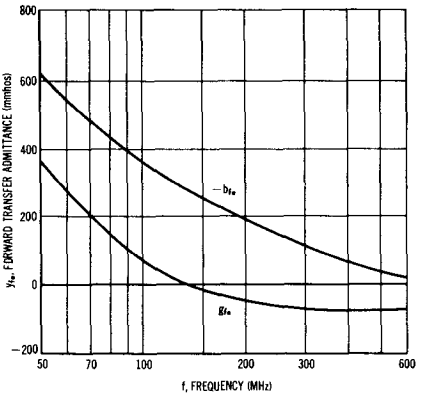
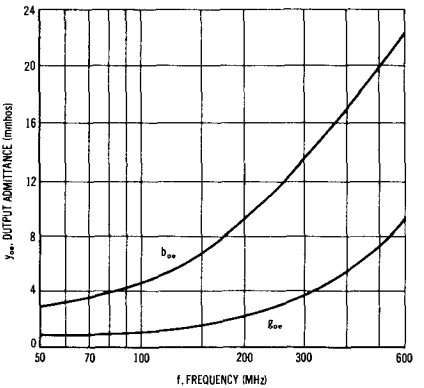


FIGURE 18 — SMALL-SIGNAL OUTPUT ADMITTANCE versus FREQUENCY



2N3924 thru 2N3927

V_{CB} = 36 V
I_C = 0.5-3.0 A
P_D = 7.0-23.2 W

NPN silicon annular RF power transistors, optimized for large-signal power-amplifier and driver applications, feature a wide choice of power levels.



*CASE 79
(TO-39)
2N3924



*CASE 24
(TO-102)
2N3925



**CASE 36
(TO-60)
2N3926
2N3927

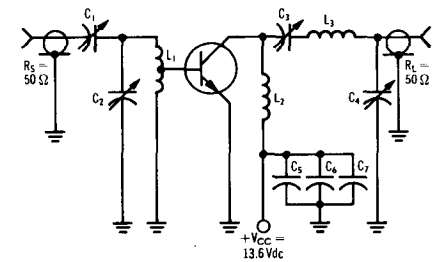
*Collector connected to case; stud isolated from case

**Emitter connected to case; stud isolated from case

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	2N3942	2N3925	2N3926	2N3927	Unit
Collector-Base Voltage	V_{CB}	36	36	36	36	Vdc
Emitter-Base Voltage	V_{EB}	4	4	4	4	Vdc
Collector-Emitter Voltage	V_{CEO}	18	18	18	18	Vdc
Collector Current	I_C	0.5	1.0	1.5	3.0	Adc
Power Dissipation @ T_C = 25°C Derate above 25°C	P_D	7.0 40	10 57.1	11.6 66.3	23.2 132.5	Watts mW/°C
Junction Temperature	T_J	← +200 →				°C
Storage Temperature Range	T_{stg}	← -65 to +200 →				°C

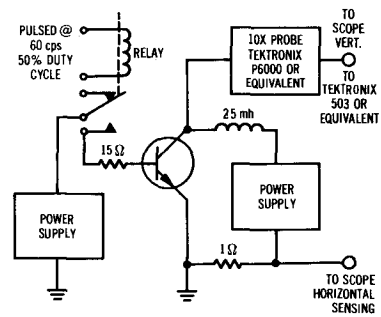
FIGURE 1 — 175 mc TEST CIRCUIT



C_1, C_2, C_4 .....5-50 pf (Air variable)
C_3 .....7-100 pf (Air variable)
C_5 .....470 pf (Disc ceramic)
C_6 .....01 μf (Disc ceramic)
C_7 .....001 μf (Disc ceramic)

L_1 — 1½ turns #14 tinned wire; ⅜" I.D. Air wound; winding length 3/16"; base tapped 1 turn from ground
L_2 — RFC
L_3 — 2 turns #14 tinned wire; ¼" I.D. Air wound; winding length 3/16"

FIGURE 2 — PULSE TEST CIRCUIT



2N3924 thru 2N3927 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
STATIC CHARACTERISTICS						
Collector Cutoff Current	V_{CB} = 15 Vdc, I_E = 0 — 2N3924 thru 2N3926	I_{CBO}	-	-	0.1	mAdc
	2N3927		-	-	0.25	
	V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C — 2N3924 thru 2N3926		-	-	5	
	2N3927		-	-	10	
Collector-Base Breakdown Voltage	I_C = 0.25 mAdc, I_E = 0 — 2N3924 thru 2N3926	BV_{CBO}	36	-	-	Vdc
	I_C = 0.50 mAdc, I_E = 0 — 2N3927		36	-	-	
Emitter-Base Breakdown Voltage	I_E = 1.0 mAdc, I_C = 0 — 2N3924 thru 2N3926	BV_{EBO}	4	-	-	Vdc
	I_E = 2.0 mAdc, I_C = 0 — 2N3927		4	-	-	
Collector-Emitter Open-Base Sustaining Voltage*	I_C = 400 mAdc — All Types	$BV_{CEO(sus)}$*	18	-	-	Vdc
DYNAMIC CHARACTERISTICS						
High-Frequency Current Gain	I_C = 100 mAdc, V_{CE} = 13.6 Vdc, f = 100 mc — 2N3924 thru 2N3926	$\lvert h_{fe} \rvert$	-	5	-	-
	I_C = 200 mAdc, V_{CE} = 13.6 Vdc, f = 100 mc — 2N3927		-	5	-	
Common-Base Output Capacitance	V_{CB} = 13.6 Vdc, I_E = 0, f = 100 kc — 2N3924 thru 2N3926	C_{ob}	-	12.5	20	pf
	2N3927		-	25	45	
FUNCTIONAL TEST						
2N3924						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1	Watt
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 mc,	G_{pe}	6	7.3	-	db
Collector Efficiency	P_{out} = 4 watts	η	70	-	-	%
2N3925						
Power Input	Test Circuit Figure 1	P_{in}	-	-	1.3	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 mc,	G_{pe}	5.84	6.5	-	db
Collector Efficiency	P_{out} = 5 watts	η	70	-	-	%
2N3926						
Power Input	Test Circuit Figure 1	P_{in}	-	-	2	Watts
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 mc,	G_{pe}	5.44	6.0	-	db
Collector Efficiency	P_{out} = 7 watts	η	70	-	-	%
2N3927						
Power Input	Test Circuit Figure 1	P_{in}	-	-	4	Watt
Common-Emitter Amplifier Power Gain	V_{CE} = 13.6 Vdc, R_S = 50 ohms, R_L = 50 ohms, f = 175 mc,	G_{pe}	4.77	5.0	-	db
Collector Efficiency	P_{out} = 12 watts	η	80	-	-	%

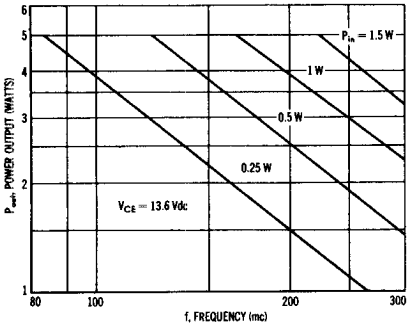
*Pulsed thru a 25-mh inductor

2N3924 thru 2N3927 (continued)

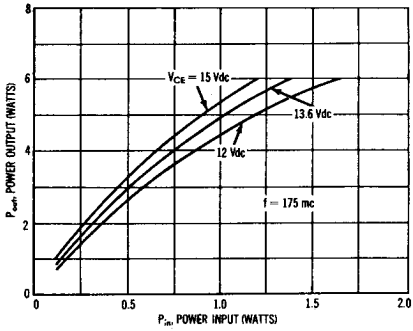
COMMON EMITTER CHARACTERISTICS @ $T_C = 25°C$

2N3924

POWER OUTPUT versus FREQUENCY

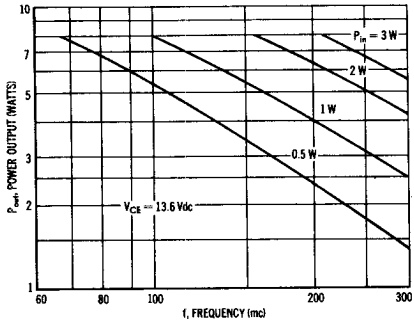


POWER OUTPUT versus POWER INPUT

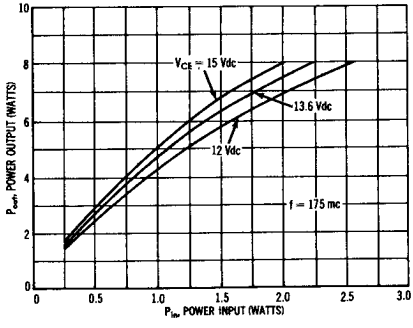


2N3925

POWER OUTPUT versus FREQUENCY



POWER OUTPUT versus POWER INPUT

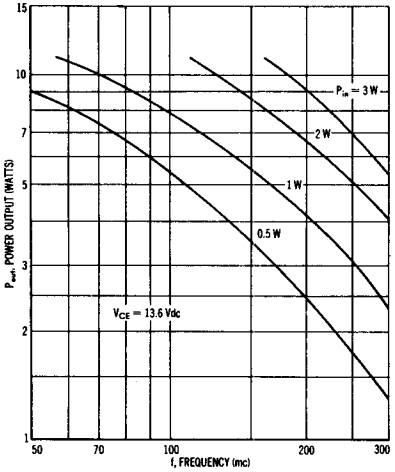


2N3924 thru 2N3927 (continued)

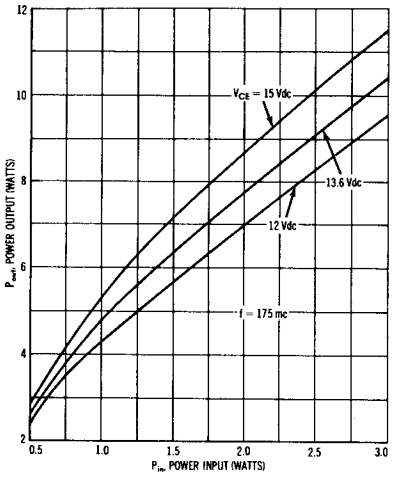
COMMON EMITTER CHARACTERISTICS @ $T_C = 25°C$

2N3926

POWER OUTPUT versus FREQUENCY

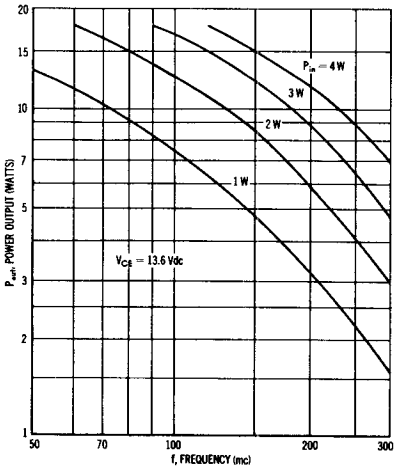


POWER OUTPUT versus POWER INPUT

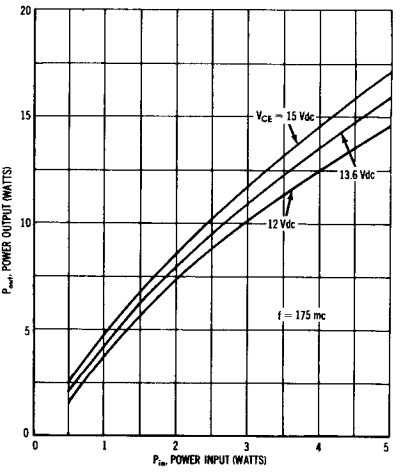


2N3927

POWER OUTPUT versus FREQUENCY



POWER OUTPUT versus POWER INPUT



2N3961

For Specifications, See 2N3375 Data Sheet

2N4012 (SILICON)

$V_{CB} = 65V$
$I_C = 1.5A$
$P_D = 11.6W$



stud isolated from case

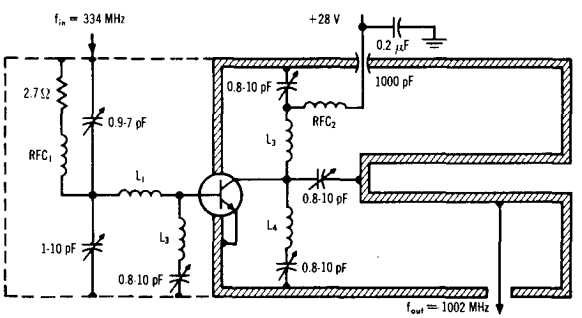
CASE 36
(TO-60)

NPN silicon annular transistor, designed for frequency-multiplication applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Emitter Voltage ($V_{EB(off)} = 1.5$ Vdc)	V_{CEV}	65	Vdc
Collector-Base Voltage	V_{CB}	65	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current	I_C	1.5	Amps
Total Device Dissipation @ $T_A = 25°C$ Derate Above 25°C	P_D	11.6 66.3	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

FIGURE 1 — TRIPLER TEST CIRCUIT



$RFC_1 = 0.22\ \mu H$
$RFC_2 = 0.33$ OHMS, W.W. RESISTOR
$L_1 = 2$ TURNS, 3/8" DIAMETER, NO. 16 WIRE
$L_2 = 1/16$" WIDTH COPPER STRIP, 3/8" LONG
$L_3 = 2$ TURNS, 3/8" DIAMETER, NO. 18 WIRE
$L_4 = 1\frac{1}{2}$ TURNS, 3/8" DIAMETER, 1/16" COPPER STRIP
OUTPUT CAVITY = 1¼" X 1¼" X 2¼"
CENTER CONDUCTOR = ¼" OD TUBE
OUTPUT DIRECT COUPLE = 1" FROM SHORTED END

2N4012 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

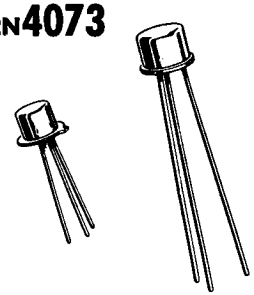
Characteristic	Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, I_B = 0)	BV_{CEO}*	40	-	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 0 to 200 mAdc, $V_{EB(off)}$ = 1.5 Vdc)	BV_{CEV}*	65	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	65	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4	-	-	Vdc
Collector Cutoff Current (V_{CE} = 30 Vdc, I_B = 0)	I_{CEO}	-	-	0.1	mAdc
ON CHARACTERISTICS					
Collector-Emitter Saturation Voltage (I_C = 500 mAdc, I_B = 100 mAdc)	$V_{CE(sat)}$	-	-	1	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain — Bandwidth Product (I_C = 150 mAdc, V_{CE} = 28 Vdc, f = 100 MHz)	f_T	-	500	-	MHz
Collector-Base Cutoff Frequency † (V_{CE} = 28 Vdc, I_C = 0)	f_c	-	25	-	GHz
Output Capacitance (V_{CB} = 30 Vdc, I_E = 0)	C_{ob}	-	-	10	pF
Base-Spreading Resistance (I_C = 250 mAdc, V_{CE} = 28 Vdc, f = 400 MHz)	$r_{bb'}$	-	10	-	Ohms
FUNCTIONAL TEST					
Power Output	Tripler (Test Circuit Figure 1) V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 334 MHz, f_{out} = 1002 MHz	P_{out}	2.5	-	-	Watts
Efficiency		η	25	-	-	%
Power Output	Doubler V_{CE} = 28 Vdc, P_{in} = 1 W, f_{in} = 400 MHz, f_{out} = 800 MHz	P_{out}	-	3.0	-	Watts
Efficiency		η	-	35	-	%

*Pulsed through a 25 mH inductor; duty cycle = 50%

†f_c is determined from Q measured at 210 MHz. f_c = Q x 210 MHz.

2N4072 (SILICON)
2N4073

G_{PE} = 10 dB @ 175 MHz
P_{out} to 500 mW @ 175 MHz
η = 50% @ 175 MHz



CASE 22
(TO-18)
2N4072

CASE 31
(TO-5)
2N4073

NPN silicon annular transistors designed as amplifiers and drivers for large-signal VHF and UHF applications.

Collector connected to case

MAXIMUM RATINGS

Characteristic	Symbol	2N4072	2N4073	Unit
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Collector-Base Voltage	V_{CB}	40		Vdc
Emitter-Base Voltage	V_{EB}	4.0		Vdc
Collector Current-Continuous	I_C	100	150	mAdc
Total Device Dissipation @ T_A = 25°C Derate Above 25°C	P_D	0.35 2.0	- -	Watt mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	- -	1.5 8.57	Watts mW/°C
Operating Junction and Storage Temperature Range	T_J, T_{stg}	-65 to +200		°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
STATIC CHARACTERISTICS					
Collector-Emitter Sustaining Voltage (I_C = 15 mAdc, I_B = 0)	$BV_{CEO(sus)}$	20	-	-	Vdc
Collector-Base Breakdown Voltage (I_C = 0.1 mAdc, I_E = 0)	BV_{CBO}	40	-	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 0.1 mAdc, I_C = 0)	BV_{EBO}	4.0	-	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	- -	- -	0.1 100	μAdc
DC Current Gain (I_C = 25 mAdc, V_{CE} = 2 Vdc)	h_{FE}	10	-	-	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 25 mAdc, V_{CE} = 10 Vdc, f = 100 MHz)	f_T	-	550	-	MHz
Output Capacitance (V_{CB} = 15 Vdc, I_E = 0, f = 100 kHz)	C_{ob}	-	3.0	4.0	pF

2N4072, 2N4073 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Typ	Max	Unit
FUNCTIONAL TEST						
Power Gain	2N4072 Test Circuit - Figure 5 P_{in} = 25 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	250	-	-	mW
Collector Efficency		η	50	60	-	%
Power Gain	2N4073 Test Circuit - Figure 5 P_{in} = 50 mW, V_{CE} = 13.6 Vdc, f = 175 MHz	G_{PE}	10	-	-	dB
Power Output		P_{out}	500	650	-	mW
Collector Efficiency		η	50	65	-	%

2N4072

FIGURE 1 — POWER OUTPUT versus FREQUENCY

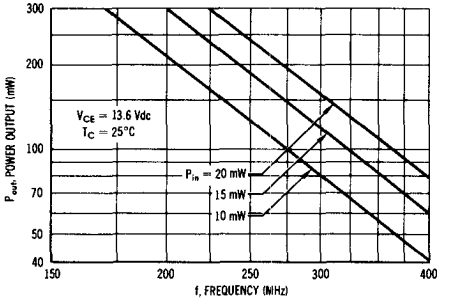
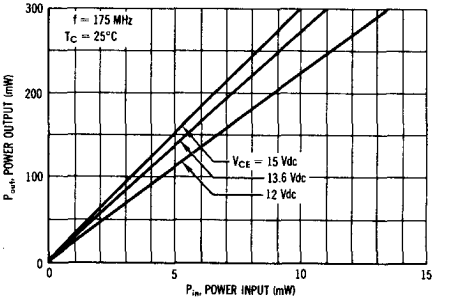


FIGURE 2 — POWER OUTPUT versus POWER INPUT



2N4073

FIGURE 3 — POWER OUTPUT versus FREQUENCY

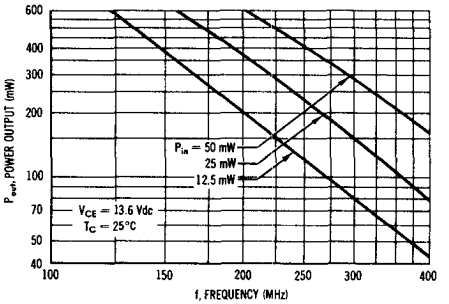


FIGURE 4 — POWER OUTPUT versus POWER INPUT

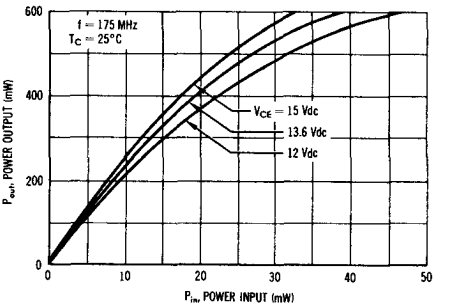
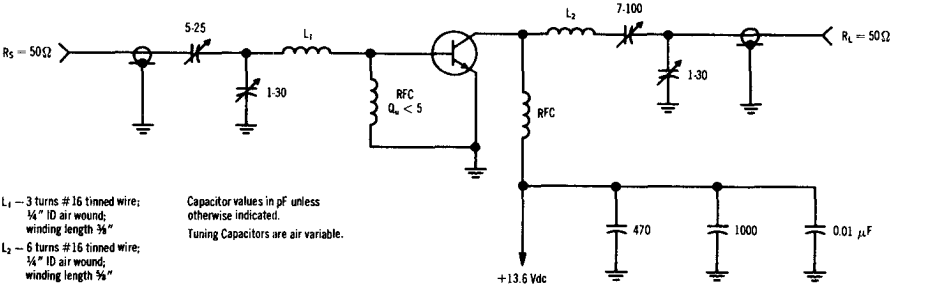


FIGURE 5 — 175 MHz TEST CIRCUIT



L_1 — 3 turns #16 tinned wire; ¼" ID air wound; winding length ⅜"

L_2 — 6 turns #16 tinned wire; ¼" ID air wound; winding length ⅝"

Capacitor values in pF unless otherwise indicated.

Tuning Capacitors are air variable.

MM1803

For Specifications, See 2N3137 Data Sheet

MM1941

G_e = 9 db @ 175 Mc
P_o = 100 mW @ 175 Mc



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency power oscillator, multiplier and driver applications.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	30	Volts
Collector-Emitter Voltage	V_{CES}	30	Volts
Emitter-Base Voltage	V_{EB}	3.0	Volts
Base Current	I_B	30	mAdc
Collector Current	I_C	200	mAdc
Input Power	P_{in}	100	mW
Output Power	P_{out}	250	mW
Power Dissipation @ T_C = 25°C Derate above 25°C	P_C*	600 4.0	mW mW/°C
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D*	300 2.0	mW mW/°C
Junction Temperature	T_J	175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 15 mA, R_{BE} = 0	30	40	-	Volts
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	30	40	-	Volts
Collector Emitter-Open Base Sustain Voltage	$BV_{CEO(sus)}$*	I_C = 15 mA, I_B = 0	20	-	-	Volts
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_C = 100°C	- -	0.01 -	0.1 25	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	-	0.1	10	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	25	50	-	-
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 100 mc	6	8	-	-
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kc	-	-	2.5	pf
Power Output	P_{out}	P_{in} = 20 mW max, f = 175 mc	100	-	-	mW
Power Gain	G_e	V_{CC} = 13.6 Vdc, $I_{C(max)}$ = 25 mA	7	9	-	db

*See Safe Area Curve

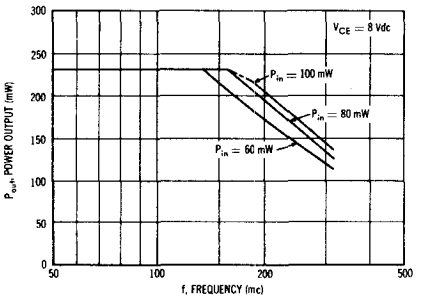
MM1941 (continued)

ELECTRICAL CHARACTERISTICS (continued)

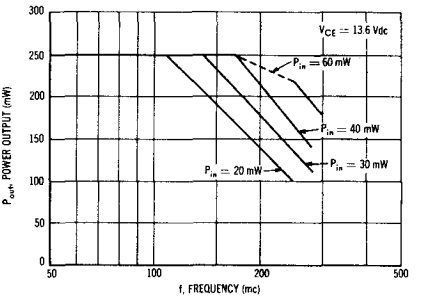
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Power Output (Oscillator)	P_{out}	f = 80 mc, V_{CC} = 13.6 Vdc, $I_{C(typ)}$ = 20 mAdc	-	50	-	mW
Power Gain (Multiplier)	G_e	f_{in} = 80 mc, f_{out} = 240 mc, V_{CC} = 13.6 Vdc, P_{out} ≈ 30 mW, $I_{C(typ)}$ = 25 mAdc	-	3	-	db

*Pulse Test: PW = 100 μsec; DC = 2%

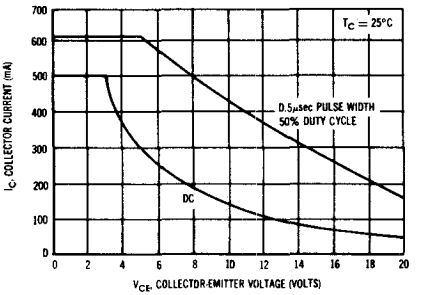
POWER OUTPUT versus FREQUENCY



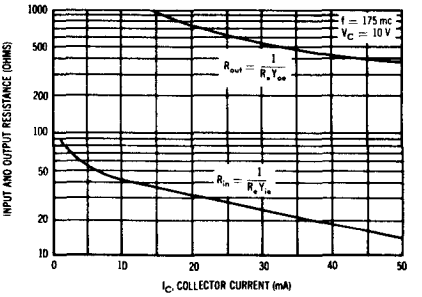
POWER OUTPUT versus FREQUENCY



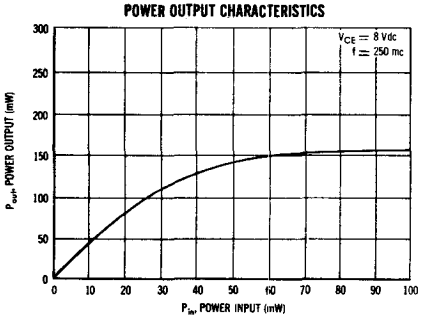
SAFE OPERATING AREA



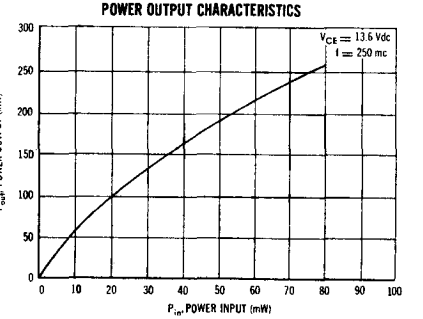
INPUT AND OUTPUT IMPEDANCE versus COLLECTOR CURRENT PARALLEL EQUIVALENT



POWER OUTPUT CHARACTERISTICS

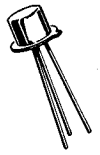


POWER OUTPUT CHARACTERISTICS



MM1943 (SILICON)

G_e = 9 db @ 175 Mc
P_o = 300 mW @ 175 Mc



Collector connected to case

CASE 22
(TO-18)

NPN silicon annular transistor for high-frequency multiplier and driver applications.

MAXIMUM RATINGS (at 25°C case temperature unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	40	Vdc
Collector-Emitter Voltage	V_{CES}	40	Vdc
Emitter-Base Voltage	V_{EB}	3.0	Vdc
Base Current	I_B	30	mA
Collector Current	I_C	200	mA
Input Power	P_{in}	100	mW
Output Power	P_{out}	400	mW
Device Dissipation @ T_C = 25°C Derate above 25°C	P_C	600 4.0	mW mW/°C
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	300 2	mW mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector-Emitter Sustain Voltage	$V_{CES(sus)}$*	I_C = 15 mA, R_{BE} = 0	40	50	-	Volts
Collector-Base Breakdown Voltage	BV_{CBO}	I_C = 100 μAdc, I_E = 0	40	45	-	Volts
Collector Emitter-Open Base Sustain Voltage	$BV_{CEO(sus)}$*	I_C = 15 mA, I_B = 0	20	-	-	Volts
Collector Cutoff Current	I_{CBO}	V_{CB} = 15 Vdc, I_E = 0 V_{CB} = 15 Vdc, I_E = 0, T_C = 100°C	- -	0.01 -	0.1 25	μAdc
Emitter Cutoff Current	I_{EBO}	V_{EB} = 3 Vdc, I_C = 0	-	0.1	10	μAdc
DC Current Gain	h_{FE}	I_C = 10 mAdc, V_{CE} = 10 Vdc	25	50	-	-
AC Current Gain	$\|h_{fe}\|$	V_{CE} = 10 Vdc, I_C = 10 mAdc f = 100 mc	5	7	-	-
Power Output	P_{out}	P_{in} = 47.5 mW max, f = 175 mc	300	-	-	mW
Power Gain	G_e	V_{CC} = 13.6 Vdc, $I_{C(max)}$ = 13.6 mA	8	9	-	db
Efficiency	η		45	55	-	%

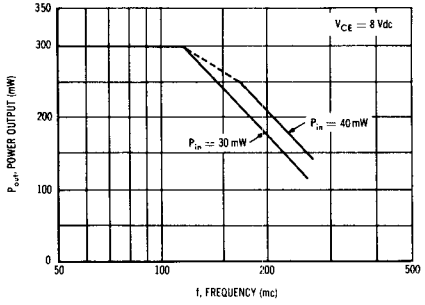
MM1943 (continued)

ELECTRICAL CHARACTERISTICS (continued)

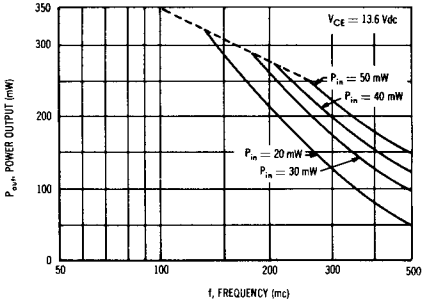
Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Collector Output Capacitance	C_{ob}	V_{CB} = 15 Vdc, I_E = 0, f = 100 kc	-	-	4	pf
Power Gain (Multiplier)	G_e	f_{in} = 80 mc, f_{out} = 240 mc V_{CC} = 13.6 Vdc, P_{out} ≈ 70 mW $I_{C(typ)}$ = 20 mAdc	-	3	-	db

*Pulse Test: PW = 100 μsec; DC = 2%

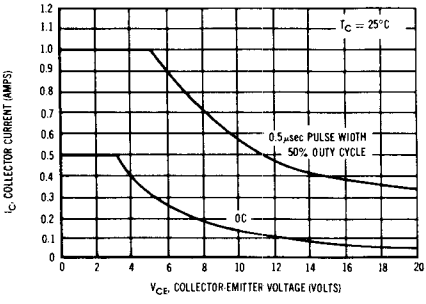
POWER OUTPUT versus FREQUENCY



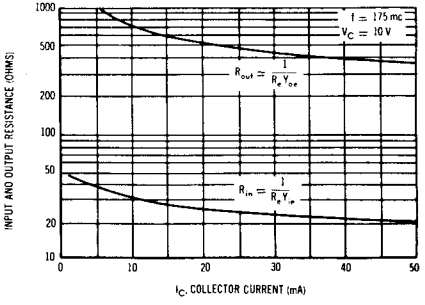
POWER OUTPUT versus FREQUENCY



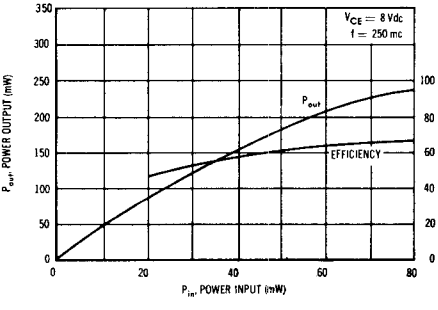
SAFE OPERATING AREA



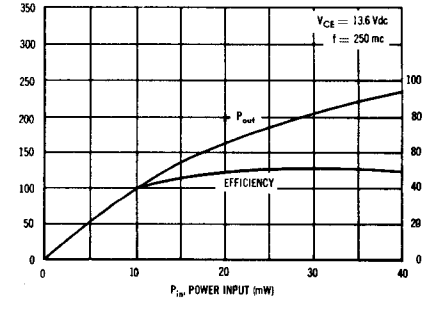
INPUT AND OUTPUT IMPEDANCE versus COLLECTOR CURRENT PARALLEL EQUIVALENT



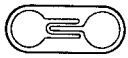
POWER OUTPUT CHARACTERISTICS



POWER OUTPUT CHARACTERISTICS



MM2503 (GERMANIUM)



$V_{CBO} = 30$ V
$G_e = 20$ db @ 200 Mc



CASE 20
(TO-72)

PNP germanium annular transistor for high-gain, low-noise amplifier, oscillator and frequency multiplier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CBO}	-30	Vdc
Collector-Emitter Voltage	V_{CES}	-30	Vdc
Collector-Emitter Voltage	V_{CEO}	-15	Vdc
Emitter-Base Voltage	V_{EBO}	-0.5	Vdc
Collector Current	I_C	-20	mA
Total Device Dissipation (25° C Ambient Temp.) Derate above 25° C	P_D	75 1.0	mW mW/° C
Junction Temperature	T_J	+100	° C
Storage Temperature	T_{stg}	-65 to +100	° C

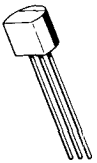
MM2503 (continued)

ELECTRICAL CHARACTERISTICS (T_C = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Typ
Collector-Base Breakdown Voltage I_C = -100μAdc, I_E = 0	BV_{CBO}	-30		Vdc
Collector-Emitter Breakdown Voltage I_C = -100μAdc, V_{BE} = 0	BV_{CES}	-30		Vdc
Collector-Emitter Breakdown Voltage I_C = -1mAdc, I_B = 0	BV_{CEO}	-15		Vdc
Emitter-Base Breakdown Voltage I_E = -100μAdc, I_C = 0	BV_{EBO}	-0.5		Vdc
Collector-Cutoff Current V_{CB} = -6Vdc V_{CB} = -6Vdc, T_A = +55° C	I_{CBO}		-10 -100	μAdc μAdc
DC Forward Current Ratio V_{CE} = -6Vdc, I_C = -3mAdc	h_{FE}	20		
Collector-Emitter Saturation Voltage I_C = -3mAdc, I_B = -0.3mAdc	$V_{CE(sat)}$		-0.2	Vdc
Base-Emitter Saturation Voltage I_C = -3mAdc, I_B = -0.3mAdc	$V_{BE(sat)}$		-0.7	Vdc
Small Signal Forward Current Ratio V_{CE} = -6Vdc, I_C = -3mAdc, f = 1KC	h_{fe}	25		
Collector-Base Capacitance V_{CB} = -6Vdc, I_E = 0, f = 100KC	C_{ob}		2.0	pf
Collector-Base Time Constant V_{CB} = -6Vdc, I_E = +3mAdc, f = 79.8MC	$r_b'C_c$		6	psec
Current Gain-Bandwidth Product V_{CE} = -6Vdc, I_C = -3mAdc, f = 100MC	f_τ	1000		mc
Power Gain V_{CE} = -6Vdc, I_C = -3mAdc, f = 200MC	Ge	20		db
Noise Figure V_{CE} = -6Vdc, I_C = -3mAdc R_g = 50 Ω, f = 200MC	NF		3.0	db
Power Gain (AGC) V_{CE} = -5Vdc, I_C = -15mAdc, f = 200MC	G_e		0	db

MPS918 (SILICON)
MPS3563

G_e = 14-15 db @ 200 Mc
NF = 6 db @ 200 Mc
P_o = 30 mW @ 500 Mc



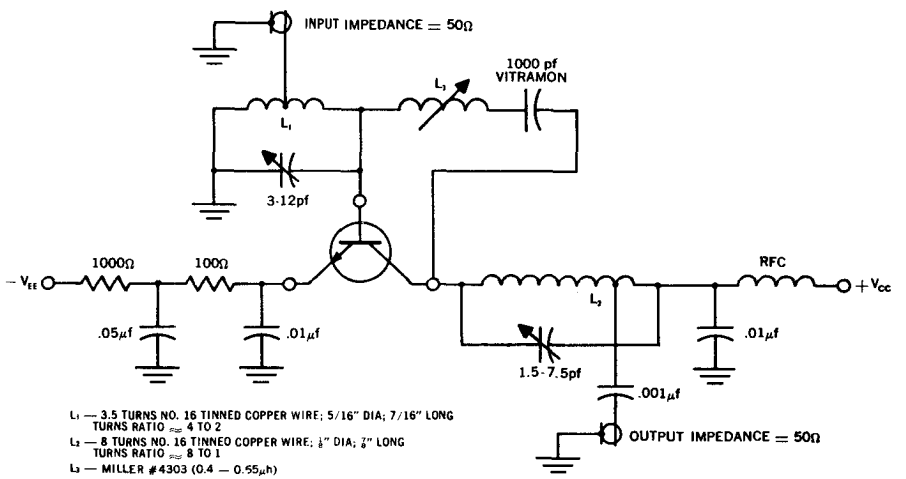
NPN silicon annular, plastic encapsulated transistors for low-cost amplifier and oscillator applications at VHF and UHF.

CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	MPS918	MPS3563	Unit
Collector-Base Voltage	V_{CBO}	30	30	Volts
Collector-Emitter Voltage	V_{CEO}	15	12	Volts
Emitter-Base Voltage	V_{EBO}	3	2	Volts
Total Dissipation @ 25°C Case Temperature @ 25°C Ambient Temperature	P_D	 0.5 0.2	 0.5 0.2	Watts
Operating Junction Temperature	T_J	125	125	°C
Storage Temperature	T_{stg}	-55 to +125		°C

200 MC POWER GAIN TEST CIRCUIT



MPS918, MPS3563 (continued)

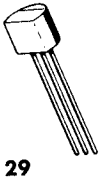
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current V_{CB} = 15V, I_E = 0	MPS918 MPS3563	I_{CBO}	– –	10 50	nA
Collector-Base Breakdown Voltage I_C = 1.0 μA, I_E = 0 I_C = 100 μA, I_E = 0	 MPS918 MPS3563	BV_{CBO}	 30 30	 – –	Volts
Emitter-Base Breakdown Voltage I_E = 10 μA, I_C = 0	MPS918 MPS3563	BV_{EBO}	3.0 2.0	– –	Volts
Collector-Emitter Voltage I_C = 3.0 mA, I_E = 0	MPS918 MPS3563	BV_{CEO}*	15 15	– –	Volts
DC Current Gain V_{CE} = 1V, I_C = 3mA V_{CE} = 10V, I_C = 8mA	 MPS918 MPS3563	h_{FE}*	 20 20	 – 200	—
Collector-Emitter Saturation Voltage I_C = 10mA, I_B = 1mA	MPS918	$V_{CE(sat)}$	–	0.4	Volts
Base-Emitter Saturation Voltage I_C = 10mA, I_B = 1mA	MPS918	$V_{BE(sat)}$	–	1.0	Volts
Small Signal Current Gain I_C = 4mA, V_{CE} = 10V, f = 100mc I_C = 8mA, V_{CE} = 10V, f = 100mc I_C = 8mA, V_{CE} = 10V, f = 1kc	 MPS918 MPS3563 MPS3563	h_{fe}	 6 6 20	 – 15 250	—
Output Capacitance V_{CB} = 10V. I_E = 0, f = 140kc V_{CB} = 10V, I_E = 0, f = 1mc V_{CB} = 0V, I_E = 0, f = 140kc	 MPS918 MPS3563 MPS918	C_{ob}	 – – –	 1.7 1.7 3.0	pf
Input Capacitance V_{EB} = 0.5V, I_C = 0	MPS918	C_{ib}	–	2.0	pf
Amplifier Power Gain I_C = 6mA, f = 200mc, V_{CB} = 12V I_C = 8mA, V_{CE} = 10V, f = 200mc $G_{fd} + G_{re}$ < -20db	 MPS918 MPS3563	Ge	 15 14	 – –	db
Power Output I_C = 8mA, V_{CB} = 15V, f = 500mc	MPS918	Pout	30		mW
Collector Efficiency I_C = 8mA, V_{CB} = 15V, f = 500mc	MPS918	eff	25		%
Noise Figure I_C = 1mA, V_{CE} = 6V, f = 60mc, Rg = 400	MPS918	NF	–	6	db

*PW ≤ 300 μsec. DC ≤ 1%

MPS6507 (SILICON)

$V_{CB} = 30V$
$f_T = 700$ MHz



CASE 29
(TO-92)

NPN silicon transistor designed as a VHF mixer in TV applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3	Volts
Collector Current	I_C	100	mA
Total Device Dissipation @ $T_A = 60°C$ @ $T_A = 25°C$	P_D	210 310	mW
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW
Junction Temperature	T_J	135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Emitter Breakdown Voltage (I_C = 1 mAdc, I_B = 0)	BV_{CEO}	20	—	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, V_{EB} = 0)	BV_{CES}*	30	—	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = 60 °C)	I_{CBO}	— —	— —	0.05 1.0	μAdc
DC Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—	—
High Frequency Current Gain (I_C = 2 mAdc, V_{CE} = 10 Vdc, f = 44 mc)	$\|h_{fe}\|$	20	—	—	db
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	—	—	2.5	pf
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 10 Vdc)	f_T	700	—	—	mc
Conversion Gain (See Figures 7, 8, 9) (I_C = 3 mAdc, V_{CE} = 10 Vdc, 213 to 44 mc)		—	23	—	db

* Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

MPS6507 (continued)

FIGURE 1 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

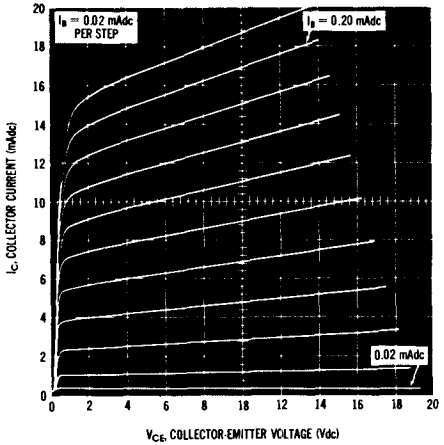
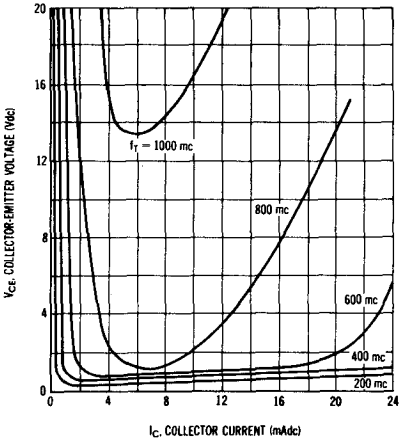


FIGURE 2 — CONTOURS OF CONSTANT GAIN-BANDWIDTH PRODUCT



y PARAMETER VARIATIONS

(V_{CE} = 10 Vdc, I_C = 3 mAdc, T_A = 25°C)

FIGURE 3 — y_{ie}, INPUT ADMITTANCE versus FREQUENCY

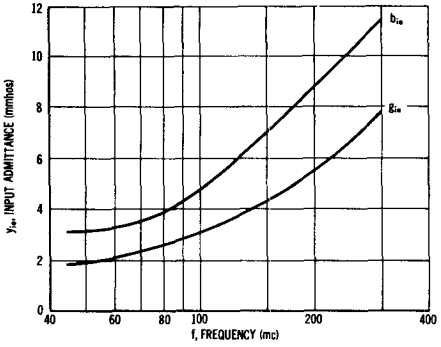


FIGURE 4 — y_{re}, REVERSE TRANSFER ADMITTANCE versus FREQUENCY

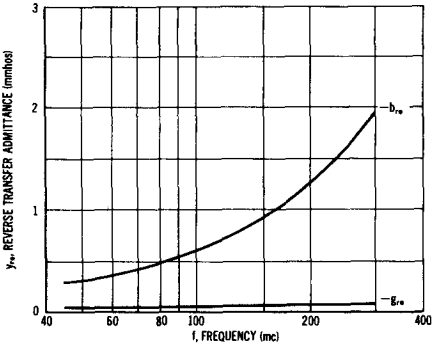


FIGURE 5 — y_{fe}, FORWARD TRANSFER ADMITTANCE versus FREQUENCY

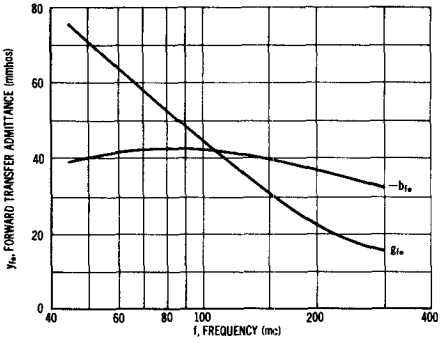
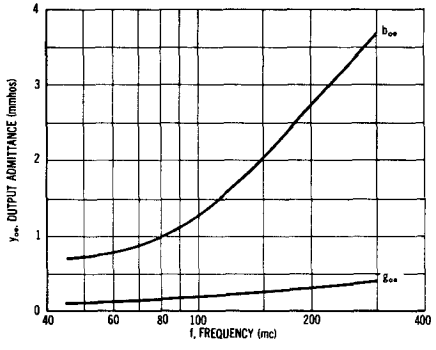


FIGURE 6 — y_{oe}, OUTPUT ADMITTANCE versus FREQUENCY



MPS6507 (continued)

FIGURE 7 — CONVERSION GAIN versus COLLECTOR CURRENT

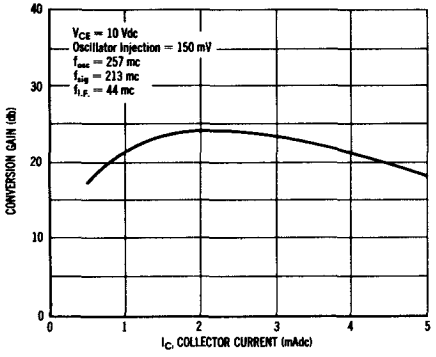


FIGURE 8 — CONVERSION GAIN versus OSCILLATOR INJECTION

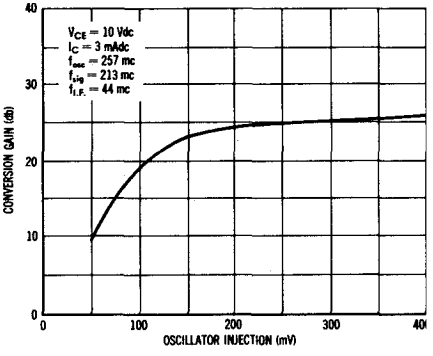
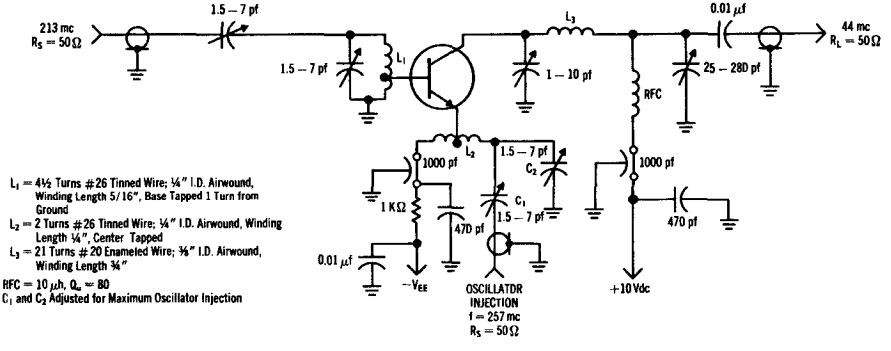


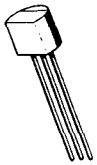
FIGURE 9 — MIXER TEST CIRCUIT



L_1 = 4½ Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length 5/16", Base Tapped 1 Turn from Ground
L_2 = 2 Turns #26 Tinned Wire; ¼" I.D. Airwound, Winding Length ¼", Center Tapped
L_3 = 21 Turns #20 Enameled Wire; ⅜" I.D. Airwound, Winding Length ¾"
RFC = 10 μh, Q_u = 80
C_1 and C_2 Adjusted for Maximum Oscillator Injection

MPS6511

$V_{CB} = 30$ V
$G_{pe} = 30$ dB @ 45 mHz



CASE 29
(TO-92)

NPN silicon transistor designed for use in non-AGC IF applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Collector-Base Voltage	V_{CB}	30	Volts
Collector-Emitter Voltage	V_{CES}	30	Volts
Collector-Emitter Voltage	V_{CEO}	20	Volts
Emitter-Base Voltage	V_{EB}	3	Volts
Collector Current	I_C	100	mAdc
Total Device Dissipation @ $T_A = 60°C$ @ $T_A = 25°C$	P_D	210 310	mW
Junction Temperature	T_J	135	°C

THERMAL RESISTANCE

$\theta_{JA(air)} = 0.357°C/mW$

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Max	Unit
Collector-Emitter Breakdown Voltage*	BV_{CES}*	$I_C = 10$ mAdc, $V_{EB} = 0$	30	—	Vdc
Collector-Emitter Breakdown Voltage	BV_{CEO}	$I_C = 0.5$ mAdc, $I_B = 0$	20	—	Vdc
Collector Cutoff Current	I_{CBO}	$V_{CB} = 15$ Vdc, $I_E = 0$ $V_{CB} = 15$ Vdc, $I_E = 0$, $T_A = 60°C$	— —	0.05 1.0	μAdc
Current Gain	h_{FE}	$V_{CE} = 10$ Vdc, $I_C = 10$ mAdc	25	—	—
Output Capacitance	C_{ob}	$V_{CB} = 10$ Vdc, $I_E = 0$, f = 100 kc	—	2.5	pf
Power Gain	G_{pe}	$V_{CC} = 12$ Vdc, $I_C = 10$ mAdc, f = 45 mc (Figure 1)	30	—	db

*Pulse Test: PW ≤ 300 μsec, duty cycle ≤ 2%.

MPS6511 (continued)

FIGURE 1 — 45 mc POWER GAIN TEST CIRCUIT

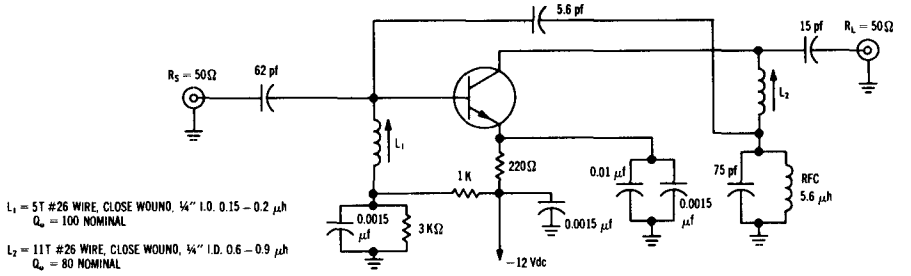


FIGURE 2 — CONTOURS OF CONSTANT GAIN — BANDWIDTH PRODUCT

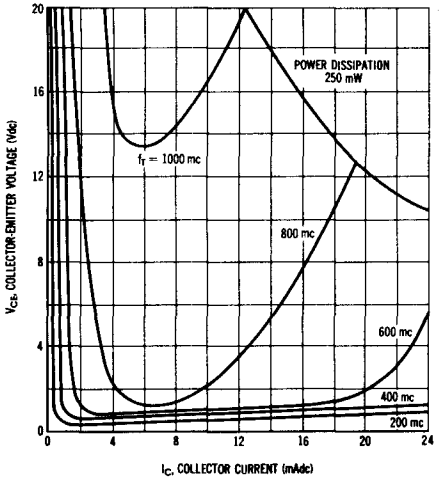


FIGURE 3 — COLLECTOR CURRENT versus COLLECTOR-EMITTER VOLTAGE

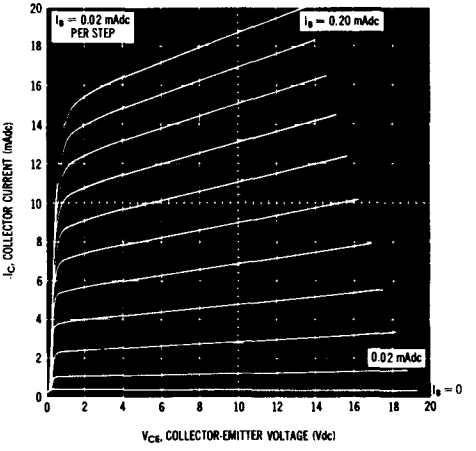


FIGURE 4 — INPUT ADMITTANCE versus COLLECTOR CURRENT

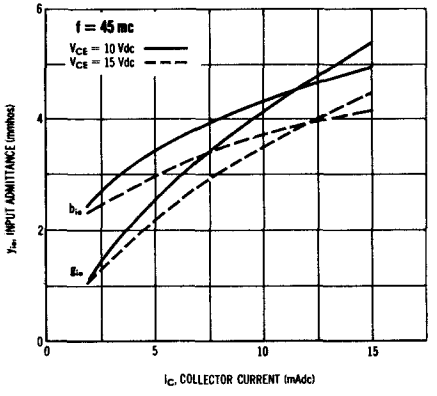
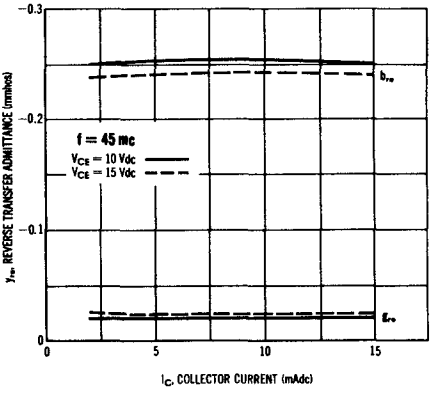


FIGURE 5 — REVERSE TRANSFER ADMITTANCE versus COLLECTOR CURRENT



MPS6511 (continued)

FIGURE 6 — FORWARD TRANSFER ADMITTANCE versus COLLECTOR CURRENT

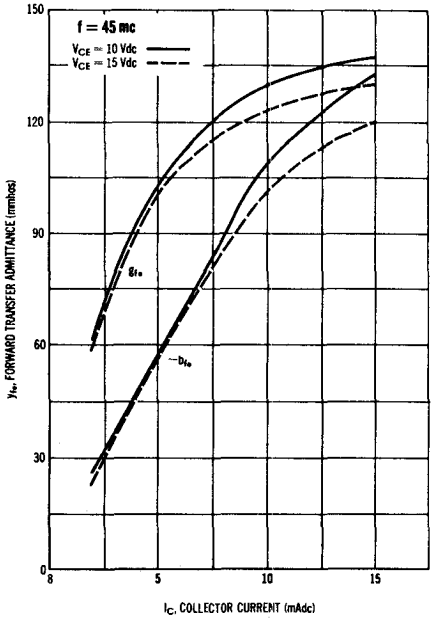


FIGURE 7 — OUTPUT ADMITTANCE versus COLLECTOR CURRENT

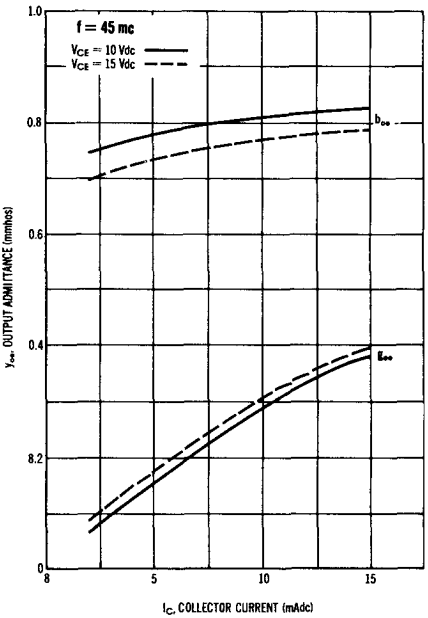
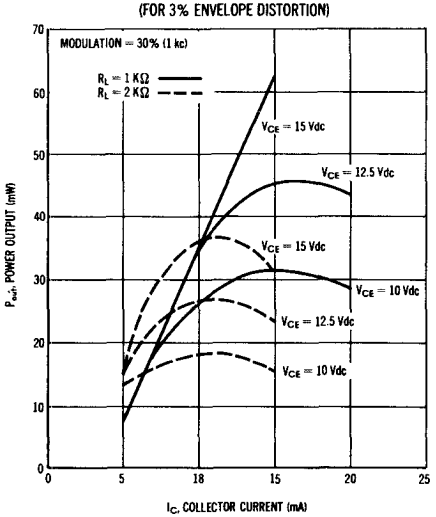


FIGURE 8 — POWER OUTPUT versus COLLECTOR CURRENT

(FOR 3% ENVELOPE DISTORTION)



ADDITIONS AND MODIFICATIONS

ADDITIONS AND MODIFICATIONS

FIELD-EFFECT TRANSISTORS

For case outline dimensions, see page 1-186.

FIELD-EFFECT TRANSISTORS

This section includes field-effect transistors designed for audio as well as RF amplifier applications and for switching purposes.

APPLICATIONS SELECTOR GUIDE

APPLICATIONS	TYPE NO.	CONSTR.	CONDUCTIVITY	OPERATING MODE	COMMENTS
General Purpose (low-frequency amplifiers and switches)	3N124	JFET	N-CHANNEL	TYPE A	Gate 1 and Gate 2 terminals externally accessible
	3N125	JFET	N-CHANNEL	TYPE A	
	3N126	JFET	N-CHANNEL	TYPE A	
	MFE2094	JFET	N-CHANNEL	TYPE A	Source and Drain Interchangeable
	MFE2095	JFET	N-CHANNEL	TYPE A	
Audio Amplifiers	2N3796	MOS	N-CHANNEL	TYPE B	
	2N3797	MOS	N-CHANNEL	TYPE B	
	2N4220	JFET	N-CHANNEL	TYPE A	Low noise figure for preamplifiers
	2N4221	JFET	N-CHANNEL	TYPE A	
	2N4222	JFET	N-CHANNEL	TYPE A	
High-Speed Switching	2N4351	MOS	N-CHANNEL	TYPE C	Complementary
	2N4352	MOS	P-CHANNEL	TYPE C	
RF Amplifiers and mixers	2N4223	JFET	N-CHANNEL	TYPE A	
	2N4224	JFET	N-CHANNEL	TYPE A	

2N3796 (SILICON)
2N3797



V_{DS} = 20-25 V
I_D = 20 mA
P_D = 200 mW



CASE 20
(TO-72)

N-channel insulated gate silicon field effect transistors for low power applications in the audio frequency range.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage 2N3796 2N3797	V_{DS}	 25 20	Vdc
Gate-Source Voltage	V_{GS}	±10	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation at T_A = 25°C Derating Factor above 25°C	P_D	200 1.14	mW mW/°C
Operating Junction Temperature	T_J	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

HANDLING CONSIDERATIONS

Insulated gate field-effect transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedures should be followed:

1. The leads of the devices should remain wrapped in the shipping foil except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the **can** instead of the leads.
3. The substrate and case should be operated at the same or approximately the same dc potential as the gate.
4. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

2N3796, 2N3797 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
Drain-Source Breakdown Voltage		BV_{DSX}				Vdc
(V_{GS} = -4 V, I_D = 5 μA)	2N3796		25	30	—	
(V_{GS} = -7 V, I_D = 5 μA)	2N3797		20	25	—	
Zero-Gate-Voltage Drain Current		I_{DSS}				mAdc
(V_{DS} = 10 V, V_{GS} = 0)	2N3796		0.5	2	3	
	2N3797		2	4	6	
Gate-Source Voltage Cutoff		$V_{GS(off)}$				Vdc
(I_D 0.5 μA, V_{DS} = 10 V)	2N3796		—	-3	-4	
(I_D 2.0 μA, V_{DS} = 10 V)	2N3797		—	-5	-7	
"On" Drain Current		$I_{D(on)}$				mAdc
(V_{DS} = 10 V, V_{GS} = +3.5 V)	2N3796		7	9	14	
	2N3797		9	14	16	
Drain-Gate Reverse Current *		I_{DGO}*				pAdc
(V_{DG} = 10 V, I_S = 0)			—	0.1	1.0	
Gate-Reverse Current *		I_{GSS}*				pAdc
(V_{GS} = -10 V, V_{DS} = 0)			—	0.1	1.0	
(V_{GS} = -10 V, V_{DS} = 0, T_A = 150°C)			—	50	200	
Small-Signal, Common-Source Forward Transfer Admittance		$\|y_{fs}\|$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1 kc)	2N3796		900	1300	1800	
	2N3797		1500	2100	3000	
(V_{DS} = 10 V, V_{GS} = 0, f = 1.0 mc)	2N3796		900	1500	—	
	2N3797		1500	2500	—	
Small-Signal, Common-Source, Output Admittance		$\|y_{os}\|$				μmhos
(V_{DS} = 10 V, V_{GS} = 0, f = 1 kc)	2N3796		—	12	25	
	2N3797		—	30	60	
Small-Signal, Common-Source, Input Capacitance		C_{iss}				pf
(V_{DS} = 10 V, V_{GS} = 0, f = 1 kc)	2N3796		—	5	7	
	2N3797		—	6	8	
Small-Signal, Common-Source, Reverse Transfer Capacitance		C_{rss}				pf
(V_{DS} = 10 V, V_{GS} = 0, f = 1 kc)			—	0.5	0.8	
Noise Figure		NF				db
(V_{DS} = 10 V, V_{GS} = 0, f = 1 kc, R_g = 3 megohms)			—	4.0	—	

* This value of current includes both the FET leakage current as well as the leakage current associated with the test socket and fixture when measured under optimum conditions.

2N3796, 2N3797 (continued)

TYPICAL DRAIN CHARACTERISTICS

FIGURE 1 — 2N3796

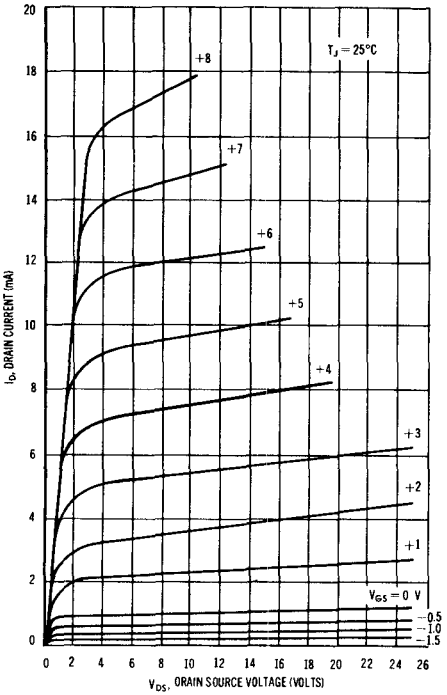
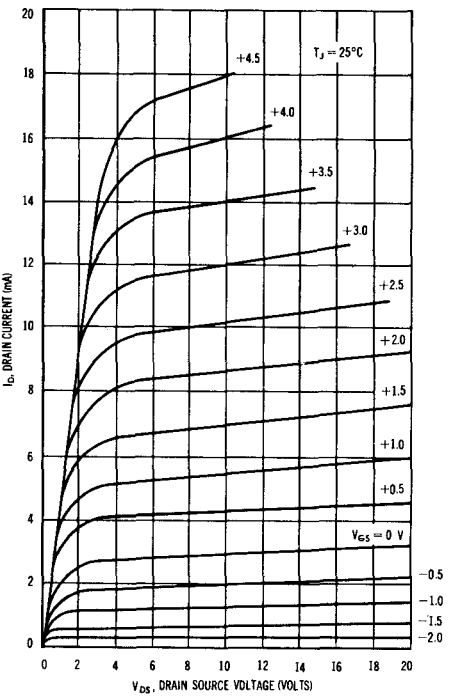


FIGURE 2 — 2N3797



COMMON SOURCE TRANSFER CHARACTERISTICS

FIGURE 3 — 2N3796

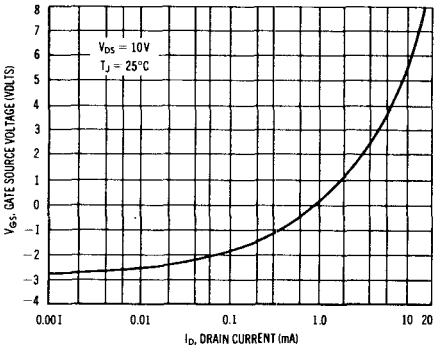
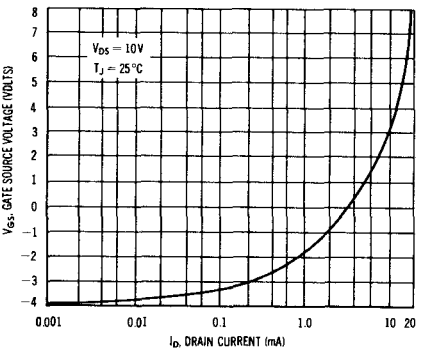


FIGURE 4 — 2N3797



2N3796, 2N3797 (continued)

FIGURE 5 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

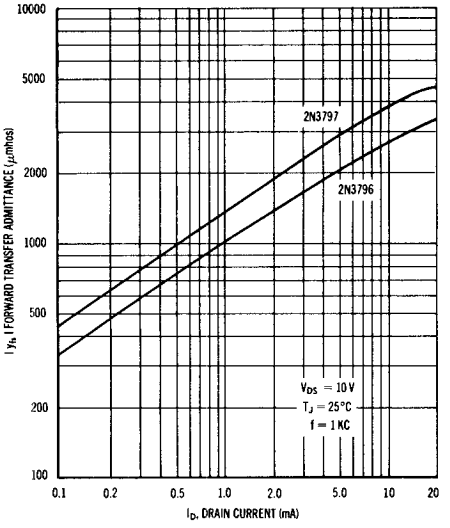


FIGURE 6 — AMPLIFICATION FACTOR versus DRAIN CURRENT

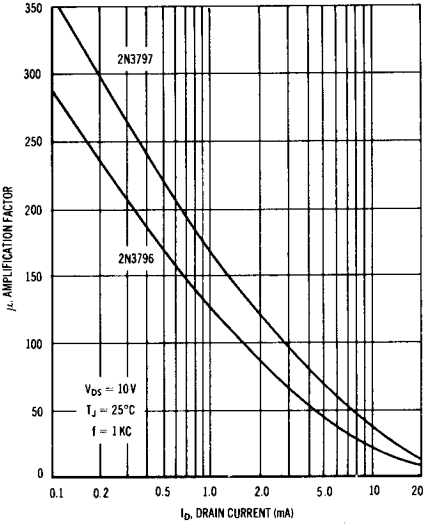


FIGURE 7 — OUTPUT ADMITTANCE versus DRAIN CURRENT

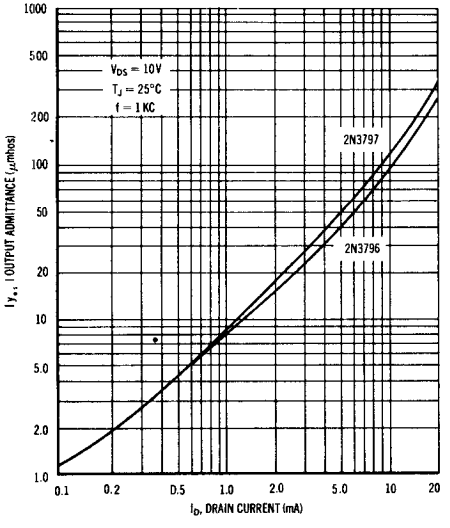
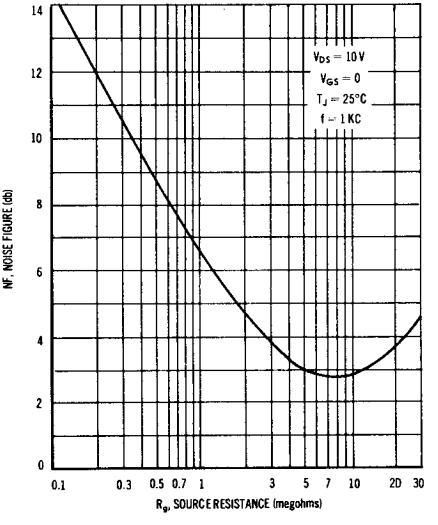


FIGURE 8 — NOISE FIGURE versus SOURCE RESISTANCE



2N3821 (SILICON)
2N3822
2N3824



CASE 20
(TO-72)



$V_{DS} = 50V$
$I_D = 10$ mA
$P_D = 300$ mW

Silicon N-channel junction field-effect transistors, designed for audio amplifier, chopper and switching applications. Drain and Source Interchangeable.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	-50	Vdc
Drain Current	I_D	10	mAdc
Power Dissipation Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to + 200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage ($I_G = -1$ μAdc, $V_{DS} = 0$)		$V_{(BR)GSS}$	-50	-	Vdc
Gate Reverse Current ($V_{GS} = -30$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-0.1	nAdc
($V_{GS} = -30$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)			-	-100	
Gate-Source Cutoff Voltage ($I_D = 0.5$ nAdc, $V_{DS} = 15$ Vdc)	2N3821 2N3822	$V_{GS(off)}$	- -	-4 -6	Vdc
Gate-Source Voltage ($I_D = 58$ μAdc, $V_{DS} = 15$ Vdc)	2N3821	V_{GS}	-0.5	-2.0	Vdc
($I_D = 200$ μAdc, $V_{DS} = 15$ Vdc)	2N3822		-1.0	-4.0	
Drain Cutoff Current ($V_{DS} = 15$ Vdc, $V_{GS} = -8$ Vdc)	2N3824	$I_{D(off)}$	-	0.1	nAdc
($V_{DS} = 15$ Vdc, $V_{GS} = -8$ Vdc, $T_A = 150°C$)	2N3824		-	100	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N3821 2N3822	I_{DSS}*	0.5 2.0	2.5 10	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 kHz)*	2N3821 2N3822	$\lvert y_{fs} \rvert$	1500 3000	4500 6500	μmhos
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 100 MHz)	2N3821 2N3822		1500 3000	- -	
Output Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 kHz)	2N3821 2N3822	$\lvert y_{os} \rvert$*	- -	10 20	μmhos
Drain-Source Resistance ($V_{GS} = 0$, $I_D = 0$, f = 1 kHz)	2N3824	$r_{ds(on)}$	-	250	Ohms
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 MHz)		C_{iss}	-	6	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 MHz)	2N3821 2N3822	C_{rss}	- -	3 3	pF
($V_{GS} = -8$ Vdc, $V_{DS} = 0$, f = 1 MHz)	2N3824		-	3	

*Pulse Test: Pulse Width ≤ 100 ms, Duty Cycle ≤ 10%

2N4220 (SILICON)
2N4221
2N4222

$V_{DS} = 30V$
$I_D = 15$ mA
$P_D = 300$ mW

CASE 20
(TO-72)



Silicon N-channel junction field-effect transistors, designed for general purpose amplifier and switching applications. Drain and Source interchangeable.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Drain Current	I_D	15	mAdc
Total Device Dissipation Derate Above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — NOISE FIGURE versus FREQUENCY

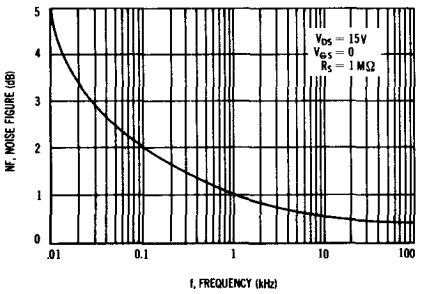
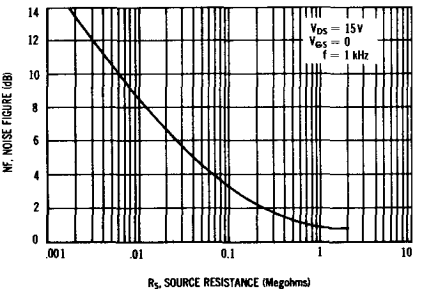


FIGURE 2 — NOISE FIGURE versus SOURCE RESISTANCE



2N4220, 2N4221, 2N4222 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	-30	-	-	Vdc
Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-	-0.1	nAdc
($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)			-	-	-100	
Gate-Source Cutoff Voltage ($I_D = 0.1$ nAdc, $V_{DS} = 15$ Vdc)	2N4220	$V_{GS(off)}$	-	-	-4	Vdc
	2N4221		-	-	-6	
	2N4222		-	-	-8	
Gate-Source Voltage ($I_D = 50\ \mu Adc$, $V_{DS} = 15$ Vdc)	2N4220	V_{GS}	-0.5	-	-2.5	Vdc
($I_D = 200\ \mu Adc$, $V_{DS} = 15$ Vdc)	2N4221		-1.0	-	-5.0	
($I_D = 500\ \mu Adc$, $V_{DS} = 15$ Vdc)	2N4222		-2.0	-	-6.0	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	2N4220	I_{DSS}*	0.5	-	3.0	mAdc
	2N4221		2.0	-	6.0	
	2N4222		5.0	-	15	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 kHz)	2N4220	$\lvert y_{fs} \rvert$*	1000	2500	4000	μmhos
	2N4221		2000	3500	5000	
	2N4222		2500	4500	6000	
Output Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 kHz)	2N4220	$\lvert y_{os} \rvert$*	-	-	10	μmhos
	2N4221		-	-	20	
	2N4222		-	-	40	
Drain-Source Resistance ($V_{DS} = 0$, $V_{GS} = 0$)	2N4220	$r_{ds(on)}$	-	500	-	Ohms
	2N4221		-	400	-	
	2N4222		-	300	-	
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 MHz)		C_{iss}	-	4.5	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, f = 1 MHz)		C_{rss}	-	1.2	2.0	pF

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

FIGURE 3 — TYPICAL DRAIN CHARACTERISTICS

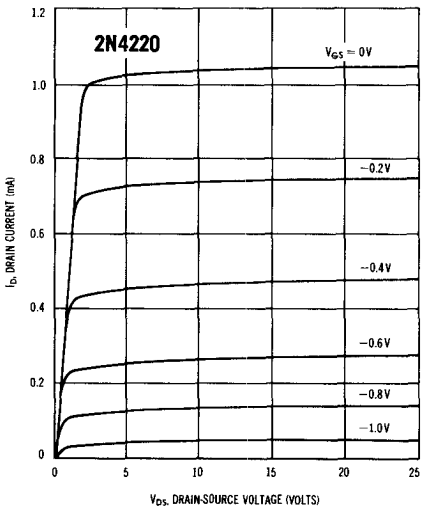
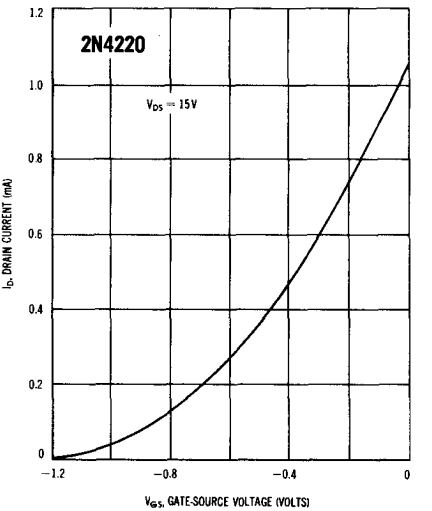


FIGURE 4 — COMMON SOURCE TRANSFER CHARACTERISTICS



2N4220, 2N4221, 2N4222 (continued)

FIGURE 5 — TYPICAL DRAIN CHARACTERISTICS

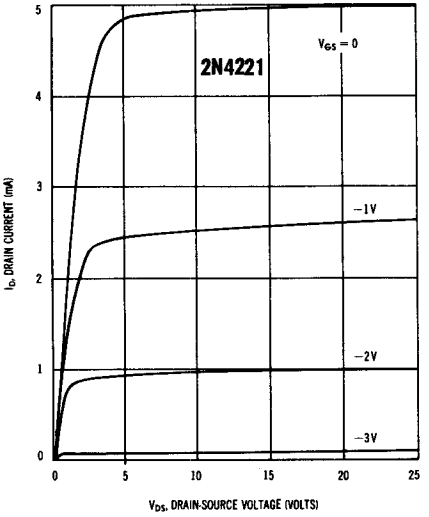


FIGURE 6 — COMMON SOURCE TRANSFER CHARACTERISTICS

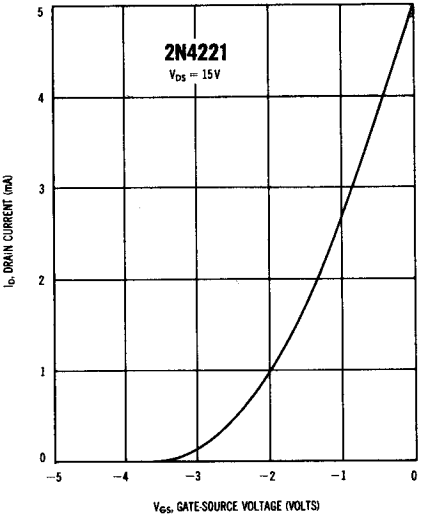


FIGURE 7 — TYPICAL DRAIN CHARACTERISTICS

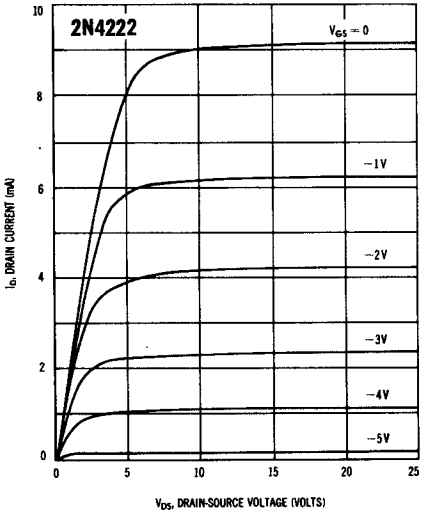
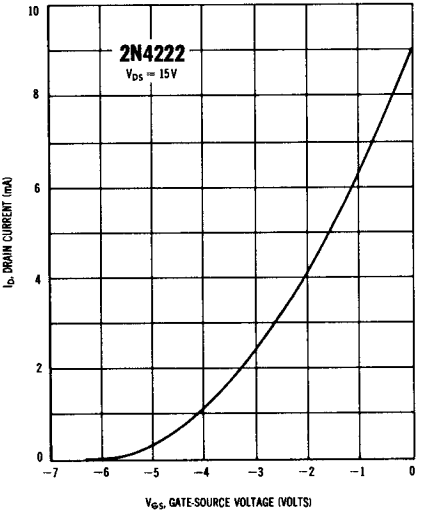


FIGURE 8 — COMMON SOURCE TRANSFER CHARACTERISTICS



2N4223 (SILICON)
2N4224

$V_{DS} = 30V$
$I_D = 20$ mA
$P_D = 300$ mW



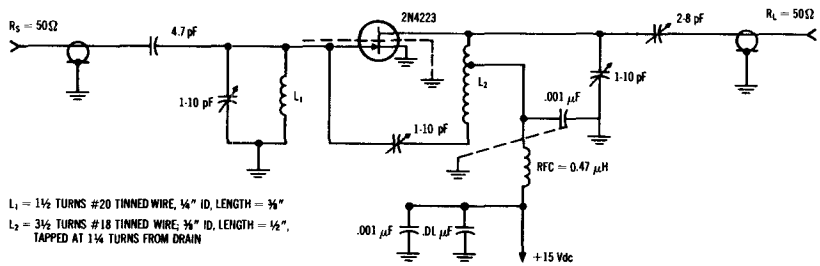
CASE 20
(TO-72)

Silicon N-channel junction field-effect transistors, designed for VHF amplifier and mixer applications. Drain and Source interchangeable.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Drain Current	I_D	20	mAdc
Power Dissipation Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

FIGURE 1 — NOISE FIGURE AND POWER GAIN TEST CIRCUIT



2N4223, 2N4224 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Gate-Source Breakdown Voltage (I_G = -10 μAdc, V_{DS} = 0)		$V_{(BR)GSS}$	-30	-	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0)	2N4223 2N4224	I_{GSS}	- -	-0.25 -0.50	nAdc
(V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 100°C)	2N4223 2N4224		- -	-250 -500	
Gate-Source Cutoff Voltage (I_D = 0.25 nAdc, V_{DS} = 15 Vdc)	2N4223	$V_{GS(off)}$	-	-8	Vdc
(I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	2N4224		-	-8	
Gate-Source Voltage (I_D = 0.3 mAdc, V_{DS} = 15 Vdc)	2N4223	V_{GS}	-1.0	-7.0	Vdc
(I_D = 0.2 mAdc, V_{DS} = 15 Vdc)	2N4224		-1.0	-7.5	
ON CHARACTERISTICS					
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	2N4223 2N4224	I_{DSS}*	3 2	18 20	mAdc
DYNAMIC CHARACTERISTICS					
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)*	2N4223 2N4224	$\|y_{fs}\|$	3000 2000	7000 7500	μmhos
(V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223 2N4224		2700 1700	- -	
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{is})$	-	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)		$Re(y_{os})$	-	200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{iss}	-	6	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)		C_{rss}	-	2	pF
Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1 kohm, f = 200 MHz)	2N4223	NF	-	5	dB
Small-Signal Power Gain (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	2N4223	G_{ps}	10	-	dB

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

FIGURE 2 — TYPICAL DRAIN CHARACTERISTICS

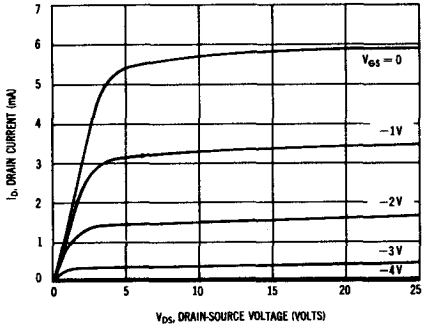
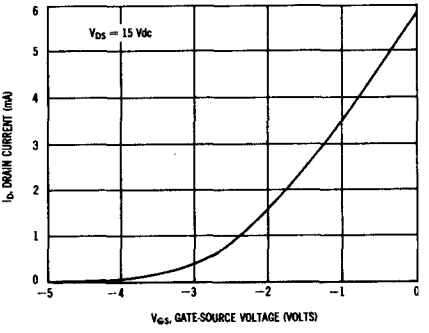


FIGURE 3 — COMMON SOURCE TRANSFER CHARACTERISTICS



2N4223, 2N4224 (continued)

FIGURE 4 — INPUT IMPEDANCE

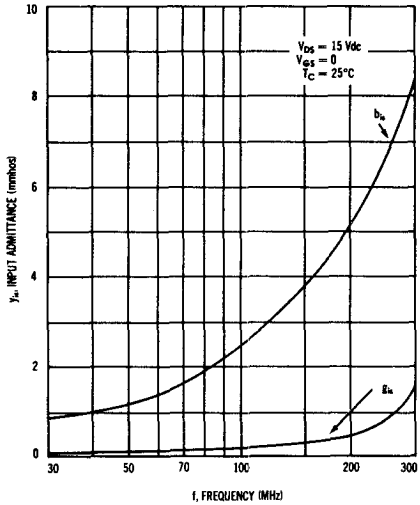


FIGURE 5 — REVERSE TRANSFER ADMITTANCE

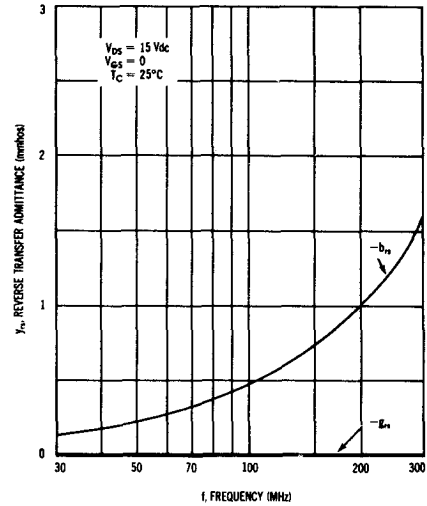


FIGURE 6 — FORWARD TRANSFER ADMITTANCE

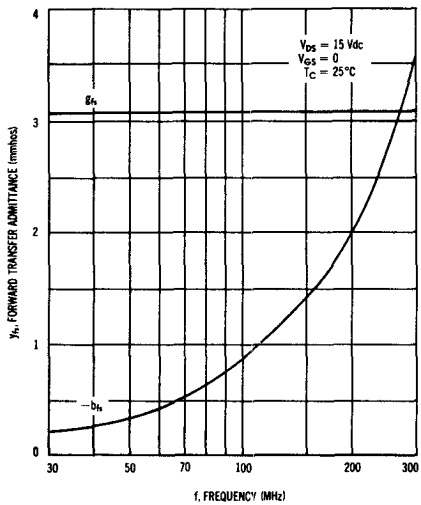
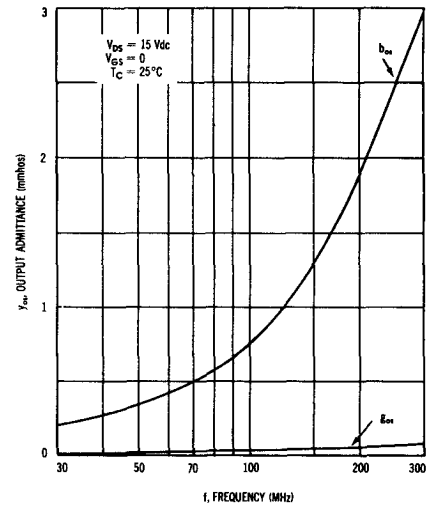
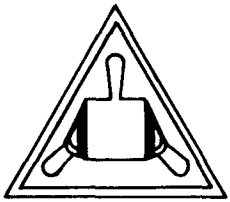


FIGURE 7 — OUTPUT ADMITTANCE



2N4351 (SILICON)



$V_{DS} = 25V$
$I_D = 30mA$
$P_D = 800mW$



CASE 20
(TO-72)

Silicon N-channel insulated-gate field effect transistors, designed for enhancement-mode operation in low power switching applications. The 2N4351 is complementary with type 2N4352 .

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	75	Vdc
Gate-Source Voltage	V_{GS}	±75	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Power Dissipation @ $T_C = 25°C$ Derate above 25°C	P_D	800 4.56	mW mW/°C
Operating Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

HANDLING CONSIDERATIONS

Insulated gate field-effect transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedure should be followed:

1. The leads of the devices should remain wrapped in the shipping foil except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the **can** instead of the leads.
3. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

2N4351 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = 10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	25	—	Vdc
Gate Leakage Current (V_{GS} = ±25 V, V_{DS} = 0)	—	I_{GSS}	—	10	pAdc
Zero-Gate-Voltage Drain Current (V_{DS} = 10 V, V_{GS} = 0)	—	I_{DSS}	—	10	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = 10 V, I_D = 10 μA)	—	$V_{GS(TH)}$	1.0	5.0	Vdc
"ON" Drain Current (V_{GS} = 10 V, V_{DS} = 10 V)	3	$I_{D(on)}$	3.0	—	mA
Drain-Source "ON" Voltage (I_D = 2 mA, V_{GS} = 10 V)	—	$V_{DS(on)}$	—	1.0	V
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = 10 V, I_D = 0, f = 1 kc)	4	$r_{ds(on)}$	—	300	ohms
Forward Transfer Admittance (V_{DS} = 10 V, I_D = 2 mA, f = 1 kc)	1	$\|y_{fs}\|$	1000	—	μmho
Reverse Transfer Capacitance (V_{DS} = 0, V_{GS} = 0, f = 140 kc, substrate connected to source)	2	C_{rss}	—	2.5	pf
Input Capacitance (V_{DS} = 10 V, V_{GS} = 0, f = 140 kc, substrate connected to source)	2	C_{iss}	—	5.5	pf
Drain-Substrate Capacitance ($V_{D(SUB)}$ = 10 V, f = 140 kc, substrate connected to source)	—	$C_{d(sub)}$	—	4.0	pf
SWITCHING CHARACTERISTICS					
Turn-On Delay	6, 10	t_{d1}	—	45	nsec
Rise Time	7, 10	t_r	—	65	nsec
Turn-Off Delay	8, 10	t_{d2}	—	35	nsec
Fall Time	9, 10	t_f	—	75	nsec

I_D = 2 mA, V_{DD} = 10 V, V_{GS} = 10 V, R_D = R_S = 4.5 kohms

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

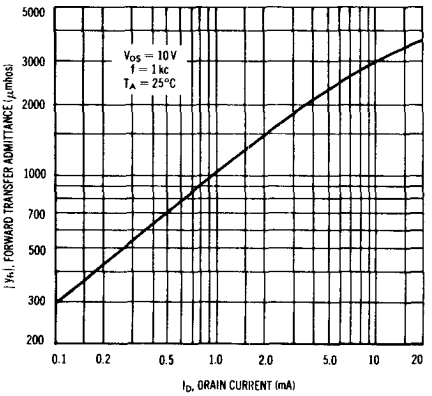
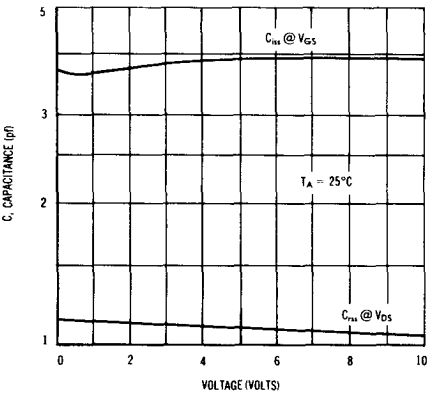


FIGURE 2 — CAPACITANCE



2N4351 (continued)

FIGURE 3 — TRANSFER CHARACTERISTICS

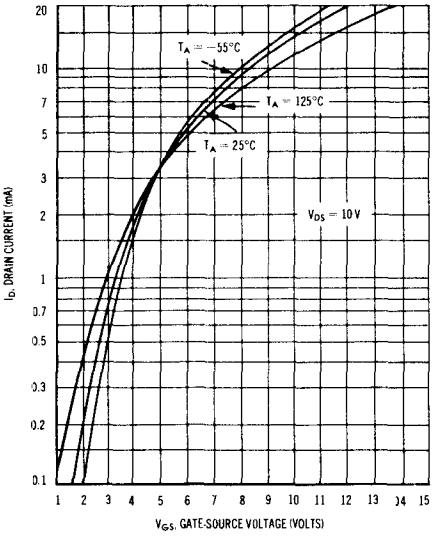


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

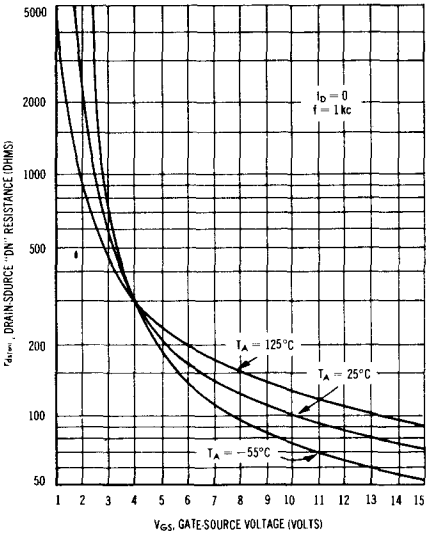
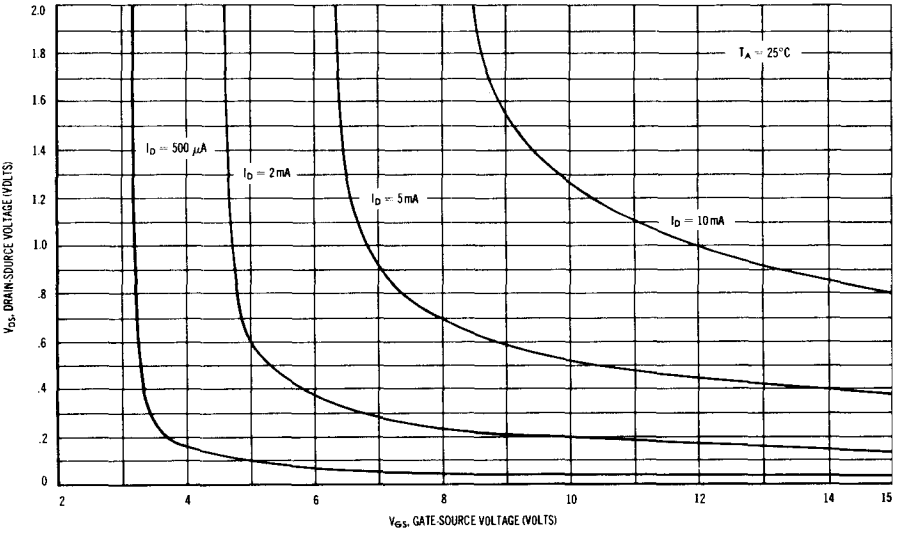


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



2N4351 (continued)

SWITCHING CHARACTERISTICS

($T_A = 25°C$)

FIGURE 6 — TURN-ON DELAY TIME

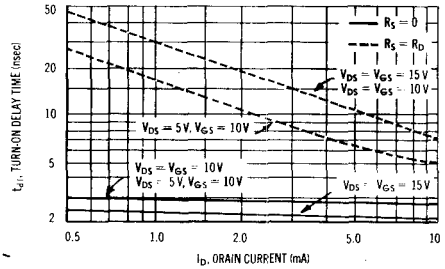


FIGURE 7 — RISE TIME

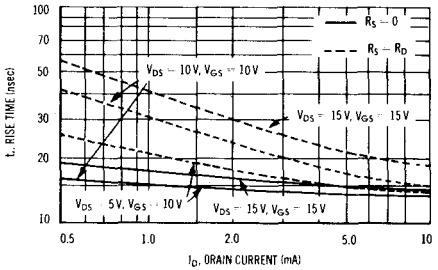


FIGURE 8 — TURN-OFF DELAY TIME

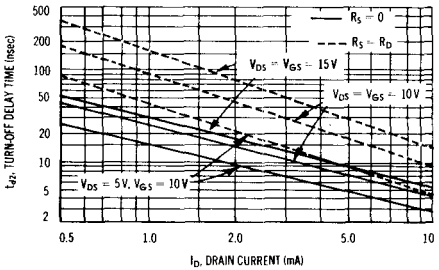


FIGURE 9 — FALL TIME

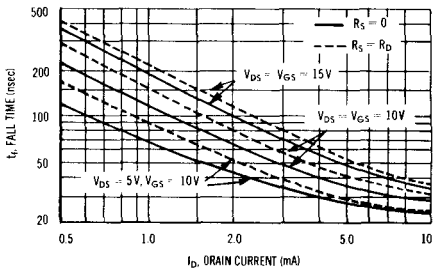


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS

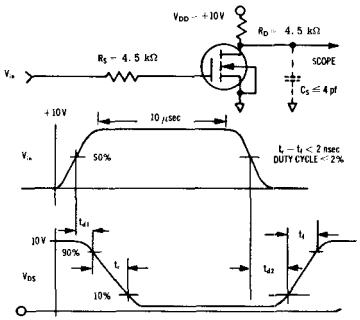
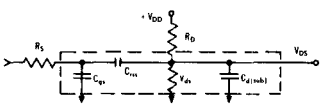


FIGURE 11 — SWITCHING CIRCUIT with IGFET EQUIVALENT MODEL



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

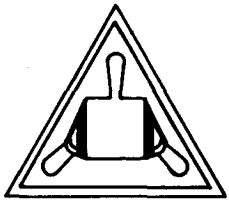
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

2N4352 (SILICON)



$V_{DS} = 25V$
$I_D = 30mA$
$P_D = 800mW$



CASE 20
(TO-72)

Silicon P-channel insulated gate field effect transistor, designed for enhancement-mode operation in low power switching applications. The 2N4352 is complementary with type 2N4351 .

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	25	Vdc
Drain-Gate Voltage	V_{DG}	75	Vdc
Gate-Source Voltage	V_{GS}	± 75	Vdc
Drain Current	I_D	30	mAdc
Power Dissipation at $T_A = 25°C$ Derate above $25°C$	P_D	300 1.7	mW $mW/°C$
Power Dissipation @ $T_C = 25°C$ Derate above $25°C$	P_D	800 4.56	mW $mW/°C$
Operating Junction Temperature	T_J	200	$°C$
Storage Temperature	T_{stg}	-65 to +200	$°C$

HANDLING CONSIDERATIONS

Insulated gate field-effect transistors, due to their extremely high input resistance, are subject to potential damage by the accumulation of excess static charge. To avoid possible damage to the devices while handling, testing, or in actual operation, the following procedures should be followed:

1. The leads of the devices should remain wrapped in the shipping foil except when being tested or in actual operation to avoid the build-up of static charge.
2. Avoid unnecessary handling; when handled, the devices should be picked up by the **can** instead of the leads.
3. The devices should not be inserted or removed from circuits with the power on as transient voltages may cause permanent damage to the devices.

2N4352 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Drain-Source Breakdown Voltage (I_D = -10 μA, V_{GS} = 0)	—	$V_{(BR)DSS}$	-25	—	Vdc
Gate Leakage Current (V_{GS} = ±25 V, V_{DS} = 0)	—	I_{GSS}	—	±10	pAdc
Zero-Gate-Voltage Drain Current (V_{DS} = -10 V, V_{GS} = 0)	—	I_{DSS}	—	5	nAdc
ON CHARACTERISTICS					
Gate-Source Threshold Voltage (V_{DS} = -10 V, I_D = -10 μA)	—	$V_{GS(TH)}$	-1.5	-6.0	Vdc
"ON" Drain Current (V_{GS} = -10 V_{DS} = -10 V)	3	$I_{D(on)}$	2.0	—	mA
Drain-Source "ON" Voltage (I_D = -1 mA, V_{GS} = -10 V)	—	$V_{DS(on)}$	—	3	V
SMALL SIGNAL CHARACTERISTICS					
Drain-Source Resistance (V_{GS} = -10 V, I_D = 0, f = 1 kc)	4	$r_{ds(on)}$	—	600	ohms
Forward Transfer Admittance (V_{DS} = -10 V, I_D = 2 mA, f = 1 kc)	1	$\lvert y_{fs} \rvert$	1000	—	μmho
Reverse Transfer Capacitanre (V_{DS} = 0, V_{GS} = 0, f = 140 kc, substrate connected to sourre)	2	C_{rss}	—	2.5	pf
Input Capacitance (V_{DS} = -10 V, V_{GS} = 0, f = 140 kc, substrate connected to soucce)	2	C_{iss}	—	6.5	pf
Drain-Substrate Capacitance ($V_{D(SUB)}$ = -10 V, f = 140 kc, substrate connected to sourre)	—	$C_{d(sub)}$	—	2.0	pf
SWITCHING CHARACTERISTICS					
Turn-On Delay	6, 10	t_{d1}	—	80	nsec
Rise Time	7, 10	t_r	—	95	nsec
Turn-Off Delay	8, 10	t_{d2}	—	75	nsec
Fall Time	9, 10	t_f	—	100	nsec

I_D = -1 mA, V_{DD} = -10 V, V_{GS} = -10 V, R_D = R_S = 7 kohms

FIGURE 1 — FORWARD TRANSFER ADMITTANCE

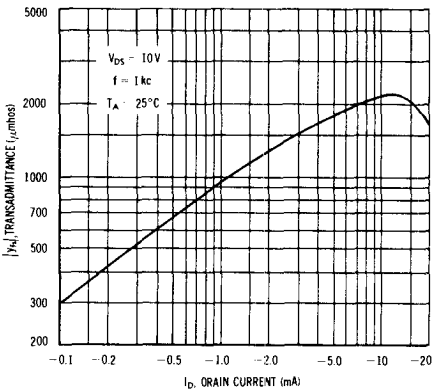
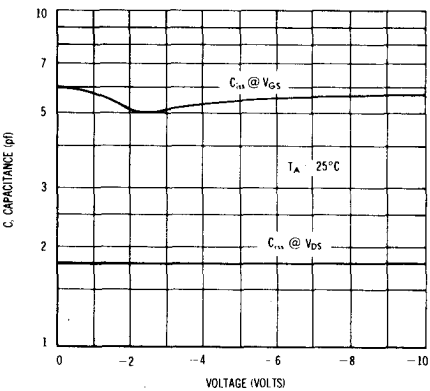


FIGURE 2 — CAPACITANCE



2N4352 (continued)

FIGURE 3 — TRANSFER CHARACTERISTICS

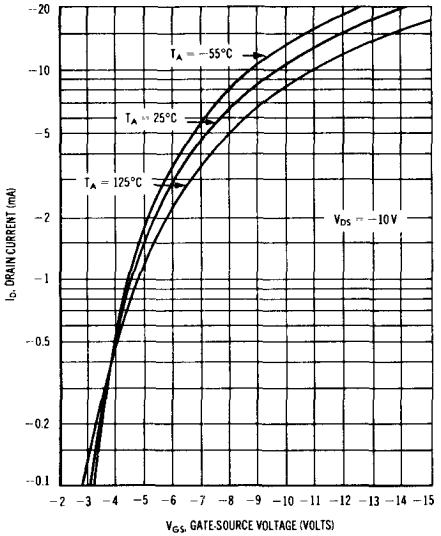


FIGURE 4 — DRAIN SOURCE "ON" RESISTANCE

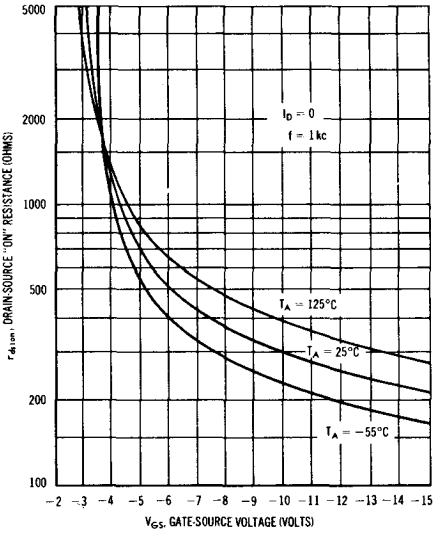
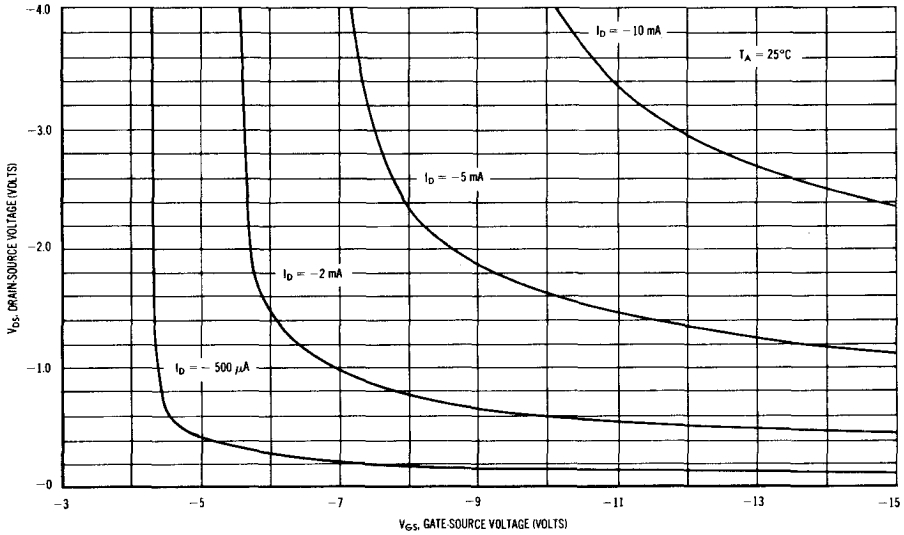


FIGURE 5 — "ON" DRAIN-SOURCE VOLTAGE



2N4352 (continued)

SWITCHING CHARACTERISTICS

($T_A = 25°C$)

FIGURE 6 — TURN-ON DELAY TIME

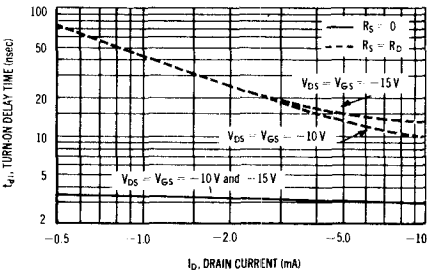


FIGURE 7 — RISE TIME

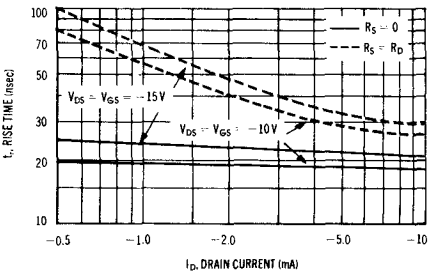


FIGURE 8 — TURN-OFF DELAY TIME

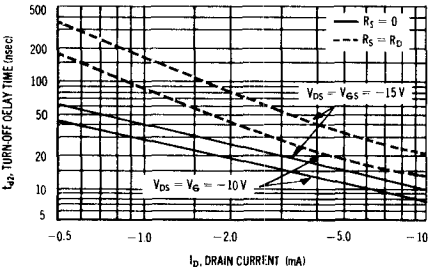


FIGURE 9 — FALL TIME

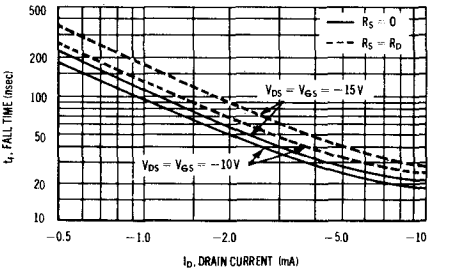
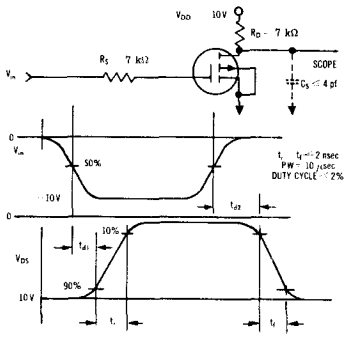


FIGURE 10 — SWITCHING CIRCUIT and WAVEFORMS



The switching characteristics shown above were measured in a test circuit similar to Figure 10. At the beginning of the switching interval, the gate voltage is at ground and the gate-source capacitance ($C_{gs} = C_{iss} - C_{rss}$) has no charge. The drain voltage is at V_{DD}, and thus the feedback capacitance (C_{rss}) is charged to V_{DD}. Similarly, the drain-substrate capacitance ($C_{d(sub)}$) is charged to V_{DD} since the substrate and source are connected to ground.

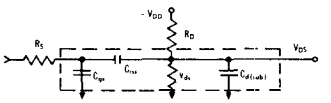
During the turn-on interval, C_{gs} is charged to V_{GS} (the input voltage) through R_S (generator impedance) (Figure 11). C_{rss} must be discharged to $V_{GS} - V_{D(on)}$ through R_S and the parallel combination of the load resistor (R_D) and the channel resistance (r_{ds}). In addition, $C_{d(sub)}$ is discharged to a low value ($V_{D(on)}$) through R_D in parallel with r_{ds}. During turn-off this charge flow is reversed.

Predicting turn-on time proves to be somewhat difficult since the channel resistance (r_{ds}) is a function of the gate-source voltage (V_{GS}). As C_{gs} becomes charged V_{GS} is approaching V_{in} and r_{ds} decreases (see Figure 4) and since C_{rss} and $C_{d(sub)}$ are charged through r_{ds}, turn-on time is quite non-linear.

If the charging time of C_{gs} is short compared to that of C_{rss} and $C_{d(sub)}$, then r_{ds} (which is in parallel with R_D) will be low compared to R_D during the switching interval and will largely determine the turn-on time. On the other hand, during turn-off r_{ds} will be almost an open circuit requiring C_{rss} and $C_{d(sub)}$ to be charged through R_D and resulting in a turn-off time that is long compared to the turn-on time. This is especially noticeable for the curves where $R_S = 0$ and C_{gs} is charged through the pulse generator impedance only.

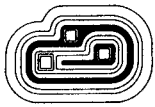
The switching curves shown with $R_S = R_D$ simulate the switching behavior of cascaded stages where the driving source impedance is normally the same as the load impedance. The set of curves with $R_S = 0$ simulates a low source impedance drive such as might occur in complementary logic circuits.

FIGURE 11 — SWITCHING CIRCUIT with IGFET EQUIVALENT MODEL



3N124 (SILICON)
3N125
3N126

$V_{DS} = 50V$
$I_D = 20mA$
$P_D = 800mW$





CASE 20
(TO-72)

N-channel silicon annular tetrode-connected field-effect transistors, designed for low-power switching and amplifier applications in the audio through VHF frequency range, features high breakdown voltage, low transfer capacitance, and tetrode configuration for a broad range of applications.

MAXIMUM RATINGS

Characteristics	Symbol	Rating	Units
Reverse Gate-Source Voltage			Vdc
Gate 1	V_{G1S}	50	
Gate 2	V_{G2S}	50	
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage			Vdc
Gate 1	V_{DG1}	50	
Gate 2	V_{DG2}	50	
Gate 1-Gate 2 Current	I_{G1G2}	1.0	mAdc
Gate 2-Gate 1 Current	I_{G2G1}	1.0	mAdc
Gate Current			mAdc
Gate 1	I_{G1}	20	
Gate 2	I_{G2}	20	
Drain Current	I_D	20	mAdc
Junction Operating Temperature	T_J	200	°C
Storage Temperature Range	Tstg	-65 to+ 200	°C
Total Device Dissipation @ $T_A = 25°C$	P_D	300	mW
Derate Above 25°C		1.71	mW/°C
Total Device Dissipation @ $T_C = 25°C$	P_D	800	mW
Derate Above 25°C		4.57	mW/°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Gate-Source Breakdown Voltage ($I_G = 10\ \mu A$, $V_{DS} = 0$, $V_{G1G2} = 0$)		$V_{(BR)GSS}$	50	—	Vdc
Gate Reverse Current		I_{GSS}			nAdc
($V_{GS} = 25$ V, $V_{DS} = 0$, $V_{G1G2} = 0$)			—	0.250	
($V_{GS} = 25$ V, $V_{DS} = 0$, $V_{G1G2} = 0$, $T_A = 150°C$)			—	250	
Zero-Gate-Voltage Drain Current		I_{DSS}			mAdc
($V_{DS} = 15$ V, $V_{G1G2} = 0$, $V_{GS} = 0$)	3N124		0.2	2.0	
	3N125		1.5	4.5	
	3N126		3.0	9.0	

3N124, 3N125, 3N126 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise specified.)

Characteristic		Symbol	Min	Max	Unit
Gate-Source Voltage		V_{GS}			Vdc
(I_D = 20 μA, V_{DS} = 15 V, V_{G1G2} = 0)	3N124		0.2	2.0	
(I_D = 150 μA, V_{DS} = 15 V, V_{G1G2} = 0)	3N125		1.0	3.0	
(I_D = 300 μA, V_{DS} = 15 V, V_{G1G2} = 0)	3N126		1.5	5.5	
Gate-Source Cutoff Voltage		$V_{GS(off)}$			Vdc
(V_{DS} = 15 V, I_D = 1 μA, V_{G1G2} = 0)	3N124		—	-2.5	
	3N125		—	-4.0	
	3N126		—	-6.5	
Gate 1-Source Cutoff Voltage		$V_{G1S(off)}$			Vdc
(V_{DS} = 15 V, I_D = 1 μA, V_{G2S} = 0)	3N124		—	-5	
	3N125		—	-8	
	3N126		—	-18	
Gate 2-Source Cutoff Voltage		$V_{G2S(off)}$			Vdc
(V_{DS} = 15 V, I_D = 1 μA, V_{G1S} = 0)	3N124		—	-8	
	3N125		—	-14	
	3N126		—	-26	
Gate 1-Gate 2 Reach Through Voltage		V_{G1G2}			Vdc
(V_{DS} = 15 V, I_{G1G2} = 10 μA, V_{G2S} = 0)	3N124		1	—	
	3N125		3	—	
	3N126		5	—	
Gate 2-Gate 1 Reach Through Voltage		V_{G2G1}			Vdc
(V_{DS} = 15 V, I_{G2G1} = 10 μA, V_{G1S} = 0)	3N124		2	—	
	3N125		6	—	
	3N126		10	—	
Gate 1-Gate 2 Reach Through Drain Current		I_D			μA
(V_{DS} = 15 V, I_{G1} = 10 μA, V_{G2S} = 0)			—	1.0	
Gate 2-Gate 1 Reach Through Drain Current		I_D			μA
(V_{DS} = 15 V, I_{G2} = 10 μA, V_{G1S} = 0)			—	1.0	

SMALL-SIGNAL COMMON-SOURCE CHARACTERISTICS

Forward Transfer Admittance					μmhos
(V_{DS} = 15 V, V_{G1S} = V_{G2S} = 0, f = 1 kc)					
Gate 1-Gate 2	3N124	$\lvert y_{fs} \rvert$	500	2000	
	3N125		800	2400	
	3N126		1200	3600	
Gate 1 only	3N124	$\lvert y_{fs1} \rvert$	250	1000	
	3N125		400	1600	
	3N126		600	2700	
Gate 2 only	3N124	$\lvert y_{fs2} \rvert$	200	800	
	3N125		250	1000	
	3N126		400	1200	
(f = 100 mc) Gate 1 only	3N124	$\lvert y_{fs1} \rvert$	250	—	
	3N125		400	—	
	3N126		600	—	
Output Admittance		$\lvert y_{os} \rvert$			μmhos
(V_{DS} = 15 V, V_{G1S} = V_{G2S} = 0, f = 1 kc)	3N124		—	2.0	
	3N125		—	10.0	
	3N126		—	20.0	
Input Capacitance					pf
(V_{DS} = 15 V, V_{G1S} = V_{G2S} = 0, f = 1 kc)					
Gate 1-Gate 2		C_{iss}	—	14	
Gate 1 only		C_{iss1}	—	5	
Gate 2 only		C_{iss2}	—	9	
Reverse Transfer Capacitance					pf
(V_{DS} = 15 V, V_{G1S} = V_{G2S} = 0, f = 1 kc)					
Gate 1-Gate 2		C_{rss}	—	2.0	
Gate 1 only		C_{rss1}	—	0.5	
Gate 2 only		C_{rss2}	—	1.5	
Spot Noise Figure		NF			db
(V_{DS} = 15 V, V_{G1S} = V_{G2S} = 0, R_g = 1 megohm, f = 1 kc, BW = 100 cps)			—	4	
Static Drain-Source "ON" Resistance		$r_{DS(on)}$	Typical		ohms
(V_{GS} = 0, V_{DS} = 0)	3N124		1000		
	3N125		750		
	3N126		500		

3N124, 3N125, 3N126 (continued)

FIGURE 1 — DRAIN CURRENT versus GATE SOURCE VOLTAGE

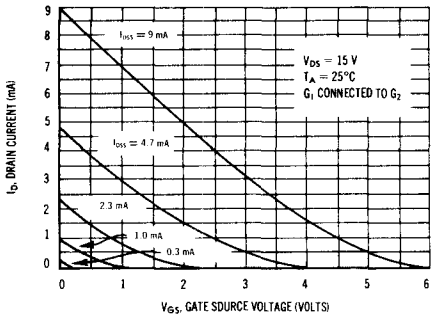


FIGURE 2 — PARAMETER INTER-RELATIONSHIPS

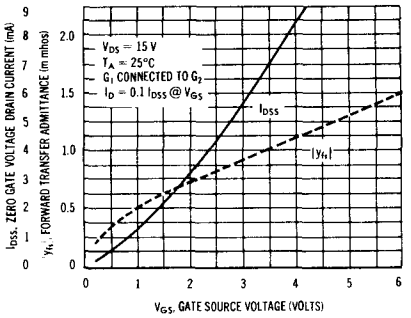


FIGURE 3 — FORWARD TRANSFER ADMITTANCE versus DRAIN CURRENT

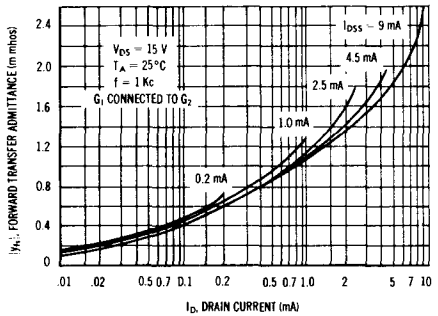
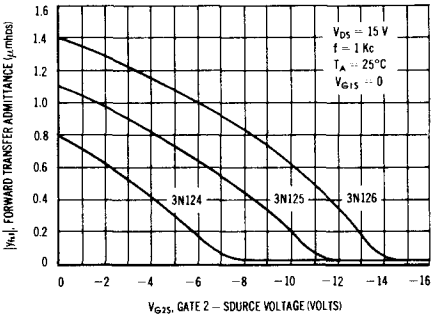


FIGURE 4 GATE 1 — FORWARD TRANSFER ADMITTANCE versus GATE 2 — SOURCE VOLTAGE



NOISE CHARACTERISTICS

V_{DS} = 15 V, I_D = I_{DSS}, T_A = 25°C

GATE 1 CONNECTED TO GATE 2

FIGURE 5A — FREQUENCY VARIATIONS

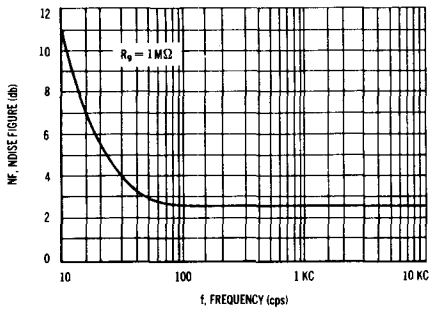
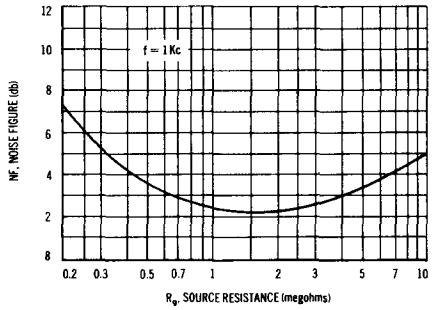


FIGURE 5B — SOURCE RESISTANCE VARIATIONS



3N124, 3N125, 3N126 (continued)

HIGH FREQUENCY y PARAMETER CHARACTERISTICS

$V_{DS} = 15$ V, $V_{GS} = 0$, $T_A = 25°C$ — GATE 2 CONNECTED TO SOURCE

FIGURE 6 — INPUT ADMITTANCE

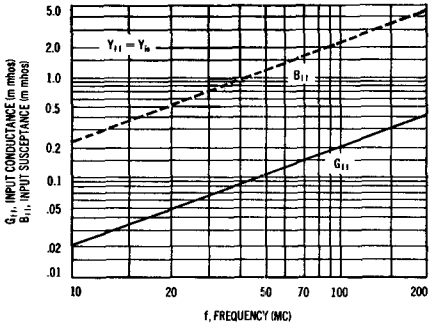


FIGURE 7 — REVERSE TRANSFER ADMITTANCE

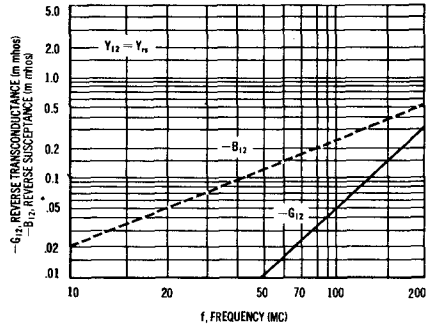


FIGURE 8 — FORWARD TRANSFER ADMITTANCE

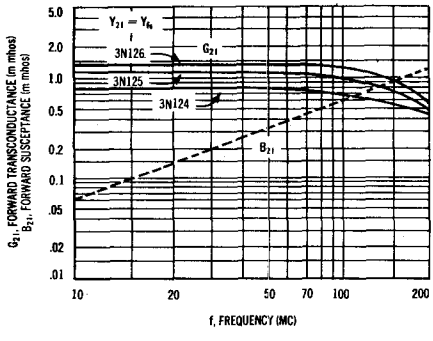
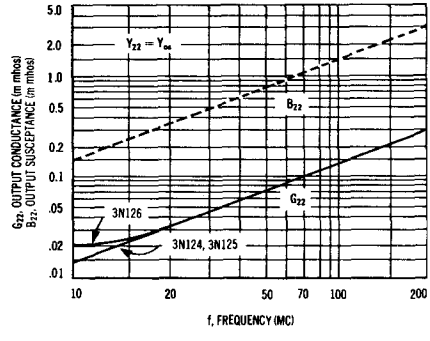
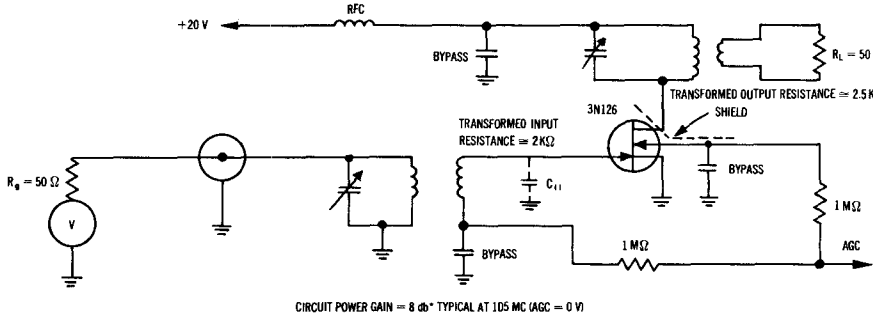


FIGURE 9 — OUTPUT ADMITTANCE



TYPICAL PERFORMANCE USING THE 3N126



CIRCUIT POWER GAIN = 8 db* TYPICAL AT 105 MC (AGC = 0 V)

*includes circuit losses

MFE2093 (SILICON)
MFE2094
MFE2095



CASE 20
(TO-72)

$V_{DS} = 50V$
$I_D = 3$ mA
$P_D = 300$ mW

Silicon N-channel junction field-effect transistors, designed for low-power audio amplifier and switching applications. Drain and Source interchangeable.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	50	Vdc
Drain-Gate Voltage	V_{DG}	50	Vdc
Gate-Source Voltage	V_{GS}	-50	Vdc
Drain Current	I_D	3	mAdc
Power Dissipation	P_D	300	mW
Derate above 25°C		2	mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Gate-Source Breakdown Voltage ($I_G = -10\ \mu Adc$, $V_{DS} = 0$)		$V_{(BR)GSS}$	-50	-	-	Vdc
Gate Reverse Current ($V_{GS} = -15$ Vdc, $V_{DS} = 0$)		I_{GSS}	-	-	-0.1	nAdc
($V_{GS} = -15$ Vdc, $V_{DS} = 0$, $T_A = 150°C$)			-	-	-100	
Gate-Source Cutoff Voltage ($I_D = 0.1$ nAdc, $V_{DS} = 15$ Vdc)	MFE2093	$V_{GS(off)}$	-	-1.5	-2.5	Vdc
	MFE2094		-	-3.0	-4.5	
	MFE2095		-	-4.5	-5.5	
ON CHARACTERISTICS						
Zero-Gate-Voltage Drain Current* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$)	MFE2093	I_{DSS}*	0.1	0.35	0.7	mAdc
	MFE2094		0.4	0.7	1.4	
	MFE2095		1.0	1.5	3.0	
DYNAMIC CHARACTERISTICS						
Forward Transfer Admittance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1$ kHz)*	MFE2093	$\lvert y_{fs} \rvert$	250	400	500	μmhos
	MFE2094		350	500	700	
	MFE2095		400	600	800	
($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 100$ MHz)	MFE2093		150	-	-	
	MFE2094		250	-	-	
	MFE2095		300	-	-	
Output Admittance* ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 1$ kHz)	MFE2093	$\lvert y_{os} \rvert$*	-	0.5	1.5	μmhos
	MFE2094		-	1.0	3.0	
	MFE2095		-	4.0	10.0	
Drain-Source Resistance ($V_{DS} = 0$, $V_{GS} = 0$)	MFE2093	$r_{ds(on)}$	-	2500	-	Ohms
	MFE2094		-	1600	-	
	MFE2095		-	1300	-	
Input Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 140$ kHz)		C_{iss}	-	4.0	6.0	pF
Reverse Transfer Capacitance ($V_{DS} = 15$ Vdc, $V_{GS} = 0$, $f = 140$ kHz)		C_{rss}	-	1.2	2.0	pF

*Pulse Test: Pulse Width ≤ 630 ms, Duty Cycle ≤ 10%

ADDITIONS AND MODIFICATIONS

MULTIPLE & SPECIAL DEVICES

For case outline dimensions, see page 1-186.

MULTIPLE and SPECIAL DEVICES

This section contains data-sheet specifications for multiple devices such as dual transistors and dual diodes, and other special semiconductors that have no specific category.

Device type numbers included in this section are:

DUAL TRANSISTORS FOR DIFFERENTIAL AMPLIFIER APPLICATIONS (MATCHED PAIRS)

TYPE	PAGE NUMBER	MATERIAL	POLARITY
2N2060	11-4 thru 11-6	Silicon	NPN
2N2060A		Silicon	NPN
2N2223		Silicon	NPN
2N2223A		Silicon	NPN
2N2480		Silicon	NPN
2N2480A	11-4 thru 11-6	Silicon	NPN
2N3409	11-9, 11-10	Silicon	NPN
2N3410	11-9, 11-10	Silicon	NPN
2N3411	11-9, 11-10	Silicon	NPN
MD1120	11-18, 11-19	Silicon	NPN
MD1121	11-18, 11-19	Silicon	NPN
MD1122	11-18, 11-19	Silicon	NPN
MD1129	11-24, 11-25	Silicon	NPN
MD1130	11-26, 11-27	Silicon	PNP
MD1132	11-30, 11-31	Silicon	NPN

DUAL TRANSISTORS FOR HIGH SPEED SWITCHING AND AMPLIFIER APPLICATIONS

TYPE	PAGE NUMBER	MATERIAL	POLARITY	COMPLEMENTARY CIRCUITRY WITH
2N2913 thru 2N2920	11-7, 11-8	Silicon	NPN	
2N2972 thru 2N2979	11-7, 11-8	Silicon	NPN	
2N3800 thru 2N3811	11-11, 11-12	Silicon	PNP	
MD984	11-14, 11-15	Silicon	PNP	
MD1126	11-20, 11-21	Silicon	NPN	
MD1127	11-20, 11-21	Silicon	NPN	
MD1128	11-22, 11-23	Silicon	NPN	
MD1131	11-28, 11-29	Silicon	NPN	
MD1134	11-32, 11-33	Silicon	NPN	
MD2218, A	11-34 thru 11-40	Silicon	NPN	MD2904
MD2219, A	11-34 thru 11-40	Silicon	NPN	Series
MD2904, A	11-41 thru 11-46	Silicon	PNP	MD2218
MD2905, A	11-41 thru 11-46	Silicon	PNP	Series
MD3250, A	11-47 thru 11-50	Silicon	PNP	
MD3251, A	11-47 thru 11-50	Silicon	PNP	

DUAL TRANSISTORS, NPN-PNP FOR COMPLEMENTARY SWITCHING AND AMPLIFICATION

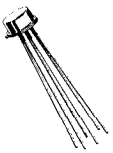
TYPE	PAGE NUMBER	MATERIAL	POLARITY	CONCURRENT COMPLEMENTARY WITH
MD986	11-16, 11-17	Silicon	NPN-PNP	NPN - 2N2218 and 2N2219 PNP - 2N2904 and 2N2905
MD6001	11-51, 11-52	Silicon	NPN-PNP	NPN - 2N2218 and 2N2219
MD6002	11-51, 11-52	Silicon	NPN-PNP	PNP - 2N2904 and 2N2905

SPECIAL DEVICES

TYPE	PAGE NUMBER	MATERIAL	DESCRIPTION	APPLICATION
MCL1300	11-13	Silicon	Field-Effect Diode	Current Limiter
MCL1301			Effect	
MCL1302			Diode	
MCL1303				
MCL1304	11-13	Silicon		
MSD6100	11-53, 11-54	Silicon	Dual Switching Diode (Plastic Case)	High Speed Switch
MSD6101	11-55, 11-56	Silicon	Discriminator Diode (Plastic Case)	FM Discriminator

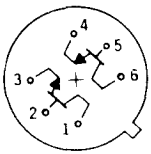
2N2060, A
2N2223, A
2N2480, A

V_{CEO} = 40-60 V
I_C = 500 mA



NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

CASE 32A



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage 2N2060, 2N2060A, 2N2223, 2N2223A 2N2480 2N2480A	V_{CBO}	100 75 80		Vdc
Collector-Emitter Voltage 2N2060, 2N2060A, 2N2223, 2N2223A 2N2480, 2N2480A	V_{CEO}	60 40		Vdc
Collector-Emitter Voltage ($R_{BE} \leq 10\Omega$) 2N2060, 2N2060A, 2N2223, 2N2223A	V_{CER}	80		Vdc
Emitter-Base Voltage 2N2060, 2N2060A, 2N2223, 2N2223A 2N2480, 2N2480A	V_{EBO}	7 5		Vdc
DC Collector Current	I_C	500		mAdc
Operating Junction Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +300		°C
		One Side	Both Sides	
Total Device Dissipation @ T_C = 25 °C Derate above 25°C	P_D	1.6 9.1	3.0 17.2	Watts
Total Device Dissipation @ T_A = 25 °C Derate above 25 °C	P_D	0.5 2.86	0.6 3.43	Watt

2N2060, A, 2N2223, A, 2N2480, A (continued)

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480 2N2480A	BV_{CBO}	100 75 80	- - -	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 20 mAdc, I_B = 0) (I_C = 30 mAdc, I_B = 0)	2N2480, 2N2480A 2N2060, 2N2060A, 2N2223, 2N2223A	BV_{CEO}*	40 60	- -	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 100 mA, $R_{BE} \leq 10\Omega$)	2N2060, 2N2060A, 2N2223, 2N2223A	BV_{CER}*	80	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480, 2N2480A	BV_{EBO}	7 5	- -	Vdc
Collector Cutoff Current (V_{CB} = 60 Vdc, I_E = 0) (V_{CB} = 30 Vdc, I_E = 0, T_A = 150°C) (V_{CB} = 80 Vdc, I_E = 0) (V_{CB} = 80 Vdc, I_E = 0, T_A = 150°C)	2N2480 2N2480A 2N2480, 2N2480A 2N2060, 2N2060A 2N2223, 2N2223A 2N2060, 2N2060A 2N2223, 2N2223A	I_{CBO}	- - - - - - -	.050 .020 15 .002 .010 10 15	μAdc
Emitter Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480 2N2480A	I_{EBO}	- - - -	2 10 50 20	nAdc
DC Current Gain (I_C = 10 μAdc, V_{CE} = 5 Vdc) (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 1 mAdc, V_{CE} = 5 Vdc) (I_C = 10 mAdc, V_{CE} = 5 Vdc)*	2N2060, 2N2060A 2N2223, 2N2223A 2N2060, 2N2060A 2N2223, 2N2223A 2N2480 2N2480A 2N2060, 2N2060A 2N2480 2N2480A 2N2060, 2N2060A 2N2223, 2N2223A	h_{FE}	25 15 30 25 20 35 40 30 50 50 50	75 - 90 150 - - 120 350 200 150 200	-
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2060, 2N2060A, 2N2223A 2N2223, 2N2480, 2N2480A 2N2060, 2N2060A 2N2480, 2N2480A	h_{FE1}/h_{FE2}**	0.9 0.8 0.9 0.8	1.0 1.0 1.0 1.0	-
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 5 Vdc) (I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2060A 2N2060, 2N2223A, 2N2480A 2N2480 2N2223 2N2060, 2N2060A, 2N2480A 2N2480	$\lvert V_{BE1} - V_{BE2} \rvert$	- - - - - -	3 5 10 15 5 10	mVdc

2N2060, A, 2N2223, A, 2N2480, A (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic		Symbol	Min	Max	Unit
Collector-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)	2N2060A 2N2060, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{CE(sat)}$	- - -	0.6 1.2 1.3	Vdc
Base-Emitter Saturation Voltage (I_C = 50 mAdc, I_B = 5 mAdc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A 2N2480	$V_{BE(sat)}$	- -	0.9 1.0	Vdc
Small-Signal Forward Current Transfer Ratio (I_C = 50 mAdc, V_{CE} = 10 Vdc, f = 20 mc)	2N2223, 2N2223A, 2N2480, 2N2480A 2N2060, 2N2060A	h_{fe}	2.5 3.0	- -	-
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 1 mc)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A 2N2480	C_{ob}	- - -	15 18 20	pf
Collector Input Capacitance (V_{EB} = 0.5 Vdc, F = 1 mc)	2N2060, 2N2060A, 2N2223, 2N2223A, 2N2480A	C_{ib}	-	85	pf
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N2060, 2N2060A 2N2223, 2N2223A 2N2480A	h_{fe}	50 40 50	150 120 300	-
Input Impedance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc) (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N2060, 2N2060A, 2N2223, 2N2223A 2N2480A 2N2060, 2N2060A 2N2480A	h_{ib} h_{ib} h_{ie} h_{ie}	20 20 1000 1000	30 35 4000 5000	ohms
Output Admittance (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc) (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N2223, 2N2223A 2N2060, 2N2060A, 2N2480A	h_{ob} h_{oe}	- 4.0	0.5 16	μmhos
Voltage Feedback Ratio, Common Base (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kc)	2N2223, 2N2223A	h_{rb}	-	3	$X10^{-4}$
Noise Figure (I_C = 0.3 mAdc, V_{CE} = 10 Vdr, f = 1 kc, R_G = 510Ω, BW = 1 rps) (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, f = 1 kc, R_G = 510Ω, BW = 200 cps) (I_C = 0.3 mAdc, V_{CE} = 10 Vdc, f = 1 kc, R_G = 1 kΩ, BW = 15.7 kc†)	2N2480, 2N2480A 2N2060, 2N2060A 2N2060, 2N2060A	NF	- - -	8 8 8	db
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C) (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	2N2060A 2N2060 2N2223, 2N2223A 2N2480, 2N2480A 2N2060 2N2060A 2N2223, 2N2223A 2N2480, 2N2480A	$\Delta(V_{BE1}-V_{BE2})$	- - - - - - - -	0.4 0.8 2.0 1.2 1.0 0.5 2.5 1.5	mVdc

* Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2% ** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

† Amplifier: 3 db points at 25 cps and 10 kc with a roll-off of 6 db per octave

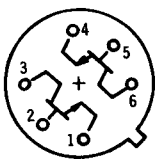
2N2913 thru 2N2920
2N2972 thru 2N2979

V_{CEO} = 45-60 V
I_C = 30 mA
P_D = 300 mW one side
600 mW both sides

Dual NPN silicon annular transistors, especially designed for low-level, low-noise differential amplifier applications, feature very high Beta guaranteed from 10 μAdc to 1.0 mAdc and excellent noise characteristics.

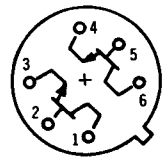


CASE 35
(TO-71)





CASE 32A



Pin Connections, Bottom View
All Leads Electrically Isolated From Case

MAXIMUM RATINGS (each side) (at 25°C ambient temperature unless otherwise noted)

Characteristics	Symbol	Rating		Unit
		2N2913-18 2N2972-77	2N2919-20 2N2978-79	
Collector-Base Voltage	V_{CBO}	45	60	Vdc
Collector-Emitter Voltage	V_{CEO}	45	60	Vdc
Emitter-Base Voltage	V_{EBO}	6		Vdc
DC Collector Current	I_C	30		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D			
TO-5 Case Derate above 25°C		300 1.7	600 3.4	mW mW/°C
TO-18 Case Derate above 25°C		250 1.43	300 1.72	mW mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
TO-5 Case Derate above 25°C		750 4.3	1500 8.6	mW mW/°C
TO-18 Case Derate above 25°C		500 2.85	750 4.3	mW mW/°C

2N2913 thru 2N2920, 2N2972 thru 2N2979 (continued)

ELECTRICAL CHARACTERISTICS (each side)
(at 25°C ambient temperature unless otherwise noted)

Characteristics		Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	2N2913 thru 2N2918, 2N2972 thru 2N2977	BV_{CBO}	45	—	—	Vdc
	2N2919, 2N2920, 2N2978, 2N2979		60	90	—	
Collector-Emitter Sustaining Voltage (I_C = 10 mAdc, I_B = 0)	2N2913, thru 2N2918, 2N2972 thru 2N2977	$BV_{CEO(sus)}$	45	—	—	Vdc
	2N2919, 2N2920, 2N2978, 2N2979		60	70	—	
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	All Types	BV_{EBO}	6	7	—	Vdc
Collector-Base Cutoff Current (V_{CB} = 45 Vdc, I_E = 0)	2N2913 thru 18, 2N2972 thru 77	I_{CBO}	—	—	0.010	μAdc
	2N2919, 2N2920, 2N2978, 2N2979		—	—	0.002	
(V_{CB} = 45 Vdc, I_E = 0, T_A = 150°C)	All Types		—	—	10	
Collector-Emitter Cutoff Current (V_{CE} = 5 Vdc, I_B = 0)	All Types	I_{CEO}	—	—	0.002	μAdc
Emitter-Base Cutoff Current (V_{EB} = 5 Vdc, I_C = 0)	All Types	I_{EBO}	—	—	0.002	μAdc
Collector-Emitter Saturation Voltage (I_C = 1 mAdc, I_B = 0.1 mAdc)	All Types	$V_{CE(sat)}$	—	—	0.35	Vdc
Base-Emitter "ON" Voltage (I_C = 100 μAdc, V_{CE} = 5 Vdc)	All Types	$V_{BE(ON)}$	—	—	0.7	Vdc
DC Current Gain* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78	h_{FE}	60	—	240	—
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		150	—	600	
(I_C = 10 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		15	—	—	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		30	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		100	—	—	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		225	—	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N2913, 15, 17, 19, 2N2972, 74, 76, 78		150	—	—	
	2N2914, 16, 18, 20, 2N2973, 75, 77, 79		300	—	—	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 140 kc)	All Types	C_{obo}	—	4	6	pf
High Frequency Current Gain (I_C = 500 μA, V_{CE} = 5 V, f = 20 mc)	All Types	$\|h_{fe}\|$	3.0	—	—	—
Input Impedance (I_C = 1.0 mA, V_{CB} = 5 V, f = 1 kc)	All Types	h_{ib}	25	28	32	ohms
Output Admittance (I_C = 1.0 mA, V_{CB} = 5 V, f = 1 kc)	All Types	h_{ob}	—	—	1.0	μmhos
Noise Figure (I_C = 10 μA, V_{CE} = 5 V, R_G = 10 kohms)		NF				db
f = 1 kc, BW = 200 cps	2N2914, 16, 18, 20, 73, 75, 77, 79		—	2	3	
	2N2913, 15, 17, 19, 72, 74, 76, 78		—	3	4	
f = 10 cps to 15.7 kc, BW = 10 kc	2N2914, 16, 18, 20, 73, 75, 77, 79		—	2	3	
	2N2913, 15, 17, 19, 72, 74, 76, 78		—	3	4	

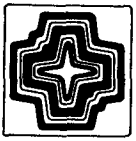
MATCHING CHARACTERISTICS

DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2917, 18, 76, 77	h_{FE1}/h_{FE2}**	0.8	—	1.0	—
	2N2915, 16, 19, 20, 74, 75, 78, 79		0.9	—	1.0	
Base Voltage Differential (I_C = 10 μA, to 1.0 mA, V_{CE} = 5 Vdc)	2N2917, 18, 76, 77	$\|V_{BE1}-V_{BE2}\|$	—	—	10	mVdc
	2N2915, 16, 19, 20, 74, 75, 78, 79		—	—	5	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N2917, 18, 76, 77		—	—	5	
	2N2915, 16, 19, 20, 74, 75, 78, 79,		—	—	3	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C)	2N2917, 18, 76, 77	$\Delta(V_{BE1}-V_{BE2})$	—	—	1.6	mVdc
	2N2915, 16, 19, 20, 74, 75, 78, 79		—	—	0.8	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	2N2917, 18, 76, 77		—	—	2.0	
	2N2915, 16, 19, 20, 74, 75, 78, 79		—	—	1.0	

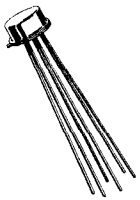
* Pulse Test ≤ 300 μsec, duty cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this ratio

2N3409 thru 2N3411

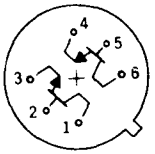


$V_{CEO} = 30$ V
$I_C = 500$ mA



NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

CASE 32



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Collector Voltage	V_{CCO}	100		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
D.C. Collector Current (Limited by P_D)	I_C	500		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	—	Vdc

2N3409-2N3411 (continued)

ELECTRICAL CHARACTERISTICS (each side) (continued)

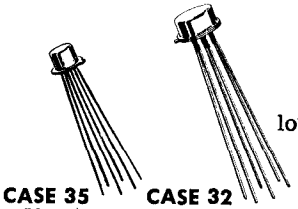
Characteristic		Symbol	Min	Max	Unit
Collector Cutoff Current (V_{CB} = 50 Vdc) (V_{CB} = 50 Vdc, T_A = 150°C)		I_{CBO}	— —	.010 10	μAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc)		I_{EBO}	—	10	nAdc
Collector to Collector Current (V_{CC} = 100 Vdc)		I_{CCO}	—	100	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE(sat)}$	—	0.15	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE(sat)}$	—	0.85	Vdc
DC Forward Current Transfer Ratio (I_C = 10 μAdc, V_{CE} = 10 Vdc) (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc) (I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N3410, 2N3411 All Types All Types All Types	h_{FE}	 20 30 40 50	 100 120 160 200	—
DC Current Gain Ratio ** (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	2N3409 2N3410, 2N3411 2N3411	h_{FE1}/h_{FE2} **	0.8 0.9 0.9	1.0 1.0 1.0	—
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc) (I_C = 1 mAdc, V_{CE} = 10 Vdc)	2N3409, 2N3410 2N3411 2N3411	$\lvert V_{BE1}-V_{BE2} \rvert$	— — —	10 5 5	mVdc
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55 to +25°C) (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = 25 to 125°C)	2N3409 2N3410, 2N3411 2N3409 2N3410, 2N3411	$\Delta(V_{BE1}-V_{BE2})$	— — — —	1.6 0.8 2.0 1.0	mVdc
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 1 mc)		C_{ob}	—	8	pf
Collector Input Capacitance (V_{BE} = 0.5 Vdc, f = 1 mc)		C_{ib}	—	25	pf
Small-Signal Forward Current Transfer Ratio (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 mc)		h_{fe}	2.5	—	—
Noise Figure (I_C = 100 μA, V_{CE} = 5 V, f = 1 kc, BW = 1 cps, R_S = 1 KΩ)		NF	—	4	db

*Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this ratio

2N3800 thru 2N3811

$V_{CEO} = 60$ V
$I_C = 50$ mA



CASE 35 (TO-71)
2N3800 thru 2N3805

CASE 32
2N3806 thru 2N3811

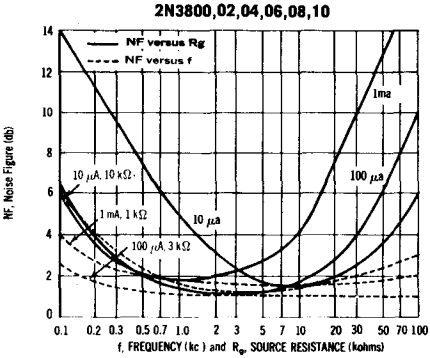
PNP silicon annular dual transistors for low-level, low-noise differential amplifier applications.

MAXIMUM RATINGS (each side)

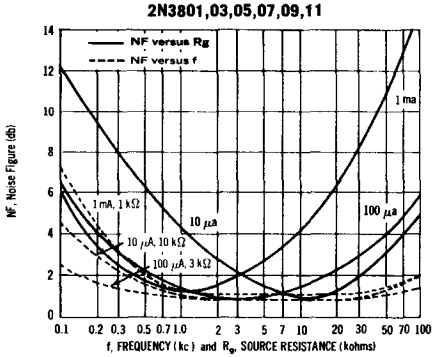
Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	60		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
DC Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ $T_A = 25°C$	P_D			
TO-5 Case		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
TO-18 Case		250	360	mW
Derate above 25°C		1.5	2.06	mW/°C

NOISE FIGURE VERSUS FREQUENCY AND SOURCE RESISTANCE

2N3800,02,04,06,08,10



2N3801,03,05,07,09,11



2N3800 thru 2N3811 (continued)

ELECTRICAL CHARACTERISTICS (at 25°C ambient temperature unless otherwise noted)

Characteristic		Symbol	Minimum	Typical	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	-	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	60	90	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	-	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	-	-	010	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)					10	
Emitter Cutoff Current (V_{EB} = 4 Vdc, I_C = 0)		I_{EBO}	-	-	20	nAdc
Collector-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{CE(sat)}$*	-	-	0.2	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			-	-	0.25	
Base-Emitter Saturation Voltage* (I_C = 100 μAdc, I_B = 10 μAdc)		$V_{BE(sat)}$*	-	-	0.7	Vdc
(I_C = 1 mAdc, I_B = 100 μAdc)			-	-	0.8	
DC Forward Current Transfer Ratio*						-
(I_C = 1 μAdc, V_{CE} = 5 Vdc)	2N3801, 03, 05, 07, 09, 11	h_{FE}*	75	-	-	
(I_C = 10 μAdc, V_{CE} = 5 Vdc)	2N3800, 02, 04, 06, 08, 10		100	-	-	
	2N3801, 03, 05, 07, 09, 11		225			
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N3800, 02, 04, 06, 08, 10		150	-	450	
	2N3801, 03, 05, 07, 09, 11		300	-	900	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	2N3800, 02, 04, 06, 08, 10		75	-	-	
	2N3801, 03, 05, 07, 09, 11		150	-	-	
(I_C = 500 μAdc, V_{CE} = 5 Vdc)	2N3800, 02, 04, 06, 08, 10		150	-	450	
	2N3801, 03, 05, 07, 09, 11		300	-	900	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N3800, 02, 04, 06, 08, 10		150	-	450	
	2N3801, 03, 05, 07, 09, 11		300	-	900	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	2N3800, 02, 04, 06, 08, 10		125	-	-	
	2N3801, 03, 05, 07, 09, 11		250	-	-	
Base Emitter "ON" Voltage (I_C = 100 μAdc, V_{CE} = 5 V)		$V_{BE(ON)}$	-	-	0.7	Vdc
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)		C_{ob}	-	-	4	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	-	-	8	pf
Small Signal Current Gain						-
(I_C = 500 μA, V_{CE} = 5 V, f = 30 mc)		h_{fe}	1.0	-	-	
(I_C = 1 mA, V_{CE} = 5 V, f = 100 mc)			1.0	-	5	
(I_C = 1 mA, V_{CE} = 10 V, f = 1 kc)	2N3800, 02, 04, 06, 08, 10		150	-	600	
	2N3801, 03, 05, 07, 09, 11		300	-	900	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)		h_{re}	-	-	25	$X10^{-4}$
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	2N3800, 02, 04, 06, 08, 10	h_{ie}	3	-	15	k ohms
	2N3801, 03, 05, 07, 09, 11		10	-	40	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)		h_{oe}	5	-	60	μmhos
Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_S = 3 K)		NF				db
f = 100 cps	2N3800, 02, 04, 06, 08, 10		-	4	7	
	2N3801, 03, 05, 07, 09, 11		-	2.5	4	
f = 1 kc	2N3800, 02, 04, 06, 08, 10		-	1.5	3	
	2N3801, 03, 05, 07, 09, 11		-	0.8	1.5	
f = 10 kc	2N3800, 02, 04, 06, 08, 10		-	1.0	2.5	
	2N3801, 03, 05, 07, 09, 11		-	0.8	1.5	
Noise Bandwidth 10 cps to 15.7 kc	2N3800, 02, 04, 06, 08, 10		-	2.5	3.5	
	2N3801, 03, 05, 07, 09, 11		-	1.5	2.5	

MATCHING CHARACTERISTICS

DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N3802, 03, 08, 09	h_{FE1}/h_{FE2}**	0.8	-	1.0	-
	2N3804, 05, 10, 11		0.9	-	1.0	
Base Voltage Differential (I_C = 10 μA, to 10 mA, V_{CE} = 5 Vdc)	2N3802, 03, 08, 09	$\lvert V_{BE1}-V_{BE2}\rvert$	-	-	8	mVdc
	2N3804, 05, 10, 11		-	-	5	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	2N3802, 03, 08, 09		-	-	5	
	2N3804, 05, 10, 11		-	-	3	
Base Voltage Differential Change		$\Delta(V_{BE1}-V_{BE2})$				mVdc
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C)	2N3802, 03, 08, 09		-	-	1.6	
	2N3804, 05, 10, 11		-	-	0.8	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	2N3802, 03, 08, 09		-	-	2.0	
	2N3804, 05, 10, 11		-	-	1.0	

* Pulse Test ≤ 300μsec, duty cycle ≤ 2% V_{OB} - Base-Emitter Reverse Bias

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

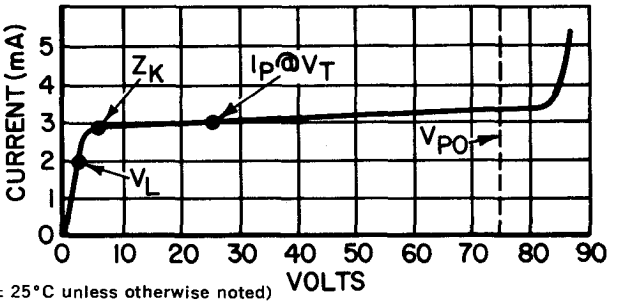
MCL1300 thru MCL1304 (SILICON)

Field-effect current limiting diodes designed for applications requiring a current reference or a constant current over a specified voltage range.



CASE 51
(DO-7)

CURRENT-LIMITER CHARACTERISTICS AND SYMBOL IDENTIFICATION
(See Notes 1 thru 6)



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Junction and Storage Temperature: -65°C to +200°C

Peak Operating Voltage: See Table

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Type Number	Nominal Pinch-Off Current Note 1 I_P (ma)	Tol. (ma)	Test Volt. Note 2 V_T (volts)	Limiter Imped. Note 3 Z_T (min) (megohms)	Knee Imped. at 6 V Note 4 Z_K (min) (megohms)	Limiting Voltage Note 5 V_L (max) (volts)	Peak Operating Voltage Note 6 V_{PO} (volts)
MCL1300	0.5	±0.3	25	4.000	0.500	1.0	75
MCL1301	1.0	±0.6	25	0.800	0.200	1.5	75
MCL1302	2.0	±0.6	25	0.400	0.100	2.0	75
MCL1303	3.0	±0.6	25	0.300	0.050	2.0	75
MCL1304	4.0	±0.6	25	0.250	0.025	2.5	75

These specifications are preliminary. Selections may be made to obtain nominal currents between those shown, as well as tighter tolerance units.

SYMBOL DEFINITIONS:

Note 1 I_P - The pinch-off current is the guaranteed current at a specified V_T. I_P is specified as a nominal with a tolerance.

Note 2 V_T - The test voltage for measurement of I_P.

Note 3 Z_T - The impedance at the test voltage, V_T, specified. To provide the most constant current Z_T should be as high as possible; thus a minimum Z_T is specified. Z_T is derived from the 90 cycle per second current which results when an AC voltage having an RMS value equal to 10% of the test voltage (V_T) is superimposed on V_T.

Note 4 Z_K - Knee impedance is specified as a minimum also since again the highest value is desired. V_K is established as 6.0 V for convenience.

Note 5 V_L - Limiting Voltage. This specification is provided with Z_K to indicate the sharp knee of the device. The specification is analogous to I_R and Z_K of a zener diode. V_L a maximum specification is measured at 80% on I_P tolerance.

Note 6 V_{PO} - The peak-operating voltage is provided and indicates the maximum voltage to be applied to the device. The specification is necessary since the device is either power limited or breakdown limited beyond this specified voltage.

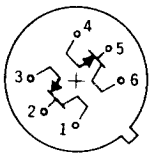
MD984

$V_{CEO} = 20$ V
$I_C = 200$ mA



CASE 32

PNP silicon annular dual transistors for high-speed switching and amplifier applications.



PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	20		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	200		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation (25°C Case Temperature) Derate above 25°C	P_D	1.6 9.1	3.0 17.2	W mW/°C
Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	0.5 2.9	0.6 3.4	W mW/°C

MD984 (continued)

ELECTRICAL CHARACTERISTICS (each side)

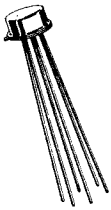
(at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = -10 mAdc, I_B = 0)	BV_{CEO}*	20	---	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector Cutoff Current (V_{CB} = -20 Vdc, I_E = 0) (V_{CB} = -20 Vdc, I_E = 0, T_A = 150°C)	I_{CBO}	--- ---	.025 30	μAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc) (I_C = -50 mAdc, I_B = -5 mAdc)	$V_{CE(sat)}$	--- ---	0.3 0.5	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	---	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = -10 mAdc, V_{CE} = -10 Vdc)	h_{FE}	25	---	---
Output Capacitance (V_{CB} = -10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	---	4	pf
Small-Signal Forward Current Transfer Ratio (I_C = -20 mAdc, V_{CE} = -20 Vdc, f = 100 mc)	h_{fe}	2.5	---	---
Current-Gain–Bandwidth Product (I_C = -20 mAdc, V_{CE} = -20 Vdc)	f_τ	250	---	mc

* Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

MD986

V_{CEO} = 15 V
I_C = 200 mA

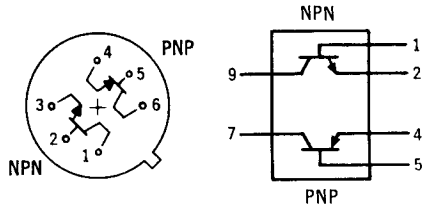




CASE 32
MD986

CASE 33
MD986F

NPN-PNP silicon annular Star complementary pair dual transistors for high-speed switching circuits and DC to UHF amplifier applications.



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D			
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
TO-5 Package		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C

MD986 (continued)

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

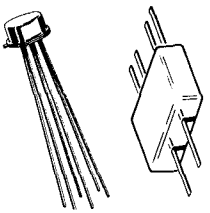
Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)	I_{CBO}	—	.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)		—	30	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.3	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)		—	0.5	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 10 Vdc)	h_{FE}	25	—	—
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	—	4	pf
Current-Gain — Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc) TO-5 Package	f_T	200	—	mc
(V_{CE} = 10 Vdc, I_C = 20 mAdc) Flat Package		200	—	

*Pulse Test: Pulse Width ≦ 300 μsec, Duty Cycle ≦ 2%

MD1120
MD1121
MD1122

$V_{CEO} = 30$ V
$I_C = 500$ mA



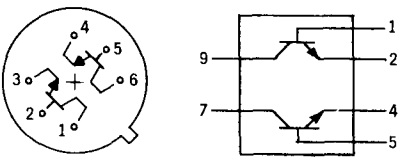
CASE 32

MD1120
thru
MD1122

CASE 33

MD1120F
thru
MD1122F

NPN silicon annular Star dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
D.C. Collector Current	I_C	500		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to + 200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_D	 1.6 9.1	 3.0 17.2	 W mW/°C
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	 0.5 2.9	 0.6 3.4	 W mW/°C

MD1120-MD1122 (continued)

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

Characteristics		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)		BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)		BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc)		I_{CBO}	—	010	μAdc
(V_{CB} = 50 Vdc, T_A = 150°C)			—	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc)		I_{EBO}	—	10	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{CE\ (sat)}$	—	0.1	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		$V_{BE\ (sat)}$	—	0.85	Vdc
DC Forward Current Transfer Ratio		h_{FE}			—
(I_C = 10 μAdc, V_{CE} = 10 Vdc)	MD1121, MD1122†		20	100	
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	All Types		30	120	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	All Types		40	160	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	All Types		50	200	
DC Current Gain Ratio **		h_{FE1}/h_{FE2}**			—
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1120†		0.8	1.0	
	MD1121, MD1122†		0.9	1.0	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MD1122†		0.9	1.0	
Base Voltage Differential		$\lvert V_{BE1}-V_{BE2} \rvert$			mVdc
(I_C = 100 μAdc, V_{CE} = 10 Vdc)	MD1120, MD1121†		—	10	
	MD1122†		—	5	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MD1122†		—	5	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 10 Vdc, T_A = -55°C to + 125°C)	MD1121, MD1122†	$\Delta (V_{BE1}-V_{BE2})$	—	10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 100 kc)		C_{ob}	—	8	pf
Small-Signal Forward Current Transfer Ratio (I_C = 20 mAdc, V_{CE} = 20 Vdc, f= 100 mc) TO-5 Package		h_{fe}	2.5	—	—
(I_C = 20 mAdc, V_{CE} = 10 Vdc, f= 100 mc) Flat Package			2.0	—	
Current-Gain-Bandwidth Product (V_{CE} = 20 Vdc, I_C = 20 mAdc) TO-5 Package		f_T	250	—	mc
(V_{CE} = 10 Vdc, I_C = 20 mAdc) Flat Package			200	—	

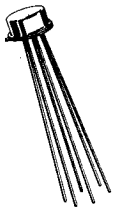
* Pulse Test: Pulse Width ≤ 300 μsec. Duty Cycle≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

† Applies to corresponding Flat Package device type also

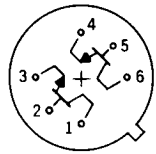
MD1126
MD1127

V_{CEO} = 15 V
I_C = 200 mA



CASE 32

NPN silicon annular dual transistors for high-speed switching applications.



PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side)

Characteristics	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation (25°C Case Temperature) (Derate above 25°C)	P_D	 0.75 4.3	 1.5 8.6	 W mW/°C
Total Device Dissipation (25°C Ambient Temperature) (Derate above 25°C)	P_D	 0.30 1.7	 0.40 2.3	 W mW/°C

MD1126, MD1127 (continued)

ELECTRICAL CHARACTERISTICS (each side)

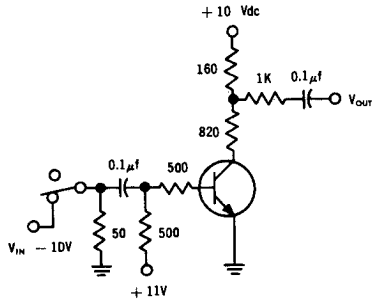
(At 25° ambient temperature unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 1.0 μAdc, I_E = 0)		BV_{CBO}	40	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 30 mAdc, I_B = 0)		BV_{CEO}*	15	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	---	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	---	.025	μAdc
(V_{CB} = 20 Vdc, I_E = 0, T_A = 150°C)			---	15	
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	MD1126	V_{CE} (sat)	---	0.40	Vdc
	MD1127		---	0.25	
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)		V_{BE} (sat)	0.7	0.85	Vdc
DC Forward Current Transfer Ratio* (I_C = 10 mAdc, V_{CE} = 1 Vdc)		h_{FE}*	30	---	---
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	---	6.0	pf
Small-Signal Forward Current Transfer Ratio (I_C = 20 mAdc, V_{CE} = 10 Vdc, f = 100 mc)		h_{fe}	3.0	---	---
Charge-Storage Time Constant (I_C = I_{B1} = I_{B2} =10 mAdc)	MD1126	τ_S	---	40	nsec
(I_C = I_{B1} = I_{B2} = 20 mAdc)	MD1127		---	25	

*Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

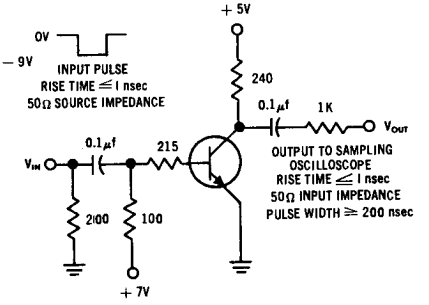
CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

MD1126



CHARGE STORAGE TIME CONSTANT TEST CIRCUIT

MD1127

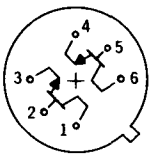


MD1128

$V_{CEO} = 15$ V
$I_C = 200$ mA



NPN silicon annular dual transistors for high-speed switching applications.



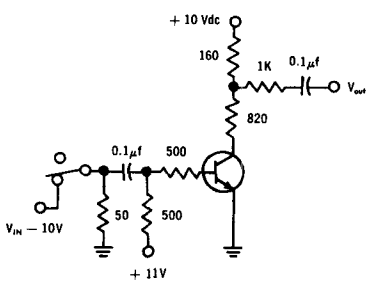
PIN CONNECTIONS
BOTTOM VIEW

CASE 32

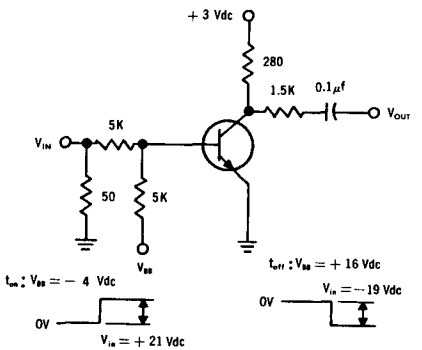
MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	40		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		^oC
Storage Temperature	T_{stg}	-65 to +200		^oC
		ONE SIDE	BOTH SIDES	
Total Device Dissipation (25^oC Case Temperature) (25^oC Case Temperature)	P_D	0.75	1.5	W
(25^oC Case Temperature) (Derate above 25^oC)		4.3	8.6	mW/^oC
Total Device Dissipation (25^oC Ambient Temperature)	P_D	0.30	0.40	W
(25^oC Ambient Temperature) (Derate above 25^oC)		1.7	2.3	mW/^oC

CHARGE STORAGE TIME CONSTANT TEST CIRCUIT



TURN-ON AND TURN-OFF TIME TEST CIRCUIT



MD1128 (continued)

ELECTRICAL CHARACTERISTICS (each side)

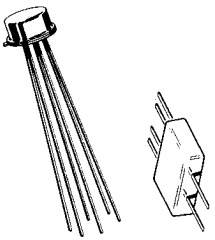
(at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	BV_{CBO}	40	---	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	BV_{CEO}*	15	---	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	---	Vdc
Collector Cutoff Current (V_{CE} = 20 Vdc, V_{BE} = 0)	I_{CES}	---	10	μAdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0) (V_{CB} = 20 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	--- ---	.025 30	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc) (I_C = 50 mAdc, I_B = 5 mAdc)	$V_{CE\ (sat)}$	--- ---	0.3 0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	---	0.9	Vdc
DC Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 1 Vdc)	h_{FE}	25	---	---
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)	C_{ob}	---	4	pf
Small-Signal Forward Current Transfer Ratio (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	h_{fe}	3.5	---	---
Current-Gain-Bandwidth Product (V_{CE} = 20 Vdc, I_C = 10 mAdc)	f_T	350	---	mc
Charge-Storage Time Constant (I_C = I_{B1} = I_{B2} = 10 mAdc)	τ_S	---	30	nsec
Turn-On Time (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{on}	---	20	nsec
Turn-Off Time (I_C = 10 mAdc, I_{B1} = 3 mAdc, I_{B2} = 1 mAdc)	t_{off}	---	35	nsec

*Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

MD1129

V_{CEO} = 30 V
I_C = 200 mA

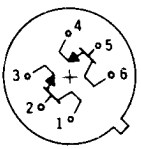


NPN silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

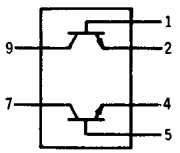
CASE 32 — MD1129

CASE 33 — MD1129F

MD1129



MD1129F



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current (Limited by P_D)	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Flat Package Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 250 1.5	 350 2	 mW mW/°C
TO-5 Package Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 500 2.9	 600 3.4	 mW mW/°C

MD1129 (continued)

ELECTRICAL CHARACTERISTICS (each side)

(At 25° ambient temperature unless otherwise noted)

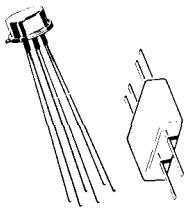
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc)	BV_{CEO}*	30	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc)	I_{CBO}	-	.010	μAdc
(V_{CB} = 50 Vdc, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc)	I_{EBO}	-	10	nAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.1	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	-	0.85	Vdc
DC Forward Current Transfer Ratio (I_C = 10 μAdc, V_{CE} = 10 Vdc)	h_{FE}	60	-	-
(I_C = 100 μAdc, V_{CE} = 10 Vdc)		100	300	
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		100	-	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)		100	-	
DC Current Gain Ratio** (I_C = 100 μAdc, V_{CE} = 10 Vdc)	h_{FE1}/h_{FE2}**	0.9	1.0	-
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		0.9	1.0	
Base Voltage Differential (I_C = 100 μAdc, V_{CE} = 10 Vdc)	$\lvert V_{BE1}-V_{BE2}\rvert$	-	5	mVdc
(I_C = 1 mAdc, V_{CE} = 10 Vdc)		-	5	
Base Voltage Differential Change (I_C - 100 μAdc, V_{CE} = 10 Vdc, T_A = -55°C to +125°C)	$\Delta(V_{BE1}-V_{BE2})$	-	10	μV/°C
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 100 kc)	C_{ob}	-	8	pf
Current-Gain–Bandwidth Product (V_{CE} = 10 Vdc, I_C = 20 mAdc)	f_T	200	-	mc

*Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

**The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1130

$V_{CEO} = 40$ V
$I_C = 200$ mA

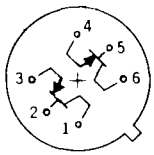


PNP silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.

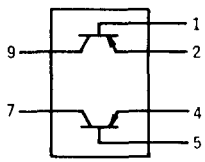
CASE 32 **CASE 33**

MD1130 **MD1130F**

MD1130



MD1130F



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current (Limited by P_D)	I_C	200		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Flat Package Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 250 1.5	 350 2	 mW mW/°C
TO-5 Package Total Device Dissipation (25°C Ambient Temperature) Derate above 25°C	P_D	 500 2.9	 600 3.4	 mW mW/°C

MD1130 (continued)

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

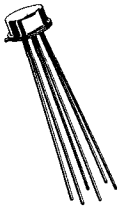
Characteristic	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = -10 μAdc)	BV_{CBO}	60	-	Vdc
Collector-Emitter Breakdown Voltage* (I_C = -10 mAdc)	BV_{CEO}*	40	-	Vdc
Emitter-Base Breakdown Voltage (I_E = -10 μAdc)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = -50 Vdc)	I_{CBO}	-	010	μAdc
(V_{CB} = -50 Vdc, T_A = 150°C)		-	10	
Emitter Cutoff Current (V_{EB} = -3 Vdc)	I_{EBO}	-	10	nAdc
Collector-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{CE(sat)}$	-	0.25	Vdc
Base-Emitter Saturation Voltage (I_C = -10 mAdc, I_B = -1 mAdc)	$V_{BE(sat)}$	-	0.9	Vdc
DC Forward Current Transfer Ratio	h_{FE}			-
(I_C = -10 μAdc, V_{CE} = -10 Vdc)		60	-	
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		100	300	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		100	-	
(I_C = -10 mAdc, V_{CE} = -10 Vdc)		100	-	
DC Current Gain Ratio**	h_{FE1}/h_{FE2}**			-
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		0.9	1.0	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		0.9	1.0	
Base Voltage Differential	$\lvert V_{BE1}-V_{BE2}\rvert$			mVdc
(I_C = -100 μAdc, V_{CE} = -10 Vdc)		-	5	
(I_C = -1 mAdc, V_{CE} = -10 Vdc)		-	5	
Base Voltage Differential Change (I_C = -100 μAdc, V_{CE} = -10 Vdc, T_A = -55°C to +125°C)	$\Delta(V_{BE1}-V_{BE2})$	-	10	μV/°C
Collector Output Capacitance (V_{CB} = -10 Vdc, F = 100 kc)	C_{ob}	-	4	pf
Current-Gain – Bandwidth Product (V_{CE} = -10 Vdc, I_C = -20 mAdc)	f_T	200	-	mc

* Pulse Test: Pulse Width ≤ 300 μsec, Duty Cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1131

$V_{CEO} = 15$ V
$I_C = 50$ mA





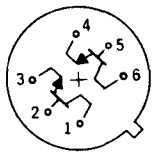
NPN silicon annular dual transistors for high-frequency oscillator and amplifier applications.

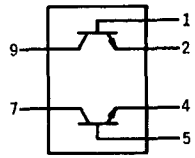
CASE 32

MD1131

CASE 33

MD1131F





PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	30		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	50		mAdc
Operating Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		One Side	Both Sides	
Total Device Dissipation @ T_A = 25°C	P_D			
TO-5 Package		300	400	mW
Derate above 25°C		1.7	2.3	mW/°C
Flat Package		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C

MD1131 (continued)

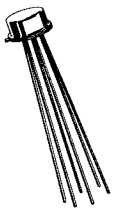
ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Collector-Base Breakdown Voltage (I_C = 1 μAdc, I_E = 0)	BV_{CBO}	30	-	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc, I_B = 0)	BV_{CEO}	15	-	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc, I_E = 0) (V_{CB} = 15 Vdc, I_E = 0, T_A = +150°C)	I_{CBO}	- -	.010 1.0	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	-	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	-	1.0	Vdc
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	-	-
Output Capacitance (V_{CB} = 10 Vdc, f = 140 kc) (V_{CB} = 0 Vdc, f = 140 kc)	C_{ob}	- -	1.7 3.0	pf
Input Capacitance (V_{EB} = 0.5 Vdc, f = 140 kc)	C_{ib}	-	2.0	pf
Small-Signal Forward Current Transfer Ratio (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	h_{fe}	6.0	-	-

MD1132

$V_{CEO} = 15$ V
$I_C = 50$ mA



CASE 32

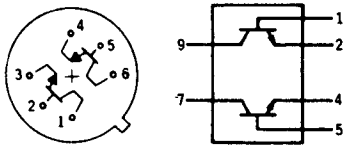
MD1132



CASE 33

MD1132F

NPN silicon annular dual transistors for differential amplifiers and other applications requiring a matched pair with a high degree of parameter uniformity.



PIN CONNECTIONS
BOTTOM VIEW

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	30		Vdc
Collector-Emitter Voltage	V_{CEO}	15		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ $T_A = 25°C$	P_D			
TO-5: MD1132		300	400	mW
Derating Factor Above 25°C		1.7	2.3	mW/°C
Flat Package: MD1132F		250	350	mW
Derating Factor Above 25°C		1.5	2.0	mW/°C

MD1132 (continued)

ELECTRICAL CHARACTERISTICS (each side)

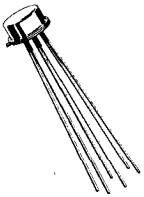
(At 25° ambient temperature unless otherwise noted)

Characteristics	Symbol	Min	Max	Unit
Collector-Base Breakdown Voltage (I_C = 1 μAdc)	BV_{CBO}	30	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 3 mAdc)	BV_{CEO}	15	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CB} = 15 Vdc) (V_{CB} = 15 Vdc, T_A = 150°C)	I_{CBO}	— —	.010 1.0	μAdc
Collector-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{CE(sat)}$	—	0.4	Vdc
Base-Emitter Saturation Voltage (I_C = 10 mAdc, I_B = 1 mAdc)	$V_{BE(sat)}$	—	1.0	Vdc
DC Forward Current Transfer Ratio (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE}	50	—	—
DC Current Gain Ratio* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	h_{FE1}/h_{FE2}*	0.9	1.0	—
Base Voltage Differential (I_C = 1 mAdc, V_{CE} = 5 Vdc)	$\lvert V_{BE1}-V_{BE2} \rvert$	—	5	mVdc
Base Voltage Differential Change (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C) (I_C = 1 mAdc, V_{CE} = 5 Vdc, T_A = +25 to +125°C)	$\Delta(V_{BE1}-V_{BE2})$	— —	0.8 1.0	mVdc
Collector Output Capacitance (V_{CB} = 10 Vdc, f = 140 kc) (V_{CB} = 0 Vdc, f = 140 kc)	C_{ob}	— —	1.7 3.0	pf
Input Capacitance (V_{EB} = 0.5 Vdc, f = 140 kc)	C_{ib}	—	2.0	pf
Small Signal Forward Current Transfer Ratio (I_C = 4 mAdc, V_{CE} = 10 Vdc, f = 100 mc)	h_{fe}	6.0	—	—

*The lowest h_{FE} reading is taken as h_{FE1} for this ratio

MD1134

V_{CEO} = 15 V
I_C = 500 mA (peak)



NPN silicon annular dual transistor for high-speed switching applications.

CASE 32

MAXIMUM RATINGS (each side)

Characteristic	Symbol	Rating	Unit
Collector to Base Voltage	V_{CBO}	40	Vdc
Collector to Emitter Voltage	V_{CEO}	15	Vdc
Emitter to Base Voltage	V_{EBO}	5	Vdc
Collector Current (10μsec pulse) (limited by P_D)	$I_{C(peak)}$	500	mAdc
Operating Junction Temperature	T_j	+200	°C
Storage Temperature	T_{stg}	-65 to +200	°C
Total Device Dissipation 25°C Ambient Temperature One Side Both Sides Derate 2.9 mW/°C above 25°C (one side) Derate 3.4 mW/°C above 25°C (both sides)	P_D	 500 600	 mW mW

MD1134 (continued)

ELECTRICAL CHARACTERISTICS (At 25° ambient temperature unless otherwise noted)

Characteristic	Symbol	Minimum	Maximum	Unit
Cnllector Base Breakdown Voltage I_C = 10μA, I_E = 0	BV_{CBO}	40	-	Vdc
Collector-Emitter Breakdown Voltage I_C = 10mA, I_B = 0	BV_{CEO}*	15	-	Vdc
Emitter-Base Breakdown Voltage I_E = 10μA, I_C = 0	BV_{EBO}	5	-	Vdc
Collector Cutoff Current V_{CB} = 20V, I_E = 0	I_{CBO}	-	0.4	μAdc
Collector Cutoff Current V_{CB} = 20V, I_E = 0, T_A = 150°C	I_{CBO}	-	30	μAdc
Forward Current Transfer Ratio I_C = 10mA, V_{CE} = 1V I_C = 10mA, V_{CE} = 1V, T_A = -55°C I_C = 100mA, V_{CE} = 2V	h_{FE}	 50 20 20	 - - -	 - - -
Collector Saturation Voltage I_C = 10mA, I_B = 1mA	$V_{CE(sat)}$	-	0.25	Vdc
Base Saturation Voltage I_C = 10mA, I_B = 1mA	$V_{BE(sat)}$	0.70	0.85	Vdc
Output Capacitance V_{CB} = 5V, I_E = 0, f = 140kc	C_{ob}	-	4	pf
Input Capacitance V_{EB} = 1V, I_C = 0, f = 140kc	C_{ib}	-	4	pf
Forward Current Transfer Ratio I_C = 10mA, V_{CE} = 10V, f = 100mc	h_{fe}	5.0	-	-

* Pulse Condition:
P. W. ≤ 300μsec, D. C. ≤ 2%

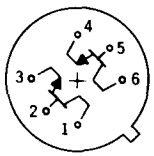
MD2218, A
MD2219, A



V_{CB} = 60-75 V
I_C = 600 mA
P_D = 500 mW one side
600 mW both sides



Dual NPN silicon annular transistors, designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry with the MD2904 series.



PIN CONNECTIONS
BOTTOM VIEW

CASE 32

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating		Unit
		MD2218 MD2219	MD2218A MD2219A	
Collector-Base Voltage	V_{CB}	60	75	Vdc
Collector-Emitter Voltage	V_{CEO}	30	40	Vdc
Emitter-Base Voltage	V_{EB}	5	6	Vdc
Collector Current	I_C	600		mAdc
Junction Operating Temperature	T_J	200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D	500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.2	2.0	W
Derate above 25°C		6.9	11.43	mW/°C

MD2218, A and MD2219, A (continued)

ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)	MD2218, MD2219 MD2218A, MD2219A	BV_{CBO}	60 75	— —	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2218, MD2219 MD2218A, MD2219A	BV_{CEO}*	30 40	— —	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)	MD2218, MD2219 MD2218A, MD2219A	BV_{EBO}	5 6	— —	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3 Vdc)	MD2218, MD2219 MD2218A, MD2219A	I_{CEX}	— —	0.020 0.015	μAdc
(V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3 Vdc, T_A = 150°C)	All Types		—	25	
Base Cutoff Current (V_{CE} = 50 Vdc, $V_{EB(off)}$ = 3 Vdc)		I_{BL}	—	0.030	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2218, MD2218A MD2219, MD2219A	h_{FE}*	20 35	— —	—
(I_C = 1 mAdc, V_{CE} = 10 Vdc)	MD2218, MD2218A MD2219, MD2219A		25 50	— —	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2218, MD2218A MD2219, MD2219A		35 75	— —	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2218, MD2218A MD2219, MD2219A		40 100	120 300	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	MD2218, MD2218A MD2219, MD2219A		20 50	— —	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD2218 MD2218A MD2219 MD2219A		20 25 30 40	— — — —	
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218, MD2219 MD2218A, MD2219A	$V_{CE(sat)}$*	— —	0.4 0.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218, MD2219 MD2218A, MD2219A		— —	1.2 0.9	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)	MD2218, MD2219 MD2218A, MD2219A	$V_{BE(sat)}$*	0.6 0.6	1.3 1.2	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)	MD2218, MD2219 MD2218A, MD2219A		— —	2.0 1.8	

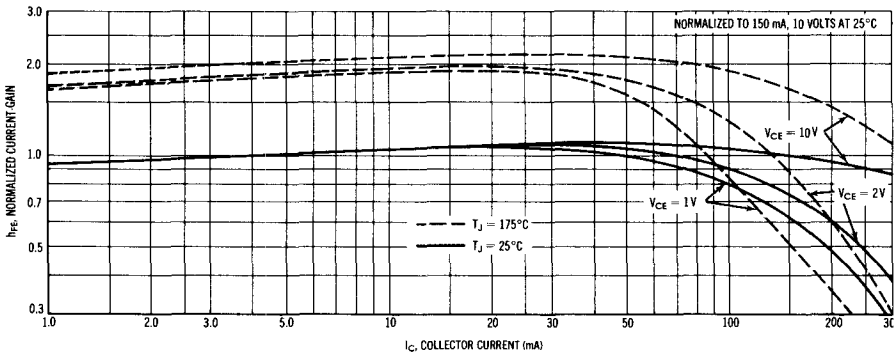
MD2218, A and MD2219, A (continued)

ELECTRICAL CHARACTERISTICS (continued)

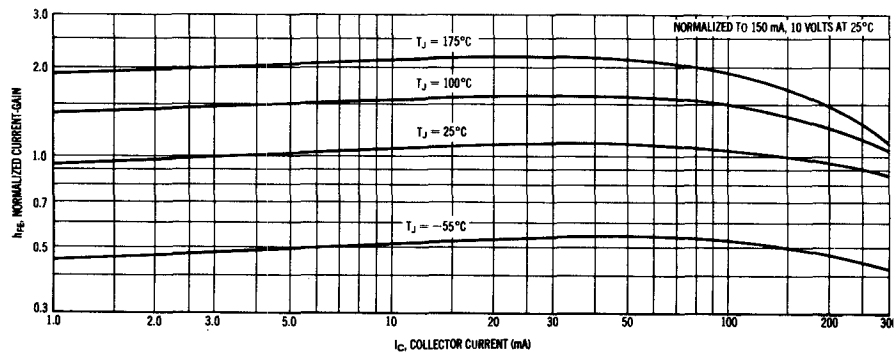
Characteristic			Symbol	Min	Max	Unit
TRANSIENT CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 20 mAdc, V_{CE} = 20 Vdc, f = 100 mc)		MD2218 MD2218A, MD2219 MD2219A	f_T	200 250 300	— — —	mc
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)			C_{ob}	—	8	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		MD2218, MD2219 MD2218A, MD2219A	C_{ib}	— —	30 25	pf
Delay Time	V_{CC} = 30 V, $V_{BE(off)}$ = 0.5 V I_C = 150 mA, I_{B1} = 15 mA	MD2218, MD2219 MD2218A, MD2219A	t_d	— —	20 15	nsec
Rise Time		MD2218, MD2219 MD2218A, MD2219A	t_r	— —	40 30	nsec
Storage Time	V_{CC} = 30 V, I_C = 150 mA I_{B1} = I_{B2} = 15 mA	MD2218, MD2219 MD2218A, MD2219A	t_s	— —	280 250	nsec
Fall Time		MD2218, MD2219 MD2218A, MD2219A	t_f	— —	70 60	nsec

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

NORMALIZED CURRENT GAIN CHARACTERISTICS

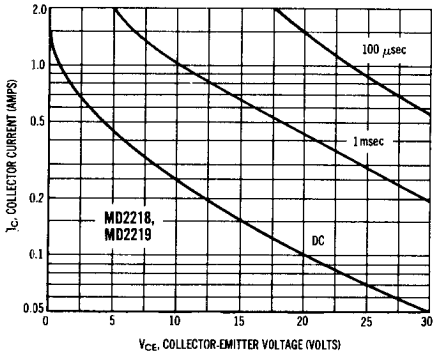


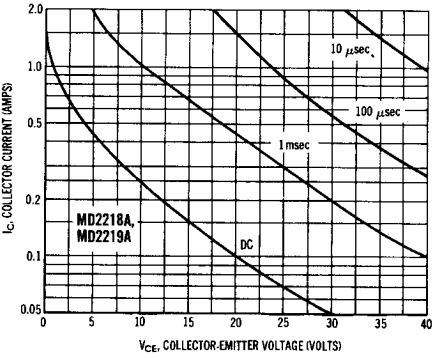
NORMALIZED CURRENT GAIN CHARACTERISTICS



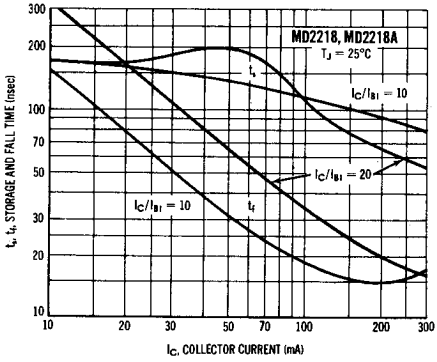
MD2218, A and MD2219, A (continued)

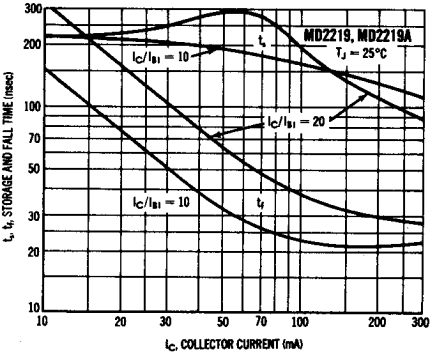
SAFE OPERATING AREA



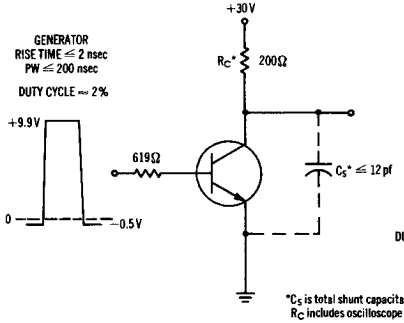


TURN-OFF BEHAVIOR

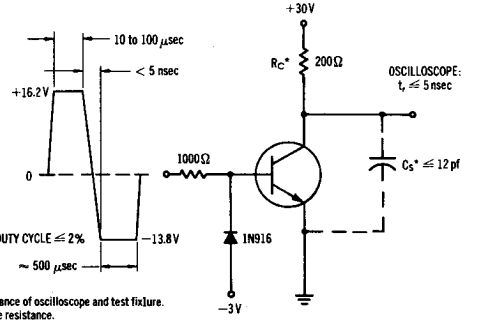




DELAY AND RISE TIME EQUIVALENT TEST CIRCUIT



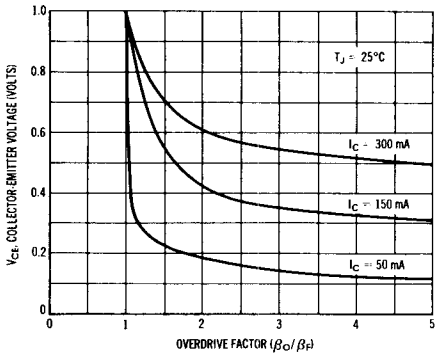
STORAGE TIME AND FALL TIME EQUIVALENT TEST CIRCUIT



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

MD2218, A and MD2219, A (continued)

COLLECTOR CHARACTERISTICS IN SATURATION REGION



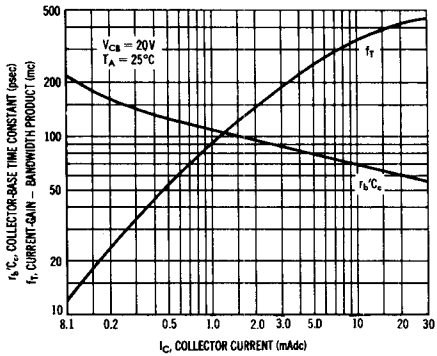
This graph shows the effect of base current on collector current. β_o (current gain at the edge of saturation) is the current gain of the transistor at 1 volt, and β_f (forced gain) is the ratio of I_c/I_w in a circuit.

EXAMPLE: For type MD2219, estimate a base current (I_w) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

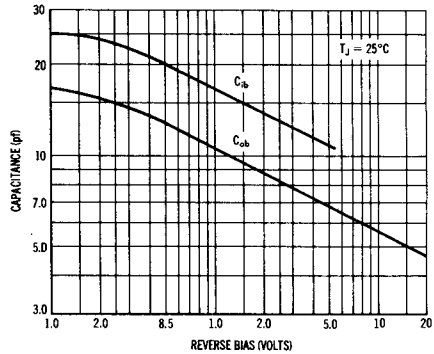
Observe that at I_c = 150 mA an overdrive factor of at least 2.5 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{fe} @ 1 volt is approximately 0.62 of h_{fe} @ 10 volts. Using the guaranteed minimum gain of 100 @ 150 mA and 10 V, β_o = 62 and substituting values in the overdrive equation, we find:

$$\frac{\beta_o}{\beta_f} = \frac{h_{fe}\ @\ 1\ V}{I_c/I_w} \qquad 2.5 = \frac{62}{150/I_w} \qquad I_w \approx 6\ mA$$

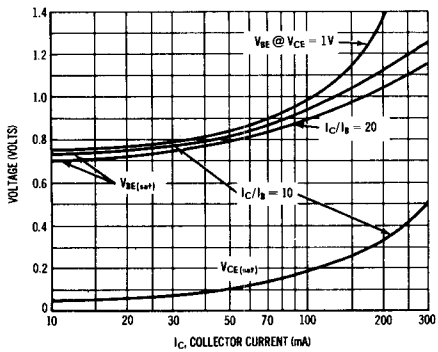
CURRENT-GAIN — BANDWIDTH PRODUCT AND COLLECTOR-BASE TIME CONSTANT DATA



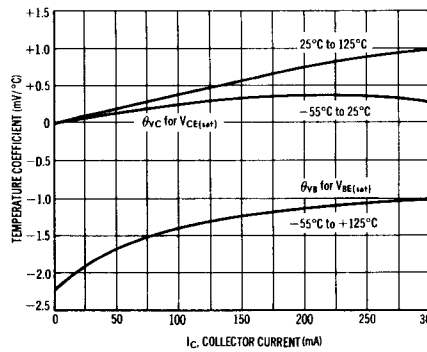
CAPACITANCE VARIATIONS



"ON" VOLTAGES

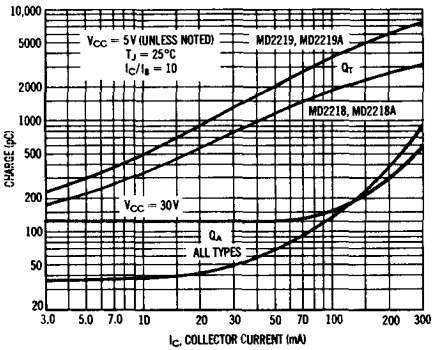


TEMPERATURE COEFFICIENTS

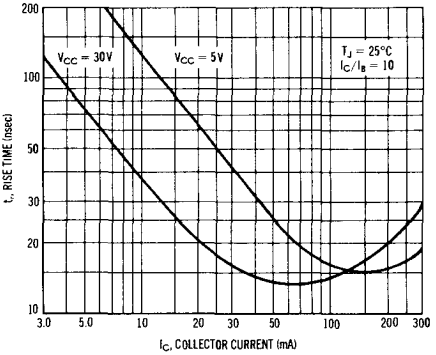


MD2218, A and MD2219, A (continued)

CHARGE DATA



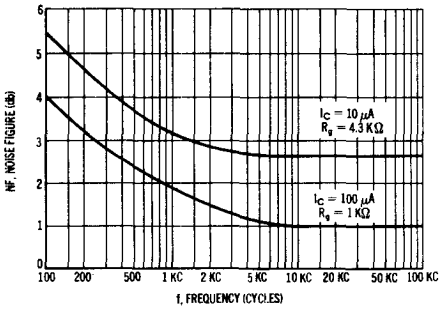
RISE TIME VARIATIONS

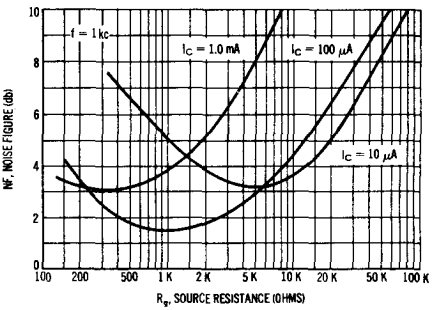


AUDIO SMALL SIGNAL CHARACTERISTICS

NOISE FIGURE VARIATIONS

(V_{CE} = 10V, T_A = 25°C)



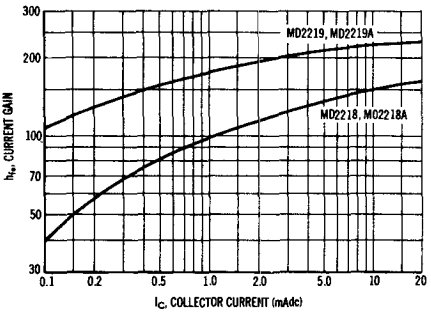


MD2218, A and MD2219, A (continued)

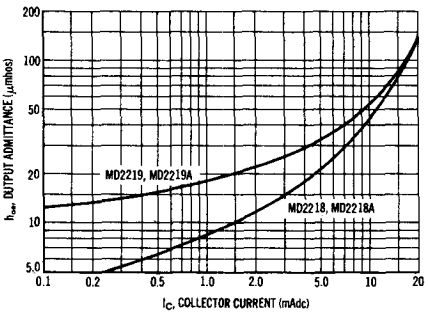
h PARAMETERS

$V_{CE} = 10$ V, $f = 1$ kc, $T_A = 25°C$

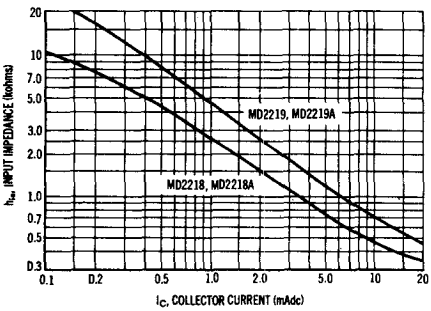
CURRENT GAIN



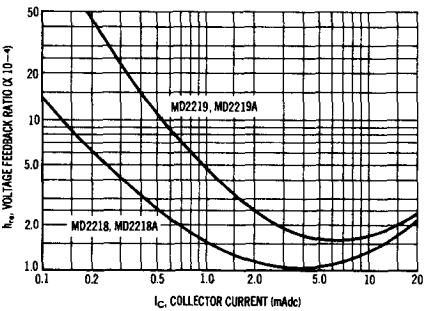
OUTPUT ADMITTANCE



INPUT IMPEDANCE



VOLTAGE FEEDBACK RATIO



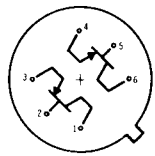
MD2904
MD2905
MD2904A
MD2905A

V_{CEO} = 5 V
I_C = 600 mA
P_D = 500 mW one side
600 mW both sides

Dual PNP silicon annular transistors, designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry with the MD2218 series.



CASE 32



Pin Connections, Bottom View
All Leads Electrically Isolated from Case

MAXIMUM RATINGS (each side) (at 25°C ambient temperature unless otherwise noted)

CHARACTERISTICS	SYMBOL	RATING		UNIT
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage MD2904-2N2905 MD2904A-2N2905A	V_{CEO}	 40 60		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
Collector Current	I_C	600		mAdc
Junction Operating Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 2.9	600 3.4	mW mW/°C
Total Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	1.2 6.9	2.0 11.43	W mW/°C

MD2904, MD2905, MD2904A, MD2905A (continued)

ELECTRICAL CHARACTERISTICS (each side)

(at 25°C ambient temperature unless otherwise noted)

CHARACTERISTICS		SYMBOL	MIN	MAX	UNIT
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MD2904, MD2905	BV_{CEO}*	40	—	Vdc
	MD2904A, MD2905A		60	—	
Emitter-Base Breakdown Voltage (I_B = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3 Vdc)		I_{CEX}	—	.020	μAdc
(V_{CE} = 50 Vdc, $V_{BE(off)}$ = 3 Vdc, T_A = 150°C)			—	30	
Base Cutoff Current (V_{CE} = 50 V, $V_{BE(off)}$ = 3 V)		I_{BL}	—	.030	μAdc
ON CHARACTERISTICS					
DC Forward Current Transfer Ratio* (I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD2904	h_{FE}*	20	—	—
	MD2905		35	—	
	MD2904A		25	—	
	MD2905A		50	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD2904		25	—	
	MD2905		50	—	
	MD2904A		40	—	
	MD2905A		100	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD2904		35	—	
	MD2905		75	—	
	MD2904A		40	—	
	MD2905A		100	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD2904, MD2904A,		40	120	
	MD2905, MD2905A		100	300	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	MD2904, MD2904A,		20	—	
	MD2905, MD2905A		40	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD2904		20	—	
	MD2905		30	—	
	MD2904A		40	—	
	MD2905A		50	—	
Collector Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	—	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			—	1.0	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	—	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			—	2.0	
TRANSIENT CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	8	pf
Input Capacitance (V_{BE} = 2 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	30	pf
Current-Gain–Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 mc)		f_T	200	—	mc
Delay Time	V_{CC} = 30 V, $V_{BE(off)}$ = 0.5 V,	t_d	—	10	nsec
Rise Time	I_C = 150 mA, I_{B1} = 15 mA	t_r	—	40	nsec
Storage Time	V_{CC} = 30 V, I_C = 150 mA,	t_s	—	180	nsec
Fall Time	I_{B1} = I_{B2} = 15 mA	t_f	—	50	nsec

*Pulse Test: Pulse Width ≤ 300 μsec, duty cycle ≤ 2%

MD2904, MD2905, MD2904A, MD2905A (continued)

FIGURE 1 — NORMALIZED DC CURRENT GAIN

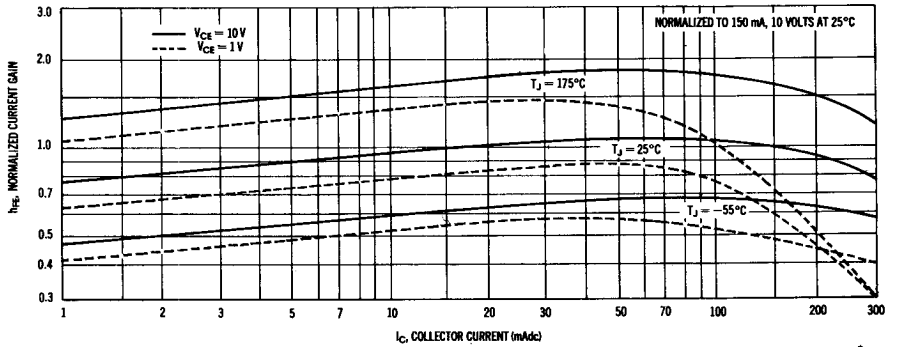
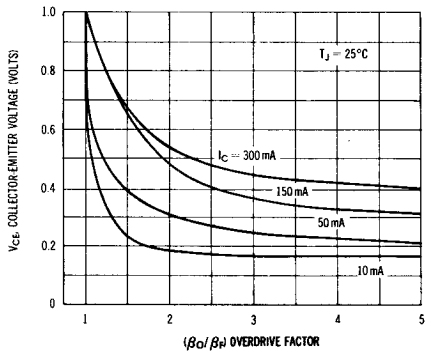


FIGURE 2 — NORMALIZED COLLECTOR SATURATION REGION



This graph shows the effect of base current on collector current. β_o (current gain at edge of saturation) is the current gain of the transistor at 1 volt, and β_f (forced gain) is the ratio of I_C/I_{BF} in a circuit.

EXAMPLE: For type MD2905, estimate a base current (I_{BF}) to insure saturation at a temperature of 25°C and a collector current of 150 mA.

Observe that at I_C = 150 mA an overdrive factor of at least 3 is required to drive the transistor well into the saturation region. From Figure 1, it is seen that h_{FE} @ 1 volt is approximately 0.60 of h_{FE} @ 10 volts. Using the guaranteed minimum of 100 @ 150 mA and 10 V, β_o = 60 and substituting values in the overdrive equation, we find:

$$\frac{\beta o}{\beta f} = \frac{h_{FE} @ 1\ V}{I_C/I_{BF}} \qquad 3 = \frac{60}{150/I_{BF}} \qquad I_{BF} \simeq 7.5\ mA$$

FIGURE 3 — "ON" VOLTAGES

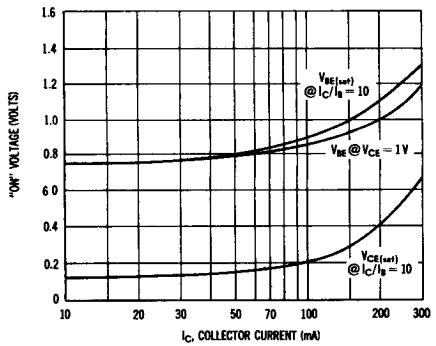
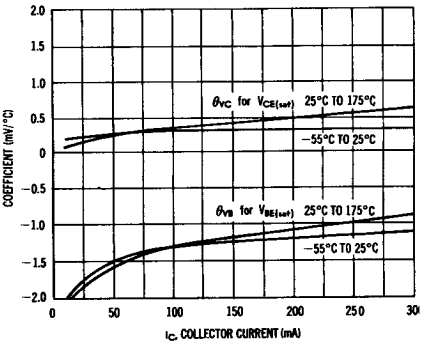


FIGURE 4 — TEMPERATURE COEFFICIENTS



MD2904, MD2905, MD2904A, MD2905A (continued)

SMALL-SIGNAL CHARACTERISTICS
NOISE FIGURE
$V_{CE} = 10V, T_A = 25°C$

FIGURE 5 — FREQUENCY VARIATION

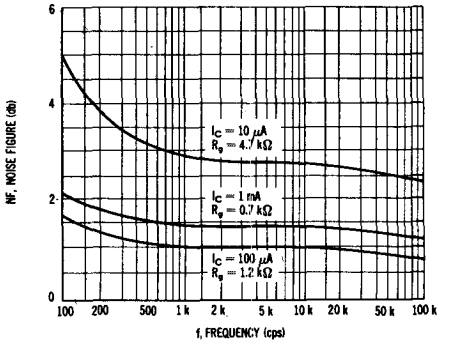
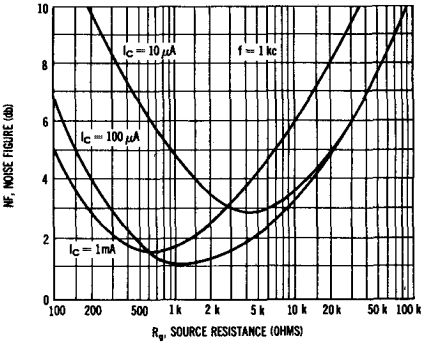


FIGURE 6 — SOURCE RESISTANCE VARIATION



h PARAMETERS
$V_{CE} = 10V, f = 1$ kc, $T_A = 25°C$

FIGURE 7 — CURRENT GAIN

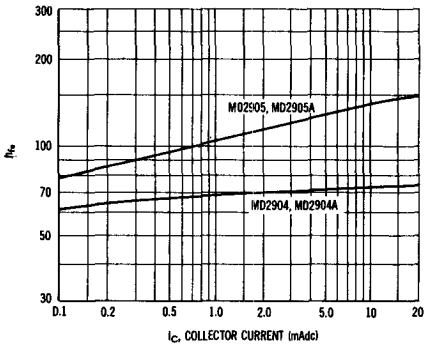


FIGURE 8 — OUTPUT ADMITTANCE

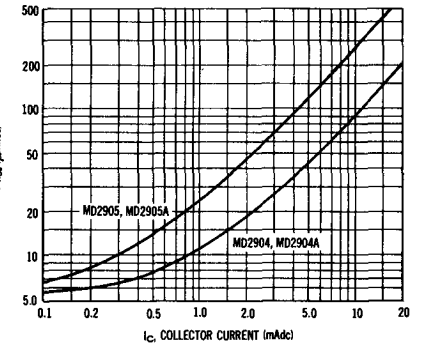


FIGURE 9 — INPUT IMPEDANCE

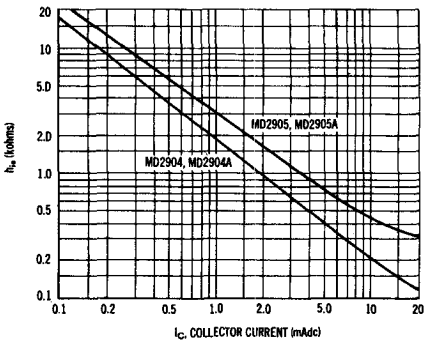
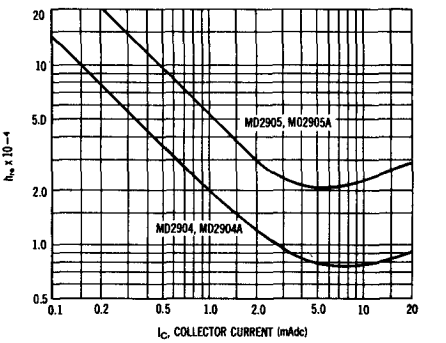


FIGURE 10 — VOLTAGE FEEDBACK RATIO



MD2904, MD2905, MD2904A, MD2905A (continued)

SWITCHING CHARACTERISTICS
$V_{CC} = 30\,V$, $T_A = 25°C$

FIGURE 11 — TURN-ON TIME

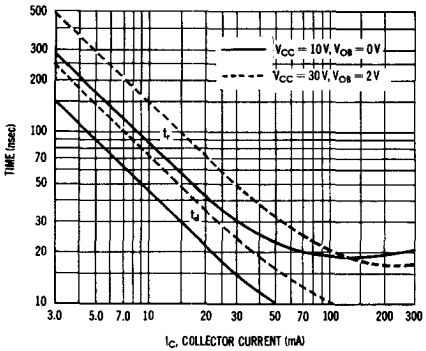


FIGURE 12 — CHARGE DATA

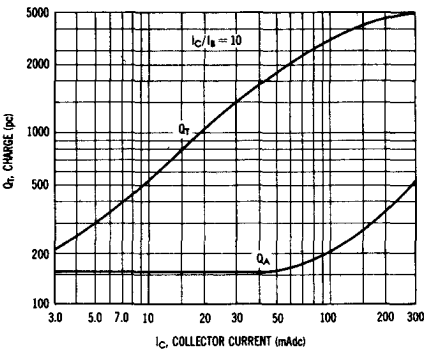


FIGURE 13 — STORAGE TIME

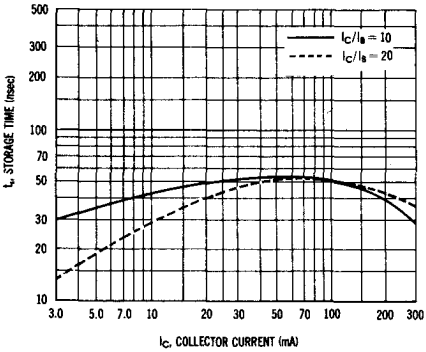
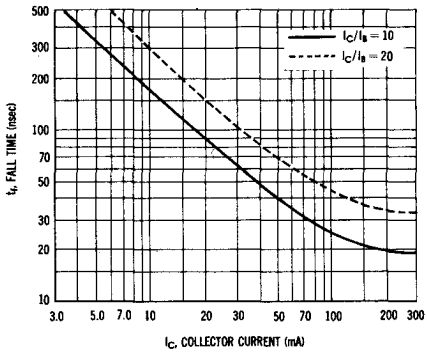


FIGURE 14 — FALL TIME



SWITCHING TIME EQUIVALENT TEST CIRCUITS

FIGURE 15 — TURN-ON TIME

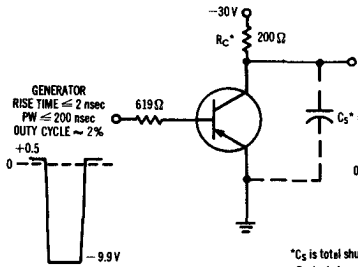
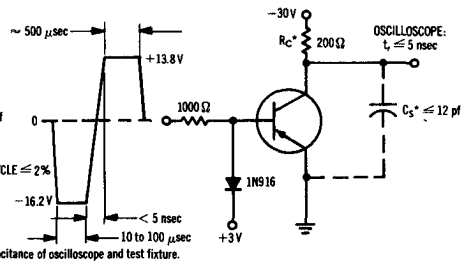


FIGURE 16 — TURN-OFF TIME



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

MD2904, MD2905, MD2904A, MD2905A (continued)

FIGURE 17 — CURRENT GAIN — BANDWIDTH PRODUCT

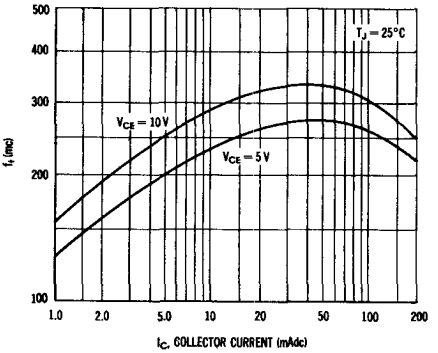


FIGURE 18 — CAPACITANCE

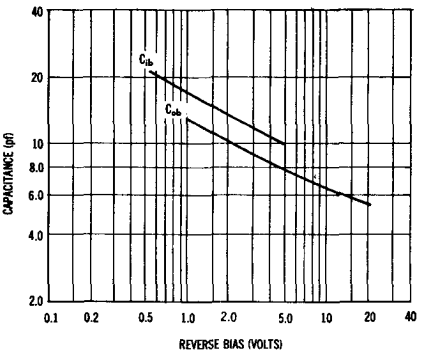
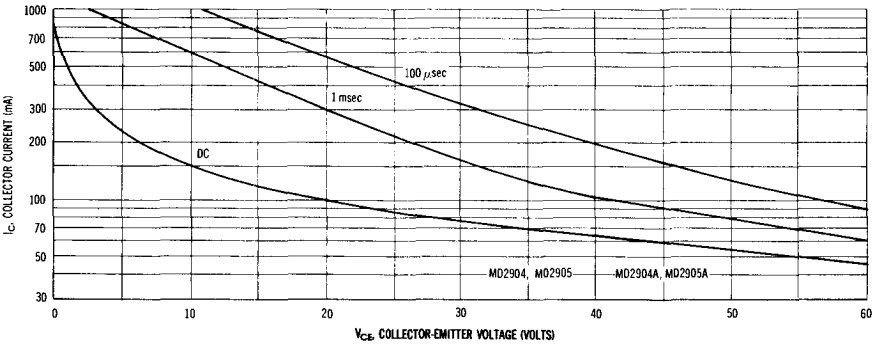


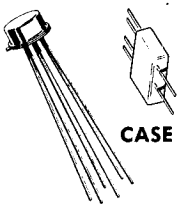
FIGURE 19 — ACTIVE REGION SAFE OPERATING AREAS



The Safe Operating Area Curves indicate I_C-V_{CE} limits below which the devices will not go into secondary breakdown. As the safe operating areas shown are independent of temperature and duty cycle, these curves can be used as long as the average power derating factor (Figure 1) is also taken into consideration to insure operation below the maximum junction temperature.

MD3250, A
MD3251, A

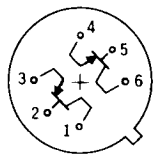
V_{CEO} = 40V
I_C = 50 mA
P_D = 500 mW one side
600 mW both sides

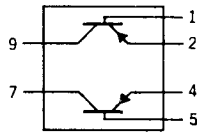


CASE 33

Dual PNP silicon annular transistors, especially designed for low-level, differential amplifier applications.

CASE 32





PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating		Unit
Collector-Base Voltage	V_{CB}	50		Vdc
Collector-Emitter Voltage	V_{CEO}	40		Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
DC Collector Current	I_C	50		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature Range	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D			
TO-5 Case		500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Flat Pack		250	350	mW
Derate above 25°C		1.5	2.0	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D			
TO-5 Case		1.2	2.0	mW
Derate above 25°C		6.85	11.42	mW/°C

MD3250, A and MD3251, A (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

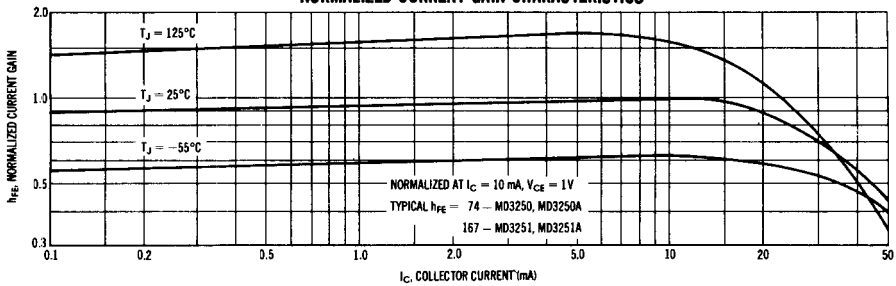
Characteristic		Symbol	Min	Typ	Max	Unit
OFF CHARACTERISTICS						
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	50	—	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 10 mAdc, I_B = 0)		BV_{CEO}	40	70	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	—	Vdc
Collector Cutoff Current (V_{CB} = 50 Vdc, I_E = 0)		I_{CBO}	—	—	0.01	μAdc
(V_{CB} = 50 Vdc, I_E = 0, T_A = 150°C)			—	—	10	
Emitter Cutoff Current (V_{EB} = 3 Vdc, I_C = 0)		I_{EBO}	—	—	20	nAdc
ON CHARACTERISTICS						
DC Forward Current Transfer Ratio* (I_C = 10 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A	h_{FE}*	25	—	—	—
	MD3251, MD3251A		50	—	—	
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55°C)	MD3250, MD3250A		25	—	—	
	MD3251, MD3251A		50	—	—	
(I_C = 1 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	150	
	MD3251, MD3251A		100	—	300	
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		50	—	—	
	MD3251, MD3251A		100	—	—	
(I_C = 50 mAdc, V_{CE} = 5 Vdc)	MD3250, MD3250A		15	—	—	
	MD3251, MD3251A		30	—	—	
Collector-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{CE(sat)}$*	—	—	0.25	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	0.50	
Base-Emitter Saturation Voltage* (I_C = 10 mAdc, I_B = 1.0 mAdc)		$V_{BE(sat)}$*	0.6	—	0.9	Vdc
(I_C = 50 mAdc, I_B = 5 mAdc)			—	—	1.2	
TRANSIENT CHARACTERISTICS						
Current-Gain — Bandwidth Product (I_C = 10 mAdc, V_{CE} = 20 Vdc, f = 100 mc)	MD3250, MD3250A	f_T	200	—	—	mc
	MD3251, MD3251A		250	—	—	
Output Capacitance (V_{CB} = 5 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	—	6	pf
Input Capacitance (V_{EB} = 0.5 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	—	8	pf
Small Signal Current Gain (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	MD3250, MD3250A	h_{fe}	50	—	200	—
	MD3251, MD3251A		100	—	400	
Voltage Feedback Ratio (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	MD3250, MD3250A	h_{re}	—	—	10	X10-4
	MD3251, MD3251A		—	—	20	
Input Impedance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	MD3250, MD3250A	h_{ie}	1	—	6	kohms
	MD3251, MD3251A		2	—	12	
Output Admittance (I_C = 1.0 mA, V_{CE} = 10 V, f = 1 kc)	MD3250, MD3250A	h_{oe}	4	—	40	μmhos
	MD3251, MD3251A		10	—	60	
Wide Band Noise Figure (I_C = 100 μA, V_{CE} = 10 V, R_g = 3 kohm,	MD3250, MD3250A	NF	—	—	4	db
Noise Bandwidth 10 cps to 15.7 kc)	MD3251, MD3251A		—	—	3	
MATCHING CHARACTERISTICS (Types MD3250A and MD3251A only)						
DC Current Gain Ratio** (I_C = 100 μAdc and 1 mAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A	h_{FE1}/h_{FE2}**	0.9	—	1.0	—
Base Voltage Differeotial (I_C = 10 μA, to 10 mA, V_{CE} = 5 Vdc)	MD3250A, MD3251A	$\lvert V_{BE1}-V_{BE2}\rvert$	—	—	5	mVdc
(I_C = 100 μAdc, V_{CE} = 5 Vdc)	MD3250A, MD3251A		—	—	3	
Base Voltage Differential Change (I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = -55 to +25°C)	MD3250A, MD3251A	$\Delta(V_{BE1}-V_{BE2})$	—	—	0.8	mVdc
(I_C = 100 μAdc, V_{CE} = 5 Vdc, T_A = 25 to 125°C)	MD3250A, MD3251A		—	—	1.0	

*Pulse Test ≤ 300 μsec, duty cycle ≤ 2%

** The lowest h_{FE} reading is taken as h_{FE1} for this ratio

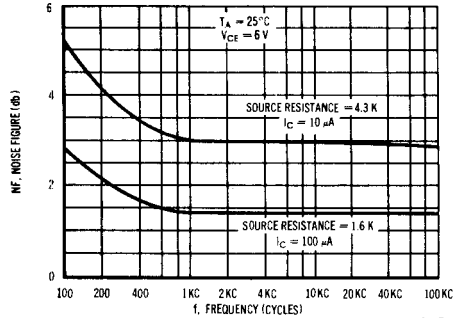
MD3250, A and MD3251, A (continued)

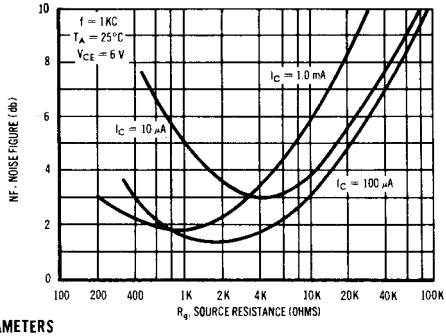
NORMALIZED CURRENT GAIN CHARACTERISTICS



AUDIO SMALL SIGNAL CHARACTERISTICS

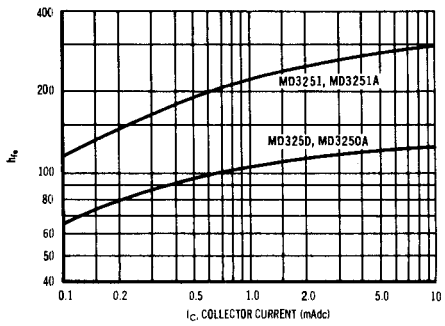
SPOT NOISE FIGURE

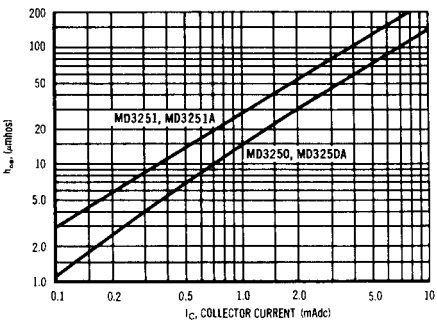


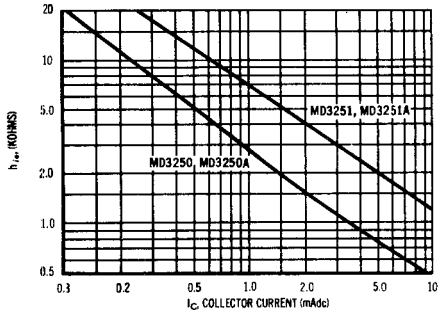


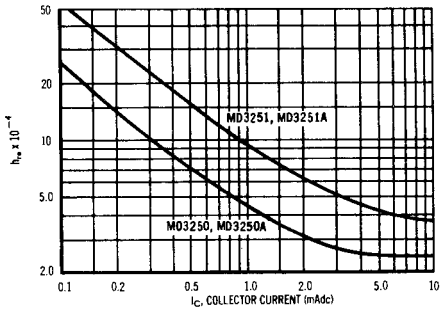
h PARAMETERS

(V_{CE} = 10V, T_A = 25°C, f = 1Kc)



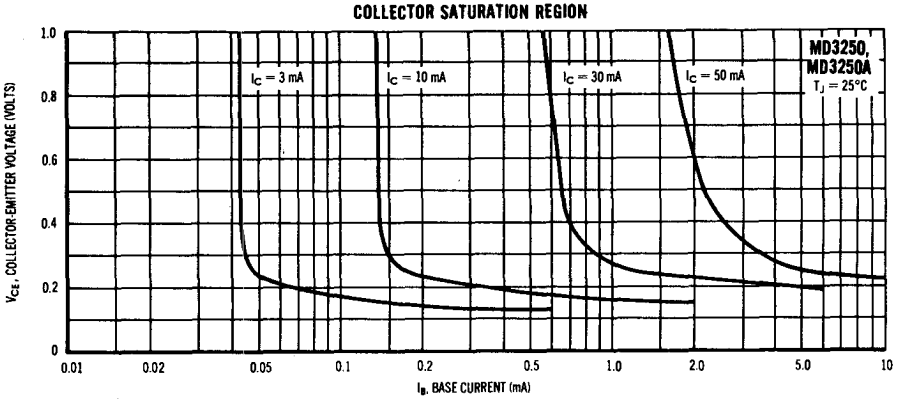


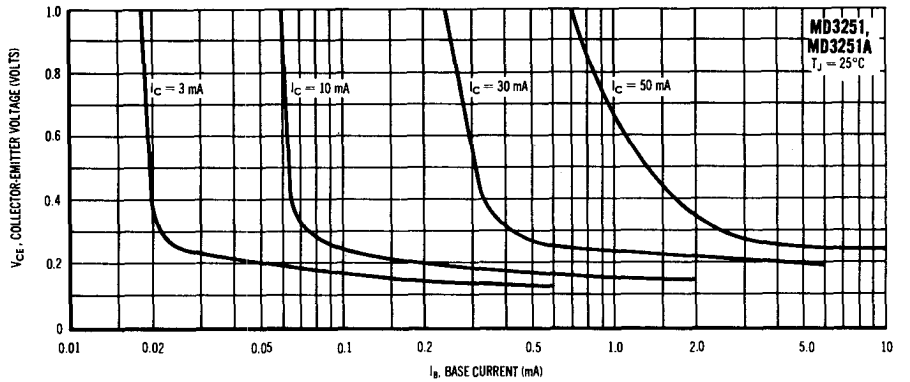


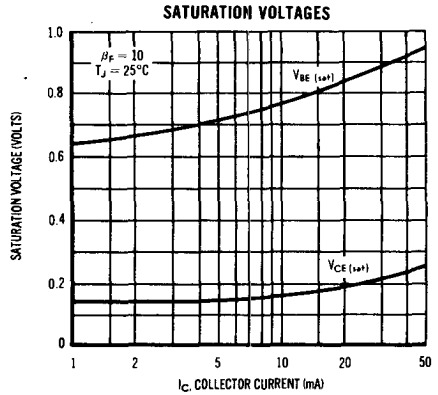


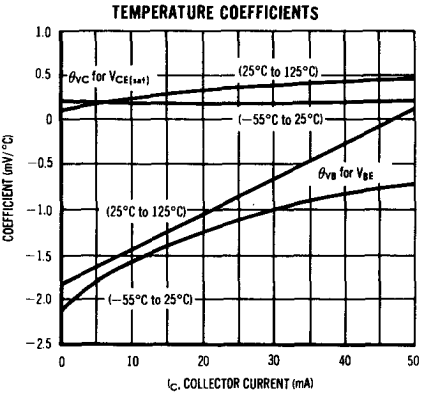
MD3250, A and MD3251, A (continued)

STATIC CHARACTERISTICS









MD6001
MD6002

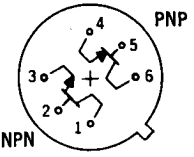


V_{CBO} = 60V
I_C = 300mA
P_D = 500 mW one side
600 mW both sides



Silicon annular complementary-pair dual transistor is designed for high-speed switching circuits, DC to VHF amplifier applications and complementary circuitry.

CASE 32



PIN CONNECTIONS
(BOTTOM VIEW)

MAXIMUM RATINGS (each side) (T_A = 25°C unless otherwise specified)

Test Conditions and Limits are given in magnitudes only. Care must be taken to insure the application of proper polarities for the NPN or PNP transistor, respectively.

Characteristics	Symbol	Rating		Unit
Collector-Base Voltage	V_{CBO}	60		Vdc
Collector-Emitter Voltage	V_{CEO}	30		Vdc
Emitter-Base Voltage	V_{EBO}	5		Vdc
DC Collector Current (Limited by P_D)	I_C	300		mAdc
Junction Temperature	T_J	+200		°C
Storage Temperature	T_{stg}	-65 to +200		°C
		ONE SIDE	BOTH SIDES	
Total Device Dissipation @ T_A = 25°C	P_D	500	600	mW
Derate above 25°C		2.9	3.4	mW/°C
Total Device Dissipation @ T_C = 25°C	P_D	1.2	2.0	W
Derate above 25°C		6.83	11.43	mW/°C

NPN SATURATED SWITCHING TIME TEST CIRCUITS

For PNP Switching Tests, reverse diodes, voltage polarities, and input pulses.

FIGURE 1 — NPN TURN-ON TIME

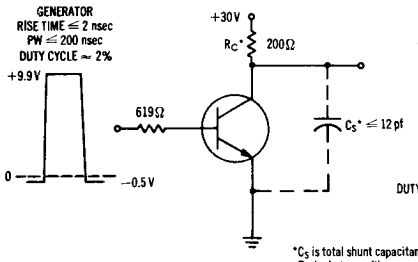
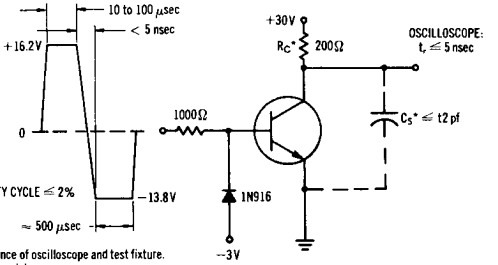


FIGURE 2 — NPN TURN-OFF TIME



*C_S is total shunt capacitance of oscilloscope and test fixture.
R_C includes oscilloscope resistance.

MD6001, MD6002 (continued)

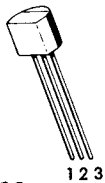
ELECTRICAL CHARACTERISTICS (each side) (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Base Breakdown Voltage (I_C = 10 μAdc, I_E = 0)		BV_{CBO}	60	—	Vdc
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)		BV_{CEO}*	30	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc, I_C = 0)		BV_{EBO}	5	—	Vdc
Collector Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)		I_{CEX}	—	0.02	μAdc
(V_{CE} = 50 Vdc, V_{EB} = 3 Vdc, T_A = 150°C)			—	30	
Base Cutoff Current (V_{CE} = 50 Vdc, V_{EB} = 3 Vdc)		I_{BL}	—	0.03	μAdc
ON CHARACTERISTICS					
DC Current Gain*		h_{FE}*			—
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	MD6001		20	—	
	MD6002		35	—	
(I_C = 1.0 mAdc, V_{CE} = 10 Vdc)	MD6001		25	—	
	MD6002		50	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	MD6001		35	—	
	MD6002		75	—	
(I_C = 150 mAdc, V_{CE} = 10 Vdc)	MD6001		40	120	
	MD6002		100	300	
(I_C = 150 mAdc, V_{CE} = 1 Vdc)	MD6001		20	—	
	MD6002		50	—	
(I_C = 300 mAdc, V_{CE} = 10 Vdc)	MD6001		20	—	
	MD6002		30	—	
Base-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{BE(sat)}$*	—	1.3	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			—	2.0	
Collector-Emitter Saturation Voltage* (I_C = 150 mAdc, I_B = 15 mAdc)		$V_{CE(sat)}$*	—	0.4	Vdc
(I_C = 300 mAdc, I_B = 30 mAdc)			—	1.4	
TRANSIENT CHARACTERISTICS					
Gain - Bandwidth Product (I_C = 50 mAdc, V_{CE} = 20 Vdc, f = 100 mc)		f_T	—	200	mc
Collector Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 100 kc)		C_{ob}	—	8	pf
Collector Input Capacitance (V_{EB} = 2 Vdc, I_C = 0, f = 100 kc)		C_{ib}	—	30	pf
Delay Time	See Figure 1 V_{CC} = 30 V, $V_{BE(off)}$ = 0.5 V	t_d	—	20	nsec
Rise Time	I_C = 150 mA, I_{B1} = 15 mA	t_r	—	40	nsec
Storage Time	See Figure 2 V_{CC} = 30 V, I_C = 150 mA	t_s	—	280	nsec
Fall Time	I_{B1} = I_{B2} = 15 mA	t_f	—	70	nsec

*Pulse Test: PW ≤ 300 μsec, Duty Cycle ≤ 2%

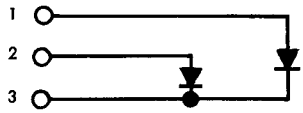
MSD6100

$V_R = 100V$
$I_F = 200mA$
$P_D = 310mW$



CASE 29
(TO-92)

Silicon epitaxial dual switching diode, designed for use in high speed switching applications, features high breakdown voltage, low capacitance, one-piece injection-molded unibloc package, and space saving common-cathode configuration.



MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	100	Vdc
Recurrent Peak Forward Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μsec)	$I_{FM(surge)}$	500	mA
Power Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating Junction Temperature	T_J	135	°C
Storage Temperature Range	T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)}$ = 100 μAdc)	—	$V_{(BR)}$	100	—	Vdc
Reverse Current (V_R = 100 Vdc) (V_R = 50 Vdc) (V_R = 50 Vdc, T_A = 125°C)	2	I_R	 — — —	 5 0.1 20	μAdc
Forward Voltage (I_F = 1 mAdc) (I_F = 10 mAdc) (I_F = 100 mAdc)	1	V_F	 0.55 0.67 0.75	 0.7 0.82 1.1	Vdc
Capacitance (V_R = 0)	3	C	—	1.5	pf
Reverse Recovery Time (I_F = I_R = 10 mAdc, V_R = 5 Vdc, i_{rr} = 1.0 mAdc)	4,5	t_{rr}	—	4.0	nsec

MSD6100 (continued)

FIGURE 1 — FORWARD CHARACTERISTICS

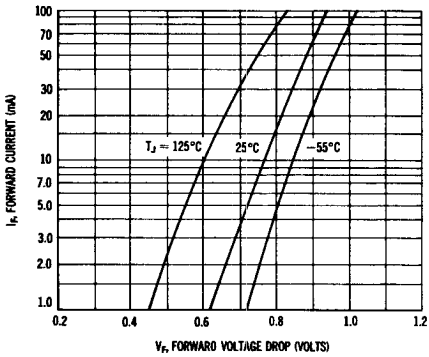


FIGURE 2 — REVERSE LEAKAGE CURRENT

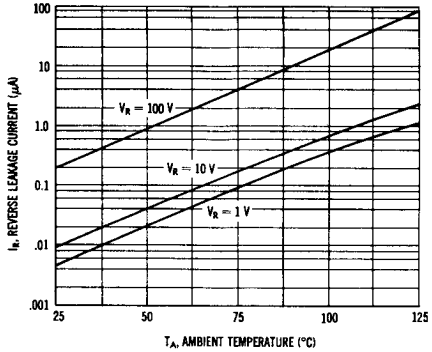


FIGURE 3 — CAPACITANCE

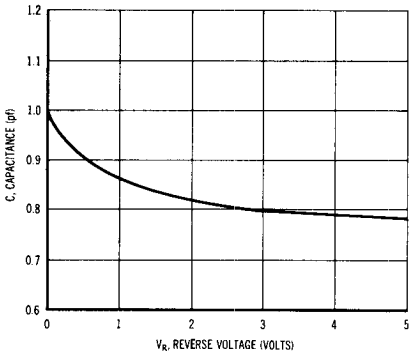


FIGURE 4 — REVERSE RECOVERY TIME

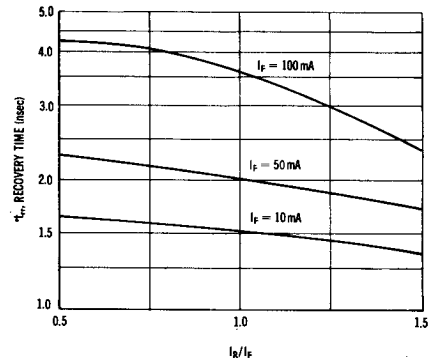
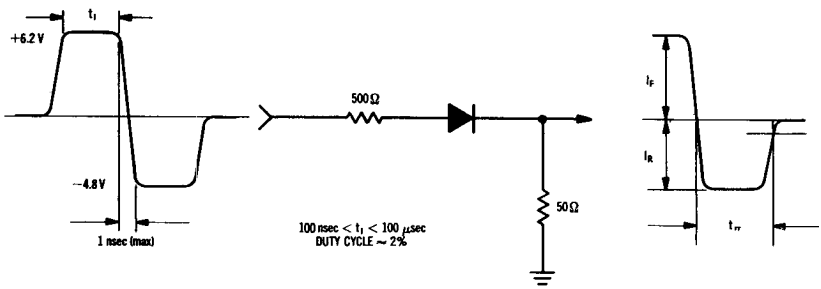
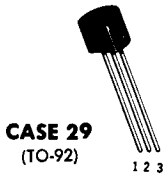


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT

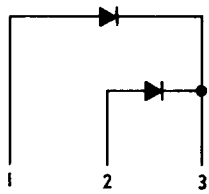


MSD6101

$V_R = 50$ V
$I_F = 200$ mA
$P_D = 310$ mW



CASE 29
(TO-92)



Silicon epitaxial dual discriminator diode designed for use in FM discriminator applications.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	50	Vdc
Peak Forward Recurrent Current	I_F	200	mA
Peak Forward Surge Current (Pulse Width = 10 μs)	$I_{FM(surge)}$	500	mA
Power Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.82	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Fig. No.	Symbol	Min	Max	Unit
Breakdown Voltage ($I_{(BR)} = 100$ μAdc)	-	$V_{(BR)}$	50	-	Vdc
Reverse Current ($V_R = 40$ Vdc) ($V_R = 40$ Vdc, $T_A = 125°C$)	2	I_R	- -	0.1 100	μAdc
Forward Voltage ($I_F = 0.1$ mAdc) ($I_F = 10$ mAdc)	1	V_F	0.43 0.67	0.57 0.82	Vdc
Capacitance ($V_R = 0$)	3	C	-	2.0	pF
Reverse Recovery Time ($I_F = I_R = 10$ mAdc, $V_R = 5$ Vdc, $i_{rr} = 1.0$ mAdc)	4, 5	t_{rr}	-	10	ns
Forward Voltage Matching $\lvert V_{F1} - V_{F2} \rvert$ ($I_{F1} = I_{F2} = 0.1$ mAdc)	-	ΔV_F	-	0.003	Vdc

MSD6101 (continued)

FIGURE 1 — FORWARD CHARACTERISTICS

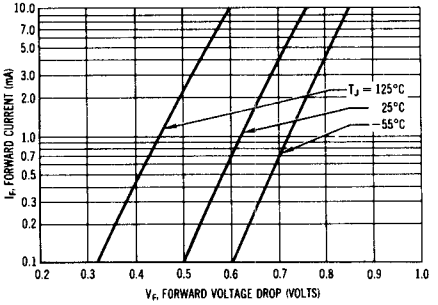


FIGURE 2 — REVERSE LEAKAGE CURRENT

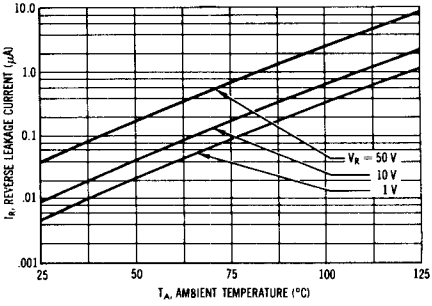


FIGURE 3 — CAPACITANCE

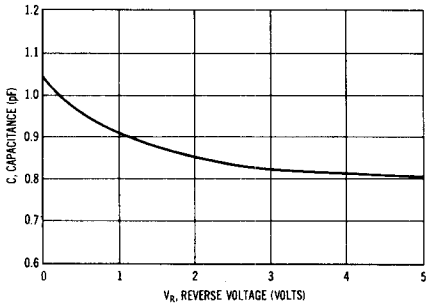


FIGURE 4 — REVERSE RECOVERY TIME

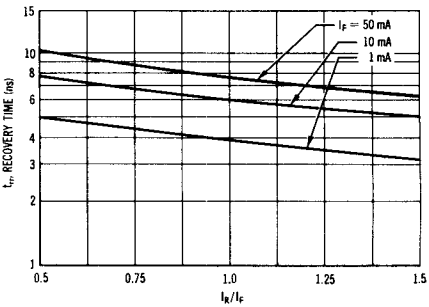
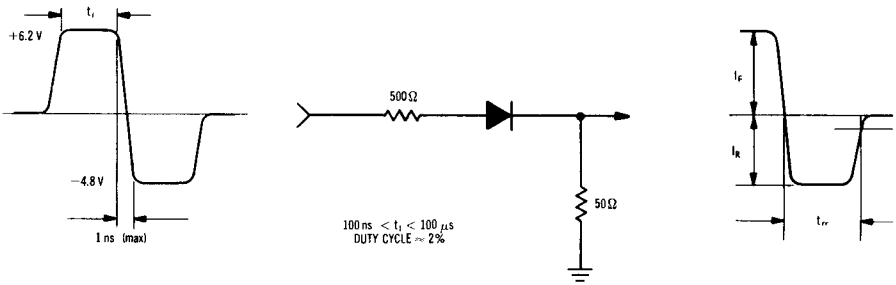


FIGURE 5 — RECOVERY TIME EQUIVALENT TEST CIRCUIT



ADDITIONS AND MODIFICATIONS

VARACTORS

Including

VARACTOR DIODES

VOLTAGE-VARIABLE CAPACITANCE DIODES

RF SWITCHING DIODE

For case outline dimensions, see page 1-186.

VARACTORS

Varactor diodes are voltage-variable capacitance diodes utilized for electronic tuning and for frequency multiplication and RF switching in receivers and transmitters. This section contains devices suitable for both purposes. The frequency-multiplier devices are step-recovery types intended to provide high power output at frequencies normally beyond the limits of RF power transistors.

Devices in this section include:

TUNING DIODES		MULTIPLIER DIODES				RF SWITCHING DIODES	
Device	Pg. No.	Device	Pg. No.	Device	Pg. No.	Device	Pg. No.
1N5139, A thru 1N5148, A	12-10	1N4386	12-5	1N5151 (MV1808A)	12-15	MV1892	12-25
MV830 thru MV840	12-21	1N4387	12-7	1N5152 (MV1808B)	12-15		
MV1864A, B	12-23	1N4388	12-8	1N5153 (MV1808C)	12-15		
		1N5149 (MV1806C)	12-12	1N5154 (MV1810A)	12-18		
		1N5150 (MV1807C)	12-12	1N5155 (MV1810B)	12-18		

PARAMETER TEST METHODS

1. L_s, SERIES INDUCTANCE

A. PILL / PILL-PRONG PACKAGE
Series inductance is calculated.

B. GLASS PACKAGE
L_s is measured on a shorted package at 250 mc using an impedance bridge (Boonton Radio Model 250A Rx Meter). L = lead length.

2. C_C, CASE CAPACITANCE

C_C is measured on an open package at 1 mc using a capacitance bridge (Boonton Electronics Model 75A).

3. C_T, DIODE CAPACITANCE

($C_T = C_C + C_J$). C_T is measured at 1 mc using a capacitance bridge (Boonton Electronics Model 33AS8).

4. R_S, SERIES RESISTANCE and Q, FIGURE OF MERIT

R_S and Q are calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$R_S = \frac{G}{(2\pi f)^2 C^2} \qquad Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

5. f_{CO}, CUTOFF FREQUENCY

f_{CO} is calculated using the equation $f_{CO} = Qf$.

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE

The diode capacitance, C_T (as measured at $V_R = 4$ Vdc, f = 1 mc) is compared to C_T (as measured at $V_R = 60$ Vdc, f = 1 mc) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(60)}{\log 60 - \log 4} *$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

$$C_T = \frac{K}{V^\alpha}$$

α is not the same as γ. See page 4.

7. TC_C, DIODE CAPACITANCE TEMPERATURE COEFFICIENT

TC_C is guaranteed by comparing C_T at $V_R = 4$ Vdc, f = 1 mc, $T_A = -65°C$ with C_T at $V_R = 4$ Vdc, f = 1 mc, $T_A = +85°C$ in the following equation which defines TC_C:

$$TC_C = \left| \frac{C_T(+85°C) - C_T(-65°C)}{85 + 65} \right| \cdot \frac{10^4}{C_T(25°C)}$$

* Change 60 volt values to 30 volts for MV830-MV840.

VOLTAGE VARIABLE CAPACITANCE DIODE DEVICE CONSIDERATIONS

A. VVC NETWORK PRESENTATION

The equivalent circuit in Figure 1 shows the voltage capacitance and parasitic elements of a VVC diode. For design purposes at all but very high and very low frequencies, L_S, R_J, and C_C can be neglected. The simplified equivalent circuit of Figure 2 represents the diode under these conditions.

FIGURE 1

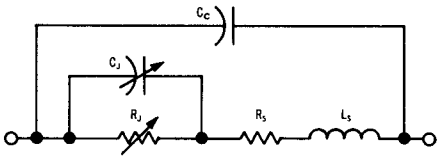
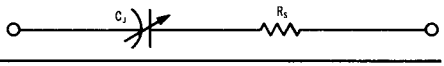


FIGURE 2



Definitions:
- C_J — Voltage Variable Junction Capacitance
- R_S — Series Resistance (semiconductor bulk, contact, and lead resistance)
- C_C — Case Capacitance
- L_S — Series Inductance
- R_J — Voltage Variable Junction Resistance (negligible above 100 kHz)

B. VVC CAPACITANCE vs. REVERSE BIAS VOLTAGE

The most important design characteristic of a VVC diode is the C_T versus V_R variation as shown in equations 1 and 2. Since the designer is primarily interested in the slope of C_T versus V_R, the C_C, C_O, ϕ, and γ characteristics have been encompassed by the simplified equation 3. Min/max limits on α (as defined in Note 6) can be guaranteed over a specified V_R range.

$$C_T = C_C + C_J \tag{1}$$

$$C_T = C_C + \frac{C_o}{(1 + \frac{V_R}{\phi})^\gamma} \tag{2}$$

C_o = C_J at $V_R = 0$ $\quad$ V_R = Reverse Bias

ϕ = Contact Potential, $\phi \approx 0.6$ Volt $\quad$ γ = C_J slope, $\gamma \approx 0.5$

$$C_T = \frac{K}{V_R^\alpha} \tag{3}$$

C. VVC CAPACITANCE vs. FREQUENCY

Variations in VVC effective capacitance, as a function of operating frequency, can be derived from a simplified equivalent circuit similar to that of Figure 1, but neglecting R_S and R_J. The admittance expression for such a circuit is given in equation 4. Examination of equation 4 yields the following information:

At low frequencies, $C_{eq} \approx C_J$; at very high frequencies ($f \approx \infty$) $C_{eq} \approx C_C$.

As frequency is increased from 1 MHz, C_{eq} increases until it is maximum at $\omega^2 = 1/L_SC_J$; and ω^2 is increased from $1/L_SC_J$ toward infinity, C_{eq} increases from a very negative capacitance (inductive) toward $C_{eq} = C_C$, a positive capacitance.

Very simple calculations for C_{eq} at higher frequencies indicate the problems encountered when capacity measurements are made above 1 MHz. As ω approaches $\omega_o = 1/\sqrt{L_SC_J}$, small variations in L_S cause extreme variations in measured diode capacitance.

$$Y = j\omega C_{eq} = j\omega C_c + \frac{j\omega C_J}{1 - \omega^2 L_S C_J} \tag{4}$$

D. VVC FIGURE OF MERIT (Q) AND CUTOFF FREQUENCY (f_{CO})

The efficiency of VVC response to an input frequency is related to the Figure of Merit of the device as defined in equation 5. For very low frequencies, equation 6 applies whereas at high frequencies, where R_J can be neglected, equation 5 may be written into the familiar form of equation 7.

Another useful parameter for VVC devices in the cutoff frequency (f_{co}). This is merely that frequency at which Q is equal to 1. Equation 8 gives this relationship.

$$Q = \frac{X_{Seq}}{R_{Seq}} \tag{5}$$

$$Q_{Lf} = \frac{\omega C_J R_J^2}{R_J + R_S(1 + \omega^2 C_J^2 R_J^2)} \tag{6}$$

$$Q_{hf} = \frac{1}{\omega R_S C_{eq}} \tag{7}$$

$$f_{co} = Qf_{max} \approx \frac{1}{2\pi R_S C_{BVR}} \tag{8}$$

E. HARMONIC GENERATION USING VVC's

Efficient harmonic generation is possible with VVC because of their high cutoff frequency and breakdown voltage. Since VVC junction capacitance varies inversely with the square root of the breakdown voltage, harmonic generator performance can be accurately predicted from various idealized models. Equation 9 gives the level of maximum input power for the VVC and equation 10 gives the relationships governing VVC circuit efficiency. In these equations, adequate heat sinking has been assumed.

$$P_{in(max)} = \frac{M(BV_R + \phi)^2}{R_S} \frac{f_{in}}{f_{co}} \tag{9}$$

M(x2) = 0.0285; M(x3) = 0.0241; M(x4) = 0.196

$$Eff = 1 - N\frac{f_{out}}{f_{co}} \tag{10}$$

N(x2) = 20.8; N(x3) = 34.8; N(x4) = 62.5

M and N are Constants

1N4386

V_R = 250 V
P_{out} = 37.5 W @ 150 Mc
η = 75% ($f_{out.}$ = 150 Mc)



CASE 49
(DO-4)
cathode connected to stud

Silicon varactor diode for high-power frequency multiplication applications.

MAXIMUM RATINGS

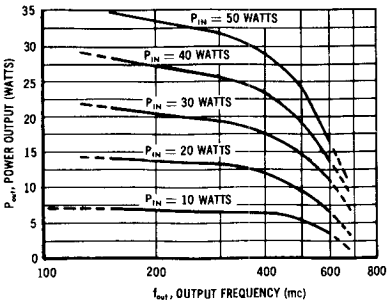
Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	250	Volts
RF Power Input	P_{in}	100	Watts
Total Device Dissipation @ T_C = 75°C (derate 0.25 W/°C above 75°C)	P_D	25	Watts
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (T_C = 25°C)

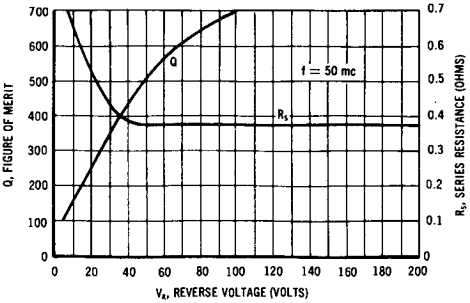
Characteristic	Symbol	Condition	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	250	300	—	Vdc
Series Resistance	R_S	V_R = 6 Vdc, f = 50 mc	—	0.75	1.5	Ohms
Junction Capacitance	C_J	V_R = 6 Vdc, f = 50 mc	—	35	50	pf
Figure of Merit	Q	V_R = 6 Vdc, f = 50 mc	75	125	—	—
Power Output	P_{out}	TRIPLER TEST CIRCUIT	32.5	37.5	—	Watts
Efficiency	η	P_{in} = 50 W, f_{in} = 50 mc, f_{out} = 150 mc	65	75	—	%

1N4386 (continued)

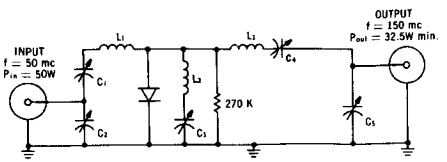
POWER OUTPUT versus OUTPUT FREQUENCY FOR HARMONIC TRIPLING



SERIES RESISTANCE AND FIGURE OF MERIT versus REVERSE VOLTAGE



50 mc TO 150 mc TRIPLER TEST CIRCUIT



Coil.	LENGTH	DIAMETER (Inside)	TURNS	WIRE DIA.
L_1	1⅜"	1 1/16"	7	3/32"
L_2	1½"	11/16"	4¾	3/32"
L_3	1¼"	½	3½	3/32"

C_1	2.8-11 pf	E. F. JOHNSON	167-1	VARIABLE CAPACITOR
C_2	6.7-140 pf	HAMMARLUND	APC-140	VARIABLE CAPACITOR
C_3	3.0-25 pf	HAMMARLUND	APC-25	VARIABLE CAPACITOR
C_4	2.9-35 pf	HAMMARLUND	MAPC-35	VARIABLE CAPACITOR
C_5	3.0-25 pf	HAMMARLUND	APC-25	VARIABLE CAPACITOR

APPLICATION NOTES

VARACTOR CHARACTERISTICS:

The 1N4386 is designed for RF power inputs up to 100 watts and for output frequencies up to 300 mc. Although power handling capability is stressed in device construction, high-multiplication efficiency is maintained with input powers as low as 10 watts.

Where frequencies with input powers below 10 watts are to be multiplied, or where higher output frequencies are desired, the 1N4387 varactor diode is recommended. That device is designed for maximum power levels up to 40 watts and output frequencies up to 600 mc. (see the 1N4387 data sheet for device specifications.)

Both the 1N4386 and 1N4387 power varactors are fabricated by the formation of a deep diffused silicon junction with a unique impurity profile. One of the significant characteristics of such a profile is enhancement of nonlinearities due to the sharp recovery of stored minority carriers injected during the forward voltage swing. This increased nonlinearity results in better efficiency retention at high power levels and considerably less distortion of amplitude modulated signals.

Published design theory for abrupt junction varactors can be used for approximate calculations of diffused varactor impedance and power handling capability, but the engineer is cautioned to use the results of such calculations for performance estimates only. Functional specifications and circuit-determined curves are included with data sheet information in order to facilitate circuit design.

The DO-4 package is well suited to varactor shunt circuits as the stud can be mounted to a chassis for ground and heat sink purposes.

GENERAL DESIGN CONSIDERATIONS:

In the design of varactor harmonic multipliers, lumped circuit techniques are useful up to 450 mc with little performance degradation provided coil and capacitor "Q" values of 200 to 300 are maintained.

Above 450 mc, coaxial, stripline, or helical coil resonators are recommended. Component values are not particularly critical; however, excessive inductance or insufficient coupling can cause low efficiency, and insufficient inductance or excessive coupling can cause poor filtering. Simple experimentation with well constructed and shielded breadboards is generally sufficient for circuit optimization. Note that an adequate tuning range must be provided to insure input match over normal varactor variations, and that spurious signals between stages should be kept below 30 db by suitable filter circuits.

If self bias is used, bias resistor values between 68K and 270K ohms are optimum. The higher values give more efficient operation, whereas the lower values permit more linear operation. Amplitude modulated signals can be passed with relatively low distortion if $R_B \approx 100K$ ohms and the varactor RF input power level is kept less than 65% of the rated maximum limit.

For all multiplications other than doubling, idler circuits should be provided in order to optimize circuit efficiencies.

In typical applications doubling efficiency is 5% greater than that for tripling and quadrupling efficiency 5% less than that for tripling. (See data sheet curves.)

1N4387

$V_R = 150$ V
$P_{out} = 18$ W @ 450 Mc
$\eta = 60\%$ ($f_{out} = 450$ Mc)



CASE 49
(DO-4)

cathode connected to stud

Silicon varactor diode for high-power frequency multiplication applications.

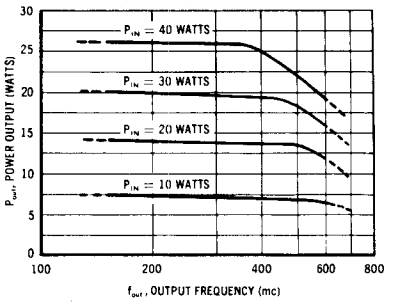
MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	150	Volts
RF Power Input	P_{in}	40	Watts
Total Device Dissipation @ $T_C = 75^oC$ (derate 0.2 W/^{o}C above 75°C)	P_D	20	Watts
Junction Temperature	T_J	+175	^{o}C
Storage Temperature Range	T_{stg}	-65 to +175	^{o}C

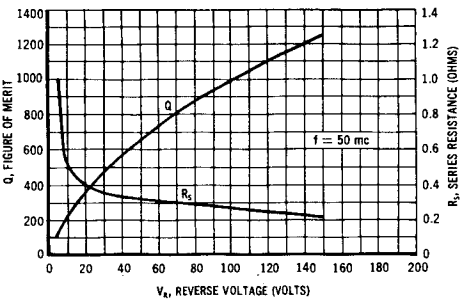
ELECTRICAL CHARACTERISTICS ($T_C = 25°$)

Characteristic	Symbol	Condition	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	$I_R = 10\,\mu$Adc	150	200	—	Vdc
Series Resistance	R_S	$V_R = 6$ Vdc, $f = 50$ mc	—	1.0	1.5	Ohms
Junction Capacitance	C_J	$V_R = 6$ Vdc, $f = 50$ mc	—	25	35	pf
Figure of Merit	Q	$V_R = 6$ Vdc, $f = 50$ mc	150	200	—	—
Power Output	P_{out}	TRIPLER CIRCUIT	15	18	—	Watts
Efficiency	η	$P_{in} = 30$ W, $f_{in} = 150$ mc, $f_{out} = 450$ mc	50	60	—	%

POWER OUTPUT versus OUTPUT FREQUENCY FOR HARMONIC TRIPLING



SERIES RESISTANCE AND FIGURE OF MERIT versus REVERSE VOLTAGE



1N4388

$V_R = 100$ V
$C_T = 10$ pf
$\eta = 60\%$ ($f_{out} = 1000$ Mc)
$P_{out} = 12$ W @ 1000 Mc



CASE 49
(DO-4)

cathode connected to stud

Silicon varactor diode for high-frequency harmonic generation applications.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Characteristics	Symbol	Rating	Unit
Reverse Voltage	V_R	100	Volts
Forward Current	I_F	1	Amp
RF Power Input	P_{in}	25	Watts
Total Device Dissipation @ $T_C = 75°C$	P_D	10	Watts
Derate above 75°C		0.10	W/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

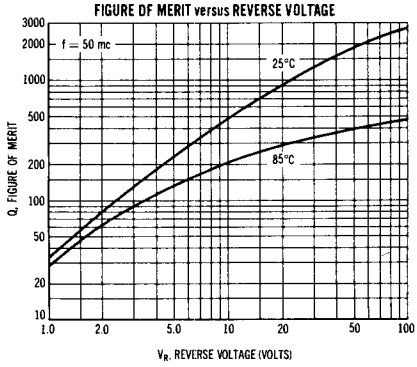
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristics	Symbol	Condition	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	$I_R = 10$ μAdc	100	150	--	Vdc
Reverse Current	I_R	$V_R = 75$ Vdc	--	0.5	2	μAdc
		$V_R = 75$ Vdc, $T_A = 150°C$	--	--	100	
Series Resistance	R_S	$V_R = 6$ Vdc, f = 50 mc	--	1.2	2.0	Ohms
Diode Capacitance	C_T*	$V_R = 6$ Vdc, f = 50 mc	--	10	20	pF
		$V_R = 90$ Vdc, f = 50 mc	--	5	10	
Figure of Merit	Q	$V_R = 6$ Vdc, f = 50 mc	200	300	--	--
		$V_R = 90$ Vdc, f = 50 mc	1000	--	--	
Power Output	P_{out}	TEST CIRCUIT (Figure 1)	11.0	12.0	--	Watts
Efficiency	η	$P_{in} = 20$ W, $f_{in} = 500$ mc, $f_{out} = 1000$ mc	55	60	--	%

*$C_T = C_J + C_C$

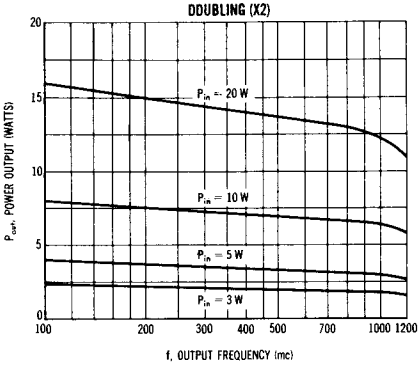
1N4388 (continued)

FIGURE OF MERIT versus REVERSE VOLTAGE

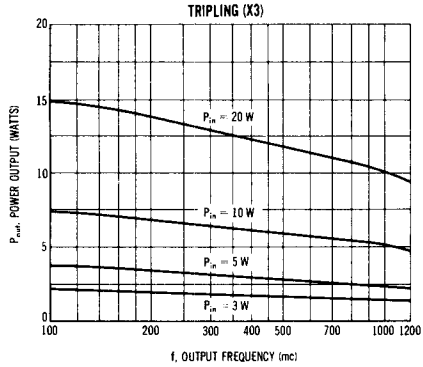


POWER OUTPUT versus OUTPUT FREQUENCY

DOUBLING (X2)



TRIPLING (X3)



QUADRUPLING (X4)

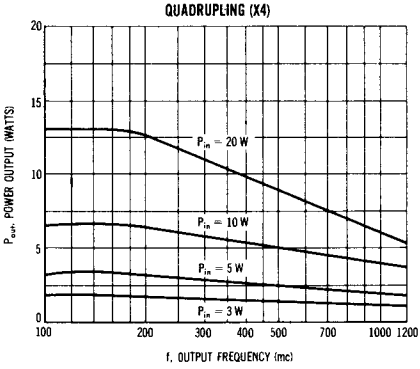
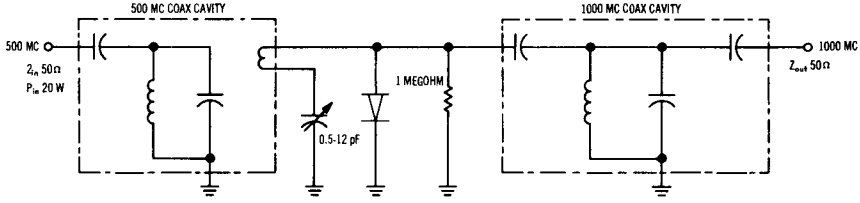


FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

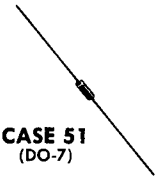


1N5139,A thru 1N5148,A

$V_R = 60$ V

$I_F = 250$ mA

Q = 200-350 (min) @ $V_R = 4$ V and f = 50 MHz



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable capacitance diodes, designed for electronic tuning and harmonic-generation applications, and providing solid-state reliability to replace mechanical tuning methods.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
RF Power Input†	P_{in}	5	Watts
Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ $T_C = 25°C$ Derate above 25°C	P_C	2 13.3	Watts mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

†The RF power input rating assumes that an adequate heat sink is provided.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic – All Types	Test Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	$I_R = 10\ \mu Adc$	B_{VR}	60	70	—	Vdc
Reverse Voltage Leakage Current	$V_R = 55$ Vdc, $T_A = 25°C$ $V_R = 55$ Vdc, $T_A = 150°C$	I_R	— —	— —	0.02 20	μAdc
Series Inductance	$f = 250$ MHz, $L \approx 1/16''$	L_S	—	5	—	nH
Case Capacitance	$f = 1$ MHz, $L \approx 1/16''$	C_C	—	0.25	—	pF
Diode Capacitance Temperature Coefficient	$V_R = 4$ Vdc, $f = 1$ MHz	TC_C	—	200	300	ppm/°C

	C_T, Diode Capacitance $V_R = 4$ Vdc, f = 1 MHz pF			Q, Figure of Merit $V_R = 4$ Vdc, f = 50 MHz	α $V_R = 4$ Vdc, f = 1 MHz		TR, Tuning Ratio C_4/C_{60} f = 1 MHz	
Device	Min	Typ	Max	Min	Min	Typ	Min	Typ
1N5139	6.1	6.8	7.5	350	0.37	0.40	2.7	2.9
1N5139A	6.5	6.8	7.1	350	0.37	0.40	2.7	2.9
1N5140	9.0	10.0	11.0	300	0.36	0.41	2.6	3.0
1N5140A	9.5	10.0	10.5	300	0.38	0.41	2.8	3.0
1N5141	10.8	12.0	13.2	300	0.36	0.41	2.6	3.0
1N5141A	11.4	12.0	12.8	300	0.36	0.41	2.8	3.0
1N5142	13.5	15.0	16.5	250	0.38	0.41	2.8	3.0
1N5142A	14.3	15.0	15.7	250	0.38	0.41	2.8	3.0
1N5143	16.2	16.0	19.8	250	0.38	0.41	2.6	3.0
1N5143A	17.1	18.0	18.9	250	0.38	0.41	2.6	3.0
1N5144	19.6	22.0	24.2	200	0.43	0.45	3.2	3.4
1N5144A	20.9	22.0	23.1	200	0.43	0.45	3.2	3.4
1N5145	24.3	27.0	29.7	200	0.43	0.45	3.2	3.4
1N5145A	25.7	27.0	26.3	200	0.43	0.45	3.2	3.4
1N5146	29.7	33.0	36.3	200	0.43	0.45	3.2	3.4
1N5146A	31.4	33.0	34.6	200	0.43	0.45	3.2	3.4
1N5147	36.1	39.0	42.9	200	0.43	0.45	3.2	3.4
1N5147A	37.1	39.0	40.9	200	0.43	0.45	3.2	3.4
1N5148	42.3	47.0	51.7	200	0.43	0.45	3.2	3.4
1N5148A	44.7	47.0	49.3	200	0.43	0.45	3.2	3.4

1N5139 thru 1N5148 (continued)

FIGURE 1 — DIODE CAPACITANCE versus REVERSE VOLTAGE

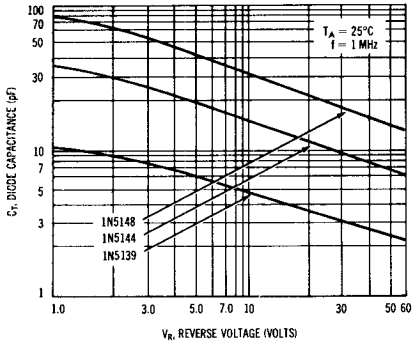


FIGURE 2 — FIGURE OF MERIT versus REVERSE VOLTAGE

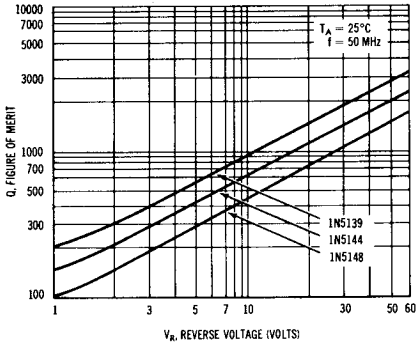


FIGURE 3 — NORMALIZED DIODE CAPACITANCE versus JUNCTION TEMPERATURE

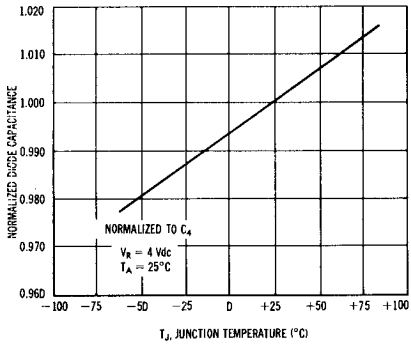


FIGURE 4 — NORMALIZED FIGURE OF MERIT versus JUNCTION TEMPERATURE

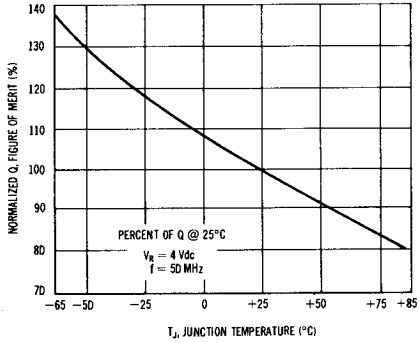


FIGURE 5 — REVERSE CURRENT versus REVERSE BIAS VOLTAGE

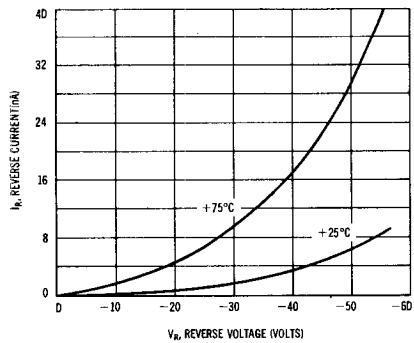
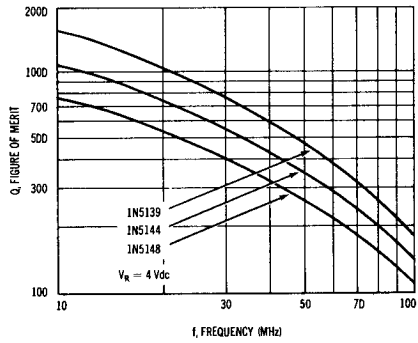


FIGURE 6 — FIGURE OF MERIT versus FREQUENCY



1N5149
(MV1806C)

1N1550
(MV1807C)

$V_R = 80$ V

$I_F = 1.0$ A

P_D to 14 W

Silicon high-frequency step-recovery power varactors for 100 MHz to 2 GHz harmonic-generation applications with output power up to 25 watts at 1 GHz.

CASE 47
(cartridge)



MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Rating	Unit
Reverse Voltage		V_R	80	Volts
Forward Current		I_F	1.0	Amp
RF Power Input	1N5149 1N5150	P_{in}	25 40	Watts
Total Device Dissipation @ $T_A = 75°C$	1N5149 1N5150	P_D	10 14	Watts
Derate above 75°C	1N5149 1N5150		0.08 0.11	W/°C
Junction Temperature		T_J	+200	°C
Storage Temperature Range		T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	$I_R = 10\ \mu$Adc	80	90	—	Vdc
Reverse Current	I_R	$V_R = 70$ Vdc	—	—	2	μAdc
		$V_R = 70$ Vdc, $T_A = 150°C$	—	—	100	
Diode Capacitance	C_T	$V_R = 6$ Vdc, f = 50 MHz	5	11.5	20	pF
Figure of Merit	Q	$V_R = 6$ Vdc, f = 50 MHz	—	800	—	—
Thermal Resistance	θ_{JC}	IN5150	—	—	9	°C/W

FUNCTIONAL TEST

1N5149

RF Power Output	P_{out}	Test Setup Figure 1 $P_{in} = 20$ watts	11	—	—	Watts
Doubler Efficiency	η	$f_{in} = 0.5$ GHz $f_{out} = 1.0$ GHz	55	—	—	%

1N5150

RF Power Output	P_{out}	Test Setup Figure 1 $P_{in} = 37$ watts	24	25	—	Watts
Doubler Efficiency	η	$f_{in} = 0.5$ GHz $f_{out} = 1.0$ GHz	65	68	—	%

1N5149, 1N5150 (continued)

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

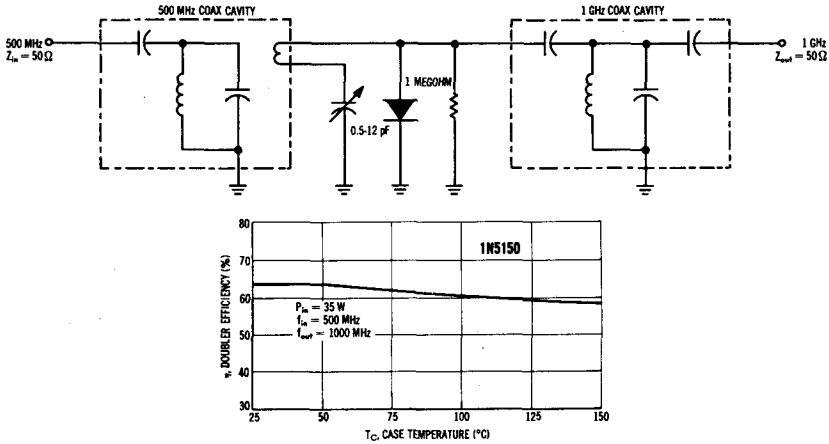


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING

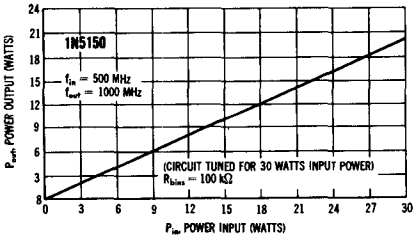
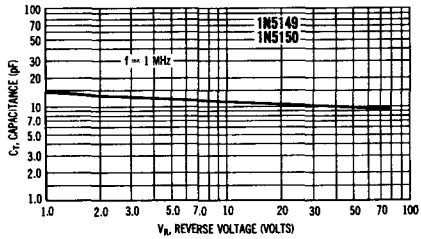


FIGURE 3 — CAPACITANCE versus REVERSE VOLTAGE



1N5149, 1N5150 (continued)

POWER OUTPUT versus OUTPUT FREQUENCY

1N5149

FIGURE 4A — DOUBLING (X2)

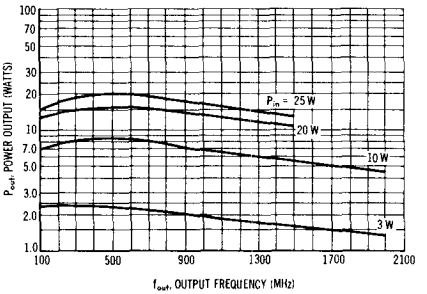


FIGURE 4B — TRIPLING (X3)

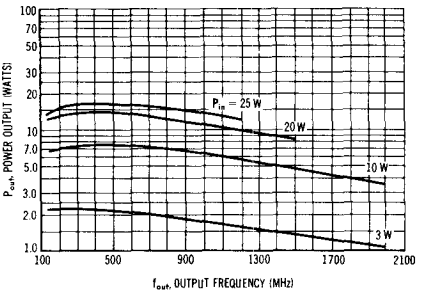
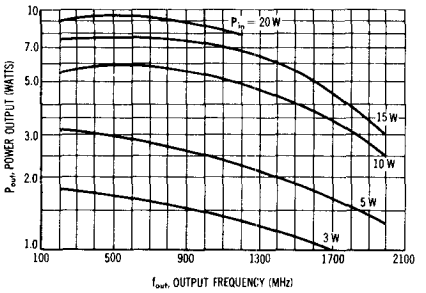


FIGURE 4C — QUADRUPLING (X4)



1N5150

FIGURE 5A — DOUBLING (X2)

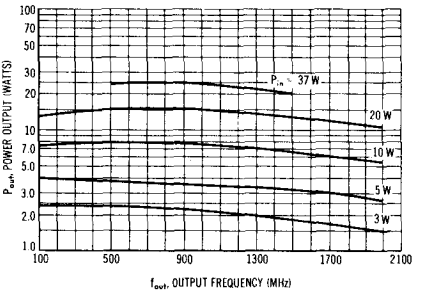


FIGURE 5B — TRIPLING (X3)

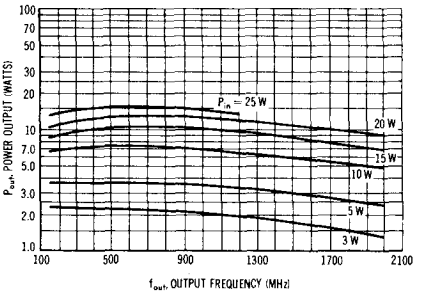
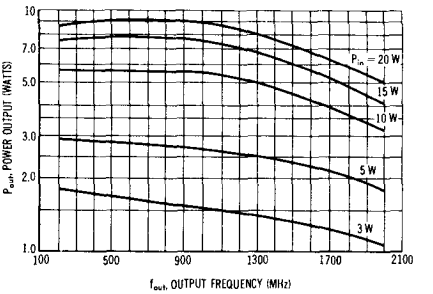


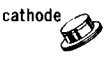
FIGURE 5C — QUADRUPLING (X4)



1N5151 (MV1808A)
1N5152 (MV1808B)
1N5153 (MV1808C)

$V_R = 75$ V
$I_F = 0.25$ A
$P_D = 5.5$ W

Silicon high-frequency step-recovery power varactors, designed for high-power, high-frequency harmonic generation applications.



CASE 48
(1N5151)
(pill)



CASE 46
(1N5152)
(pill with prongs)



CASE 47
(1N5153)
(cartridge)

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	75	Vdc
Forward Current	I_F	0.25	Adc
RF Power Input	P_{in}	15	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above 75°C	P_D	5.5 45	Watts mW/°C
Junction Temperature	T_J	200	°C
Storage Temperature	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Condition	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	$I_R = 10$ μAdc	BV_R	75	80	—	Vdc
Reverse Current	$V_R = 60$ Vdc $V_R = 60$ Vdc, $T_A = 150°C$	I_R	— —	0.5 —	1 100	μAdc
Series Resistance	$V_R = 6$ Vdc, f = 50 MHz	R_S	—	0.5	—	Ohms
Diode Capacitance	$V_R = 6$ Vdc, f = 50 MHz $V_R = 70$ Vdc, f = 50 MHz	C_T*	5.0 —	5.8 4	7.5 —	pF
Figure of Merit	$V_R = 6$ Vdc, f = 50 MHz	Q	—	1100	—	—
Power Output	DOUBLER TEST CIRCUIT (Figure 1) $P_{in} = 12$ W, $f_{in} = 1$GHz $f_{out} = 2$ GHz	P_{out}	6.0	7.2	—	Watts
Efficiency		η	50	60	—	%
Thermal Resistance		θ_J	—	19	23	°C/Watt

*$C_T = C_J + C_C$

1N5151, 1N5152, 1N5153 (continued)

FIGURE 1 — HARMONIC DOUBLER EFFICIENCY TEST CIRCUIT

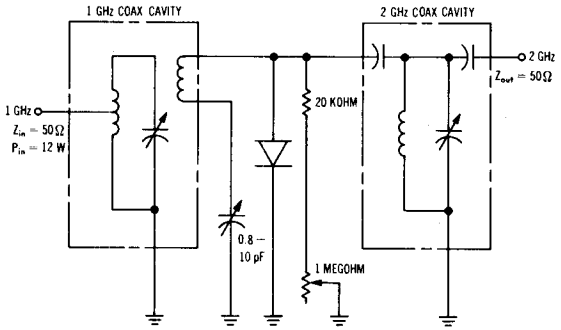
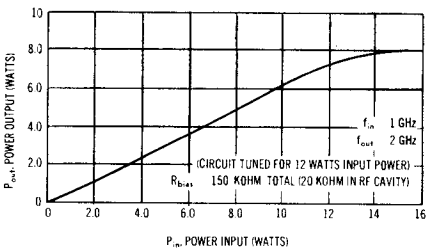


FIGURE 2 — LINEARITY CHARACTERISTIC WITHOUT RETUNING



1N5151, 1N5152, 1N5153 (continued)

POWER OUTPUT versus OUTPUT FREQUENCY

FIGURE 3A — DOUBLING (X2)

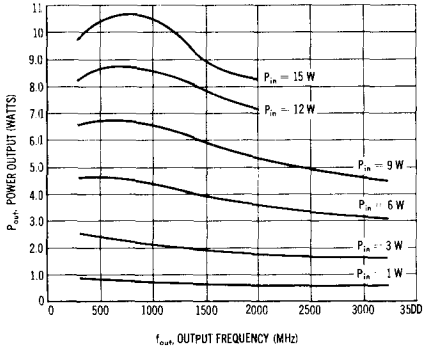


FIGURE 3B — TRIPLING (X3)

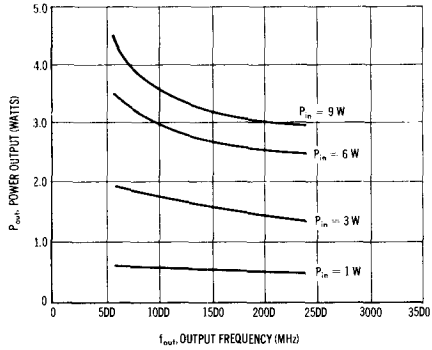
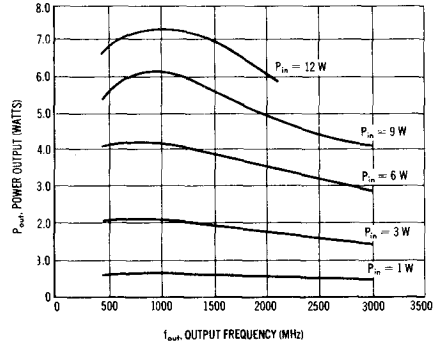


FIGURE 3C — QUADRUPLING (X4)



TYPICAL CHARACTERISTICS at 25°C

FIGURE 4 — FIGURE OF MERIT versus REVERSE VOLTAGE

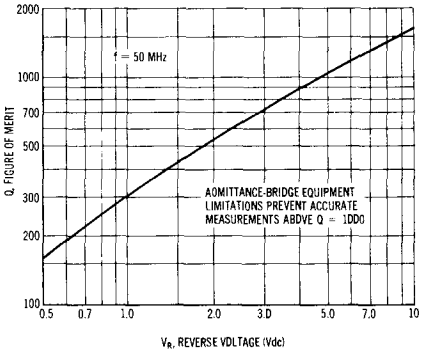


FIGURE 5 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

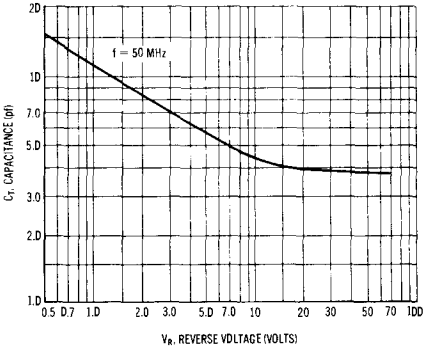
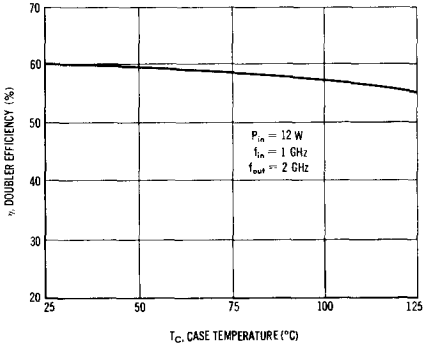


FIGURE 6 — DOUBLER EFFICIENCY versus CASE TEMPERATURE



1N5154
(MV1810A)
1N5155
(MV1810B)

$V_R = 35V$
$I_F = 200$ mA
$P_D = 3.5W$

CASE 48
(1N5154)
(pill)



CASE 46
(1N5155)
(pill with prongs)



Silicon high-frequency step-recovery power varactors, for multiplier applications from 2 to 8.5 GHz with 2 watts minimum power output guaranteed at 6 GHz.

MAXIMUM RATINGS ($T_C = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	35	Vdc
Forward Current	I_F	200	mAdc
RF Power Input	P_{in}	7	Watts
Total Device Dissipation @ $T_C = 75°C$ Derate above $75°C$	P_D	3.5 30	Watts mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Conditions	Symbol	Min	Typ	Max	Unit
Reverse Breakdown Voltage	$I_R = 10$ μAdc	BV_R	35	45	—	Vdc
Reverse Current	$V_R = 26$ Vdc $V_R = 26$ Vdc, $T_A = 150°C$	I_R	— —	— —	1 100	μAdc
Series Resistance	$V_R = 6$ Vdc, f = 50 MHz	R_S	—	0.9	—	Ohms
Diode Capacitance	$V_R = 6$ Vdc, f = 1 MHz	C_T	1.0	2.1	3.0	pF
Figure of Merit	$V_R = 6$ Vdc, f = 50 MHz	Q	—	1700	—	—
Thermal Resistance		θ_{JC}	—	—	35	°C/W

FUNCTIONAL TEST

RF Power Output	Test Circuit Figure 5 $P_{in} = 5$ watts, $f_{in} = 2$ GHz, $f_{out} = 6$ GHz	P_{out}	2	—	—	Watts
Tripling Efficiency		η	40	—	—	%

1N5154, 1N5155 (continued)

POWER OUTPUT
versus OUTPUT FREQUENCY

TYPICAL CHARACTERISTICS
$T_C = 25°C$

FIGURE 1A — DOUBLING (X2)

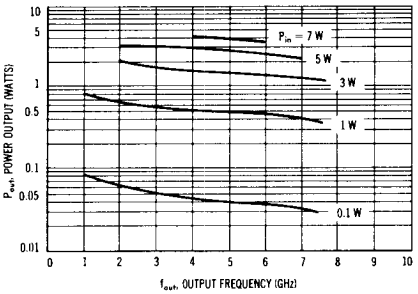


FIGURE 2 — VARACTOR CAPACITANCE versus REVERSE VOLTAGE

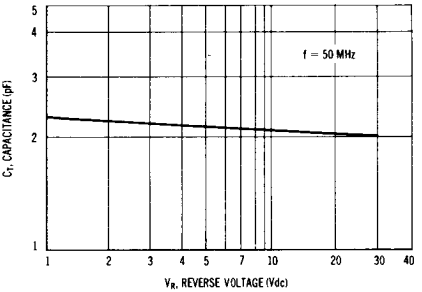


FIGURE 1B — TRIPLING (X3)

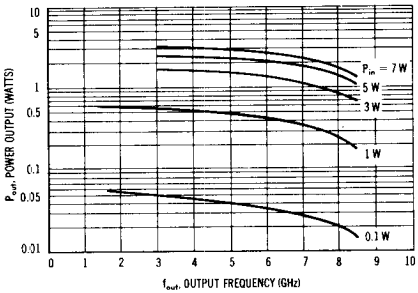


FIGURE 3 — TRIPLER POWER OUTPUT versus TEMPERATURE 2 GHz to 6 GHz

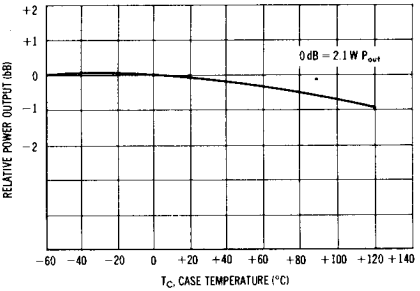


FIGURE 1C — QUADRUPLING (X4)

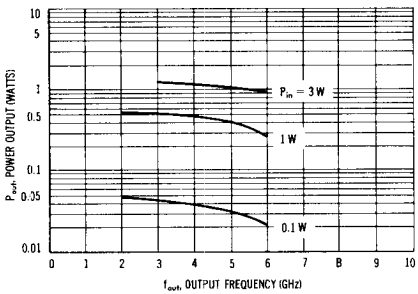
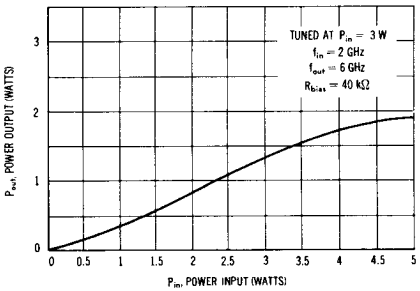


FIGURE 4 — TRIPLER LINEARITY CHARACTERISTIC



1N5154, 1N5155 (continued)

FIGURE 5 — HARMONIC TRIPLER — 2 GHz to 6 GHz

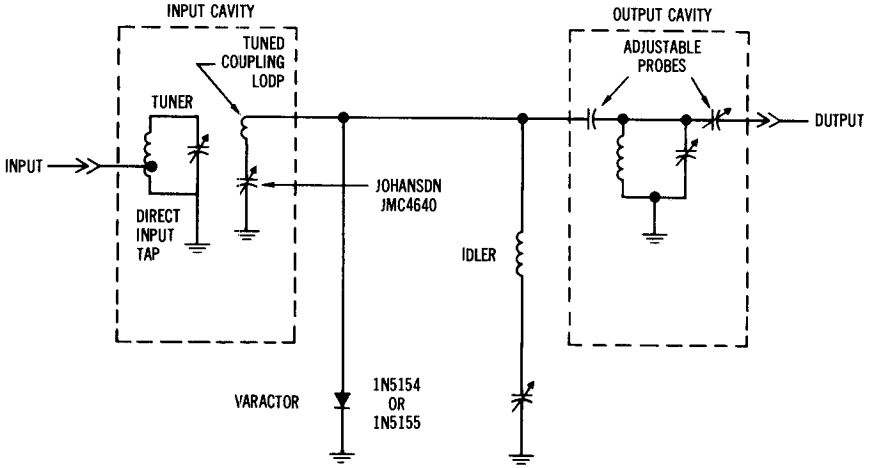
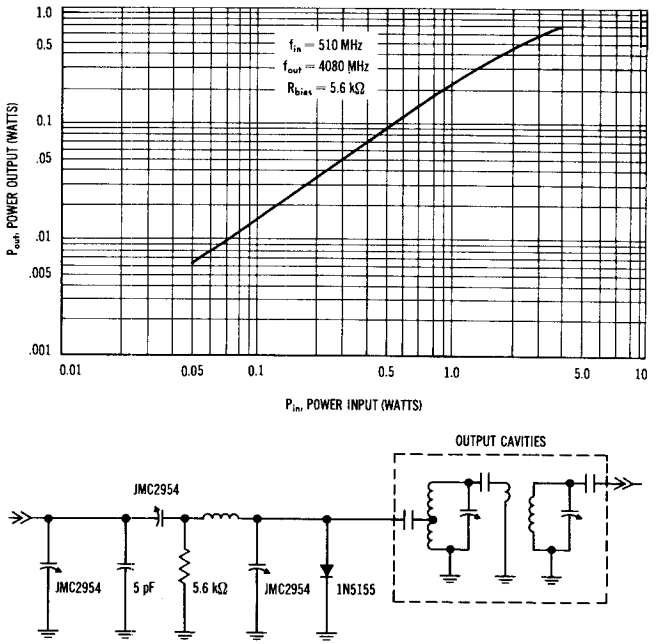


FIGURE 6 — HARMONIC OCTUPLER — 510 MHz to 4080 MHz



MV830 thru MV840

V_R = 30 V
I_F = 250 mA
Q = 15-35 (typ) @ V_R = 4 V and f = 50 Mc



CASE 51
(DO-7)

Polarity band on cathode end

Silicon voltage-variable-capacitance diodes, designed for electronic-tuning applications from 15 to 100 pf.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	30	Volts
Forward Current	I_F	250	mA
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	400 2.67	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2 13.3	W mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature Range	T_{stg}	-65 to+200	°C

MV830 thru MV840 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted) See Notes

Characteristic — All Types	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	30	—	—	Vdc
Reverse Voltage Leakage Current	I_R	V_R = 25 Vdc	—	—	0.2	μAdc
Series Inductance	L_S	f = 250 mc, L ≈ 1/16"	—	5	10	nhy
Case Capacitance	C_C	f = 1 mc, L = 0	—	0.25	0.3	pf

	C_T, Diode Capacitance V_R = 4 Vdc, f = 1 mc pf			TR, Tuning Ratio f = 1 mc C_4/C_{25}		Q, Figure of Merit V_R = 4 Vdc, f = 50 mc		α	
Device	Min	Typ	Max	Min	Typ	Min	Typ	Min	Typ
MV830	13.5	15.0	16.5	1.8	2.00	30	35	0.32	0.375
MV831	16.2	18.0	19.8	1.8	2.00	25	30	0.32	0.375
MV832	19.8	22.0	24.2	1.8	2.10	25	30	0.32	0.40
MV833	24.3	27.0	29.7	1.8	2.10	25	30	0.32	0.40
MV834	29.7	33.0	36.3	1.9	2.12	20	25	0.35	0.41
MV835	35.1	39.0	42.9	1.9	2.12	20	25	0.35	0.41
MV836	42.3	47.0	51.7	1.9	2.15	15	20	0.35	0.415
MV837	50.4	56.0	61.6	1.9	2.15	15	20	0.35	0.415
MV838	61.2	68.0	74.8	2.0	2.18	15	20	0.375	0.425
MV839	73.8	82.0	90.2	2.0	2.18	10	15	0.375	0.425
MV840	90.0	100.0	110.0	2.0	2.18	10	15	0.375	0.425

PARAMETER TEST METHODS

1. L_S, SERIES INDUCTANCE
L_S is measured on a shorted package at 250 mc using an impedance bridge (Boonton Radio Model 250A RX Meter). L = lead length.

2. C_C, CASE CAPACITANCE
C_C is measured on an open package at 1 mc using a capacitance bridge (Boonton Electronics Model 75A).

3. C_T, DIODE CAPACITANCE
($C_T = C_C + C_J$). C_T is measured at 1 mc using a capacitance bridge (Boonton Electronics Model 33AS8).

4. TR, TUNING RATIO
TR is the ratio of C_T measured at 4 Vdc divided by C_T measured at 25 Vdc.

5. Q, FIGURE OF MERIT
Q is calculated by taking the G and C readings of an admittance bridge at the specified frequency and substituting in the following equations:

$$Q = \frac{2\pi fC}{G}$$

(Boonton Electronics Model 33AS8).

6. α, DIODE CAPACITANCE REVERSE VOLTAGE SLOPE
The diode capacitance, C_T (as measured at V_R = 4 Vdc, f = 1 mc) is compared to C_T (as measured at V_R = 30 Vdc, f = 1 mc) by the following equation which defines α.

$$\alpha = \frac{\log C_T(4) - \log C_T(30)}{\log 30 - \log 4}$$

Note that a C_T versus V_R law is assumed as shown in the following equation where C_C is included.

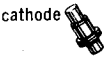
$$C_T = \frac{K}{V^{\alpha}}$$

MV1864A, B

$C_T = 6.8$ pf
$V_R = 60$ V
$f_{CO} = 320$ Gc
$P_{in} = 5$ W *



CASE 48
MV1864A



CASE 46
MV1864B

Silicon voltage variable capacitance diode for electronic tuning and harmonic generation applications.

MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Characteristics	Symbol	Rating	Unit
Reverse Voltage	V_R	60	Volts
Forward Current	I_F	250	mA
RF Power Input*	P_{in}*	5	Watts
Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	500 3.33	mW mW/°C
Device Dissipation @ T_C = 25°C Derate above 25°C	P_D	2 13.3	W mW/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +200	°C

*The RF power input rating assumes that an adequate heat sink is provided.

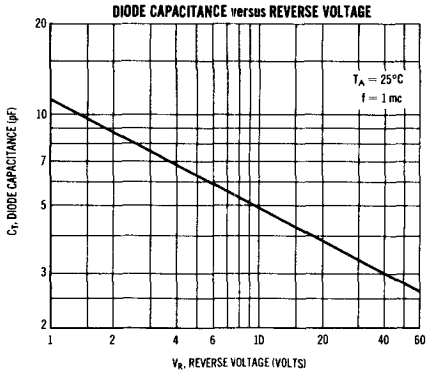
ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

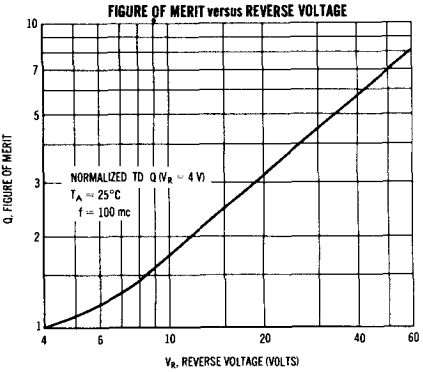
Characteristics	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	BV_R	I_R = 10 μAdc	60	75	--	Vdc
Reverse Voltage Leakage Current	I_R	V_R = 48 Vdc V_R = 48 Vdc, T_A = 75°C	-- --	-- --	0.5 10.0	μAdc

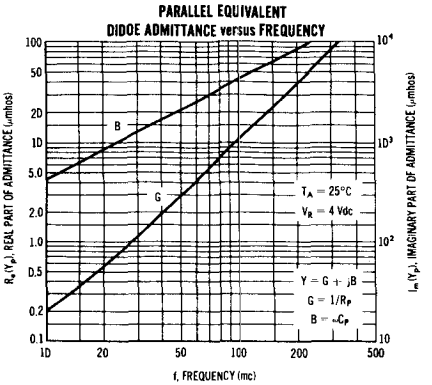
Series Inductance	L_S		--	0.4	1	nhy
Case Capacitance	C_C	f = 1 mc, L ~ 0	0.2	0.3	0.4	pF
Diode Capacitance	C_T	V_R = 4 Vdc, f = 1 mc	6.1	6.8	7.5	pF
Series Resistance	R_S	V_R = 4 Vdc, f = 100 mc	--	0.5	0.9	ohm
Figure of Merit	Q	V_R = 4 Vdc, f = 100 mc V_R = 60 Vdc, f = 100 mc	300 1000	400 3200	-- --	--
Cutoff Frequency	f_{co}	V_R = 60 Vdc, f = 100 mc	--	320	--	gc

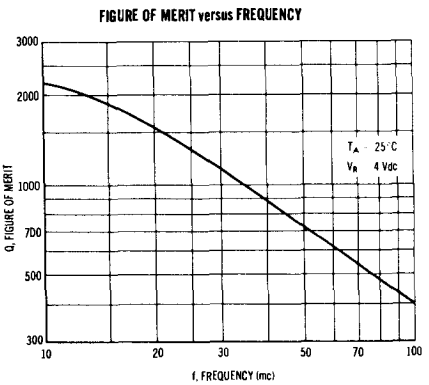
Diode Capacitance Reverse Voltage Slope	α	V_R = 4 Vdc, f = 1 mc	0.37	0.40	0.43	--
Diode Capacitance Temperature Coefficient	TC_C	V_R = 4 Vdc, f = 1 mc	--	200	300	ppm/°C

MV1864A, B (continued)









MV1892

$V_R = 700$ V
$I_F = 4$ A
$C_T = 2.5$ pf
$P_{SW} = 500$ W



cathode connected to stud

CASE 49
(DO-4)

Silicon diode for switching high-power, RF signals. Particularly well suited as a replacement for mechanical antenna and coaxial relays.

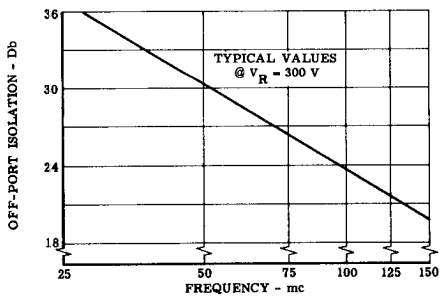
MAXIMUM RATINGS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Reverse Voltage	V_R	700	Volts
Forward Current	I_F	4	Amp
RF Power Switching Capability	P_{sw}	500	Watts
Total Device Dissipation at or below 75° C Case Temperature	P_D	20	Watts
Above 75 C Derate Linearly	-	0.2	W/°C
Junction Temperature	T_J	+175	°C
Storage Temperature	T_{stg}	-65 to +175	°C

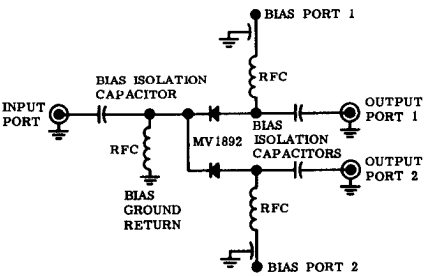
ELECTRICAL CHARACTERISTICS (Tc = 25°C unless otherwise noted)

Characteristic	Symbol	Test Conditions	Minimum	Maximum	Unit
Reverse Breakdown Volt.	BV_R	I_R = 10 μAdc	700	-	Vdc
Series Resistance (See Note 1)	R_f	I_F = 100 ma; f = 1 kc	-	0.62	Ohms
Diode Capacitance	C_T	V_R = 100 Vdc; f = 140 kc	-	2.5	pf

NOTE 1. Laboratory measurements show that R_f at 1 kc is within 15% of R_f at 50 mc.



OFF-PORT ISOLATION vs FREQUENCY FOR SPDT SWITCH



TYPICAL RF SWITCHING CIRCUIT

ADDITIONS AND MODIFICATIONS

INTEGRATED CIRCUITS

For case outline dimensions, see page 1-186.

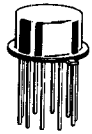
DIGITAL INTEGRATED CIRCUITS

TYPE NO.	DESCRIPTION	PAGE NO.
Current-Mode Logic		
MC300 Series	High—speed current—mode logic series operating over a temperature range of -55°C to +125°C.	13-58
MC350 Series	High—speed current—mode logic series with an operating temperature range of 0 to +75°C for commercial applications.	13-75
Diode-Transistor Logic		
MC200 Series	High—speed, low—power MDTL circuits operating over a temperature range of -55°C to +125°C.	13-4
MC250 Series	High—speed, low—power MDTL circuits with an operating temperature range of 0 to +75°C for commercial applications.	13-29
Modified Diode-Transistor Logic		
MC830F Series MC830G Series	MDTL circuits designed for use over the temperature range of 0 to +75°C.	13-152
MC930F Series MC930G Series	MDTL circuits designed for use over the temperature range of -55°C to +125°C.	13-152
Resistor-Transistor Logic		
MC700G Series	MRTL series operates over a temperature range of +15°C to +55°C. Includes milliwatt and medium power devices.	13-102
MC800G Series	General-purpose MRTL series operates over a range of 0 to +100°C.	13-104
MC900G Series	General-purpose MRTL series operates over a range of -55°C to +125°C.	13-104
MC908 Series	Milliwatt MRTL circuits operating over the temperature range of -55°C to +125°C.	13-136
Variable-Threshold Logic		
MC650G Series	MVTL allows designer to select noise immunity levels to suit application. Operates over a temperature range of 0 to +75°C.	13-92 13-98

MC200 DTL series



SUFFIX "F" DEVICES
CASE 72



SUFFIX "G" DEVICES
CASE 71A

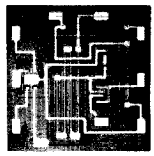
Monolithic integrated Diode Transistor Logic circuits for low-power, high-speed applications. The MC200 series provides a high noise immunity of 0.5 Volts and operates over the temperature range of -55 to +125°C.

SERIES MC200 DTL INTEGRATED CIRCUITS

Type	Description	Typical Propagation Delay (nsec)	Maximum Power Dissipation		Maximum Fan Out (—55 to +125°C)
			Output Off (mW)	Output On (mW)	
MC201	4-Input NAND/NOR Gate	30	8.5	6	5
MC202	3-Input NAND/NOR Gate	30	8.5	6	5
MC203	6-Input Diode AND Gate	—	—	—	—
MC204	3-Input Power NAND/NOR Gate	40	20	60	20
MC205	Line Driver	50	30	60	20(MC201) 15(MC209)
MC206	Dual (2-2) Input NAND/NOR Gate	30	17	12	5
MC207	Dual (3-2) Input NAND/NOR Gate	30	17	12	5
MC208	Dual (3-2) Input NAND/NOR Gate	30	17	12	5
MC209	Flip-Flop	—	16	16	8
MC212	Dual (3-3) Input NAND/NOR Gate	30	15	12	5
MC213	Dual (3-3) Input NAND/NOR Gate	30	15	30	4
MC215	Dual (3-3) Input AND Gate	—	—	—	—
MC217	Dual-Diode Array	—	—	—	—

MC201
MC202

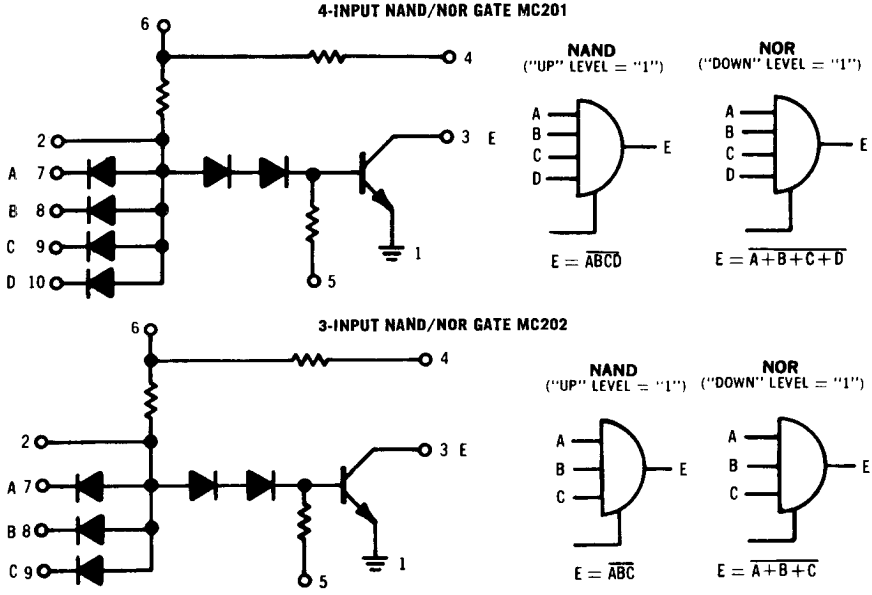
MC200 DTL SERIES



4-Input and 3-Input Diode Transistor Logic NAND/NOR Gates.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage			Volts
	$V_{3,4,6}$	+8	
	V_5	-8	
	$V_{7 \text{ thru } 10}$	+6	
Forward Current	$I_{2 \text{ thru } 10}$	30	mA
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C



MC201, MC202 (continued)

ELECTRICAL CHARACTERISTICS

* (V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

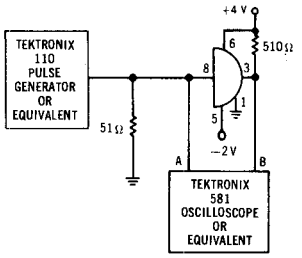
Characteristic	Symbol	Min	Typ	Max	Unit
Output Saturation Voltage (I_3 = 10 mAdc, $V_{7 \text{ thru } 10}$ = 2 Vdc, T_J = -55 to +125°C)	V_3	—	—	0.6	Vdc
Output Breakdown Voltage (I_3 = 1 μAdc, $V_{1,5,6}$ = 0)	BV_3	8	—	—	Vdc
Output Sustaining Voltage (I_3 = 10 mAdc, $V_{1,5,6}$ = 0)	LV_3	5	—	—	Vdc
Output Leakage Current (V_7 = 0.7 Vdc, $V_{8,9,10}$ = 2 Vdc, V_3 = 5 Vdc)	I_3	—	—	0.5	μAdc
(V_7 = 0.7 Vdc, $V_{8,9,10}$ = 2 Vdc, V_3 = 5 Vdc, T_J = 125°C)		—	—	50	
Input Diode Leakage Current** (Diode under test at 5 Vdc, all other inputs = 0)	$I_{7 \text{ thru } 10}$	—	—	0.25	μAdc
(Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)		—	—	25	
Turn-Off Current at Input ** ($V_{7 \text{ thru } 10}$ = 0)	$I_{7 \text{ thru } 10}$	-1.4	—	-1.8	mAdc
($V_{7 \text{ thru } 10}$ = 0, T_J = -55 to +125°C)	$I_{7 \text{ thru } 10}$	—	—	-1.9	
(V_2 = 0)	I_2	-1.6	—	-2.4	
Load Resistor Current (V_4 = 0)	I_4	-1.6	—	-2.4	mAdc
Output Capacitance (V_3 = 4 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	—	—	15	pf
Input Capacitance ** ($V_{7 \text{ thru } 10}$ = 4 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	$C_{7 \text{ thru } 10}$	—	—	8	pf
Power Consumption from Power Supply (Output "Off", V_7 = 0)		—	—	8.5	mW
(Output "On")		—	—	6.0	
Switching Time					nsec
Turn-On Delay	t_{on}	—	—	60	
Turn-Off Delay	t_{off}	—	—	50	
Average Propagation Delay	pd	—	30	—	nsec
Fan-Out (T_J = -55 to +125°C)	n	—	—	5	—

* Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

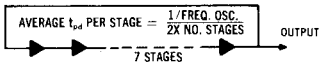
** Input diode at pin 10 available on MC201 only

MC201, MC202 (continued)

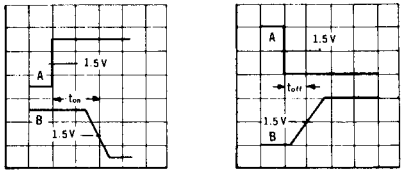
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT

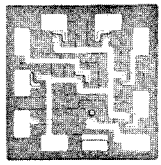


SWITCHING TIME WAVE FORMS



MC203

MC200 DTL SERIES



6-Input Diode Transistor Logic AND Gate.

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristics	Symbol	Rating	Unit
Applied Voltage	V_3 thru 8 $V_{2, 9}$	+8 ±8	Vdc
Forward Current	$I_{2 \text{ thru } 10}$	30	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

Numerical subscripts refer to pin numbers.

MC203 (continued)

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

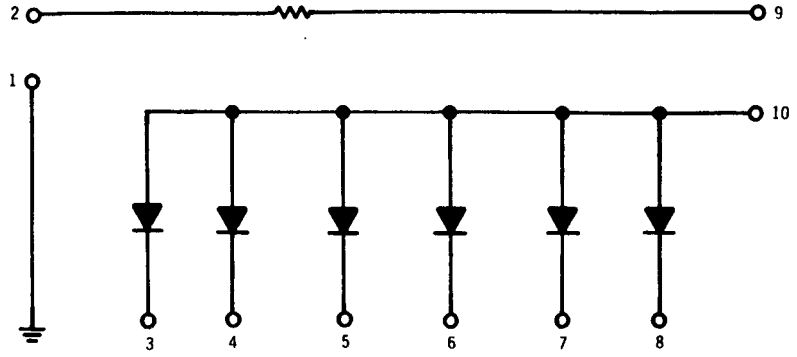
Characteristics	Symbol	Min	Typ	Max	Unit
Diode Breakdown Voltage ($I_{3\ thru\ 8}$ = 10 μAdc, $V_{10} = V_1 = 0$)	$V_{3\ thru\ 8}$	8	-	-	Vdc
Diode Forward Voltage (I_{10} = 2 mAdc, $V_{3\ thru\ 8}$ = 0)	V_{10}	-	-	0.85	Vdc
Diode Reverse Leakage Current ($V_{3\ thru\ 8}$ = 5 Vdc, $V_{10} = V_1 = 0$) ($V_{3\ thru\ 8}$ = 5 Vdc, $V_{10} = V_1 = 0$, T_J = 125°C)	$I_{3\ thru\ 8}$	- -	- -	0.25 25	μAdc
Input Capacitance ($V_{3\ thru\ 8}$ = 2 Vdc, $V_{10} = V_1 = 0$, f = 1 mc, V_{in} = 25 mVrms, unused inputs grounded)	$C_{3\ thru\ 8}$	-	-	10	pf
Reverse Recovery Time ($I_{F\ 3\ thru\ 8} = I_{R\ 3\ thru\ 8}$ = 2 mAdc, $V_{10} = V_1 = 0$, recover to 0.2 mAdc)	$t_{rr\ 3\ thru\ 8}$	-	-	4	nsec
Resistor Current (V_9 = 4 Vdc, V_2 = 0)	I_9	1.6	-	2.4	mAdc
Resistor Temperature Coefficient		-	0.1	-	%/°C
Diode Forward Conductance Change with Temperature	$\Delta V_{F\ 3\ thru\ 8}$	-	-1.7	-	mV/°C

Numerical subscripts refer to pin numbers.

Pins not specifically referenced are left electrically open.

MC203 (continued)

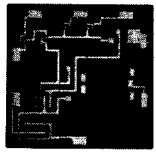
CIRCUIT SCHEMATIC



6-DIODE "AND" GATE

MC204

MC200 DTL SERIES



3-Input Diode Transistor Logic NAND/NOR Power Gate.

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3,7,8,9}$ V_5 V_6	+8 -6 +6	Vdc
Forward Current	$I_{5 \text{ thru } 10}$	30	mAdc
Load Current	I_3	75	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

* Numerical subscripts refer to pin numbers.

MC204 (continued)

ELECTRICAL CHARACTERISTICS

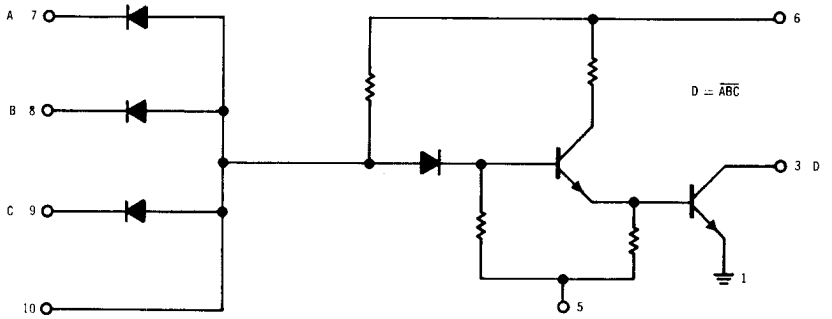
($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage (I_3 = 5 μAdc, V_7 = 0)	BV_3	8	-	-	Vdc
"1" Output Current	I_3				μAdc
($V_{7, 8, \text{ or } 9}$ = 1.1 Vdc, V_3 = 5 Vdc)		-	-	100	
($V_{7, 8, \text{ or } 9}$ = 0.7 Vdc, V_3 = 5 Vdc, T_J = 125°C)		-	-	100	
($V_{7, 8, \text{ or } 9}$ = 1.4 Vdc, V_3 = 5 Vdc, T_J = -55°C)		-	-	100	
"0" Output Current	I_3				mAdc
($V_{7, 8, \text{ or } 9}$ = 1.7 Vdc, V_3 = 0.6 Vdc)		40	-	-	
($V_{7, 8, \text{ or } 9}$ = 1.3 Vdc, V_3 = 0.6 Vdc, T_J = 125°C)		40	-	-	
($V_{7, 8, \text{ or } 9}$ = 2.0 Vdc, V_3 = 0.6 Vdc, T_J = -55°C)		40	-	-	
Input Breakdown Voltage					Vdc
(I_7 = 10 μAdc, V_8 = 0)	BV_7	8.0	-	-	
(I_8 = 10 μAdc, V_7 = 0)	BV_8	8.0	-	-	
(I_9 = 10 μAdc, V_7 = 0)	BV_9	8.0	-	-	
Input Leakage Current					μAdc
(V_7 = 5 Vdc, V_8 = 0)	I_7	-	-	0.25	
(V_7 = 5 Vdc, V_8 = 0, T_J = 125°C)	I_7	-	-	25	
(V_8 = 5 Vdc, V_7 = 0)	I_8	-	-	0.25	
(V_8 = 5 Vdc, V_7 = 0, T_J = 125°C)	I_8	-	-	25	
(V_9 = 5 Vdc, V_7 = 0)	I_9	-	-	0.25	
(V_9 = 5 Vdc, V_7 = 0, T_J = 125°C)	I_9	-	-	25	
Input Turn-Off Current					mAdc
(Alternately, V_7, V_8, V_9 = 0)	I_7, I_8, I_9	-	-	-3.75	
(Alternately, V_7, V_8, V_9 = 0, T_J = -55°C to +125°C)	I_7, I_8, I_9	-	-	-3.9	
(V_{10} = 0)	I_{10}	-	-	-4.8	
Output Capacitance (V_3 = 2.0 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	-	-	15	pf
Input Capacitance					pf
(V_7 = 2.0 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_7	-	-	10	
(V_8 = 2.0 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	-	-	10	
(V_9 = 2.0 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_9	-	-	10	
Power Supply					mW
(Output "OFF", V_7 = 0)		-	-	20	
(Output "ON")		-	-	60	
Switching Times					nsec
Turn-On Delay	t_{on}	-	-	35	
Turn-Off Delay	t_{off}	-	-	90	
Average Propagation Delay (Figure 2)	t_{pd}	-	40	-	nsec
Fan-Out (to MC201, T_J = -55°C to + 125°C)	n	-	-	20	-

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

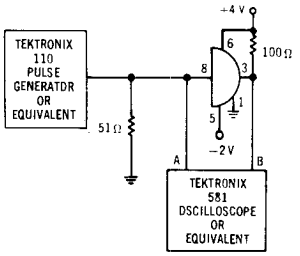
MC204 (continued)

CIRCUIT SCHEMATIC

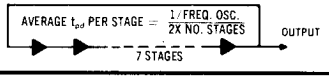


POWER GATE MC204

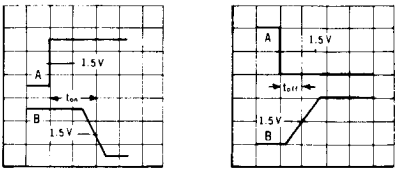
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT

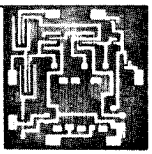


SWITCHING TIME WAVE FORMS



MC205
LINE DRIVER

MC200 DTL SERIES



Diode Transistor Logic Line Driver.

MAXIMUM RATINGS ($T_J = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3, 4, 6}$ V_5 $V_{8, 10}$	+6 -6 +8	Vdc
Forward Current	$I_{5, 8, 10}$	30	mAdc
Load Current	$I_{3, 4, 6}$	75	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

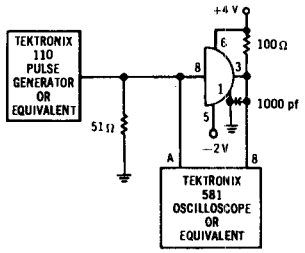
MC205 (continued)
ELECTRICAL CHARACTERISTICS

* (V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

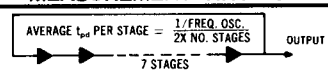
Characteristic	Symbol	Min	Typ	Max	Unit
Output Saturation Voltage (I_3 = 40 mAdc, T_J = -55°C to +125°C)	V_3	-	-	0.6	Vdc
Output Voltage, "Off" Level (I_3 = 10 mAdc, V_8 = 0.7 Vdc, T_J = -55°C to +125°C)	V_3	2.0	-	-	Vdc
Input Breakdown Voltage (I_8 = 10 μAdc, V_{10} = 0)	BV_8	8.0	-	-	Vdc
(I_{10} = 10 μAdc, V_8 = 0)	BV_{10}	8.0	-	-	
Input Leakage Current (V_8 = 5 Vdc, V_{10} = 0)	I_8			0.25	μAdc
(V_8 = 5 Vdc, V_{10} = 0, T_J = 125°C)	I_8	-	-	25	
(V_{10} = 5 Vdc, V_8 = 0)	I_{10}			0.25	
(V_{10} = 5 Vdc, V_8 = 0, T_J = 125°C)	I_{10}	-	-	25	
Turn-Off Current at Inputs (V_8 = 0)	I_8	-	-	-3.75	mAdc
(V_8 = 0, T_J = -55 to + 125°C)	I_8	-	-	-3.9	
(V_{10} = 0)	I_{10}	-	-	-3.75	
(V_{10} = 0, T_J = -55 to + 125°C)	I_{10}	-	-	-3.9	
Load Resistor	R_{6-4}	-	125	-	ohms
Input Capacitance (V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	-	-	10	pf
(V_{10} = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_{10}	-	-	10	
Power Consumption from Power Supply (Output "Off", V_8 = 0)		-	-	30	mW
(Output "On")		-	-	60	
Switching Times Turn-On Delay	t_{on}	-	-	90	nsec
Turn-Off Delay	t_{off}	-	-	50	
Average Propagation Delay (C_L = 1000 pf)	t_{pd}	-	50	-	nsec
Fan-Out (to MC201, T_J = -55 to + 125°C)	n	-	-	20	
(to MC209, T_J = -55 to + 125°C)		-	-	15	

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

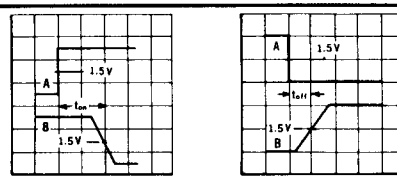
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT

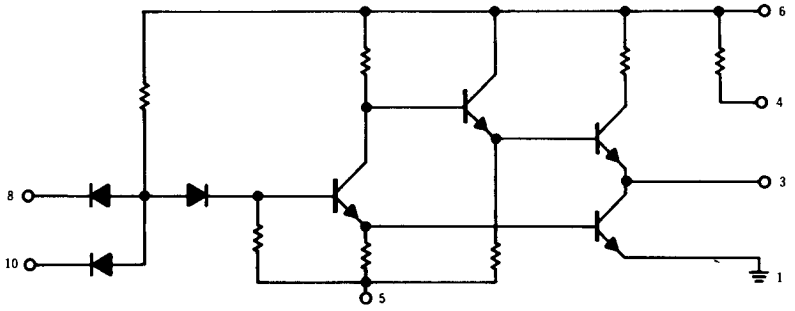


SWITCHING TIME WAVE FORMS



MC205 (continued)

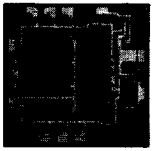
CIRCUIT SCHEMATIC



LINE DRIVER MC205

MC206

MC200 DTL SERIES

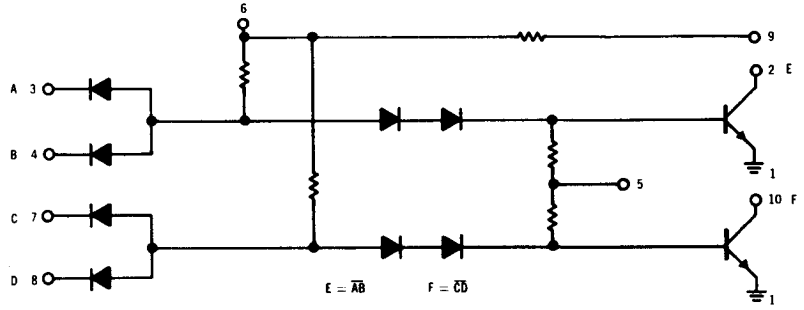


Dual (2-2) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,4,6 \text{ thru } 10}$ V_5	+8 -8	Vdc
Forward Current	$I_{2,10}$ $I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	+30 -30	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



2–2 NAND/NOR GATE

MC206 (continued)

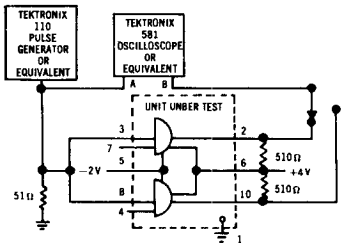
ELECTRICAL CHARACTERISTICS

* (V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

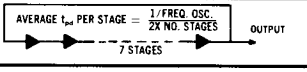
Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage					Vdc
(I_2 = 1 μAdc, V_3 = 0)	BV_2	8	-	-	
(I_{10} = 1 μAdc, V_7 = 0)	BV_{10}	8	-	-	
"1" Output Current					μAdc
(V_3 = 1.1 Vdc, V_2 = 5 Vdc	I_2	-	-	50	
(V_3 = 0.7 Vdc, V_2 = 5 Vdc, T_J = +125°C)	I_2	-	-	50	
(V_3 = 1.4 Vdc, V_2 = 5 Vdc, T_J = -55°C)	I_2	-	-	50	
(V_7 = 1.1 Vdc, V_{10} = 5 Vdc)	I_{10}	-	-	50	
(V_7 = 0.7 Vdc, V_{10} = 5 Vdc, T_J = 125°C)	I_{10}	-	-	50	
(V_7 = 1.4 Vdo, V_{10} = 5 Vdc, T_J = -55°C)	I_{10}	-	-	50	
"0" Output Current					mAdc
(V_3 = 1.7 Vdc, V_2 = 0.6 Vdc)	I_2	10	-	-	
(V_3 = 1.3 Vdc, V_2 = 0.6 Vdc, T_J = 125°C)	I_2	10	-	-	
(V_3 = 2.0 Vdc, V_2 = 0.6 Vdc, T_J = -55°C)	I_2	10	-	-	
(V_7 = 1.7 Vdc, V_{10} = 0.6 Vdc)	I_{10}	10	-	-	
(V_7 = 1.3 Vdc, V_{10} = 0.6 Vdc, T_J = 125°C)	I_{10}	10	-	-	
(V_7 = 2.0 Vdc, V_{10} = 0.6 Vdc, T_J = -55°C)	I_{10}	10	-	-	
Input Breakdown Voltage					Vdc
(I_3 = 10 μAdc, V_4 = 0)	BV_3	8	-	-	
(I_4 = 10 μAdc, V_3 = 0)	BV_4	8	-	-	
(I_7 = 10 μAdc, V_8 = 0)	BV_7	8	-	-	
(I_8 = 10 μAdc, V_7 = 0)	BV_8	8	-	-	
Input Leakage Current	I_3, I_4, I_7, I_8				μAdc
(Diode under test at 5 Vdc, all other inputs = 0)		-	-	0.250	
(Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)		-	-	25	
Input Turn-Off Current	I_3, I_4, I_7, I_8				mAdc
(Alternately V_3, V_4, V_7, V_8 = 0)		-	-	-1.8	
(Alternately V_3, V_4, V_7, V_8 = 0, T_J = -55 to +125°C)		-	-	-1.9	
Output Capacitance					pf
(V_2 = 2.0 Vdc, V_3 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_2	-	-	10	
(V_{10} = 2.0 Vdc, V_7 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_{10}	-	-	10	
Input Capacitance					pf
(V_3 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	-	-	10	
(V_4 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_4	-	-	10	
(V_7 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_7	-	-	10	
(V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	-	-	10	
Load Resistor Current	I_9				mAdc
(V_9 = 0)		-1.6	-	-2.4	
Power Consumption from Power Supply					mW
(Output "Off", V_3 = V_7 = 0)		-	-	17	
(Output "On")		-	-	12	
Switching Times					nsec
Turn-On Delay	t_{on}	-	-	60	
Turn-Off Delay	t_{off}	-	-	50	
Average Propagation Delay	t_{pd}	-	30	-	nsec
Fan-Out	n				
(T_J = -55 to +125°C)		-	-	5	

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

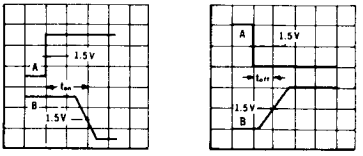
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT

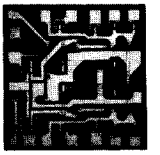


SWITCHING TIME WAVE FORMS



MC207

MC200 DTL SERIES

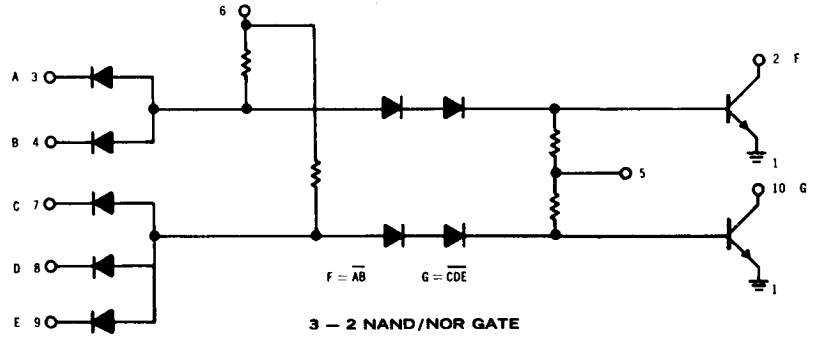


Dual (3-2) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

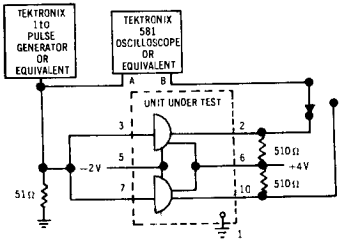
Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,4,6 \text{ thru } 10}$	+8	Vdc
	V_5	-8	
Forward Current	$I_{2,10}$	+30	mAdc
	$I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC

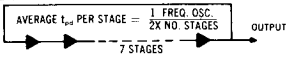


3 — 2 NAND/NOR GATE

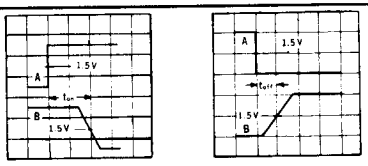
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT



SWITCHING TIME WAVE FORMS



MC207 (continued)

ELECTRICAL CHARACTERISTICS *

(V_6 = 4 Vdc, V_5 = −2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage					Vdc
(I_2 = 1 μAdc, V_3 = 0)	BV_2	8	—	—	
(I_{10} = 1 μAdc, V_7 = 0)	BV_{10}	8	—	—	
"1" Output Current					μAdc
(V_3 = 1.1 Vdc, V_2 = 5 Vdc	I_2	—	—	50	
(V_3 = 0.7 Vdc, V_2 = 5 Vdc, T_J = 125°C)	I_2	—	—	50	
(V_3 = 1.4 Vdc, V_2 = 5 Vdc, T_J = -55°C)	I_2	—	—	50	
(V_7 = 1.1 Vdc, V_{10} = 5 Vdc)	I_{10}	—	—	50	
(V_7 = 0.7 Vdc, V_{10} = 5 Vdc, T_J = 125°C)	I_{10}	—	—	50	
(V_7 = 1.4 Vdc, V_{10} = 5 Vdc, T_J = -55°C)	I_{10}	—	—	50	
"0" Output Current					μAdc
(V_3 = 1.7 Vdc, V_2 = 0.6 Vdc)	I_2	10	—	—	
(V_3 = 1.3 Vdc, V_2 = 0.6 Vdc, T_J = 125°C)	I_2	10	—	—	
(V_3 = 2.0 Vdc, V_2 = 0.6 Vdc, T_J = -55°C)	I_2	10	—	—	
(V_7 = 1.7 Vdc, V_{10} = 0.6 Vdc)	I_{10}	10	—	—	
(V_7 = 1.3 Vdc, V_{10} = 0.6 Vdc, T_J = 125°C)	I_{10}	10	—	—	
(V_7 = 2.0 Vdc, V_{10} = 0.6 Vdc, T_J = -55°C)	I_{10}	10	—	—	
Input Breakdown Voltage					Vdc
(I_3 = 10 μAdc, V_4 = 0)	BV_3	8	—	—	
(I_4 = 10 μAdc, V_3 = 0)	BV_4	8	—	—	
(I_7 = 10 μAdc, V_8 = 0)	BV_7	8	—	—	
(I_8 = 10 μAdc, V_7 = 0)	BV_8	8	—	—	
(I_9 = 10 μAdc, V_7 = 0)	BV_9	8	—	—	
Input Leakage Current	I_3,I_4,I_7,I_8,I_9				μAdc
(Diode under test at 5 Vdc, all other inputs = 0)		—	—	0.250	
(Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)		—	—	25	
Input Turn-Off Current	I_3,I_4,I_7,I_8,I_9				mAdc
(Alternately V_3, V_4, V_7, V_8, V_9 = 0)		—	—	-1.8	
(Alternately V_3, V_4, V_7, V_8, V_9 = 0, T_J = -55 to +125°C)		—	—	-1.9	
Output Capacitance					pf
(V_2 = 2.0 Vdc, V_3 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_2	—	—	10	
(V_{10} = 2.0 Vdc, V_7 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_{10}	—	—	10	
Input Capacitance					pf
(V_3 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	—	—	10	
(V_4 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_4	—	—	10	
(V_7 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_7	—	—	10	
(V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	—	—	10	
(V_9 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_9	—	—	10	
Power Consumption from Power Supply	—				mW
(Output "Off", V_3 = V_7 = 0)		—	—	17	
(Output "On")		—	—	12	
Switching Times (Figure 2)					nsec
Turn-On Delay	t_{on}	—	—	60	
Turn-Off Delay	t_{off}	—	—	50	
Average Propagation Delay (Figure 3)	t_{pd}	—	30	—	nsec
Fan-Out	n				—
(T_J = -55 to +125°C)		—	—	5	

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

MC208

MC200 DTL SERIES

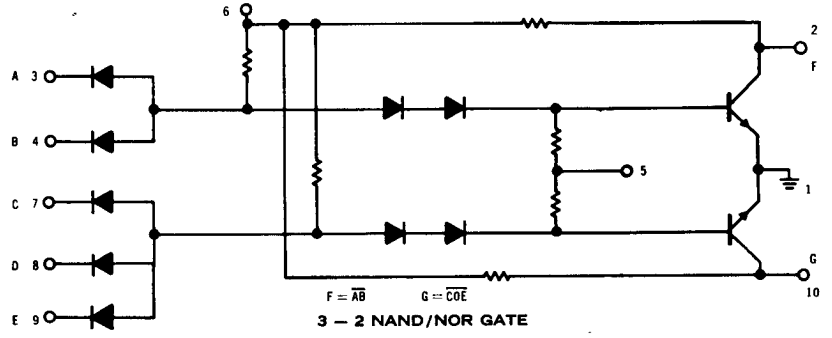


Dual (3-2) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,4,6 \text{ thru } 10}$	+8	Vdc
	V_5	-8	
Forward Current	$I_{2,10}$	+30	mAdc
	$I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



3 — 2 NAND/NOR GATE

MC208 (continued)

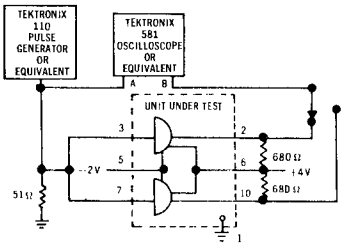
ELECTRICAL CHARACTERISTICS

(V6 = 4 Vdc, V5 = 2 Vdc, V1 = 0, TJ = 25°C unless otherwise noted)

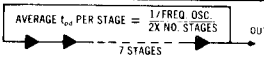
Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage					Vdc
(I_2 = 1 μAdc, V_3 = 0)	BV_2	8	—	—	
(I_{10} = 1 μAdc, V_7 = 0)	BV_{10}	8	—	—	
Output Saturation Voltage					Vdc
(I_2 = 8 mAdc, V_3 = V_4 = 2 Vdc, T_J = -55 to +125°C)	V_2	—	—	0.6	
(I_{10} = 8 mAdc, V_7 = V_8 = V_9 = 2 Vdc, T_J = -55 to +125°C)	V_{10}	—	—	0.6	
Output "Off" Voltage					Vdc
(I_2 = 100 μAdc, V_3 = 0.7 Vdc, T_J = -55 to +125°C)	V_2	3.5	—	—	
(I_{10} = 100 μAdc, V_7 = 0.7 Vdc, T_J = -55 to +125°C)	V_{10}	3.5	—	—	
Input Breakdown Voltage					Vdc
(I_3 = 10 μAdc, V_4 = 0)	BV_3	8	—	—	
(I_4 = 10 μAdc, V_3 = 0)	BV_4	8	—	—	
(I_7 = 10 μAdc, V_8 = 0)	BV_7	8	—	—	
(I_8 = 10 μAdc, V_7 = 0)	BV_8	8	—	—	
(I_9 = 10 μAdc, V_7 = 0)	BV_9	8	—	—	
Input Leakage Current	I_3,I_4,I_7,I_8,I_9				μAdc
(Diode under test at 5 Vdc, all other inputs = 0)		—	—	0.250	
(Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)		—	—	25	
Input Turn-Off Current	I_3,I_4,I_7,I_8,I_9				mAdc
(Alternately V_3, V_4, V_7, V_8, V_9 = 0)		—	—	-1.8	
(Alternately V_3, V_4, V_7, V_8, V_9 = 0, T_J = -55 to +125°C)		—	—	-1.9	
Output Capacitance					pf
(V_2 = 2.0 Vdc, V_3 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_2	—	—	10	
(V_{10} = 2.0 Vdc, V_7 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_{10}	—	—	10	
Input Capacitance					pf
(V_3 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	—	—	10	
(V_4 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_4	—	—	10	
(V_7 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_7	—	—	10	
(V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	—	—	10	
(V_9 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_9	—	—	10	
Power Consumption from Power Supply	—				mW
(Output "Off", V_3 = V_7 = 0)		—	—	17	
(Output "On")		—	—	30	
Switching Times					nsec
Turn-On Delay	t_{on}	—	—	60	
Turn-Off Delay	t_{off}	—	—	50	
Average Propagation Delay	t_{pd}	—	30	—	nsec
Fan-Out	n				—
(T_J = -55 to +125°C)		—	—	4	

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

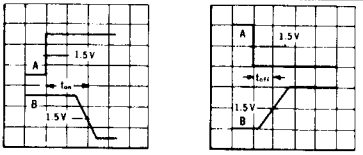
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT

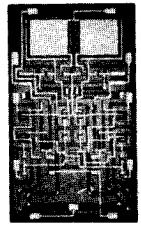


SWITCHING TIME WAVE FORMS



MC209

MC200 DTL SERIES

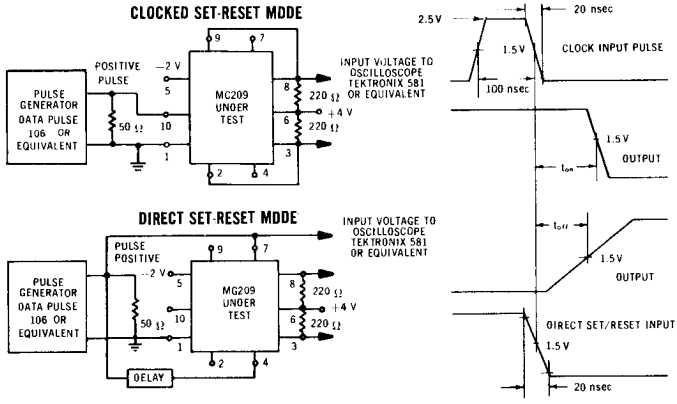


Diode Transistor Logic Flip-Flop.

MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2, 3, 4, 6, 7, 8, 9, 10}$ V_5	+8 -8	Vdc
Forward Current	$I_{3, 8}$ $I_{2, 3, 4, 7 \text{ thru } 10}$	+50 -30	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

SWITCHING TIME TEST CIRCUITS AND WAVE FORMS



MC209 (continued)

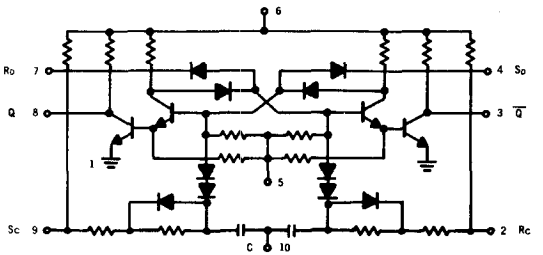
ELECTRICAL CHARACTERISTICS

(V6 = 4 Vdc, V5 = 2 Vdc, V1 = 0, TJ = 25°C unless otherwise noted)

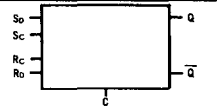
Characteristic	Logic Symbol	Logic State	Symbol	Min	Typ	Max	Unit
OUTPUT LEVEL							
"Off" Voltage							
(I_8 = -200 μAdc, V_4 = 0.6 Vdc, V_7 = 2.0 Vdc)	Q	1	V_8	2.5	—	—	Vdc
(I_3 = -200 μAdc, V_4 = 2.0 Vdc, V_7 = 0.6 Vdc)	$\bar{Q}$	1	V_3	2.5	—	—	Vdc
"On" Voltage							
(I_8 = 16 mAdc, V_4 = 2.0 Vdc, V_7 = 0.6 Vdc)	Q	0	V_8	—	—	0.6	Vdc
(I_3 = 16 mAdc, V_4 = 0.6 Vdc, V_7 = 2.0 Vdc)	$\bar{Q}$	0	V_3	—	—	0.6	Vdc
DIRECT SET-RESET INPUTS							
"Up" Voltage	S_D	1	V_4	2.0	—	—	Vdc
	R_D	1	V_7	2.0	—	—	Vdc
"Down" Voltage	S_D	0	V_4	—	—	0.6	Vdc
	R_D	0	V_7	—	—	0.6	Vdc
"Up" Current							
(V_4 = 5 Vdc, T_J = 125°C)	S_D	1	I_4	—	—	25	μAdc
(V_7 = 5 Vdc, T_J = 125°C)	R_D	1	I_7	—	—	25	μAdc
"Down" Current							
(V_4 = 0)	S_D	0	I_4	—	—	-1.8	mAdc
(V_7 = 0)	R_D	0	I_7	—	—	-1.8	mAdc
CLOCKED SET-RESET INPUTS							
"Down" Current							
($V_{9,\ 10}$ = 0, T_J = 25°C)	S_C	0	I_9	—	—	-1.4	mAdc
($V_{2,\ 10}$ = 0, T_J = 25°C)	R_C	0	I_2	—	—	-1.4	mAdc
Effective Clock Input Capacitance			C_{10}	—	75	—	pf
SWITCHING TIME							
Clocked Set-Reset Mode							
Turn-On Delay			t_{on}	—	—	100	nsec
Turn-Off Delay			t_{off}	—	—	75	nsec
Direct Set-Reset Mode							
Turn-On Delay			t_{on}	—	—	100	nsec
Turn-Off Delay			t_{off}	—	—	75	nsec
FAN-OUT			n	—	—	8	—
POWER CONSUMPTION				—	16	—	mW

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

CIRCUIT AND LOGIC DIAGRAMS



BINARY ELEMENT MC209



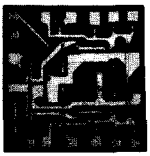
CLOCKED SET-RESET			DIRECT SET-RESET		
Sc	Rc	Q	So	Ro	Q
0	0	?	0	0	*
0	1	1	0	1	1
1	0	0	1	0	0
1	1	No Change	1	1	No Change

POSITIVE LOGIC DEFINITION: HIGH VOLTAGE = 1, LOW VOLTAGE = 0

*BOTH Q and $\bar{Q}$ IN 1 STATE UNTIL EITHER So OR Ro RISES

MC212

MC200 DTL SERIES

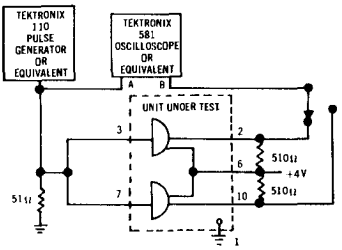


Dual (3-3) Input Diode Transistor Logic NAND/NOR Gate.

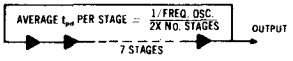
MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2 \text{ thru } 10}$	+8	Vdc
Forward Current	$I_{2,10}$	+30	mAdc
	$I_{2 \text{ thru } 5,\ 7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

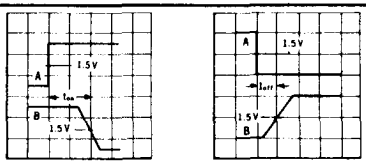
SWITCHING TIME TEST CIRCUIT



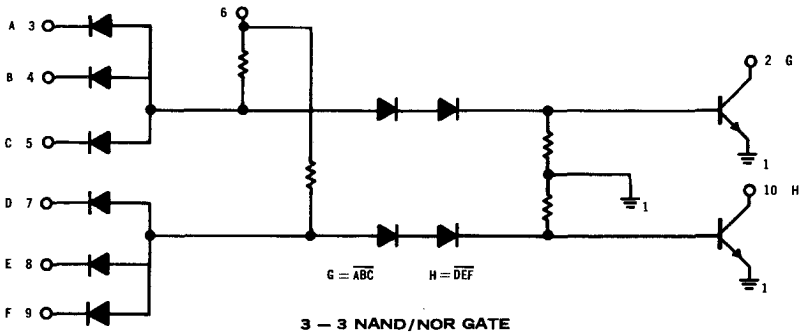
PROPAGATION DELAY MEASUREMENT CIRCUIT



SWITCHING TIME WAVE FORMS



CIRCUIT SCHEMATIC



3 — 3 NAND/NOR GATE

MC212 (continued)

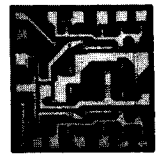
ELECTRICAL CHARACTERISTICS * ($V_6 = 4$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage					Vdc
(I_2 = 1 μAdc, V_3 = 0)	BV_2	8	—	—	
(I_{10} = 1 μAdc, V_7 = 0)	BV_{10}	8	—	—	
"1" Output Current					μAdc
(V_3 = 1.1 Vdc, V_2 = 5 Vdc	I_2	—	—	50	
(V_3 = 0.7 Vdc, V_2 = 5 Vdc, T_J = 125°C)	I_2	—	—	50	
(V_3 = 1.4 Vdc, V_2 = 5 Vdc, T_J = -55°C)	I_2	—	—	50	
(V_7 = 1.1 Vdc, V_{10} = 5 Vdc)	I_{10}	—	—	50	
(V_7 = 0.7 Vdc, V_{10} = 5 Vdc, T_J = 125°C)	I_{10}	—	—	50	
(V_7 = 1.4 Vdc, V_{10} = 5 Vdc, T_J = -55°C)	I_{10}	—	—	50	
"0" Output Current					mAdc
(V_3 = 1.7 Vdc, V_2 = 0.6 Vdc)	I_2	10	—	—	
(V_3 = 1.3 Vdc, V_2 = 0.6 Vdc, T_J = 125°C)	I_2	10	—	—	
(V_3 = 2.0 Vdc, V_2 = 0.6 Vdc, T_J = -55°C)	I_2	10	—	—	
(V_7 = 1.7 Vdc, V_{10} = 0.6 Vdc)	I_{10}	10	—	—	
(V_7 = 1.3 Vdc, V_{10} = 0.6 Vdc, T_J = 125°C)	I_{10}	10	—	—	
(V_7 = 2.0 Vdc, V_{10} = 0.6 Vdc, T_J = -55°C)	I_{10}	10	—	—	
Input Breakdown Voltage					Vdc
(I_3 = 10 μAdc, V_4 = 0)	BV_3	8	—	—	
(I_4 = 10 μAdc, V_3 = 0)	BV_4	8	—	—	
(I_5 = 10 μAdc, V_3 = 0)	BV_5	8	—	—	
(I_7 = 10 μAdc, V_8 = 0)	BV_7	8	—	—	
(I_8 = 10 μAdc, V_7 = 0)	BV_8	8	—	—	
(I_9 = 10 μAdc, V_7 = 0)	BV_9	8	—	—	
Input Leakage Current	$I_3, I_4, I_5, I_7, I_8, I_9$				μAdc
(Diode under test at 5 Vdc, all other inputs = 0)		—	—	0.250	
(Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)		—	—	25	
Input Turn-Off Current	$I_3, I_4, I_5, I_7, I_8, I_9$				mAdc
(Alternately V_3, V_4, V_5, V_7, V_8, V_9 = 0)		—	—	-1.8	
(Alternately V_3, V_4, V_5, V_7, V_8, V_9 = 0, T_J = -55 to +125°C)		—	—	-1.9	
Output Capacitance					pf
(V_2 = 2.0 Vdc, V_3 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_2	—	—	10	
(V_{10} = 2.0 Vdc, V_7 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_{10}	—	—	10	
Input Capacitance					pf
(V_3 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_3	—	—	10	
(V_4 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_4	—	—	10	
(V_5 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_5	—	—	10	
(V_7 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_7	—	—	10	
(V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_8	—	—	10	
(V_9 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	C_9	—	—	10	
Power Consumption from Power Supply	—				mW
(Output "Off", V_3 = V_7 = 0)		—	—	15	
(Output "On")		—	—	12	
Switching Times (Figure 2)					nsec
Turn-On Delay	t_{on}	—	—	60	
Turn-Off Delay	t_{off}	—	—	50	
Average Propagation Delay (Figure 3)	t_{pd}	—	30	—	nsec
Fan-Out	n				—
(T_J = -55 to +125°C)		—	—	5	

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

MC213

MC200 DTL SERIES

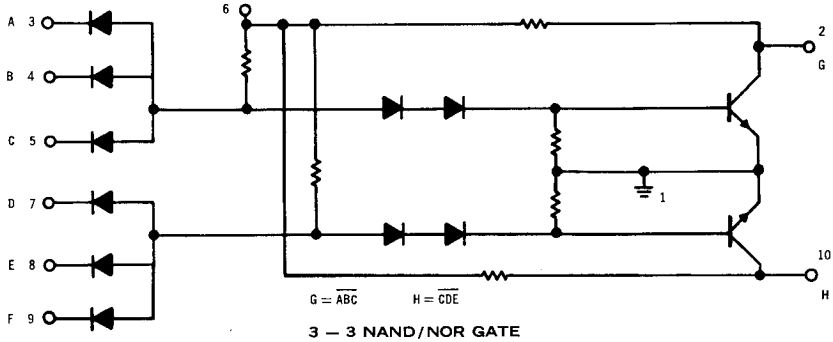


Dual (3-3) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2 \text{ thru } 10}$	+8	Vdc
Forward Current	$I_{2,10}$	+30	mAdc
	$I_{2 \text{ thru } 5, 7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



3 — 3 NAND/NOR GATE

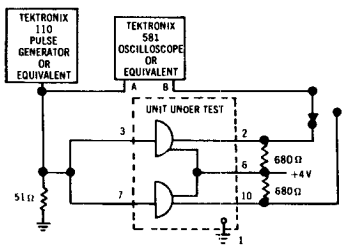
MC213 (continued)

ELECTRICAL CHARACTERISTICS ($V_6 = 4$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

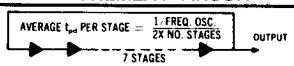
Characteristic	Symbol	Min	Typ	Max	Unit
Output Breakdown Voltage (I_2 = 1 μAdc, V_3 = 0) (I_{10} = 1 μAdc, V_7 = 0)	 BV_2 BV_{10}	 8 8	 — —	 — —	Vdc
Output Saturation Voltage (I_2 = 8 mAdc, $V_3 = V_4 = V_5$ = 2 Vdc, T_J = -55 to +125°C) (I_{10} = 8 mAdc, $V_7 = V_8 = V_9$ = 2 Vdc, T_J = -55 to +125°C)	 V_2 V_{10}	 — —	 — —	 0.6 0.6	Vdc
Output "Off" Voltage (I_2 = 100 μAdc, V_3 = 0.7 Vdc, T_J = -55 to +125°C) (I_{10} = 100 μAdc, V_7 = 0.7 Vdc, T_J = -55 to +125°C)	 V_2 V_{10}	 3.5 3.5	 — —	 — —	Vdc
Input Breakdown Voltage (I_3 = 10 μAdc, V_4 = 0) (I_4 = 10 μAdc, V_3 = 0) (I_5 = 10 μAdc, V_3 = 0) (I_7 = 10 μAdc, V_8 = 0) (I_8 = 10 μAdc, V_7 = 0) (I_9 = 10 μAdc, V_7 = 0)	 BV_3 BV_4 BV_5 BV_7 BV_8 BV_9	 8 8 8 8 8 8	 — — — — — —	 — — — — — —	Vdc
Input Leakage Current (Diode under test at 5 Vdc, all other inputs = 0) (Diode under test at 5 Vdc, all other inputs = 0, T_J = 125°C)	$I_3, I_4, I_5, I_7, I_8, I_9$	 —	 —	 0.250 25	μAdc
Input Turn-Off Current (Alternately V_3, V_4, V_5, V_7, V_8, V_9 = 0) (Alternately V_3, V_4, V_5, V_7, V_8, V_9 = 0, T_J = -55 to +125°C)	$I_3, I_4, I_5, I_7, I_8, I_9$	 — —	 — —	 -1.8 -1.9	mAdc
Output Capacitance (V_2 = 2.0 Vdc, V_3 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_{10} = 2.0 Vdc, V_7 = 0, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	 C_2 C_{10}	 — —	 — —	 10 10	pf
Input Capacitance (V_3 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_4 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_5 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_7 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_8 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded) (V_9 = 2 Vdc, V_{in} = 25 mVrms, f = 1 mc, unused pins grounded)	 C_3 C_4 C_5 C_7 C_8 C_9	 — — — — — —	 — — — — — —	 10 10 10 10 10 10	pf
Power Consumption from Power Supply (Output "Off", $V_3 = V_7$ = 0) (Output "On")	—	 — —	 — —	 15 30	mW
Switching Times (Figure 2) Turn-On Delay Turn-Off Delay	 t_{on} t_{off}	 — —	 — —	 60 50	nsec
Average Propagation Delay (Figure 3)	t_{pd}	—	30	—	nsec
Fan-Out (T_J = -55 to +125°C)	n	 —	 —	 4	—

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

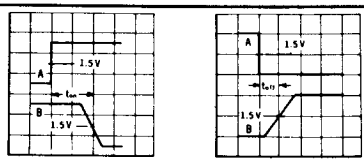
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY MEASUREMENT CIRCUIT



SWITCHING TIME WAVE FORMS



MC215

MC200 DTL SERIES

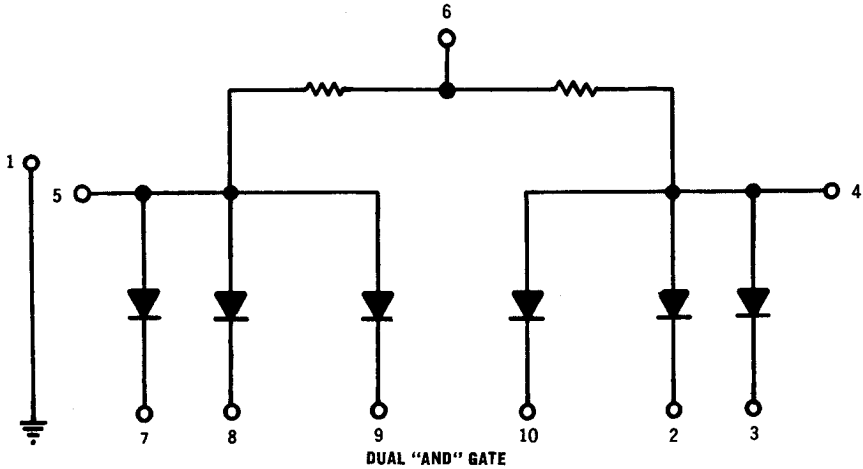


Dual (3-3) Input Diode Transistor Logic AND Gate.

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristics	Symbol	Rating	Unit
Applied Voltage	$V_{2,\ 3,\ 7\ thru\ 10}$	+8	Vdc
	V_6	±8	
Forward Current	$I_{2\ thru\ 10}$	±30	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



DUAL "AND" GATE

MC215 (continued)

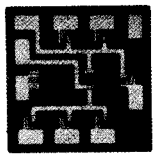
ELECTRICAL CHARACTERISTICS ($T_J = 25°C$ unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Diode Breakdown Voltage ($I_{2, 3, 10} = 10\ \mu Adc$, $V_4 = V_1 = 0$) ($I_{7, 8, 9} = 10\ \mu Adc$, $V_5 = V_1 = 0$)	$V_{2, 3, 10}$ $V_{7, 8, 9}$	8 8	- -	- -	Vdc
Diode Forward Voltage ($I_4 = 2$ mAdc, $V_{2, 3, 10} = V_1 = 0$) ($I_5 = 2$ mAdc, $V_{7, 8, 9} = V_1 = 0$)	V_4 V_5	- -	- -	0.85 0.85	Vdc
Diode Reverse Leakage Current ($V_{2, 3, 10} = 5$ Vdc, $V_4 = V_1 = 0$) ($V_{2, 3, 10} = 5$ Vdc, $V_4 = V_1 = 0$, $T_J = 125°C$) ($V_{7, 8, 9} = 5$ Vdc, $V_5 = V_1 = 0$) ($V_{7, 8, 9} = 5$ Vdc, $V_5 = V_1 = 0$, $T_J = 125°C$)	$I_{2, 3, 10}$ $I_{7, 8, 9}$ 	- - 	- - 	0.25 25 0.25 25	μAdc
Input Capacitance ($V_{2, 3, 10} = 2$ Vdc, $V_4 = V_1 = 0$, f = 1 mc, $V_{in} = 25$ mVrms, unused inputs grounded) ($V_{7, 8, 9} = 2$ Vdc, $V_5 = V_1 = 0$, f = 1 mc, $V_{in} = 25$ mVrms, unused inputs grounded)	$C_{2, 3, 10}$ $C_{7, 8, 9}$	- -	- -	10 10	pf
Reverse Recovery Time ($I_{F2, 3, 10} = I_{R2, 3, 10} = 2$ mAdc, $V_4 = V_1 = 0$, recover to 0.2 mAdc) ($I_{F7, 8, 9} = I_{R7, 8, 9} = 2$ mAdc, $V_5 = V_1 = 0$, recover to 0.2 mAdc)	$t_{rr2, 3, 10}$ $t_{rr7, 8, 9}$	- -	- -	4 4	nsec
Resistor Isolation Leakage ($V_6 = 5$ Vdc, $V_4 = V_5 = 0$)	I_1	-	-	600	nAdc
Resistor Current ($V_6 = 4$ Vdc, $V_4 = V_1 = 0$) ($V_6 = 4$ Vdc, $V_5 = V_1 = 0$)	I_4 I_5	1.6 1.6	- -	2.4 2.4	mAdc
Resistor Temperature Coefficient	-	-	0.1	-	%/°C
Diode Forward Conductance Change with Temperature	$\Delta V_{F2, 3, 10}$ $\Delta V_{F7, 8, 9}$	- -	-1.7 -1.7	- -	mV/°C

Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

MC217

MC200 DTL SERIES

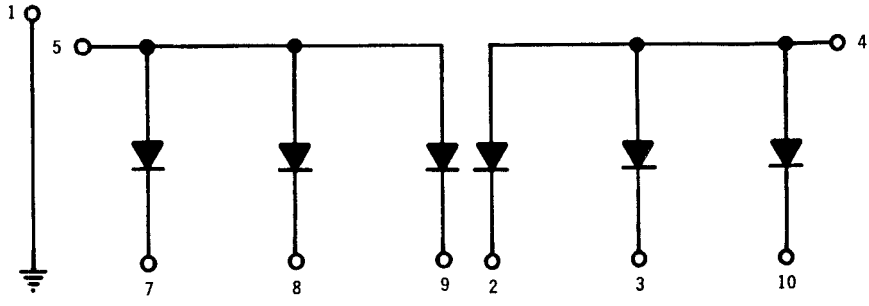


Diode Transistor Logic Dual-Diode Array.

MAXIMUM RATINGS ($T_A = 25°$)

Characteristics	Symbol	Rating	Unit
Applied Voltage	$V_{2,\ 3,\ 7\ thru\ 10}$	8	Vdc
Forward Current	$I_{2\ thru\ 5,\ 7\ thru\ 10}$	30	mAdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



DUAL DIODE ARRAY

MC217 (continued)

ELECTRICAL CHARACTERISTICS (T_J = 25°C unless otherwise noted)

Characteristics	Symbol	Min	Typ	Max	Unit
Diode Breakdown Voltage					Vdc
($I_{2,3,10}$ = 10 μAdc, $V_4 = V_1 = 0$)	$V_{2,3,10}$	8	-	-	
($I_{7,8,9}$ = 10 μAdc, $V_5 = V_1 = 0$)	$V_{7,8,9}$	8	-	-	
Diode Forward Voltage					Vdc
(I_4 = 2 mAdc, $V_{2,3,10} = V_1 = 0$)	V_4	-	-	0.85	
(I_5 = 2 mAdc, $V_{7,8,9} = V_1 = 0$)	V_5	-	-	0.85	
Diode Reverse Leakage Current					μAdc
($V_{2,3,10}$ = 5 Vdc, $V_4 = V_1 = 0$)	$I_{2,3,10}$	-	-	0.25	
($V_{2,3,10}$ = 5 Vdc, $V_4 = V_1 = 0$, T_J = 125°C)				25	
($V_{7,8,9}$ = 5 Vdc, $V_5 = V_1 = 0$)	$I_{7,8,9}$	-	-	0.25	
($V_{7,8,9}$ = 5 Vdc, $V_5 = V_1 = 0$, T_J = 125°C)				25	
Input Capacitance					pf
($V_{2,3,10}$ = 2 Vdc, $V_4 = V_1 = 0$, f = 1 mc, V_{in} = 25 mVrms, unused inputs grounded)	$C_{2,3,10}$	-	-	10	
($V_{7,8,9}$ = 2 Vdc, $V_5 = V_1 = 0$, f = 1 mc, V_{in} = 25 mVrms, unused inputs grounded)	$C_{7,8,9}$	-	-	10	
Reverse Recovery Time					nsec
($I_{F2,3,10} = I_{R2,3,10}$ = 2 mAdc, $V_4 = V_1 = 0$, recover to 0.2 mAdc)	$t_{rr2,3,10}$	-	-	4	
($I_{F7,8,9} = I_{R7,8,9}$ = 2 mAdc, $V_5 = V_1 = 0$, recover to 0.2 mAdc)	$t_{rr7,8,9}$	-	-	4	
Diode Forward Conductance Change with Temperature	$\Delta V_{F2,3,10}$	-	-1.7	-	mV/°C
	$\Delta V_{F7,8,9}$	-	-1.7	-	

*Numerical subscripts refer to pin numbers. Pins not specifically referenced are left electrically open.

MC250 DTL series



SUFFIX "F" DEVICES
CASE 72



SUFFIX "G" DEVICES
CASE 71A

Commercial monolithic integrated Diode Transistor Logic circuits for low-power, high-speed applications. The MC250 series operates over a temperature range of 0 to +75°C and provides guaranteed performance at 25°C.

SERIES MC250 DTL CIRCUITS

Type	Description	Typical Propagation Delay (nsec)	Maximum Power Dissipation		Maximum Fan Out (0 to +75°C)
			Output Off (mW)	Output On (mW)	
MC251	4-Input NAND/NOR Gate	30	10	7	5
MC252	3-Input NAND/NOR Gate	30	10	7	5
MC253	6-Input Diode AND Gate	-	-	-	-
MC254	3-Input Power NAND/NOR Gate	40	23	66	20
MC255	Line Driver	50	30	65	20(MC251) 15(MC259)
MC256	Dual (2-2) Input NAND/NOR Gate	30	20	12	5
MC257	Dual (3-2) Input NAND/NOR Gate	30	20	12	5
MC258	Dual (3-2)Input NAND/NOR Gate	30	20	34	4
MC259	Flip-Flop	-	16	16	8
MC260	Flip-Flop	-	16	16	8
MC262	Dual (3-3) Input NAND/NOR Gate	30	19	12	5
MC263	Dual (3-3) Input NAND/NOR Gate	30	19	33	4
MC265	Dual (3-3) Input AND Gate	-	-	-	-
MC267	Dual-Diode Array	-	-	-	-

MC251
MC252

MC250 DTL SERIES



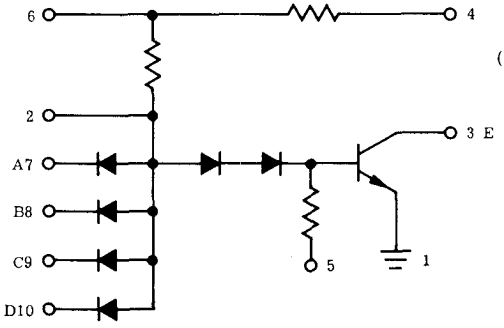
4-Input and 3-Input Diode Transistor Logic NAND/NOR Gates.

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

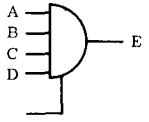
Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{4, 6 \text{ thru } 10}$	+8	Volts
	V_5	-8	
	V_3	+6	
Forward Current	$I_{2 \text{ thru } 10}$	30	mA
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT AND LOGIC DIAGRAMS

4-INPUT NAND/NOR GATE MC251

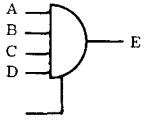


NAND ("UP" LEVEL = "1")



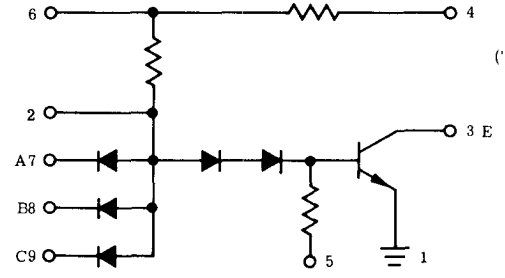
$E = \overline{ABCD}$

NOR ("DOWN" LEVEL = "1")

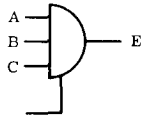


$E = \overline{A+B+C+D}$

3-INPUT NAND/NOR GATE MC252

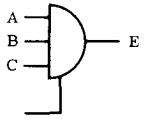


NAND ("UP" LEVEL - "1")



$E = \overline{ABC}$

NOR ("DOWN" LEVEL - "1")



$E = \overline{A+B+C}$

MC251, MC252 (continued)

ELECTRICAL CHARACTERISTICS

($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Breakdown Voltage (I_3 = 5μAdc, $V_{5,6,1}$ = 0)	BV_3	6	-	-	Vdc
"1" Output Current					μAdc
(V_{in} = 1.0Vdc, V_3 = 5Vdc)	I_3	-	-	50	
(V_{in} = 0.75Vdc, V_3 = 5Vdc, T_J = 75°C)	I_3	-	-	50	
(V_{in} = 1.1Vdc, V_3 = 5Vdc, T_J = 0°C)	I_3	-	-	50	
"0" Output Current (V_7 = 2.0Vdc, V_3 = 0.55Vdc, T_J = 0 to 75°C)	I_3	10	-	-	mAdc
Input Breakdown Voltage* (Diode under test at 5Vdc, All other diodes = 0)	$BV_{7,8,9,10}$	8	-	-	Vdc
Input Leakage Current*	$I_{7,8,9,10}$				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.50	
(Diode under test at 5Vdc, all other inputs = 0, T_J = 75°C)		-	-	25	
Input Turn-Off Current*	$I_{7,8,9,10}$				mAdc
(Alternately V_7, V_8, V_9, V_{10} = 0)		-	-	-2.3	
(Alternately V_7, V_8, V_9, V_{10} = 0, T_J = 0 to 75°C)		-	-	-2.5	
Output Capacitance (V_3 = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_3	-	-	15	pf
Input Capacitance*					pf
(V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_7	-	-	10	
(V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_8	-	-	10	
(V_9 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_9	-	-	10	
(V_{10} = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_{10}	-	-	10	
Load Resistor Current (V_4 = 0)	I_4	-1.3	-	-2.85	mAdc
Power Consumption from Power Supply					mW
(Output "Off", V_7 = 0)		-	-	10	
(Output "On")		-	-	7	
Switching Times					nsec
Turn-On Delay	t_{on}	-	-	60	
Turn-Off Delay	t_{off}	-	-	60	
Average Propagation Delay	t_{pd}	-	30	-	nsec

* Input Diode at pin 10 available on MC251 only

MC253

MC250 DTL SERIES



6-Input Diode Transistor Logic AND Gate.

MAXIMUM RATINGS ($T_A = 25°C$)

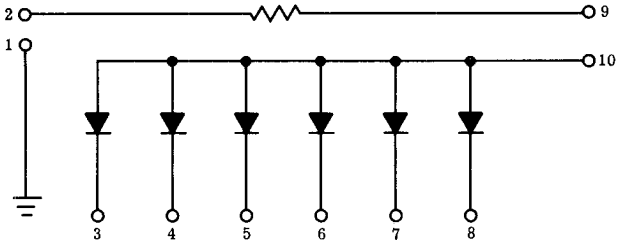
Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3 \text{ thru } 8}$	+8	Vdc
	$V_{2,\ 9}$	±8	
Forward Current	$I_{2 \text{ thru } 10}$	30	mAdc
Operating Temperature Range	T_J	0 to 75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

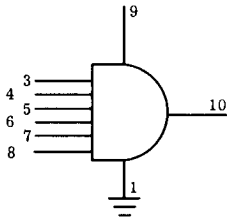
ELECTRICAL CHARACTERISTICS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Diode Breakdown Voltage ($I_{3 \text{ thru } 8}$ = 10 μAdc, $V_{10}=V_1=0$)	$V_{3 \text{ thru } 8}$	8	-	-	Vdc
Diode Forward Voltage (I_{10} = 2mAdc, $V_{3 \text{ thru } 8}$ = 0)	V_{10}	-	-	0.85	Vdc
Diode Reverse Leakage Current	$I_{3 \text{ thru } 8}$				μAdc
($V_{3 \text{ thru } 8}$ = 5Vdc, $V_{10}=V_1=0$)		-	-	0.50	
($V_{3 \text{ thru } 8}$ = 5Vdc, $V_{10}=V_1=0$, T_J=75°C		-	-	25	
Input Capacitance ($V_{3 \text{ thru } 8}$=2Vdc, $V_{10}=V_1=0$, f=1mc, V_{in}=25mVrms, unused inputs grounded)	$C_{3 \text{ thru } 8}$	-	-	10	pf
Reverse Recovery Time ($I_{F\ 3 \text{ thru } 8}$ = $I_{R\ 3 \text{ thru } 8}$=2mAdc, V_{10} = V_1 = 0, recover to 0.2mAdc)	$t_{rr\ 3 \text{ thru } 8}$	-	-	4	nsec
Resistor Current (V_9 = 4Vdc, V_2 = 0)	I_9	1.3	-	2.85	mAdc
Resistor Temperature Coefficient		-	0.1	-	%/°C
Diode Forward Conductance Change with Temperature	$\Delta V_{F\ 3 \text{ thru } 8}$	-	-1.7	-	mV/°C

MC253 (continued)

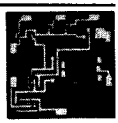
MC253 6-DIODE "AND" GATE





MC254

MC250 DTL SERIES

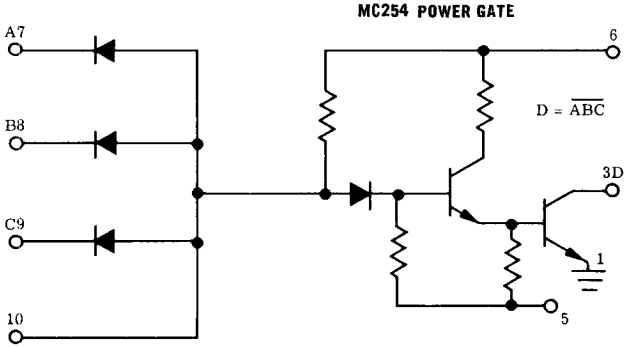


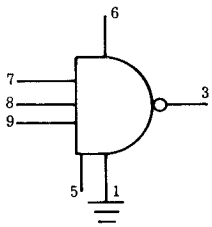
3-Input Diode Transistor Logic NAND/NOR Power Gate.

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{7,8,9}$ V_5 $V_{3,6}$	+8 -6 +6	Vdc
Forward Current	I_5 thru 10	30	mAdc
Load Current	I_3	75	mAdc
Operating Temperature Range	T_J	0 to 75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC254 POWER GATE





MC254 (continued)

ELECTRICAL CHARACTERISTICS

($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Breakdown Voltage ($I_8 = 5\mu$Adc, $V_7 = 0$	BV_3	6	-	-	Vdc
"1" Output Current ($V_{7,8 \text{ or } 9} = 1.0$Vdc, $V_3 = 5$Vdc) ($V_{7,8 \text{ or } 9} = 0.75$Vdc, $V_3 = 5$Vdc, $T_J = 75°C$) ($V_{7,8 \text{ or } 9} = 1.1$Vdc, $V_3 = 5$Vdc, $T_J = 0°C$)	I_3	- - -	- - -	100 100 100	μAdc
"0" Output Current ($V_{7,8 \text{ or } 9} = 2.0$Vdc, $V_3 = 0.55$, $T_J = 0$ to $75°C$)	I_3	30	-	-	mAdc
Input Breakdown Voltage ($I_7 = 10\mu$Adc, $V_8 = 0$) ($I_8 = 10\mu$Adc, $V_7 = 0$) ($I_9 = 10\mu$Adc, $V_7 = 0$)	BV_7 BV_8 BV_9	8.0 8.0 8.0	- - -	- - -	Vdc
Input Leakage Current ($V_7 = 5$Vdc, $V_8 = 0$) ($V_7 = 5$Vdc, $V_8 = 0$, $T_J = 75°C$) ($V_8 = 5$Vdc, $V_7 = 0$) ($V_8 = 5$Vdc, $V_7 = 0$, $T_J = 75°C$) ($V_9 = 5$Vdc, $V_7 = 0$) ($V_9 = 5$Vdc, $V_7 = 0$, $T_J = 75°C$)	I_7 I_7 I_8 I_8 I_9 I_9	- - - - - -	- - - - - -	0.50 25 0.50 25 0.50 25	μAdc
Input Turn-Off Current (Alternately, $V_7, V_8, V_9 = 0$) (Alternately, $V_7, V_8, V_9 = 0$, $T_J = 0$ to $75°C$) ($V_{10} = 0$)	I_7, I_8, I_9 I_7, I_8, I_9 I_{10}	- - -	- - -	-4.5 -5.5	mAdc
Output Capacitance ($V_3 = 2.0$Vdc, $V_{in} = 25$mVrms, f = 1mc, unused pins grounded)	C_3	-	-	15	pf
Input Capacitance ($V_7 = 2.0$Vdc, $V_{in} = 25$mVrms, f = 1mc, unused pins grounded) ($V_8 = 2.0$Vdc, $V_{in} = 25$mVrms, f = 1mc, unused pins grounded) ($V_9 = 2.0$Vdc, $V_{in} = 25$mVrms, f = 1mc, unused pins grounded)	C_7 C_8 C_9	- - -	- - -	10 10 10	pf
Power Supply (Output "OFF", $V_7 = 0$) (Output "ON")		- -	- -	23 66	mW
Switching Times Turn-On Delay Turn-Off Delay	 t_{on} t_{off}	 - -	 - -	 35 100	nsec
Average Propagation Delay	t_{pd}	-	40	-	nsec

MC255

MC250 DTL SERIES

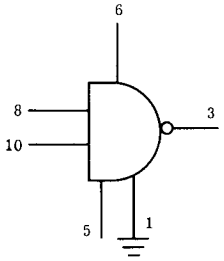


Diode Transistor Logic Line Driver.

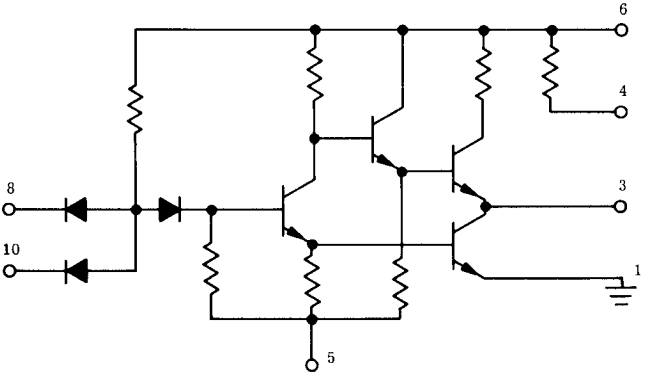
MAXIMUM RATINGS ($T_J = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3,4,6}$ V_5 $V_{8,10}$	+6 -6 +8	Vdc
Forward Current	$I_{5,8,10}$	30	mAdc
Load Current	$I_{3,4,6}$	75	mAdc
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC255



LINE DRIVER



MC255 (continued)

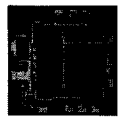
ELECTRICAL CHARACTERISTICS

($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_I = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Saturation Voltage (I_3 = 30mAdc, T_J = 0° C to +75° C	V_3	-	-	0.55	Vdc
Output Voltage, "Off" Level (I_3 = 10mAdc, V_8 = 0.7Vdc, T_J = 0 to 75° C)	V_3	2.0	-	-	
Input Breakdown Voltage (I_8 = 10μAdc, V_{10} = 0)	BV_8	8.0	-	-	Vdc
(I_{10} = 10μAdc, V_8 = 0)	BV_{10}	8.0	-	-	
Input Leakage Current (V_8 = 5Vdc, V_{10} = 0)	I_8			0.50	Adc
(V_8 = 5Vdc, V_{10} = 0, T_J = 75° C)	I_8	-	-	25	
(V_{10} = 5Vdc, V_8 = 0)	I_{10}			0.50	
(V_{10} = 5Vdc, V_8 = 0, T_J = 75° C)	I_{10}	-	-	25	
Turn-Off Current at Inputs (V_8 = 0)	I_8	-	-	-4.5	mAdc
(V_8 = 0, T_J = 0 to +75° C)	I_8	-	-	-4.7	
(V_{10} = 0)	I_{10}	-	-	-4.5	
(V_{10} = 0, T_J = 0 to +75° C)	I_{10}	-	-	-4.7	
Load Resistor	R_{6-4}	-	125	-	Ohms
Input Capacitance (V_8 = 2Vdc, V_{in} = 25mVrms, f=1mc, unused pins grounded)	C_8	-	-	10	pf
(V_{10} = 2Vdc, V_{in} = 25mVrms, f=1mc, unused pins grounded)	C_{10}	-	-	10	
Power Consumption from Power Supply (Output "Off", V_8 = 0)		-	-	30	mW
(Output "On")		-	-	65	
Switching Times Turn-On Delay	t_{on}	-	-	90	nsec
Turn-Off Delay	t_{off}	-	-	60	
Average Propagation Delay (C_L = 1000pf)	t_{pd}	-	50	-	nsec

MC256

MC250 DTL SERIES

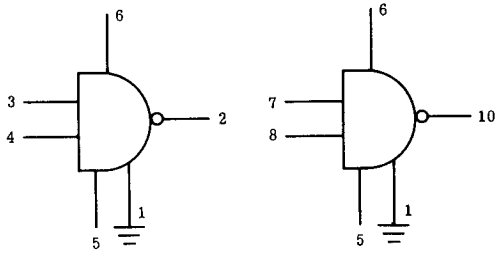


Dual (2-2) Input Diode Transistor Logic NAND/NOR Gate.

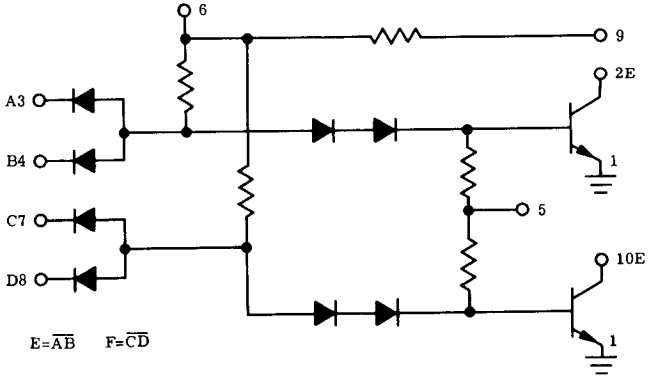
MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise not

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3,4,6 \text{ thru } 9}$ V_5 $V_{2,10}$	+8 -8 +6	Vdc
Forward Current	$I_{2,10}$ $I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	+30 -30	mAdc
Operating Temperature Range	T_J	0 to 75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC256



2-2 NAND/NOR GATE



MC256 (continued)

ELECTRICAL CHARACTERISTICS

(V_6 = 4 Vdc, V_5 = 2 Vdc, V_I = 0, T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Brekdown Voltage					Vdc
(I_2 = 5μAdc, V_3 = 0)	BV_2	6	-	-	
(I_{10} = 5μAdc, V_7 = 0)	BV_{10}	6	-	-	
"1" Output Current					μAdc
(V_3 = 1.0Vdc, V_2 = 5Vdc)	I_2	-	-	50	
(V_3 = 0.75Vdc, V_2 = 5Vdc, T_J = 75° C)	I_2	-	-	50	
(V_3 = 1.1Vdc, V_2 = 5Vdc, T_J = 0° C)	I_2	-	-	50	
(V_7 = 1.0Vdc, V_{10} = 5Vdc)	I_{10}	-	-	50	
(V_7 = 0.75Vdc, V_{10} = 5Vdc, T_J = 75° C)	I_{10}	-	-	50	
(V_7 = 1.1Vdc, V_{10} = 5Vdc, T_J = 0° C)	I_{10}	-	-	50	
"0" Output Current					mAdc
(V_3 = 2.0Vdc, V_2 = 0.55Vdc, T_J = 0 to 75° C)	I_2	10	-	-	
(V_7 = 2.0Vdc, V_{10} = 0.55Vdc, T_J = 0 to 75° C)	I_{10}	10	-	-	
Input BreakDown Voltage					Vdc
(I_3 = 10μAdc, V_4 = 0)	BV_3	8	-	-	
(I_4 = 10μAdc, V_3 = 0)	BV_4	8	-	-	
(I_7 = 10μAdc, V_8 = 0)	BV_7	8	-	-	
(I_8 = 10μAdc, V_7 = 0)	BV_8	8	-	-	
Input Leakage Current	I_3, I_4, I_7, I_8				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.50	
(Diode under test at 5Vdc, all other inputs = 0, T_J = 75° C)		-	-	25	
Input Turn-Off Current	I_3, I_4, I_7, I_8				mAdc
(Alternately V_3, V_4, V_7, V_8 = 0)		-	-	-2.3	
(Alternately V_3, V_4, V_7, V_8 = 0, T_J = 0 to 75° C)		-	-	-2.5	
Output Capacitance					pf
(V_2 = 2.0Vdc, V_3 = 0, V_{in} = 25mVrms f = 1mc, unused pins grounded	C_2	-	-	10	
(V_{10} = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_{10}	-	--	10	

MC256 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Input Capacitance (V_3 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_4 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc unused pins grounded)	C_3 C_4 C_7 C_8	-	-	10 10 10 10	pf
Load Resistor Current (V_9 = 0)	I_9	-1.3	-	-2.85	mAdc
Power Consumption from Power Supply (Output "Off", $V_3 = V_7$ = 0) (Output "On")		- -	- -	20 12	mW
Switching Times Turn-On Delay Turn-Off Delay	 t_{on} t_{off}	 - -	 - -	 60 60	nsec
Average Propagation Delay	t_{pd}	-	30	-	nsec

MC257

MC250 DTL SERIES



Dual (3-2) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3,4,6 \text{ thru } 9}$ V_5 $V_{2,10}$	+8 -8 +6	Vdc
Forward Current	$I_{2,10}$ $I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	+30 -30	mAdc
Operating Temperature Range	T_J	-0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC257 (continued)

ELECTRICAL CHARACTERISTICS

(V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

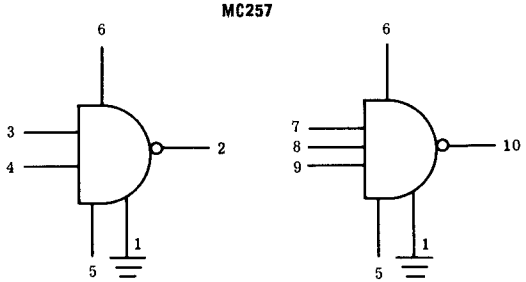
Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Breakdown Voltage					Vdc
(I_2 = 5μAdc, V_3 = 0)	BV_2	6	-	-	
(I_{10} = 5μAdc, V_7 = 0)	BV_{10}	6	-	-	
"1" Output Current					μAdc
(V_3 = 1.0Vdc, V_2 = 5Vdc	I_2	-	-	50	
(V_3 = 0.75Vdc, V_2 = 5Vdc, T_J = 75° C)	I_2	-	-	50	
(V_3 = 1.1Vdc, V_2 = 5Vdc, T_J = 0° C)	I_2	-	-	50	
(V_7 = 1.0Vdc, V_{10} = 5Vdc)	I_{10}	-	-	50	
(V_7 = 0.75Vdc, V_{10} = 5Vdc, T_J = 75° C)	I_{10}	-	-	50	
(V_7 = 1.1Vdc, V_{10} = 5Vdc, T_J = 0° C)	I_{10}	-	-	50	
"0" Output Current					mAdc
(V_3 = 2.0Vdc, V_2 = 0.55Vdc, T_J = 0 to 75° C)	I_2	10	-	-	
(V_7 = 2.0Vdc, V_{10} = 0.55Vdc, T_J = 0 to 75° C)	I_{10}	10	-	-	
Input Breakdown Voltage					Vdc
(I_3 = 10μAdc, V_4 = 0)	BV_3	8	-	-	
(I_4 = 10μAdc, V_3 = 0)	BV_4	8	-	-	
(I_7 = 10μAdc, V_8 = 0)	BV_7	8	-	-	
(I_8 = 10μAdc, V_7 = 0)	BV_8	8	-	-	
(I_9 = 10μAdc, V_7 = 0)	BV_9	8	-	-	
Input Leakage Current	I_3, I_4, I_7, I_8, I_9				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.50	
(Diode under test at 5Vdc, all other inputs = 0, T_J = 75° C)		-	-	25	
Input Turn-Off Current	I_3, I_4, I_7, I_8, I_9				mAdc
(Alternately V_3, V_4, V_7, V_8, V_9 = 0)		-	-	-2.3	
(Alternately V_3, V_4, V_7, V_8, V_9 = 0, T_J = 0 to 75° C)		-	-	-2.5	
Output Capacitance					pf
(V_2 = 2.0Vdc, V_3 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_2	-	-	10	
(V_{10} = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_{10}	-	-	10	

MC257 (continued)

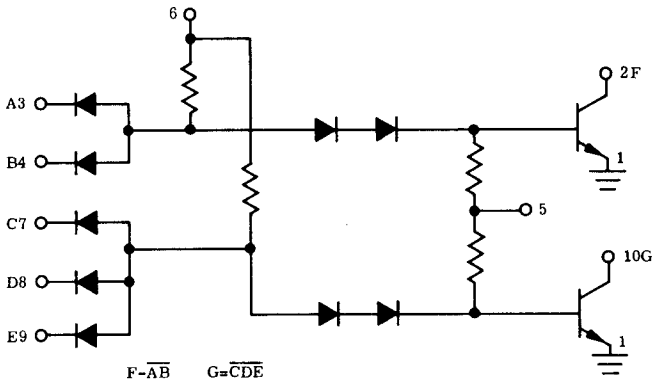
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Input Capacitance (V_3 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_4 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_9 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_3 C_4 C_7 C_8 C_9	- - - - -	- - - - -	10 10 10 10 10	pf
Power Consumption from Power Supply (Output "Off", V_3 = V_7 = 0) (Output "On")	-	- -	- -	20 12	mW
Switching Times Turn-On Delay Turn-Off Delay	 t_{on} t_{off}	 - -	 - -	 60 60	nsec
Average Propagation Delay	t_{pd}	-	30	-	nsec

MC257



3-2 NAND/NOR GATE



MC258

MC250 DTL SERIES

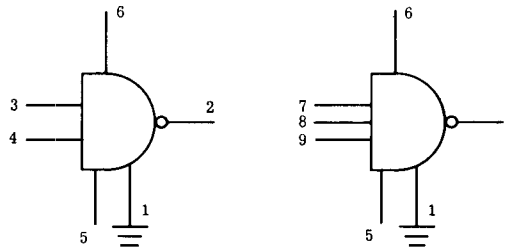


Dual (3-2) Input Diode Transistor Logic NAND/NOR Gate.

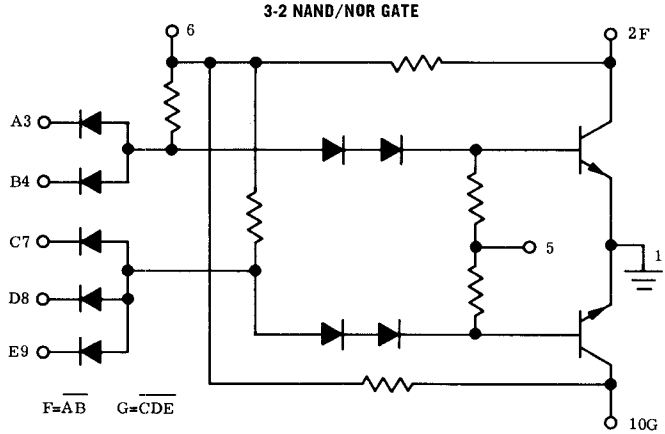
MAXIMUM RATINGS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3,4,6 \text{ thru } 9}$ V_5 $V_{2,10}$	+8 -8 +6	Vdc
Forward Current	$I_{2,10}$ $I_{2 \text{ thru } 4, 7 \text{ thru } 10}$	+30 -30	mAdc
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC258



3-2 NAND/NOR GATE



MC258 (continued)

ELECTRICAL CHARACTERISTICS

(V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Saturation Voltage					Vdc
(I_2 = 8mAdc, V_3 = V_4 = 2Vdc, T_J = 0 to 75° C)	V_2	-	-	0.55	
(I_{10} = 8mAdc, V_7 = V_8 = V_9 = 2Vdc T_J = 0 to 75° C)	V_{10}	-	-	0.55	
Output "Off" Voltage					Vdc
(I_2 = 100μAdc, V_3 = 1.0Vdc	V_2	3.5	-	-	
(I_2 = 100μAdc, V_3 = 0.75Vdc, T_J = 75° C)	V_2	3.5	-	-	
(I_2 = 100μAdc, V_3 = 1.1Vdc, T_J = 0° C)	V_2	3.5	-	-	
(I_{10} = 100μAdc, V_7 = 1.0Vdc	V_{10}	3.5	-	-	
(I_{10} = 100μAdc, V_7 = 0.75Vdc, T_J = 75° C)	V_{10}	3.5	-	-	
(I_{10} = 100μAdc, V_7 = 1.1Vdc, T_J = 0° C)	V_{10}	3.5	-	-	
Input Breakdown Voltage					Vdc
(I_3 = 10μAdc, V_4 = 0)	BV_3	8	-	-	
(I_4 = 10μAdc, V_3 = 0)	BV_4	8	-	-	
(I_7 = 10μAdc, V_8 = 0)	BV_7	8	-	-	
(I_8 = 10μAdc, V_7 = 0)	BV_8	8	-	-	
(I_9 = 10μAdc, V_7 = 0)	BV_9	8	-	-	
Input Leakage Current	I_3, I_4, I_7, I_8, I_9				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.50	
(Diode under test at 5Vdc, all other inputs = 0, T_J = 75° C)		-	-	25	
Input Turn-Off Current	I_3, I_4, I_7, I_8, I_9				mAdc
(Alternately V_3, V_4, V_7, V_8, V_9 = 0)		-	-	-2.3	
(Alternately V_3, V_4, V_7, V_8, V_9 = 0, T_J = 0 to 75° C)		-	-	-2.5	
Output Capacitance					pf
(V_2 = 2.0Vdc, V_3 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_2	-	-	10	
(V_{10} = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_{10}	-	-	10	

MC258 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Input Capacitance					pf
(V_3 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_3	-	-	10	
(V_4 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_4	-	-	10	
(V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_7	-	-	10	
(V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_8	-	-	10	
(V_9 = 2Vdc, V_{in} = 25mVrms, f = 1mc unused pins grounded)	C_9	-	-	10	
Power Consumption Power Supply	-				mW
(Output "Off", $V_3 = V_7 = 0$)		-	-	20	
(output "On")		-	-	34	
Switching Times					nsec
Turn-On Delay	t_{on}	-	-	60	
Turn-Off Delay	t_{off}	-	-	60	
Average Propagation Delay	t_{pd}	-	30	-	nsec

MC259

MC250 DTL SERIES



Diode Transistor Logic Flip-Flop.

MAXIMUM RATINGS (T_J = 25°C)

Characteristic	Symbol	Rating	Unit
Applied Voltage			Vdc
	$V_{2,3,4,6,7,8,9,10}$	+8	
	V_5	-8	
Forward Current			mAdc
	$I_{3,8}$	+50	
	$I_{2,3,4,7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC259 (continued)

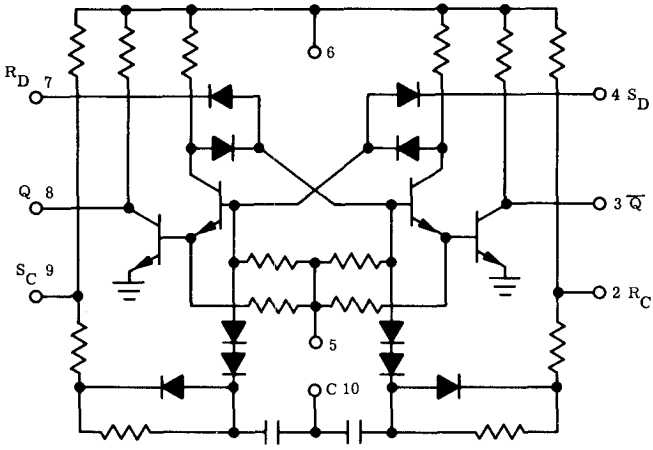
ELECTRICAL CHARACTERISTICS

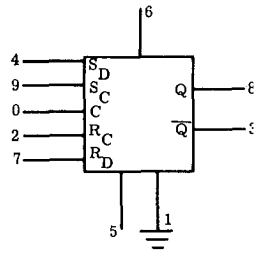
(V_6 = 4 Vdc, V_5 = 2 Vdc, V_1 = 0, T_J = 25°C unless otherwise noted)

Characteristic	Logic Symbol	Logic State	Symbol	Minimum	Typical	Maximum	Unit
OUTPUT LEVEL							
"Off" Voltage							
(I_8 = -200μAdc, V_4 = 0.55Vdc, V_7 = 2.0Vdc, T_A = 0 to 75° C)	Q	1	V_8	2.5	-	-	Vdc
(I_3 = -200μAdc, V_4 = 2.0Vdc, V_7 = 0.6Vdc, T_A = 0 to 75° C)	$\overline{Q}$	1	V_3	2.5	-	-	Vdc
"On" Voltage							
(I_8 = 16mAdc, V_4 = 2.0Vdc, V_7 = 0.55Vdc, T_A = 0 to 75° C)	Q	0	V_8	-	-	0.55	Vdc
(I_3 = 16mAdc, V_4 = 0.55Vdc, V_7 = 2.0Vdc, T_A = 0 to 75° C)	$\overline{Q}$	0	V_3	-	-	0.55	Vdc
DIRECT SET-RESET INPUTS							
"Up" Voltage	S_D	1	V_4	2.0	-	-	Vdc
	R_D	1	V_7	2.0	-	-	Vdc
"Down" Voltage	S_C	0	V_4	-	-	0.55	Vdc
	R_D	0	V_7	-	-	0.55	Vdc
"Up" Current							
(V_4 = 5Vdc, T_J = 75° C)	S_D	1	I_4	-	-	25	μAdc
(V_7 = 5Vdc, T_J = 75° C)	R_D	1	I_7	-	-	25	μAdc
"Down" Current							
(V_4 = 0)	S_D	0	I_4	-	-	-2.3	mAdc
(V_7 = 0)	R_D	0	I_7	-	-	-2.3	mAdc
CLOCKED SET-RESET INPUTS							
"Down" Current							
($V_{9,\ 10}$ = 0, T_J = 25° C)	S_C	0	I_9	-	-	-1.75	mAdc
($V_{2,10}$ = 0, T_J = 25° C)	R_C	0	I_2	-	-	-1.75	mAdc
Effective Clock Input Capacitance			C_{10}	-	75	-	pf
SWITCHING TIME							
Clocked Set-Reset Mode							
Turn-On Delay			t_{on}	-	-	100	nsec
Turn-Off Delay			t_{off}	-	-	75	nsec
Direct Set-Reset Mode							
Turn-On Delay			t_{on}	-	-	100	nsec
Turn-Off Delay			t_{off}	-	-	75	nsec
POWER CONSUMPTION				-	16	-	mW

MC259 (continued)

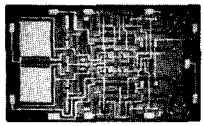
MC259 BINARY ELEMENT





MC260

MC250 DTL SERIES



Diode Transistor Logic Flip-Flop.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,4,6,7,8,9,10}$	+8	Vdc
	V_5	-8	
Forward Current	$I_{3,7}$	+50	mAdc
	$I_{2,3,4,7 \text{ thru } 10}$	-30	
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

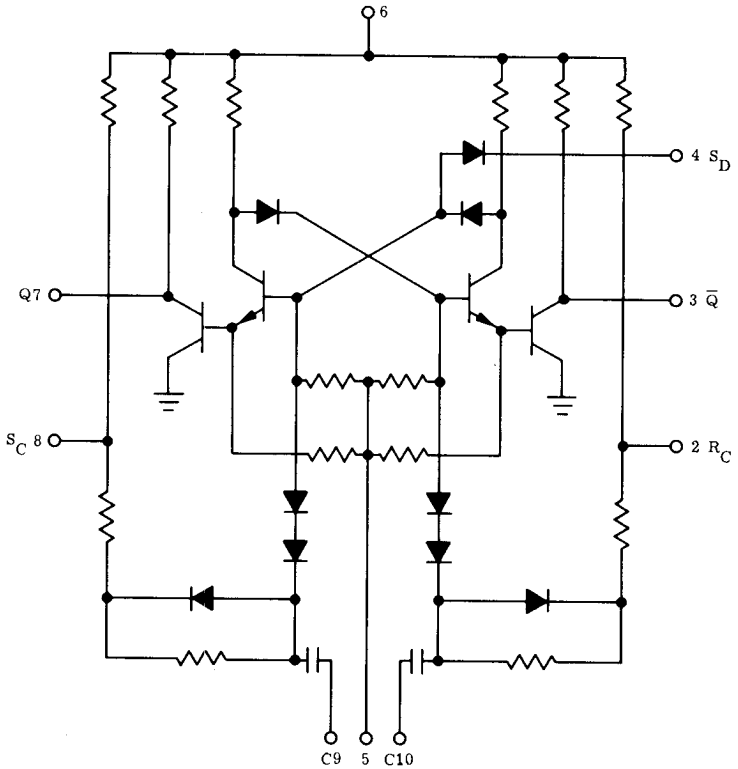
MC260 (continued)

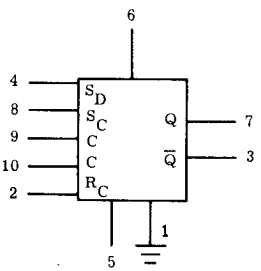
ELECTRICAL CHARACTERISTICS ($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$)

Characteristic	Logic Symbol	Logic State	Symbol	Minimum	Typical	Maximum	Unit
OUTPUT LEVEL							
"Off" Voltage							
(I_7 = -200μAdc, V_4 = 0.55Vdc, Momentarily connect pin 2 to -2.0Vdc, T_J = 0 to 75° C)	Q	1	V_7	2.5	-	-	Vdc
(I_3 = -200μAdc, V_4 = 2.0Vdc, T_J = 0 to 75° C)	$\overline{Q}$	1	V_3	2.5	-	-	Vdc
"On" Voltage							
(I_7 = 16mAdc, V_4 = 2.0Vdc, Momentarily connect pin 2 to -2.0Vdc, T_J = 0 to 75° C)	Q	0	V_7	-	-	0.55	Vdc
(I_3 = 16mAdc, V_4 = 0.55Vdc, T_J = 0 to 75° C)	$\overline{Q}$	0	V_3	-	-	0.55	Vdc
DIRECT SET INPUT CURRENT							
"Up" Current (V_4 = 5Vdc, T_J = 75° C)	S_D	1	I_4	-	-	25	μAdc
"Down" Current (V_4 = 0)	S_D	0	I_4	-	-	-2.3	mAdc
CLOCKED SET-RESET INPUTS							
"Down" Current							
($V_{8,9}$ = 0, T_J = 75° C)	S_C	0	I_8	-	-	-1.75	mAdc
($V_{2,10}$ = 0, T_J = 75° C)	R_C	0	I_2	-	-	-1.75	mAdc
Effective Clock Input Capacitance							
(V_9 = 2.0Vdc, V_8 = 0Vdc)			C_9	-	75	-	pf
(V_{10} = 2.0Vdc, V_2 = 0Vdc) (V_8 = 4.0Vdc)			C_{10}	-	75	-	pf
SWITCHING TIME							
Clocked Set-Reset Mode							
Turn-On Delay			t_{on}	-	-	100	nsec
Turn-Off Delay			t_{off}	-	-	75	nsec
Direct Set Mode							
Turn-On Delay			t_{on}	-	-	100	nsec
Turn-Off Delay			t_{off}	-	-	75	nsec
POWER CONSUMPTION				-	16	-	mW

MC260 (continued)

MC260





MC262

MC250 DTL SERIES

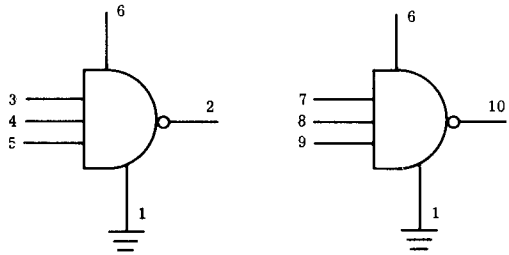


Dual (3-3) Input Diode Transistor Logic NAND/NOR Gate.

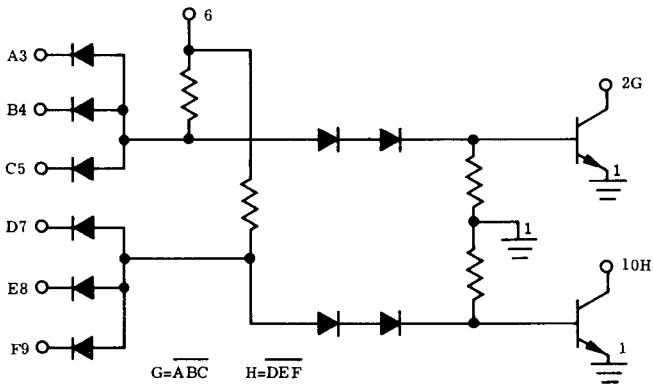
MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{3 \text{ thru } 9}$ $V_{2, 10}$	+8 +6	Vdc
Forward Current	$I_{2, 10}$ $I_{2 \text{ thru } 5, 7 \text{ thru } 10}$	+30 -30	mAdc
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC262



3-3 NAND/NOR GATE



MC262 (continued)

ELECTRICAL CHARACTERISTICS

($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Breakdown Voltage					Vdc
($I_2 = 5\mu$Adc, $V_3 = 0$)	BV_2	6	-	-	
($I_{10} = 5\mu$Adc, $V_7 = 0$)	BV_{10}	6	-	-	
"1" Output Current					Adc
($V_3 = 1.0$Vdc, $V_2 = 5$Vdc)	I_2	-	-	50	
($V_3 = 0.75$Vdc, $V_2 = 5$Vdc, $T_J = 75°C$)	I_2	-	-	50	
($V_3 = 1.1$Vdc, $V_2 = 5$Vdc, $T_J = 0°C$)	I_2	-	-	50	
($V_7 = 1.0$Vdc, $V_{10} = 5$Vdc)	I_{10}	-	-	50	
(V_7 0.75Vdc, $V_{10} = 5$Vdc, $T_J = 75°C$)	I_{10}	-	-	50	
($V_7 = 1.1$Vdc, $V_{10} = 5$Vdc, $T_J = 0°C$)	I_{10}	-	-	50	
"0" Output Current					mAdc
($V_{in} = 2$Vdc, $V_2 = 0.55$, $T_J = 0$ to $75°C$)	I_2	10	-	-	
($V_{in} = 2$Vdc, $V_{10} = 0.55$, $T_J = 0$ to $75°C$)	I_{10}	10	-	-	
Input Breakdown Voltage					Vdc
($I_3 = 10\mu$Adc, $V_4 = 0$)	BV_3	8	-	-	
($I_4 = 10\mu$Adc, $V_3 = 0$)	BV_4	8	-	-	
($I_5 = 10\mu$Adc, $V_3 = 0$)	BV_5	8	-	-	
($I_7 = 10\mu$Adc, $V_8 = 0$)	BV_7	8	-	-	
($I_8 = 10\mu$Adc, $V_7 = 0$)	BV_8	8	-	-	
($I_9 = 10\mu$Adc, $V_7 = 0$)	BV_9	8	-	-	
Input Leakage Current	$I_3, I_4, I_5, I_7, I_8, I_9$				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.50	
(Diode under test at 5Vdc, all other inputs = 0, $T_J = 75°C$)		-	-	25	
Input Turn-Off Current	$I_3, I_4, I_5, I_7, I_8, I_9$				mAdc
(Alternately $V_3, V_4, V_5, V_7, V_8, V_9 = 0$)		-	-	-2.3	
(Alternately $V_3, V_4, V_5, V_7, V_8, V_9 = 0$, $T_J = 0$ to $75°C$)		-	-	-2.5	

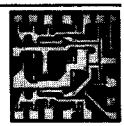
MC262 (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Capacitance (V_2 = 2.0Vdc, V_3 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_{10} = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_2 C_{10}	-	-	10 10	pf
Input Capacitance (V_3 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_4 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_5 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded) (V_9 = 2Vdc, V_{in} = 25mVrms, f = 1mc,	C_3 C_4 C_5 C_7 C_8 C_9	- - - - - -	- - - - - -	10 10 10 10 10 10	pf
Power Consumption from Power Supply (Output "Off", V_3 = V_7 = 0) (Output "On")		- -	- -	19 12	mW
Switching Times Turn-On Delay Turn-Off Delay	t_{on} t_{off}	- -	- -	60 60	nsec
Average Propagation Delay	t_{pd}	-	30	-	nsec

MC263

MC250 DTL SERIES



Dual (3-3) Input Diode Transistor Logic NAND/NOR Gate.

MAXIMUM RATINGS (T_J = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Applied Voltage	V_3 thru 9 $V_{2,10}$	+8 +6	Vdc mAdc
Forward Current	$I_{2,10}$ I_2 thru 5, 7 thru 10	+30 -30	
Operating Temperature Range	T_J	0 to 75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC263 (continued)

ELECTRICAL CHARACTERISTICS

($V_6 = 4$ Vdc, $V_5 = 2$ Vdc, $V_1 = 0$, $T_J = 25°C$ unless otherwise noted)

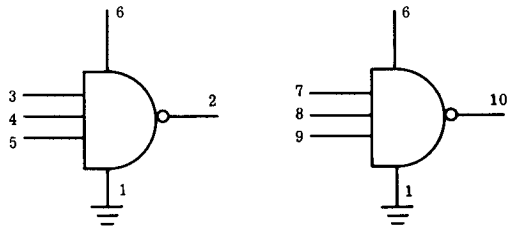
Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Output Breakdown Voltage					Vdc
(I_2 = 5μAdc, V_3 0)	BV_2	6	-	-	
(I_{10} = 5μAdc, V_7 = 0)	BV_{10}	6	-	-	
Output Saturation Voltage					Vdc
(I_2 = 8mAdc, $V_3 = V_4 = V_5$ = 2Vdc, T_J = 0 to 75° C)	V_2	-	-	0.55	
(I_{10} = 8mAdc, $V_7 = V_8 = V_9$ = 2Vdc, T_J = 0 to 75° C)	V_{10}	-	-	0.55	
Output "Off" Voltage					Vdc
(I_2 = 100μAdc, V_3 = 0.7Vdc, T_J = 0 to 75° C)	V_2	3.5	-	-	
(I_{10} = 100μAdc, V_7 = 0.7Vdc, T_J = 0 to 75° C)	V_{10}	3.5	-	-	
Input Breakdown Voltage					Vdc
(I_3 = 10μAdc, V_4 = 0)	BV_3	8	-	-	
(I_4 = 10μAdc, V_3 = 0)	BV_4	8	-	-	
(I_5 = 10μAdc, V_3 = 0)	BV_5	8	-	-	
(I_7 = 10μAdc, V_5 = 0)	BV_7	8	-	-	
(I_8 = 10μAdc, V_7 = 0)	BV_8	8	-	-	
(I_9 = 10μAdc, V_7 = 0)	BV_9	8	-	-	
Input Leakage Current	$I_3, I_4, I_5, I_7, I_8, I_9$				μAdc
(Diode under test at 5Vdc, all other inputs = 0)		-	-	0.500	
(Diode under test at 5Vdc, all other inputs = 0, T_J = 75° C)		-	-	25	
Input Turn-Off Current	$I_3, I_4, I_5, I_7, I_8, I_9$				mAdc
(Alternately $V_3, V_4, V_5, V_7, V_8, V_9$ = 0)		-	-	-2.3	
(Alternately V_3, V_4, V_5, V_7, V_8, V_9 = 0, T_J = 0 to 75° C)		-	-	-2.3	
Output Capacitance					pf
(V_2 = 2.0Vdc, V_3 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_2	-	-	10	
(V_{10} = 2.0Vdc, V_7 = 0, V_{in} = 25mVrms, f = 1mc, unused pins grounded	C_{10}	-	-	10	

MC263 (continued)

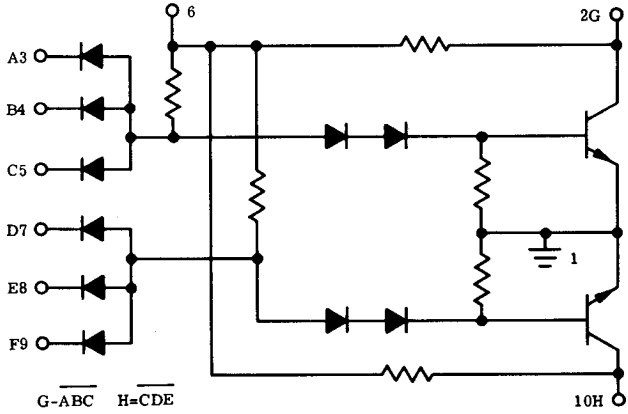
ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Input Capacitance					pf
(V_3 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_3	-	-	10	
(V_4 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_4	-	-	10	
(V_5 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_5	-	-	10	
(V_7 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_7	-	-	10	
(V_8 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_8	-	-	10	
(V_9 = 2Vdc, V_{in} = 25mVrms, f = 1mc, unused pins grounded)	C_9	-	-	10	
Power Consumption from Power Supply	-				mW
(Output "Off", $V_3 = V_7 = 0$)		-	-	19	
(Output "On")		-	-	33	
Switching Times					nsec
Turn-On Delay	t_{on}	-	-	60	
Turn-Off Delay	t_{off}	-	-	60	
Average Propagation Delay	t_{pd}	-	30	-	nsec

MC263



3-3 NAND/NOR GATE



MC265

MC250 DTL SERIES

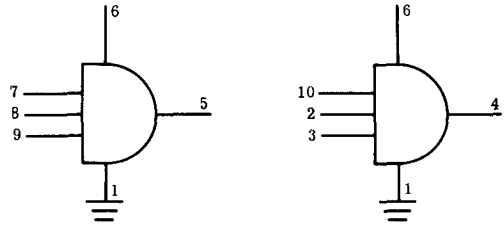


Dual (3-3) Input Diode Transistor Logic AND Gate.

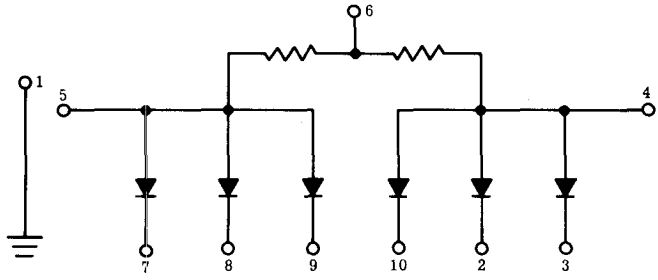
MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,7 \text{ thru } 10}$ V_6	+8 ±8	Vdc
Forward Current	$I_{2 \text{ thru } 10}$	±30	mAdc
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC265



DUAL "AND" GATE



MC265 (continued)

ELECTRICAL CHARACTERISTICS

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Diode Breakdown Voltage ($I_{2,3,10}$ = 10μAdc, $V_4 = V_1 = 0$) ($I_{7,8,9}$ = 10μAdc, $V_5 = V_1 = 0$)	$V_{2,3,10}$ $V_{7,8,9}$	8 8	- -	- -	Vdc
Diode Forward Voltage (I_4 = 2mAdc, $V_{2,3,10} = V_1 = 0$) (I_5 = 2mAdc, $V_{7,8,9} = V_1 = 0$)	V_4 V_5	- -	- -	0.85 0.85	Vdc
Diode Reverse Leakage Current ($V_{2,3,10}$ = 5Vdc, $V_4 = V_1 = 0$) ($V_{2,3,10}$ = 5Vdc, $V_4 = V_1 = 0$, T_J = 75° C) ($V_{7,8,9}$ = 5Vdc, $V_5 = V_1 = 0$) ($V_{7,8,9}$ = 5Vdc, $V_5 = V_1 = 0$, T_J = 75° C)	$I_{2,3,10}$ $I_{2,3,10}$ $I_{7,8,9}$ $I_{7,8,9}$	- - - -	- - - -	0.50 25 0.50 25	μAdc
Input Capacitance ($V_{2,3,10}$ = 2Vdc, $V_4 = V_1 = 0$, f = 1mc, V_{in} = 25mVrms, unused inputs grounded) ($V_{7,8,9}$ = 2Vdc, $V_5 = V_1 = 0$, f = 1mc, V_{in} = 25mVrms, unused pins grounded)	$C_{2,3,10}$ $C_{7,8,9}$	- -	- -	10 10	pf
Reverse Recovery Time ($I_{F2,3,10} = I_{R2,3,10}$ = 2mAdc, $V_4 = V_1 = 0$, recover to 0.2mAdc) ($I_{F7,8,9} = I_{R7,8,9}$ = 2mAdc, $V_5 = V_1 = 0$, recover to 0.2mAdc)	$t_{rr2,3,10}$ $t_{rr7,8,9}$	- -	- -	4 4	nsec
Resistor Isolation Leakage (V_6 = 5Vdc, $V_4 = V_5 = 0$)	I_1	-	-	600	mAdc
Resistor Current (V_6 = 4Vdc, $V_4 = V_1 = 0$) (V_6 = 4Vdc, $V_5 = V_1 = 0$)	I_4 I_5	1.3 1.3	- -	2.85 2.85	mAdc
Resistor Temperature Coefficient	-	-	0.1	-	%/° C
Diode Forward Conductance Change with Temperature	$\Delta V_{F2,3,10}$ $\Delta V_{F7,8,9}$	- -	-1.7 -1.7	- -	mV/° C

MC267

MC250 DTL SERIES

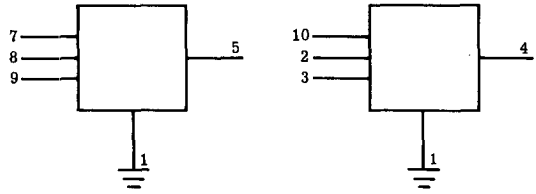


Diode Transistor Logic Dual-Diode Array.

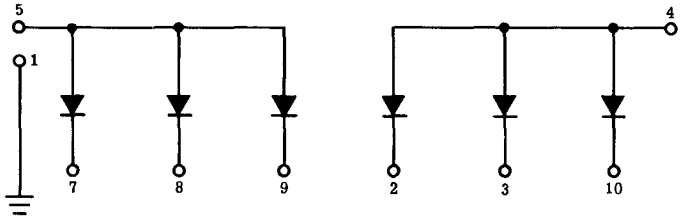
MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Symbol	Rating	Unit
Applied Voltage	$V_{2,3,}$ 7 thru 10	8	Vdc
Forward Current	I_2 thru 5 7 thru 10	30	mAdc
Operating Temperature Range	T_J	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

MC267



DUAL DIODE ARRAY



MC267 (continued)

ELECTRICAL CHARACTERISTICS ($T_J = 25°C$ unless otherwise noted)

Characteristic	Symbol	Minimum	Typical	Maximum	Unit
Diode Breakdown Voltage ($I_{2,3,10}$ = 10μAdc, $V_4 = V_1 = 0$) ($I_{7,8,9}$ = 10μAdc, $V_5 = V_1 = 0$)	$V_{2,3,10}$ $V_{7,8,9}$	8 8	- -	- -	Vdc
Diode Forward Voltage (I_4 = 2mAdc, $V_{2,3,10} = V_1 = 0$) (I_5 = 2mAdc, $V_{7,8,9} = V_1 = 0$)	V_4 V_5	- -	- -	0.85 0.85	Vdc
Diode Reverse Leakage Current ($V_{2,3,10}$ = 5Vdc, $V_4 = V_1 = 0$) ($V_{2,3,10}$ = 5Vdc, $V_4 = V_1 = 0$, T_J = 75° C) ($V_{7,8,9}$ = 5Vdc, $V_5 = V_1 = 0$) ($V_{7,8,9}$ = 5Vdc, $V_5 = V_1 = 0$, T_J = 75° C)	$I_{2,3,10}$ $I_{7,8,9}$	- -	- -	0.50 25 0.50 25	μAdc
Input Capacitance ($V_{2,3,10}$ = 2Vdc, $V_4 = V_1 = 0$, f = 1mc, V_{in} = 25mVrms, unused inputs grounded) ($V_{7,8,9}$ = 2Vdc, $V_5 = V_1 = 0$, f = 1mc, V_{in} = 25mVrms, unused inputs grounded)	$C_{2,3,10}$ $C_{7,8,9}$	- -	- -	10 10	pf
Reverse Recovery Time ($I_{F2,3,10} = I_{R2,3,10}$ = 2mAdc, $V_4 = V_1 = 0$, Recover to 0.2mAdc) ($I_{F7,8,9} = I_{R7,8,9}$ = 2mAdc $V_5 = V_1 = 0$, recover to 0.2mAdc)	$t_{rr2,3,10}$ $t_{rr7,8,9}$	- -	- -	4 4	nsec
Diode Forward Conductance Change with Temperature	$\Delta V_{F2,3,10}$ $\Delta V_{F7,8,9}$	- -	-1.7 -1.7	- -	mV/° C

MECL MC300 series

MONOLITHIC SILICON EPITAXIAL PASSIVATED

The MECL series of integrated logic circuits forms a versatile set of monolithic digital building blocks representing all the necessary circuitry for the arithmetic portion of a computer. MECL circuits combine extremely high speed with a systems-oriented design approach that permits implementation with the fewest possible number of individual devices. This represents both a cost saving and a potential increase in system reliability. The major features of the MECL series are:

- 5 nsec propagation delay per logic decision
- Virtually constant noise immunity with ±10% power supply variation, and temperature changes from −55° to +125°C
- Simultaneous "OR"-"NOR" or "AND"-"NAND" outputs
- High fan-in and fan-out capabilities

The series is comprised of the following elements:

MC301 — A high-speed five-input gate element that provides the positive logic "OR" function and its complement simultaneously.

MC302 — A DC Set-Reset flip-flop with an expandable input and the power dissipation of only one gate.

MC303 — A half-adder that provides the "SUM", "CARRY", and "NOR" function simultaneously.

MC304 — A bias driver that compensates for changes in circuit parameters with temperature.

MC305 — A five-input expander for use with the MC302 and the MC306,7.

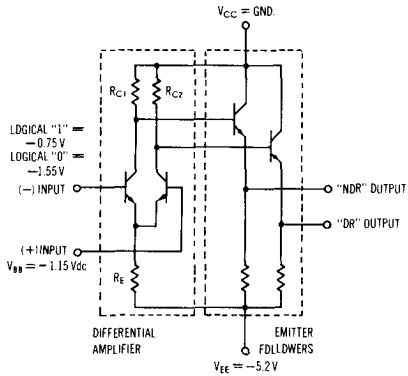
MC306,7 — A high-speed expandable three-input gate element that provides the positive logic "OR" function and its complement simultaneously.

MC308 — A clocked J-K flip-flop for counter and shift register applications with DC Set and Reset inputs.

MC309,10,11 — A high-speed dual two-input gate element that provides the positive logic "NOR" function.

MC312 — A high-speed dual three-input gate element that provides the positive logic "NOR" function.

BASIC MECL CIRCUIT



FOR LOGICAL "1" INPUT: "NOR" OUTPUT = −1.55 V
"OR" OUTPUT = −0.75 V

FOR LOGICAL "0" INPUT: "NOR" OUTPUT = −0.75 V
"OR" OUTPUT = −1.55 V

MECL — A CURRENT MODE SWITCH

The typical MECL circuit is designed with a differential amplifier input and emitter-follower output to restore dc levels. The circuit has been designed to prevent saturation of the input transistors, thus eliminating storage time and allowing for high-speed operation with non-critical transistor parameters. High fan-out operation is permitted due to the low impedance emitter-follower and the high-input impedance of the circuit. The basic gate has both the function and its complement available simultaneously. Since the current in the differential amplifier is switched from one side to the other, there is virtually no power supply noise generated.

The circuit operation is straight-forward. A fixed bias of −1.15 volts is applied to the (+) input of the differential amplifier and the logic signals are applied to the (−) input. If a logical "0" is applied to the (−) input, the current through R_E is supplied by the fixed biased transistor. A drop of 800 mV occurs across R_{C1}. The "OR" output then is −1.55 V, or one V_{BE}-drop below 800 mV. Since no current flows in the (−) input transistor, the "NOR" output is a V_{BE}-drop below ground, or −0.75 volts. When a logical "1" level is applied to the (−) input, the current through R_{C1} is switched to the (−) input transistor and a drop of 800 mV occurs across R_{C1}. The "OR" output then goes to −0.75 volts and the "NOR" output goes to −1.55 volts.

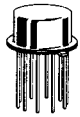
A bias driver is supplied to insure that the threshold point is always in the center of the transition region. The bias driver compensates for temperature changes and is designed to track with temperature.

MC300 MECL series (continued)



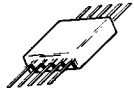
10 PIN

CASE 71



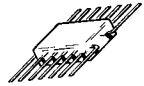
12 PIN
(MC312G ONLY)

CASE 98



10 PIN FLAT PACKAGE

CASE 72



14 PIN FLAT PACKAGE
(MC312F ONLY)

CASE 83

FAMILY CHARACTERISTICS

The following information applies to all devices of the MECL family. It is intended to provide the design engineer with meaningful information for worst-case analyses. Parameters of importance are guaranteed at three temperature levels: room, and the extremes for which the family is designed. All performance curves are based on distributional spreads and the minimum-maximum ranges can be interpreted for design purposes as 10%-90% spreads at all points on the curve except for guaranteed points on the electrical characteristics.

MAXIMUM RATINGS (at 25°C)

Characteristics	Symbol	Maximum	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Output Source Current	I_O	10	mAdc
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

SYSTEM LOGIC SPECIFICATIONS

Any one of the supply nodes, V_{BB}, V_{CC}, or V_{EE} may be used as ground; however, the manufacturer has found it most convenient to ground the V_{CC} node. In such a case:

$V_{CC} = 0$ $V_{BB} = -1.15V$ $V_{EE} = -5.2V$

The output logic swing of 0.8V then varies from a low state of $V_L = -1.55V$ to a high state of $V_H = -0.75V$ with respect to ground.

Positive logic is used when reference is made to logical "0's" or "1's". Then

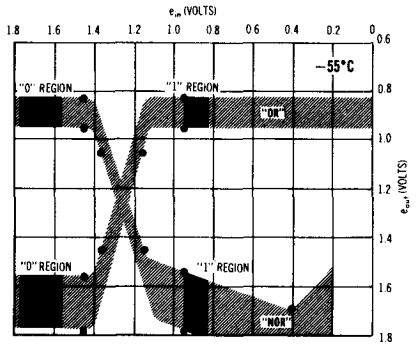
"0" = −1.55V
"1" = −0.75V
} typical

Dynamic logic refers to a change of logic states. Dynamic "0" is a negative going voltage excursion and a dynamic "1" is a positive going voltage excursion.

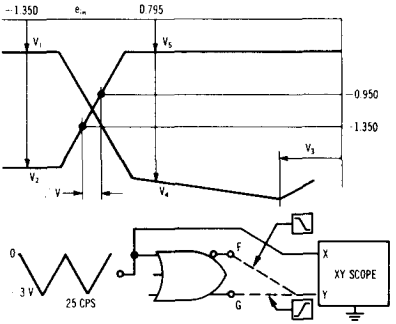
MC300 MECL series (continued)

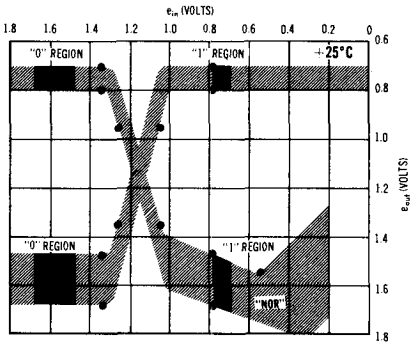
DC CHARACTERISTICS FOR MC300 SERIES

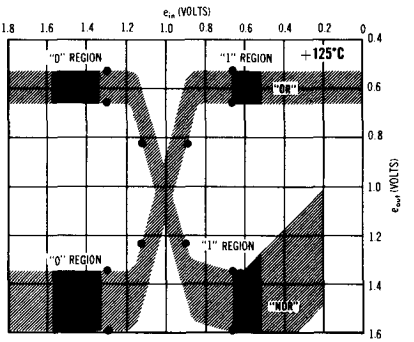
WORST CASE TRANSFER CHARACTERISTICS



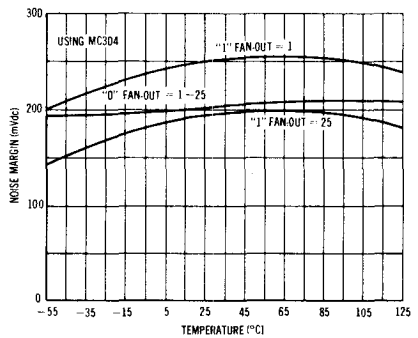
DEFINITION OF TRANSFER CHARACTERISTIC POINTS

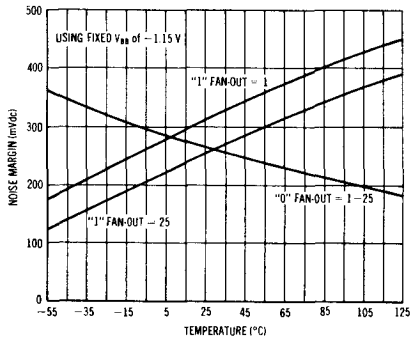






WORST CASE NOISE MARGIN





MC300 MECL series (continued)

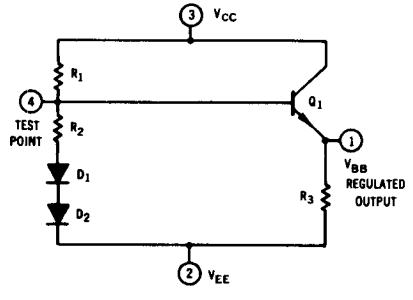
MC304
BIAS DRIVER

A temperature compensating regulator intended for use in conjunction with the MC300 "MECL" series of INTEGRATED LOGIC CIRCUITS. Insures stable and reliable operation of "MECL" logic systems over a temperature range of −55°C to +125°C.

ELECTRICAL CHARACTERISTICS

Test	Conditions	Symbol	−55°C		25°C		125°C		Unit
			min	max	min	max	min	max	
Fan-Out	—	n	—	25	—	25	—	25	—
Output Voltage	V_{CC} = 0, V_{EE} = -5.2 Vdc ±1%	V_{BB}	1.19	1.32	1.09	1.22	0.95	1.08	Vdc
(No Load to Full Load)	I_{out} = 0 to 2.5 mAdc								
Power Dissipation	V_{CC} = 0, V_{EE} = -5.2 Vdc ± 1%	P_D	—	24	—	24	—	22	mW

CIRCUIT SCHEMATIC



CIRCUIT DESCRIPTION

Circuit Operation:

The divider network R_1, R_2, D_1, D_2 compensates for temperature variations of the base-emitter voltages of Q_1, and of the driven gates, producing a bias voltage for the MECL logic circuits that maintains a constant set of dc operating conditions over the temperature range of −55°C to +125°C. In addition, compensation for power supply variations is achieved, since the bias output voltage is derived from the system supply.

Either of the supply voltage nodes may be used as ground, however the ground potential of the bias driver must coincide with that of the logic system. Thus, if V_{CC} is grounded in the logic system, then —

$V_{CC} = 0$; $V_{EE} = -5.2$V;
$V_{BB} = -1.15$ nominal output voltage at 25°C

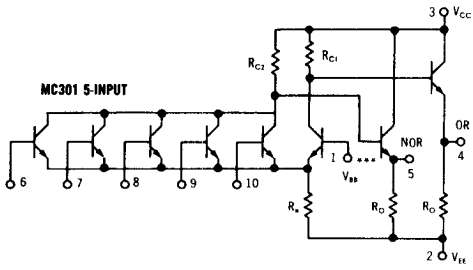
MC300 MECL series (continued)

MC301, MC306, MC307, MC309 thru MC312

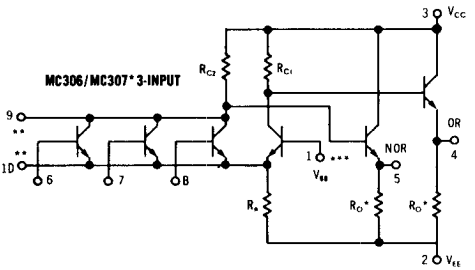
LOGIC GATES

CIRCUIT SCHEMATICS

MC301 5-INPUT



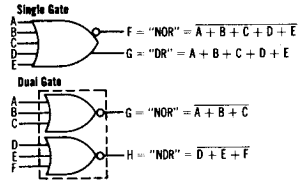
MC306/MC307* 3-INPUT



LOGIC SPECIFICATIONS

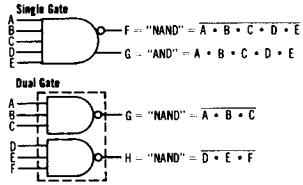
POSITIVE LOGIC

When V_H is defined as a logical "1" and V_L as a logical "0" the "OR"/"NOR" function is performed:

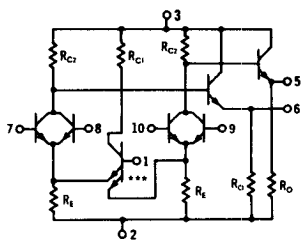


NEGATIVE LOGIC

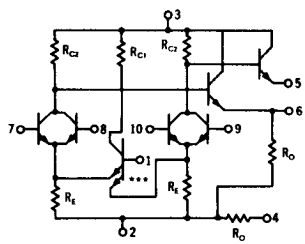
Inversely, when V_H is defined as a logical "0" and V_L as a logical "1" the "AND"/"NAND" function is performed:



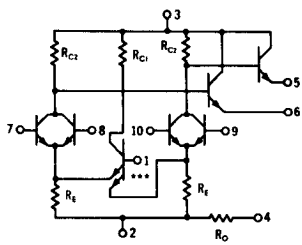
MC309 DUAL "NOR"



MC310 DUAL "NOR"



MC311 DUAL "NOR"



*Resistors R_O are omitted in MC307 circuits to permit reduction of Power Dissipation in systems where logic operations are performed at circuit outputs.

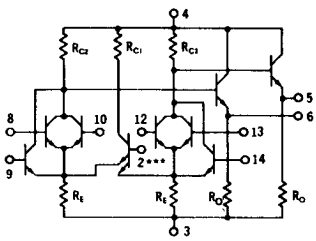
EXAMPLE: where (n) gates are to perform an "OR" function, one MC306 gate and (n-1) MC307 gates can be used to provide savings of Power Dissipation in (n-1) gates.

**Pins 9 and 10 are for use in conjunction with the MC305 input expander to increase the fan-in capability in increments of five.

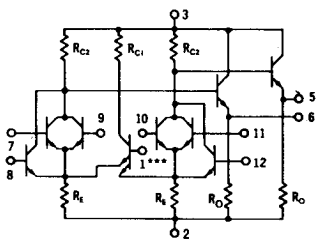
***To be supplied from bias-driver circuit MC304 for optimum temperature stability.

NOTE: Any unused inputs should be connected to V_{EE}.

MC312F DUAL "NOR"



MC312G DUAL "NOR"



MC300 MECL series (continued)

LOGIC GATES (CONTINUED)

DC ELECTRICAL CHARACTERISTICS

V_{CC} = 0, V_{EE} = −5.2 Volts, (all ±1%), V_{th} = −1.25 Vdc @ −55°C
V_{th} = −1.15 Vdc @ +25°C
Unused inputs connected to V_{th} V_{th} = −1.00 Vdc @ +125°C

Test	Conditions	Symbol	−55°C min	−55°C max	25°C min	25°C max	125°C min	125°C max	Unit
Total Unit Power Supply Current Drain	All Inputs open MC301, MC306 MC307 MC309, MC310, MC312 MC311	I_E	— — — —	8.85 3.6 13.0 19.1	— — — —	8.85 3.6 13.0 10.1	— — — —	8.15 3.3 12.0 9.25	mAdc
Input Current	V_{1min} @ 25°C	I_{IN}	—	—	—	100	—	—	μAdc
Fan-In		m	—	—	—	23	—	—	
Fan-Out		n	—	—	—	25	—	—	

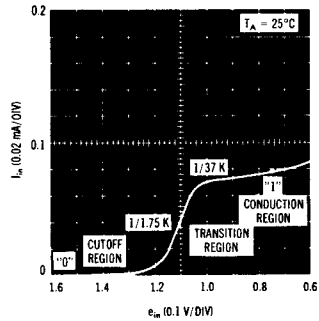
"NOR" OUTPUT – All Types

"NOR" Logical "1" Output Voltage	Each Input: V_{in} = -1.45 Vdc @ -55°C V_{in} = -1.35 Vdc @ +25°C V_{in} = -1.30 Vdc @ +125°C	V_1	0.825 — —	0.945 — —	— 0.690 —	— 0.795 —	— — 0.525	— — 0.655	Vdc
"NOR" Logical "0" Output Voltage	Each Input: V_{in} = -0.945 Vdc @ -55°C V_{in} = -0.795 Vdc @ +25°C V_{in} = -0.655 Vdc @ +125°C	V_4	1.560 — —	1.650 — —	— 1.465 —	— 1.750 —	— — 1.340	— — 1.875	Vdc
"NOR" Saturation Breakpoint Voltage	$\frac{dv\ (NOR)}{dV_{in}} = 0$	V3	—	0.40	—	0.55	—	0.680	Vdc
"NOR" Output Voltage Change (No load to full load)	All inputs open No load = 0 current at pin 5 Full load = 2.5 mAdc ±5% at pin 5	ΔV_1	—	0.055	—	0.055	—	0.060	Vdc

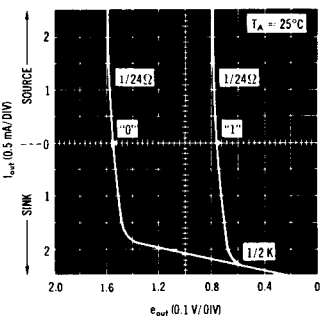
"OR" OUTPUT – Types MC301, MC306, MC307 only

"OR" Logical "1" Output Voltage	Each Input: V_{in} = -0.945 Vdc @ -55°C V_{in} = -0.795 Vdc @ +25°C V_{in} = -0.655 Vdc @ +125°C	V_5	0.825 — —	0.945 — —	— 0.690 —	— 0.795 —	— — 0.525	— — 0.655	Vdc
"OR" Logical "0" Output Voltage	Each Input: V_{in} = -1.45 Vdc @ -55°C V_{in} = -1.35 Vdc @ +25°C V_{in} = -1.30 Vdc @ +125°C	V_2	1.560 — —	1.650 — —	— 1.465 —	— 1.750 —	— — 1.340	— — 1.675	Vdc
"OR" Output Voltage Change (No load to full load)	No load = 0 current @ pin 4 Full load = 2.5 mAdc ±5% at pin 4 V_{in} = 0.945 Vdc, @ -55°C V_{in} = 0.795 Vdc, @ +25°C V_{in} = 0.655 Vdc, @ +125°C	ΔV_5	— — —	0.055 — —	— — —	— 0.055 —	— — —	— — 0.060	Vdc

TYPICAL INPUT CHARACTERISTICS



TYPICAL OUTPUT CHARACTERISTICS



MC300 MECL series (continued)

LOGIC GATES (CONTINUED)

SWITCHING CHARACTERISTICS $V_{CC} = 0$, $V_{EE} = -5.2$ Volts, (all ± 1%)

$V_{IH} = -1.25$ Vdc, $V_{IL} = -0.870$ Vdc, $V_t = -1.650$ Vdc @ −55°C
$V_{IH} = -1.15$ Vdc, $V_{IL} = -0.750$ Vdc, $V_t = -1.550$ Vdc @ +25°C
$V_{IH} = -1.00$ Vdc, $V_{IL} = -0.600$ Vdc, $V_t = -1.450$ Vdc @ +125°C

The stray capacitance introduced by the test jig was $C_t = (n + 12)$ pf where n = number of fan-outs.

Test	Conditions	Symbol	−55°C typ	−55°C max	25°C typ	25°C max	125°C typ	125°C max	Unit
MC301									
Propagation Delay "NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	6.5	10.0	6.5	11.0	7.5	14.0	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	8.0	12.0	8.5	12.5	10.0	15.5	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	7.5	11.0	8.0	12.5	10.0	15.5	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	5.5	9.0	6.0	10.0	8.0	12.0	
Rise Time "NOR" Output	Fan-In = 1, Fan-Out = 1	t_r	8.5	14.0	9.0	14.5	11.0	17.5	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1		6.5	9.0	7.0	10.0	10.5	15.0	
Fall Time "NOR" Output	Fan-In = 1, Fan-Out = 1	t_f	7.0	12.0	7.5	12.5	10.0	15.5	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1		7.0	11.5	7.5	13.0	10.0	16.0	

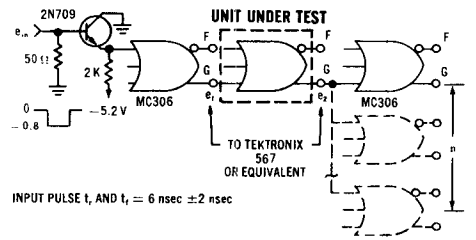
MC306, MC307 – "NOR" AND "OR" Output; MC312 – "NOR" Output only

Propagation Delay "NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	5.5	10.0	5.5	10.5	7.0	12.5	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	7.0	11.0	7.0	11.5	9.5	14.5	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	7.0	10.5	7.0	11.0	9.5	14.5	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	5.5	10.0	5.5	11.0	7.0	12.5	
Rise Time "NOR" Output	Fan-In = 1, Fan-Out = 1	t_r	7.5	11.5	7.5	12.5	9.5	15.0	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1		6.0	8.5	6.0	10.0	8.0	13.0	
Fall Time "NOR" Output	Fan-In = 1, Fan-Out = 1	t_f	6.5	12.0	6.5	12.5	9.0	15.0	nsec
"OR" Output	Fan-In = 1, Fan-Out = 1		6.5	10.5	6.5	12.0	9.0	15.0	

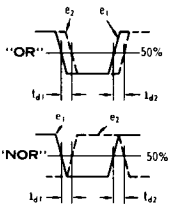
MC309, MC310, MC311 – "NOR" Output only

Propagation Delay Either Output	Fan-In = 1, Fan-Out = 1	t_{d1}	5.5	10.0	6.0	11.0	7.0	12.0	nsec
Either Output	Fan-In = 1, Fan-Out = 1	t_{d2}	6.5	13.0	7.0	13.5	9.5	15.0	
Rise Time Either Output	Fan-In = 1, Fan-Out = 1	t_r	6.0	12.0	6.0	12.0	7.0	13.5	nsec
Fall Time Either Output	Fan-In = 1, Fan-Out = 1	t_f	7.0	13.0	7.5	14.0	9.5	17.0	nsec

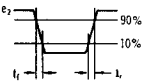
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY



RISE AND FALL TIME



The fan-in is obtained with MC305 input expanders, with all but the driven input connected to −1.550 V.

MC300 MECL series (continued)

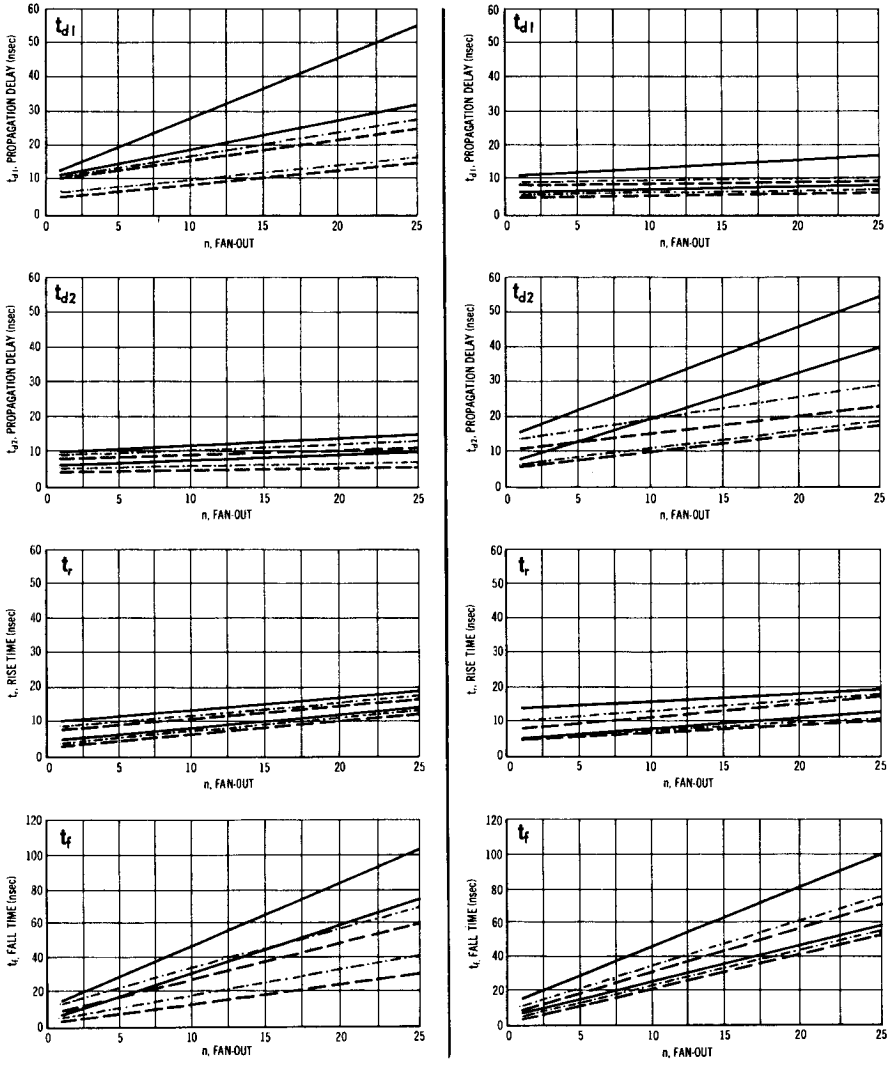
LOGIC GATES (CONTINUED)

SWITCHING CHARACTERISTICS
(10% to 90% distribution)

"OR" OUTPUT
MC301

−55°C
+25°C
+125°C

"NOR" OUTPUT
MC301



MC300 MECL series (continued)

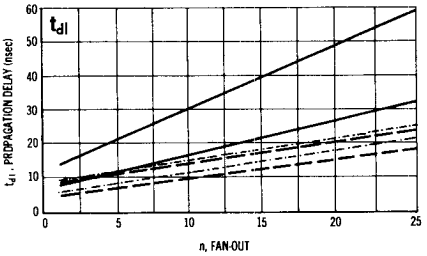
LOGIC GATES (CONTINUED)

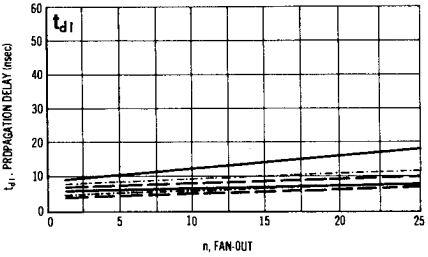
SWITCHING CHARACTERISTICS
(10% to 90% distribution)

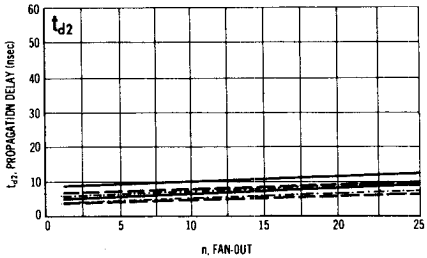
"OR" OUTPUT
MC306, MC307, MC303 "SUM"

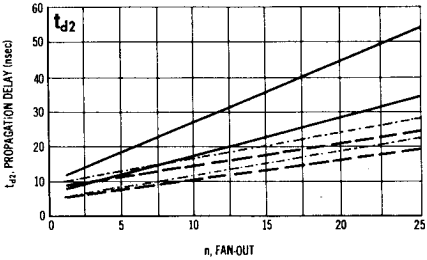
−55°C
+25°C
+125°C

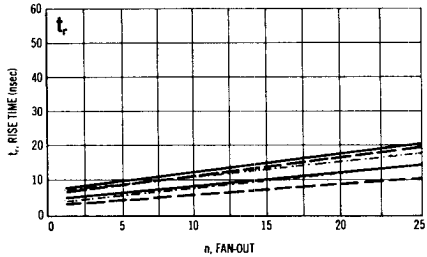
"NOR" OUTPUT
MC306, MC307, MC312

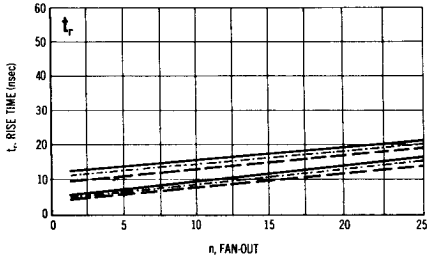


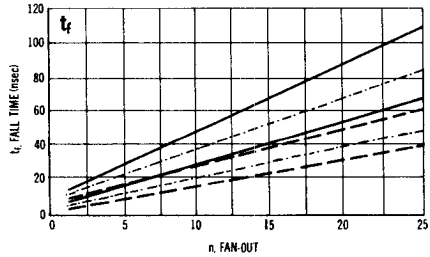


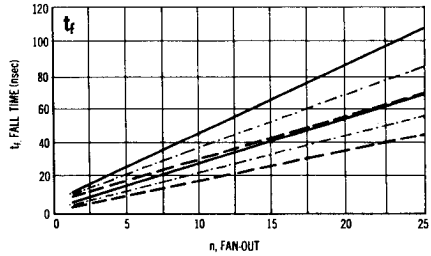












MC300 MECL series (continued)

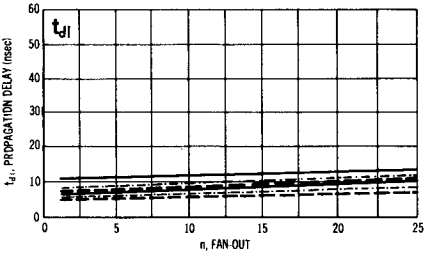
LOGIC GATES (CONTINUED)

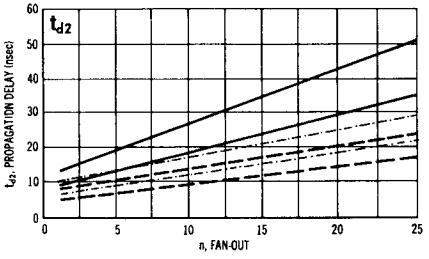
SWITCHING CHARACTERISTICS

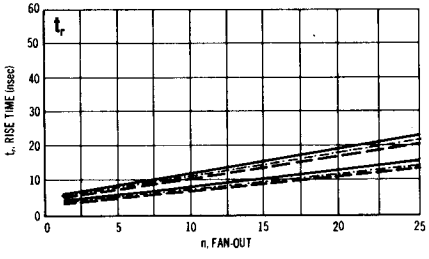
(10% to 90% distribution)

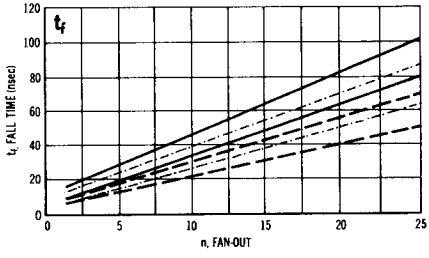
"NOR"
MC309, MC310, MC311
and MC303 "NOR" and "CARRY"

−55°C
+25°C
+125°C



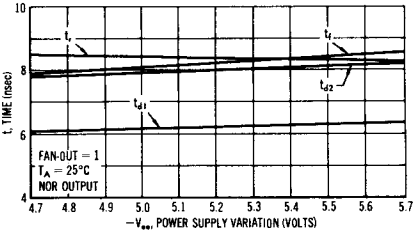




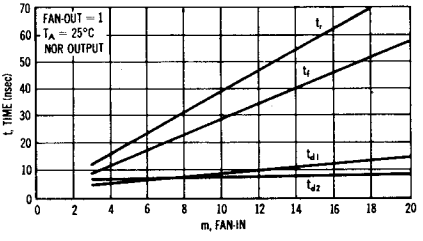


TYPICAL SWITCHING TIME VARIATIONS
MC306

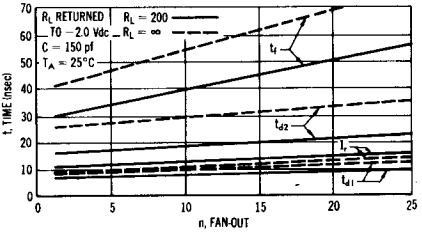
SUPPLY VOLTAGE VARIATION



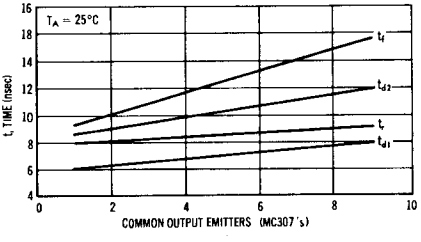
FAN-IN VARIATION



LINE DRIVER APPLICATION



OUTPUT WIRED "OR" FUNCTION



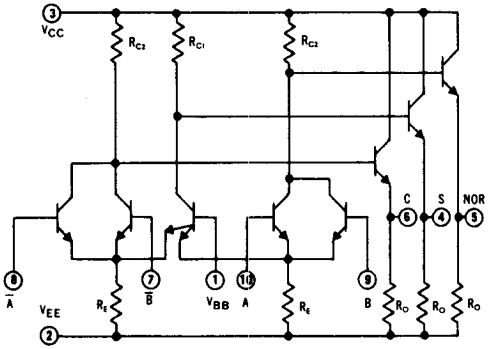
MC300 MECL series (continued)

MC303

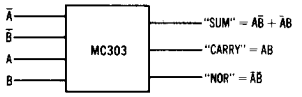
HALF-ADDER

- Provides the "SUM," "CARRY," and "NOR" Outputs for Use in Digital Computer Circuits over a Temperature Range of −55°C to +125°C.
- Average Propagation Delay — 6 nsec

CIRCUIT SCHEMATIC



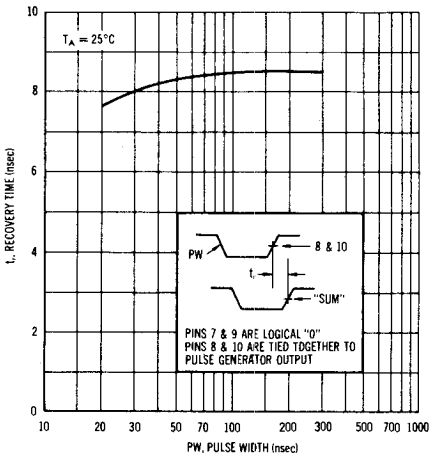
LOGIC SPECIFICATIONS



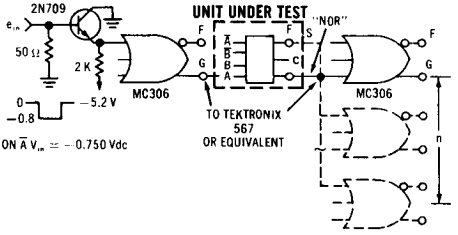
The "NOR" and "CARRY" outputs can be tied together to provide the "SUM" function.

If complement inputs are not used an undefined state can occur. When all inputs are at a logical "0" R_{C_1} has two R_E currents which saturates the V_{BB} transistor. The "SUM" output goes to −2.3 Volts. The recovery time characteristics are shown in the curve below.

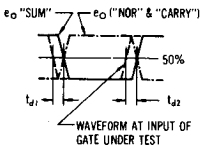
RECOVERY CHARACTERISTICS WITH SIMULTANEOUS "0" ON ALL INPUTS



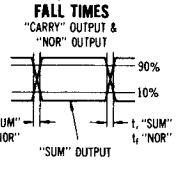
SWITCHING TIMES TEST CIRCUIT



PROPAGATION DELAY TIME



RISE AND FALL TIMES



(RISE TIME = 10% to 90% POINT OF POSITIVE GOING WAVEFORMS
FALL TIME = 90% to 10% POINT OF NEGATIVE GOING WAVEFORMS.)

MC300 MECL series (continued)

HALF-ADDER (CONTINUED)

ELECTRICAL CHARACTERISTICS

V_{EE} = −5.2 Vdc ±1%, V_{CC} = 0 V_{EE} = −1.25 Vdc @ −55°C
V_{EE} = −1.15 Vdc @ +25°C
V_{EE} = −1.00 Vdc @ +125°C
Unused inputs connected to V_{EE}

Test	Conditions	Symbol	−55°C min	−55°C max	25°C min	25°C max	125°C min	125°C max	Unit
DC CHARACTERISTICS									
"NOR" Logical "1" Output Voltage	Each Input:	V_1							Vdc
	V_{in} = −1.450 Vdc @ −55°C		0.825	0.945	—	—	—	—	
	V_{in} = −1.350 Vdc @ +25°C		—	—	9.690	0.795	—	—	
	V_{in} = −1.300 Vdc @ +125°C		—	—	—	—	0.525	0.655	
"NOR" Saturation Breakpoint Voltage	dV "NOR"/dv_{in} = 0 for all test temperatures	V_3	—	0.400	—	0.550	—	0.660	Vdc
"NOR" Logical "0" Output Voltage	Each Input:	V_4							Vdc
	V_{in} = −0.945 Vdc @ −55°C		1.560	1.650	—	—	—	—	
	V_{in} = −0.795 Vdc @ +25°C		—	—	1.465	1.750	—	—	
	V_{in} = −0.655 Vdc @ +125°C		—	—	—	—	1.340	1.675	
"SUM" Logical "1" Output Voltage	Each Input:	V_5							Vdc
	V_{in} = −0.945 Vdc @ −55°C		0.825	0.945	—	—	—	—	
	V_{in} = −0.795 Vdc @ +25°C		—	—	9.690	0.795	—	—	
	V_{in} = −0.655 Vdc @ +125°C		—	—	—	—	0.525	0.655	
"SUM" Logical "0" Output Voltage	Each Input:	V_2							Vdc
	V_{in} = −1.450 Vdc @ −55°C		1.560	1.650	—	—	—	—	
	V_{in} = −1.350 Vdc @ +25°C		—	—	1.455	1.750	—	—	
	V_{in} = −1.300 Vdc @ +125°C		—	—	—	—	1.340	1.675	
"CARRY" Logical "1" Output Voltage	Each Input:	V_1							Vdc
	V_{in} = −1.450 Vdc @ −55°C		0.825	0.945	—	—	—	—	
	V_{in} = −1.350 Vdc @ +25°C		—	—	0.690	0.795	—	—	
	V_{in} = −1.300 Vdc @ +125°C		—	—	—	—	0.525	0.655	
"CARRY" Logical "0"	Each Input:	V_4							Vdc
	V_{in} = −0.945 Vdc @ −55°C		1.560	1.650	—	—	—	—	
	V_{in} = −0.795 Vdc @ +25°C		—	—	1.465	1.750	—	—	
	V_{in} = −0.655 Vdc @ +125°C		—	—	—	—	1.340	1.675	
"CARRY" Saturation Breakdown Voltage	dv "CARRY"/dv_{in} = 0 for all test temperatures	V_3	—	0.400	—	0.550	—	0.680	Vdc
Total Unit Power Supply Current	All Inputs Open	I_E	—	15.30	—	15.30	—	14.10	mAdc
LOADING CHARACTERISTICS									
"NOR" Output Voltage Change Between No Load and Full Load Conditions	All Inputs open No load = 0 current (pin 5) Full load = 2.5 mAdc (pin 5)	ΔV_1	—	0.055	—	0.055	—	0.060	Vdc
"CARRY" Output Voltage Change Between No Load and Full Load Conditions	All inputs open No load = 0 current (pin 5) Full load = 2.5 mAdc (pin 8)	ΔV_1	—	0.055	—	0.055	—	0.060	Vdc
"SUM" Output Voltage Change Between No Load and Full Load Conditions	No load = 0 current (pin 4) Full load = 2.5 mAdc (pin 4) Input (pin 9):	ΔV_5							Vdc
	V_{in} = −0.925 Vdc @ −55°C		—	0.055	—	—	—	—	
	V_{in} = −0.795 Vdc @ +25°C		—	—	—	0.055	—	—	
	V_{in} = −0.655 Vdc @ +125°C		—	—	—	—	—	0.060	

SWITCHING CHARACTERISTICS

The stray capacitance introduced by the test jig was $C_s = (n + 12)$ pf where n = number of fan-outs.

V_{IL} = −0.870 Vdc, V_I = −1.650 Vdc @ −55°C
V_{IH} = −0.750 Vdc, V_I = −1.550 Vdc @ +25°C
V_{IH} = −0.600 Vdc, V_I = −1.450 Vdc @ +125°C

			typ	max	typ	max	typ	max	
Propagation Delay Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	8.0	12.0	6.0	12.0	10.5	17.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	8.0	10.0	6.0	11.0	7.5	13.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	6.0	10.0	6.0	11.0	7.5	13.0	
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	5.5	8.0	5.5	9.5	7.5	12.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	7.5	10.5	7.5	11.0	10.0	15.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	7.5	10.5	7.5	11.0	10.0	15.0	
Rise Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_r	6.0	10.0	6.5	11.0	10.0	16.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_r	6.0	11.5	6.5	12.0	7.5	14.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_r	6.0	11.5	6.5	12.0	7.5	14.0	
Fall Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_f	8.0	12.5	6.5	13.5	11.0	18.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_f	7.5	12.0	8.0	13.5	10.5	16.5	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_f	7.5	12.0	8.0	13.5	10.5	16.5	

MC300 MECL series (continued)

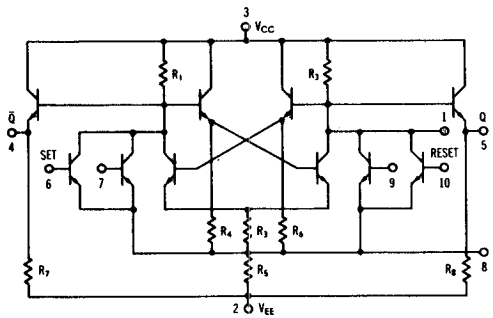
FLIP-FLOPS

MC302

DC R-S FLIP-FLOP

- Performs the Binary Function of "Q" and "$\overline{Q}$" Outputs at High Speeds over a Temperature Range of −55°C to +125°C

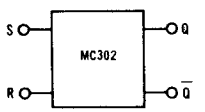
CIRCUIT SCHEMATIC



NOTE: Any unused inputs should be connected to V_{EE}.

LOGIC SPECIFICATIONS

When V_H is defined as a logical "1" and V_L as a logical "0", the function is as follows:



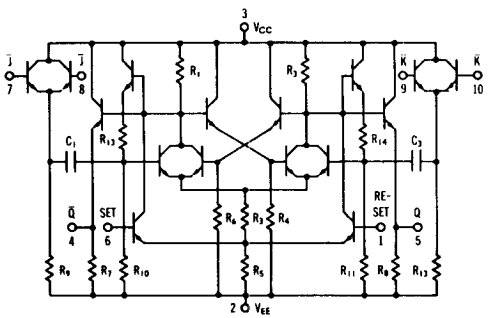
R	S	Q^{n+1}
0	1	1
1	0	0
0	0	Q^n
1	1	N.D.

MC308

J-K FLIP-FLOP

- Performs the Single Phase Binary Function of "Q" and "$\overline{Q}$" Outputs at High Speeds over a Temperature Range of −55°C to +125°C

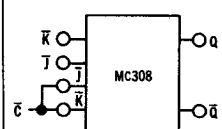
CIRCUIT SCHEMATIC



NOTE: Any unused inputs should be connected to V_{EE}.

LOGIC SPECIFICATIONS

When V_H is defined as a logical "1" and V_L as a logical "0", the function is as follows:



Clocked JK Operation

$\overline{J}$	$\overline{K}$	$\overline{C}$	Q^{n+1}
ϕ	ϕ	0	Q^n
0	0	1	$\overline{Q}^n$
0	1	1	1
1	0	1	0
1	1	1	Q^n

The $\overline{J}$ and $\overline{K}$ inputs refer to logic levels while the $\overline{C}$ input refers to dynamic logic swings. The $\overline{J}$ and $\overline{K}$ inputs should be changed to a logical "1" only while the $\overline{C}$ input is in a logic "1" state.

Set-Reset operation is the same as the MC302.

MC300 MECL series (continued)

FLIP-FLOPS (CONTINUED)

ELECTRICAL CHARACTERISTICS $V_{EE} = -5.2$ Vdc ±1%, $V_{CC} = 0$

(These characteristics apply to both the MC302 R-S Flip-Flop and the MC308 J-K Flip-Flop)

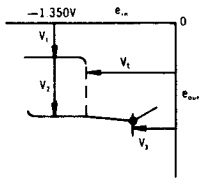
Unused inputs connected to V_{ss}

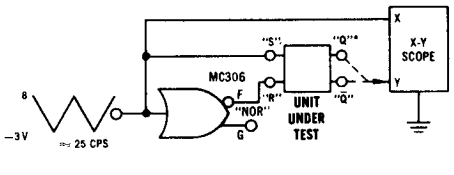
Test	Conditions	Symbol	−55°C min	−55°C max	25°C min	25°C max	125°C min	125°C max	Unit
DC CHARACTERISTICS									
"Q" or "$\bar{Q}$" Logical "1" Output Voltage	Each Input: (Set Input for Q, Reset Input for $\bar{Q}$) V_{in} = -1.45 Vdc @ -55°C V_{in} = -1.350 Vdc @ 25°C V_{in} = -1.30 Vdc @ +125°C	V_1	0.825 — —	0.945 — —	— 0.690 —	— 0.795 —	— — 0.525	— — 0.655	Vdc
"Q" or "$\bar{Q}$" Logical "0" Output Voltage	Each Input: (Set Input for Q, Reset Input for $\bar{Q}$) V_{in} = -1.45 Vdc @ -55°C V_{in} = -1.358 Vdc @ 25°C V_{in} = -1.30 Vdc @ +125°C	V_2	1.560 — —	1.850 — —	— 1.465 —	— 1.750 —	— — 1.340	— — 1.675	Vdc
"Q" or "$\bar{Q}$" Saturation Breakpoint Voltage	dV "Q"$/dV_{in} = 0$; dV "$\bar{Q}$"$/dV_{in} = 0$	V_3	—	8.50	—	0.65	—	0.75	Vdc
"Q" or "$\bar{Q}$" Latch Voltage	$dV_1/dV_{in} = \infty$	V_L	1.18	1.34	1.09	1.21	0.93	1.07	Vdc
Total Power Supply Current Drain (MC302)	All Inputs Open	I_E	—	10.35	—	10.35	—	9.52	mAdc
Total Power Supply Current Drain (MC308)	All Inputs Open	I_E	—	21.0	—	21.0	—	19.5	mAdc

LOADING CHARACTERISTICS

"Q" Output Voltage Change	All Inputs Open, measured between no load and full load No load = 0 current (pin 5) Full load = 2.5 mAdc ± 5% (pin 5) V_{in} (pin 6) = -0.945 Vdc @ -55°C V_{in} (pin 8) = -0.795 Vdc @ 25°C V_{in} (pin 6) = -0.655 Vdc @ +125°C	ΔV_1	— — —	0.055 — —	— — —	— 0.055 —	— — —	— — 0.060	Vdc
"$\bar{Q}$" Output Voltage Change	All Inputs Open, measured between no load and full load. V_{in} at pin 10 for MC302, pin 1 for MC308 No load = 0 current (pin 4) Full load = 2.5 mAdc ± 5% (pin 4) V_{in} = -0.945 Vdc @ -55°C V_{in} = -0.795 Vdc @ 25°C V_{in} = -0.655 Vdc @ +125°C	ΔV_1	— — —	0.055 — —	— — —	— 0.055 —	— — —	— — 0.060	Vdc

TRANSFER CHARACTERISTICS





*FOR "Q" TESTS REVERSE "S" & "R" CONNECTIONS

MC300 MECL series (continued)

FLIP-FLOPS (CONTINUED)

MC302

SWITCHING CHARACTERISTICS

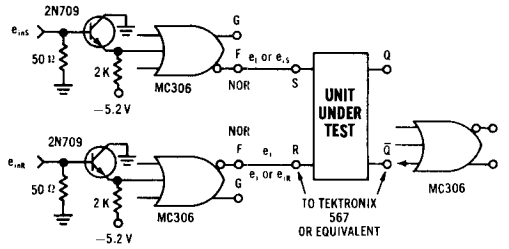
V_{CC} = 0, V_{EE} = −5.2 Volts, (all ±1%), V_{IL} = −0.870 Vdc, V_L = −1.650 Vdc @ −55°C
V_{IL} = −0.750 Vdc, V_L = −1.550 Vdc @ +25°C
V_{IH} = −0.600 Vdc, V_L = −1.450 Vdc @ +125°C

The stray capacitance introduced by the test jig was C_S = (n + 12) pf where n = number of fan-outs.

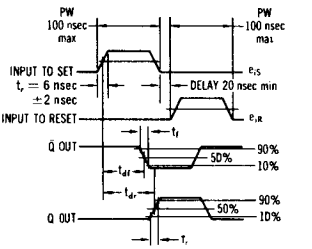
Unused inputs connected to V_{IL}

Test	Conditions	Symbol	−55°C typ	−55°C max	25°C typ	25°C max	125°C typ	125°C max	Unit
Propagation Delay Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_{dr}	9.0	14.0	10.5	16.0	22.0	29.0	nsec
	Either Output (Fan-In = 1, Fan-Out = 1)	t_{df}	8.5	14.0	11.5	19.5	16.0	24.0	
Rise Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_r	9.0	15.0	11.5	19.0	23.0	31.0	nsec
Fall Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_f	7.0	13.0	12.5	19.5	18.0	29.0	nsec

SWITCHING TIME TEST CIRCUIT



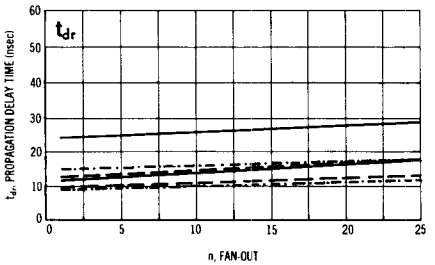
SWITCHING TIME TEST PROCEDURE

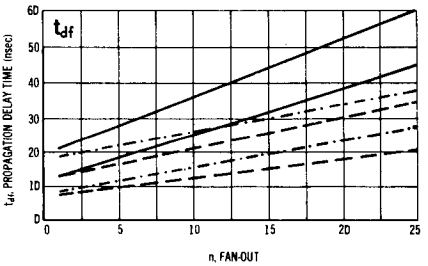


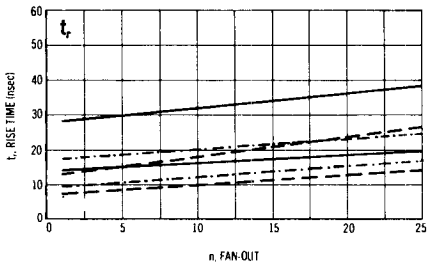
SWITCHING CHARACTERISTICS

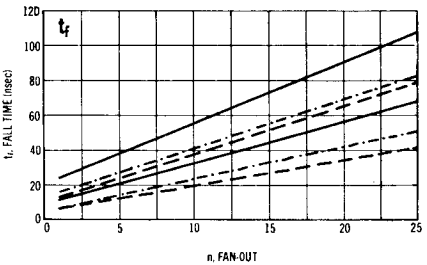
(10% to 90% distribution)

−55°C — — — —
+25°C —·—·—·—
+125°C ——————









MC300 MECL series (continued)

FLIP-FLOPS (CONTINUED)

MC308

SWITCHING CHARACTERISTICS

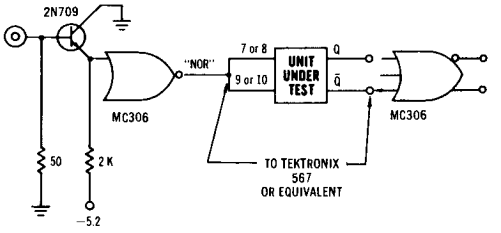
V_{CC} = 0, V_{EE} = −5.2 Volts, (all ±1%). V_{in} = −0.870 Vdc, V_{il} = −1.650 Vdc @ −55°C
V_{in} = −0.750 Vdc, V_{il} = −1.550 Vdc @ +25°C
V_{in} = −0.600 Vdc, V_{il} = −1.450 Vdc @ +125°C

The stray capacitance introduced by the test jig was C_t = (n + 12) pf where n = number of fan-outs.

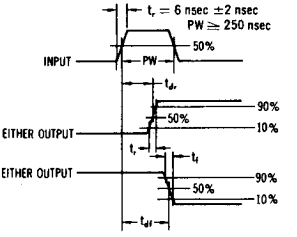
Unused inputs connected to V_{in}

Test	Conditions	Symbol	−55°C typ	−55°C max	25°C typ	25°C max	125°C typ	125°C max	Unit
Propagation Delay Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_{dr}	7.0	11.5	7.0	12.5	9.5	18.5	nsec
	Either Output (Fan-In = 1, Fan-Out = 1)	t_{df}	8.5	14.0	8.5	14.5	10.0	18.5	nsec
Rise Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_r	6.5	18.0	6.5	18.5	10.0	24.0	nsec
Fall Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_f	7.5	14.5	8.5	16.5	11.5	21.5	nsec

SWITCHING TIME TEST CIRCUIT

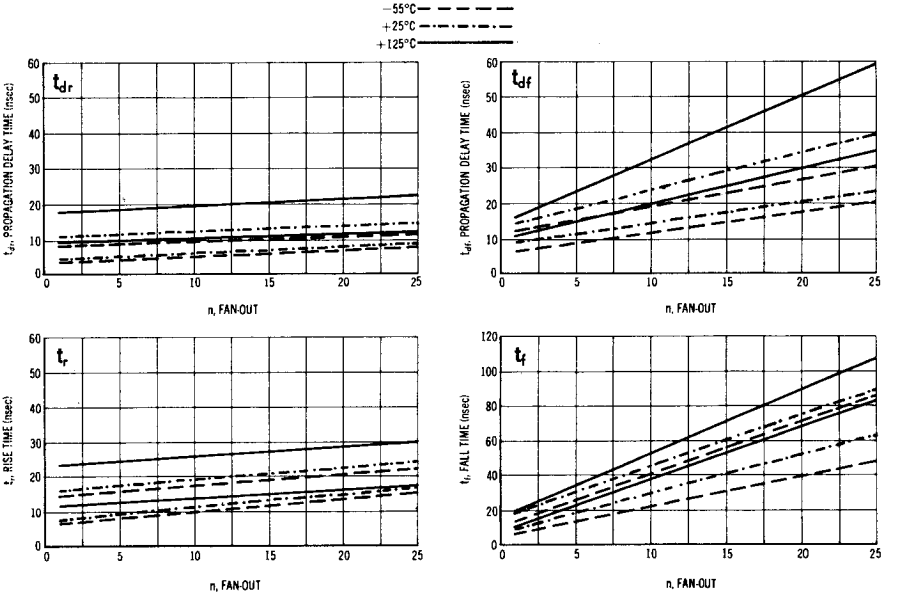


SWITCHING WAVEFORMS



SWITCHING CHARACTERISTICS

(10% to 90% distribution)



MC300 MECL series (continued)

MC305

GATE EXPANDER

Designed primarily for use in conjunction with the MC306 and MC 307 "MECL" 3-INPUT LOGIC GATES. Each expander unit increases the fan-in of the basic gate by five.

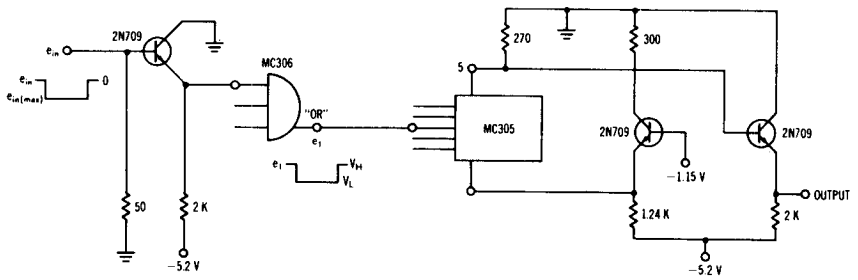
ELECTRICAL CHARACTERISTICS

Test	Conditions	Symbol	−55°C		25°C		125°C		Unit
			min	max	min	max	min	max	
Base Leakage Current	V_{EE} = 2.0 Vdc, V_{CC} = 0, V_{BB} = -5.2 Vdc	I_{BL}	—	0.5	—	0.5	—	5.0	μAdc
Input Voltage	V_{CB} = 0.7 Vdc, V_B = 0, I_E = -1.33 mAdc	V_{BE}	0.810	0.880	0.680	0.730	0.490	0.540	Vdc
Collector Leakage Current	V_{CC} = -2 Vdc, V_{BE} = 0.3 Vdc (all inputs), V_{EE} = 0	I_{CEX}	—	1.0	—	1.0	—	100.0	μAdc

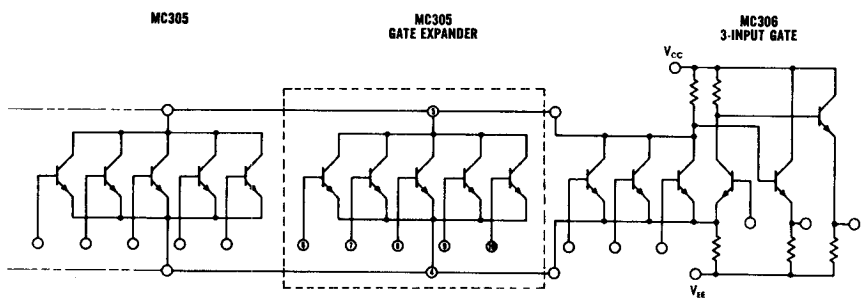
SWITCHING CHARACTERISTICS

		typ	max	typ	max	typ	max	
Propagation Delay	t_{d1}	5.0	8.0	5.0	8.5	5.5	9.5	nsec
	t_{d2}	4.0	8.0	4.0	6.0	4.5	10.0	
Rise Time	t_r	8.0	10.5	6.5	11.5	6.5	13.0	nsec
Fall Time	t_f	3.0	6.5	3.5	8.5	4.5	9.5	nsec

SWITCHING TIME TEST CIRCUIT



CIRCUIT SCHEMATIC AND INTERCONNECTION TO MC306 3-INPUT GATE



NOTE: Any unused inputs should be connected to V_{EE}.

MECL MC350 series

The MECL series of integrated logic circuits forms a versatile set of monolithic digital building blocks representing all the necessary circuitry for the arithmetic portion of a computer. MECL circuits combine extremely high speed with a systems-oriented design approach that permits implementation with the fewest possible number of individual devices. This represents both a cost saving and a potential increase in system reliability. The major features of the MECL series are:

- 5 nsec propagation delay per logic decision
- Virtually constant noise immunity with ±10% power supply variation, and temperature changes from 0 to +75°C
- Simultaneous "OR"-"NOR" or "AND"-"NAND" outputs
- High fan-in and fan-out capabilities

MECL integrated circuits are used in various combinations to provide such intermediate system blocks as adders, counters, shift registers, decoders, multivibrators, etc. They provide a line of monolithic computer circuits designed analytically and practically to meet the stringent demands of the most advanced computer systems. The series is comprised of the following elements:

MC351 — A high-speed five-input gate element that provides the positive logic "OR" function and its complement simultaneously.

MC352 — A DC Set-Reset flip-flop with an expandable input and the power dissipation of only one gate.

MC353 — A half-adder that provides the "SUM", "CARRY", and "NOR" function simultaneously.

MC354 — A bias driver that compensates for changes in circuit parameters with temperature.

MC355 — A five-input expander for use with the MC352 and the MC356,7.

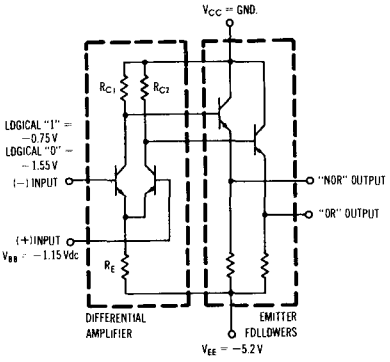
MC356,7 — A high-speed expandable three-input gate element that provides the positive logic "OR" function and its complement simultaneously.

MC358 — A clocked J-K flip-flop for counter and shift register applications with DC Set and Reset inputs.

MC359,60,61 — A high-speed dual two-input gate element that provides the positive logic "NOR" function.

MC362 — A high-speed dual three-input gate element that provides the positive logic "NOR" function.

BASIC MECL CIRCUIT



FOR LOGICAL "1" INPUT: "NOR" OUTPUT = −1.55 V
"OR" OUTPUT = −0.75 V

FOR LOGICAL "0" INPUT: "NOR" OUTPUT = −0.75 V
"OR" OUTPUT = −1.55 V

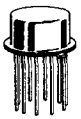
MECL — A CURRENT MODE SWITCH

The typical MECL circuit is designed with a differential amplifier input and emitter-follower output to restore dc levels. The circuit has been designed to prevent saturation of the input transistors, thus eliminating storage time and allowing for high-speed operation with non-critical transistor parameters. High fan-out operation is permitted due to the low impedance emitter-follower and the high-input impedance of the circuit. The basic gate has both the function and its complement available simultaneously. Since the current in the differential amplifier is switched from one side to the other, there is virtually no power supply noise generated.

The circuit operation is straight-forward. A fixed bias of −1.15 volts is applied to the (+) input of the differential amplifier and the logic signals are applied to the (−) input. If a logical "0" is applied to the (−) input, the current through R_E is supplied by the fixed biased transistor. A drop of 800 mV occurs across R_{C2}. The "OR" output then is −1.55 V, or one V_{BE}-drop below 800 mV. Since no current flows in the (−) input transistor, the "NOR" output is a V_{BE}-drop below ground, or −0.75 volts. When a logical "1" level is applied to the (−) input, the current through R_{C2} is switched to the (−) input transistor and a drop of 800 mV occurs across R_{C1}. The "OR" output then goes to −0.75 volts and the "NOR" output goes to −1.55 volts.

A bias driver is supplied to insure that the threshold point is always in the center of the transition region. The bias driver compensates for temperature changes and is designed to track with temperature.

MC350 MECL series (continued)



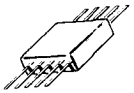
10 PIN

CASE 71



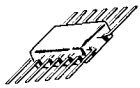
12 PIN
(MC362G ONLY)

CASE 98



10 PIN FLAT PACKAGE

CASE 72



14 PIN FLAT PACKAGE
(MC362F ONLY)

CASE 83

FAMILY CHARACTERISTICS

The following information applies to all devices of the MECL family. It is intended to provide the design engineer with meaningful information for worst-case analyses. Parameters of importance are guaranteed at three temperature levels: room, and the extremes for which the family is designed. All performance curves are based on distributional spreads and the minimum-maximum ranges can be interpreted for design purposes as 10%-90% spreads at all points on the curve except for guaranteed points on the electrical characteristics.

MAXIMUM RATINGS (at 25°C)

Characteristics	Symbol	Maximum	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Output Source Current	I_O	10	mAdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-40 to +150	°C

SYSTEM LOGIC SPECIFICATIONS

Any one of the supply nodes, V_{BB}, V_{CC}, or V_{EE} may be used as ground; however, the manufacturer has found it most convenient to ground the V_{CC} node. In such a case:
$V_{CC} = 0$ $V_{BB} = -1.15V$ $V_{EE} = -5.2V$

The output logic swing of 0.8V then varies from a low state of $V_L = -1.55V$ to a high state of $V_H = -0.75V$ with respect to ground.
Positive logic is used when reference is made to logical "0's" or "1's". Then

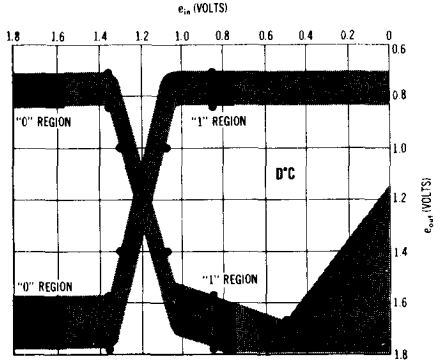
"0" = −1.55V
"1" = −0.75V
} typical

Dynamic logic refers to a change of logic states. Dynamic "0" is a negative going voltage excursion and a dynamic "1" is a positive going voltage excursion.

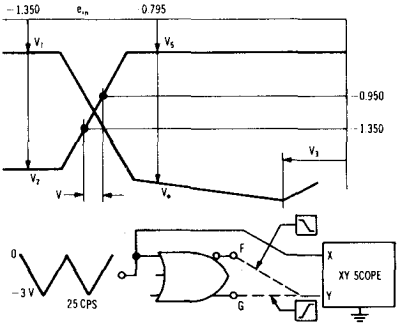
MC350 MECL series (continued)

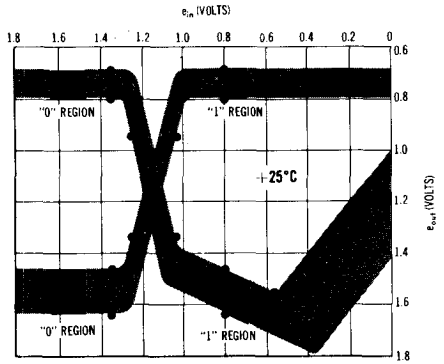
DC CHARACTERISTICS FOR MC350 SERIES

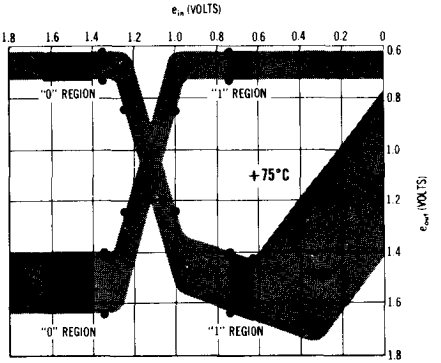
WORST CASE TRANSFER CHARACTERISTICS



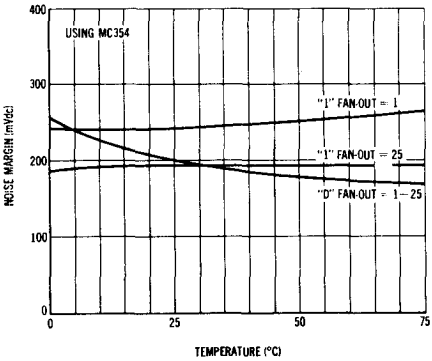
DEFINITION OF TRANSFER CHARACTERISTIC POINTS

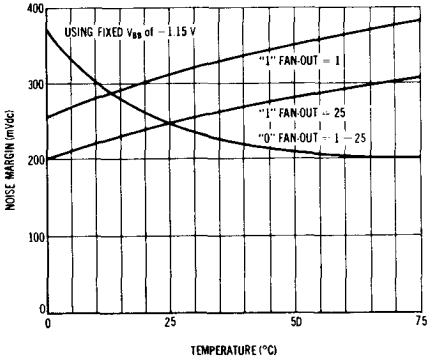






WORST CASE NOISE MARGIN





MC350 MECL series (continued)

MC354

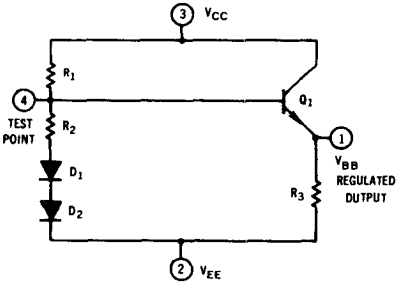
BIAS DRIVER

A temperature compensating regulator intended for use in conjunction with the MC350 "MECL" series of INTEGRATED LOGIC CIRCUITS. Insures stable and reliable operation of "MECL" logic systems over a temperature range of 0 to +75°C.

ELECTRICAL CHARACTERISTICS

Test	Conditions	Symbol	0°C		25°C		75°C		Units
			min	max	min	max	min	max	
Fan-Out	—	n	—	25	—	25	—	25	—
Output Voltage (No Load to Full Load)	V_{CC} = 0, V_{EE} = -5.2 Vdc ± 1%, I_{out} = 0 to 2.5 mAdc	V_{BB}	1.14	1.27	1.09	1.22	1.04	1.18	Vdc
Power Dissipation	V_{CC} = 0, V_{EE} = -5.2 Vdc ± 1%	P_D	—	28	—	24	—	22	mW

CIRCUIT SCHEMATIC



CIRCUIT DESCRIPTION

Circuit Operation:

The divider network R_1, R_2, D_1, D_2 compensates for temperature variations of the base-emitter voltages of Q_1, and of the driven gates, producing a bias voltage for the MECL logic circuits that maintains a constant set of dc operating conditions over the temperature range of 0 to +75°C. In addition, compensation for power supply variations is achieved, since the bias output voltage is derived from the system supply.

Either of the supply voltage nodes may be used as ground, however the ground potential of the bias driver must coincide with that of the logic system. Thus, if V_{CC} is grounded in the logic system, then —

$V_{CC} = 0$; $V_{EE} = -5.2V$;

$V_{BB} = -1.15$ nominal output voltage at 25°C

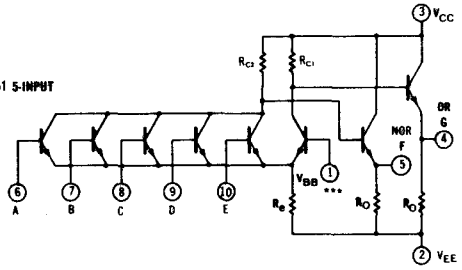
MC350 MECL series (continued)

MC351, MC356, MC357, MC359 thru MC362

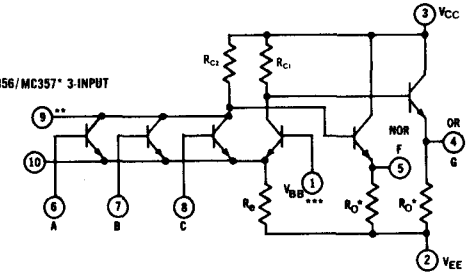
LOGIC GATES

CIRCUIT SCHEMATICS

MC351 5-INPUT



MC356/MC357* 3-INPUT

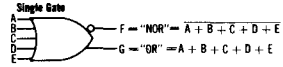


LOGIC SPECIFICATIONS

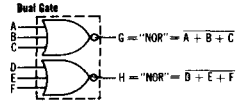
POSITIVE LOGIC

When V_H is defined as a logical "1" and V_L as a logical "0" the "OR"/"NOR" function is performed:

Single Gate



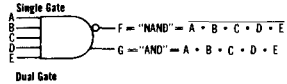
Dual Gate



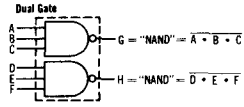
NEGATIVE LOGIC

Inversely, when V_H is defined as a logical "0" and V_L as a logical "1" the "AND"/"NAND" function is performed:

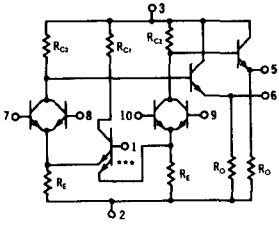
Single Gate



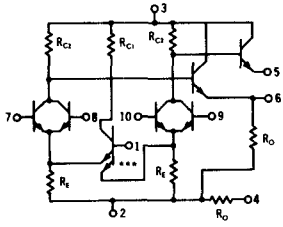
Dual Gate



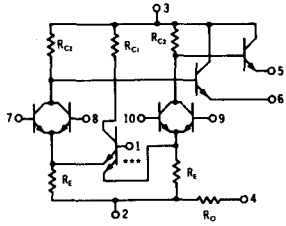
MC359 DUAL "NOR"



MC360 DUAL "NOR"



MC361 DUAL "NOR"



*Resistors R_O are omitted in MC357 circuits to permit reduction of Power Dissipation in systems where logic operations are performed at circuit outputs.

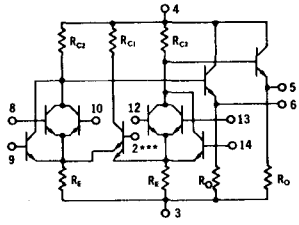
EXAMPLE: where (n) gates are to perform an "OR" function, one MC356 gate and (n-1) MC357 gates can be used to provide savings of Power Dissipation in (n-1) gates.

**Pins 9 and 10 are for use in conjunction with the MC355 input expander to increase the fan-in capability in increments of five.

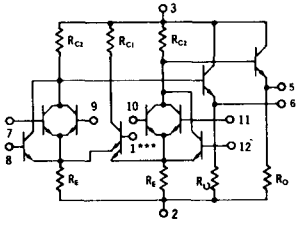
***To be supplied from bias-driver circuit MC354 for optimum temperature stability.

NOTE: Any unused inputs can normally be left open-circuited. In cases where there may be external leakage to the unused inputs they should be connected to V_{EE}.

MC362F DUAL "NOR"



MC362G DUAL "NOR"



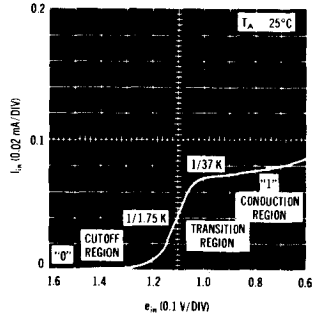
MC350 MECL series (continued)

LOGIC GATES (CONTINUED)

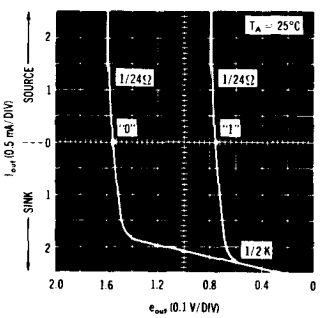
DC ELECTRICAL CHARACTERISTICS: V_{CC} = 0, V_{EE} = −5.2 Volts, (all ±1%). V_{BB} = −1.18 Vdc @ 0°C
V_{BB} = −1.15 Vdc @ +25°C
V_{BB} = −1.08 Vdc @ +75°C

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
Total Unit Power Supply Current Drain	All inputs open MC351, MC356 MC357 MC359, MC360, MC362 MC361	I_E	— — — —	9.25 3.8 13.55 10.5	— — — —	8.65 3.6 13.0 10.1	— — — —	6.15 3.3 12.0 9.25	mAdc
Input Current	V_1 min @ 25°C	I_{in}	—	—	—	100	—	—	μAdc
Fan-In		m	—	—	—	23	—	—	
Fan-Out		n	—	—	—	25	—	—	
"NOR" OUTPUT – All Types									
"NOR" Logical "O" Output Voltage	Each Input: V_{in} = −1.350 Vdc	V_1	0.715	0.850	0.670	0.795	0.590	0.725	Vdc
"NOR" Logical "O" Output Voltage	Each Input: V_{in} = −0.850 Vdc @ 0°C V_{in} = −0.795 Vdc @ 25°C V_{in} = −0.725 Vdc @ 75°C	V_4	1.570 — —	1.830 — —	— 1.465 —	— 1.700 —	— — 1.395	— — 1.680	Vdc
"NOR" Saturation Breakpoint Voltage	$\frac{dv\ "NOR"}{dV_{in}} = 0$	V_3	—	0.51	—	0.55	—	0.63	Vdc
"NOR" Output Voltage Change (No load to full load)	All inputs open No load = 0 current at pin 5 Full load = 2.5 mAdc ± 5% at pin 5	ΔV_1	—	0.055	—	0.055	—	0.075	Vdc
"OR" OUTPUT – Types MC351, MC356, MC357 only									
"OR" Logical "1" Output Voltage	Each Input: V_{in} = −0.650 Vdc @ 0°C V_{in} = −0.795 Vdc @ 25°C V_{in} = −0.725 Vdc @ 75°C	V_5	0.715 — —	0.650 — —	— 0.670 —	— 0.795 —	— — 0.590	— — 0.725	Vdc
"OR" Logical "O" Output Voltage	Each Input: V_{in} = −1.35 Vdc	V_2	1.570	1.630	1.465	1.700	1.395	1.660	Vdc
Transition Region Slope	V "OR" Between: −1.400 Vdc and −1.00 Vdc @ 0°C −1.350 Vdc and −0.950 Vdc @ 25°C −1.250 Vdc and −0.850 Vdc @ 75°C	V	— — —	0.095 — —	— — —	— 0.095 —	— — —	— — 0.105	Vdc
"OR" Output Voltage Change (No load to full load)	No load = 0 current at pin 4 Full load = 2.5 mAdc ± 5% at pin 4 V_{in} = −0.650 Vdc @ 0°C V_{in} = −0.795 Vdc @ 25°C V_{in} = −0.725 Vdc @ 75°C	ΔV_5	— — —	0.055 — —	— 0.055 —	— — —	— — —	— — 0.075	Vdc

TYPICAL INPUT CHARACTERISTICS



TYPICAL OUTPUT CHARACTERISTICS



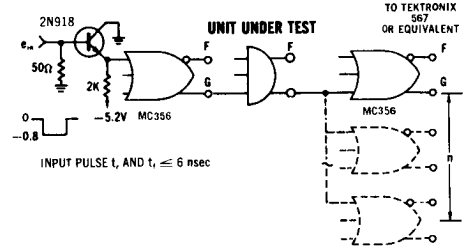
MC350 MECL series (continued)

LOGIC GATES (CONTINUED)

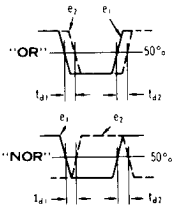
SWITCHING CHARACTERISTICS: $V_{CC} = 0$, $V_{EE} = -5.2$ Volts, (all ±1%). $V_{EE} = -1.18$ Vdc, $V_H = -0.790$ Vdc, $V_L = -1.640$ Vdc @ 0°C
The stray capacitance introduced by the test jig was; $V_{EE} = -1.15$ Vdc, $V_H = -0.750$ Vdc, $V_L = -1.550$ Vdc @ +25°C
$C_s = (n + 12)$ pf where n = number of fan-outs. $V_{EE} = -1.08$ Vdc, $V_H = -0.675$ Vdc, $V_L = -1.500$ Vdc @ +75°C

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
MC351 (See curves)									
Propagation Delay		t_{d1}							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	10.0	4.0	11.0	5.0	13.0	
	Fan-In = 1, Fan-Out = 10		4.0	13.0	5.0	15.0	6.0	17.0	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	3.0	12.0	4.0	12.0	5.0	17.0	
	Fan-In = 1, Fan-Out = 10		8.0	20.0	9.0	21.0	15.0	58.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	11.0	4.0	15.0	5.0	16.0	
	Fan-In = 1, Fan-Out = 10		6.0	17.0	7.0	20.0	15.0	50.0	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	9.0	4.0	9.0	5.0	11.0	
	Fan-In = 1, Fan-Out = 10		3.0	12.8	4.0	12.0	5.0	14.0	
Rise Time		t_r							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	12.0	4.0	14.0	5.0	15.0	
"OR" Output	Fan-In = 1, Fan-Out = 1		3.0	11.0	4.0	12.0	5.0	14.0	
Fall Time		t_f							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	t4.0	4.0	15.0	5.0	16.0	
"OR" Output	Fan-In = 1, Fan-Out = 1		3.0	14.0	4.0	15.0	5.0	16.8	
MC356, MC357 – "NOR" AND "OR" Output; MC362 – "NOR" Output only									
Propagation Delay		t_{d1}							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	8.0	4.0	5.0	5.0	11.0	
	Fan-In = 1, Fan-Out = 10		4.0	11.0	5.0	11.0	6.0	14.0	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	3.0	9.0	4.0	10.0	5.0	15.0	
	Fan-In = 1, Fan-Out = 10		8.0	18.0	9.0	20.0	15.0	37.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	10.0	4.0	11.0	5.0	13.0	
	Fan-In = 1, Fan-Out = 10		6.0	17.0	7.0	21.0	15.0	36.0	
"OR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	8.0	3.0	8.0	4.0	11.0	
	Fan-In = 1, Fan-Out = 10		3.0	11.0	4.0	11.0	5.0	13.8	
Rise Time		t_r							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	11.0	4.0	12.0	5.0	15.0	
"OR" Output	Fan-In = 1, Fan-Out = 1		3.0	8.0	3.0	10.0	5.0	11.0	
Fall Time		t_f							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	12.0	4.0	14.0	5.0	16.0	
"OR" Output	Fan-In = 1, Fan-Out = 1		3.0	11.0	4.0	14.0	5.0	16.0	
MC359, MC360, MC361 – "NOR" Output only									
Propagation Delay		t_{d1}							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	9.0	3.0	10.0	4.0	12.0	
	Fan-In = 1, Fan-Out = 10		3.0	11.0	5.0	12.0	6.0	15.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	10.0	5.0	11.0	5.0	14.0	
	Fan-In = 1, Fan-Out = 10		6.0	16.0	7.0	19.0	15.0	55.0	
Rise Time		t_r							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	9.0	4.0	10.0	4.0	12.0	nsec
Fall Time		t_f							nsec
"NOR" Output	Fan-In = 1, Fan-Out = 1		3.0	12.0	4.0	14.0	5.0	t7.0	

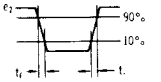
SWITCHING TIME TEST CIRCUIT



PROPAGATION DELAY



RISE AND FALL TIME

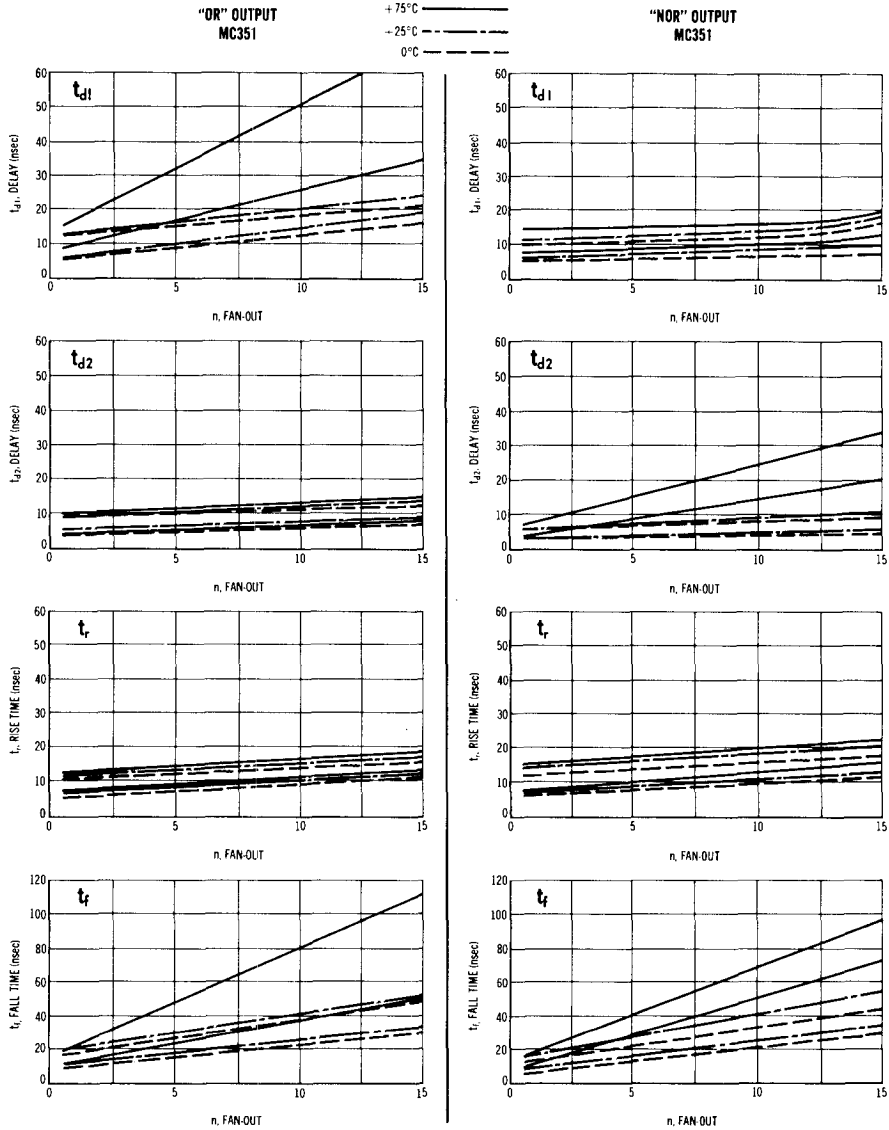


The fan-in is obtained with MC355 input expanders, with all but the driven input connected to −1.550 V

MC350 MECL series (continued)

LOGIC GATES (CONTINUED)

SWITCHING CHARACTERISTICS
(10% to 90% distribution)



MC350 MECL series (continued)

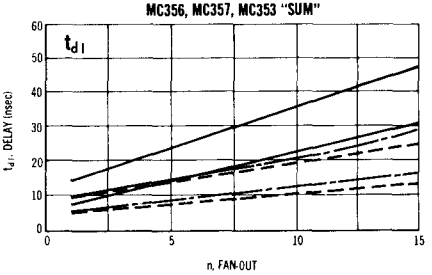
LOGIC GATES (CONTINUED)

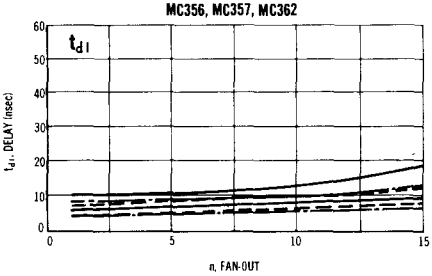
SWITCHING CHARACTERISTICS
(10% to 90% distribution)

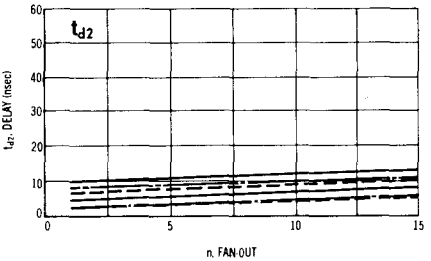
+75°C
+25°C
0°C

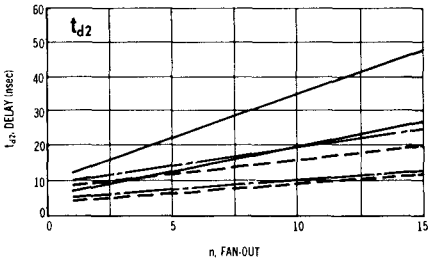
"OR" OUTPUT
MC356, MC357, MC353 "SUM"

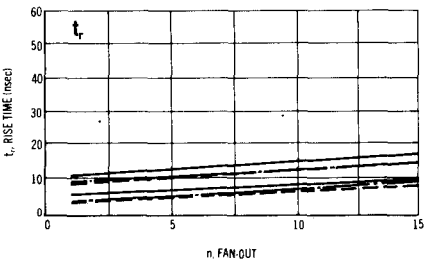
"NOR" OUTPUT
MC356, MC357, MC362

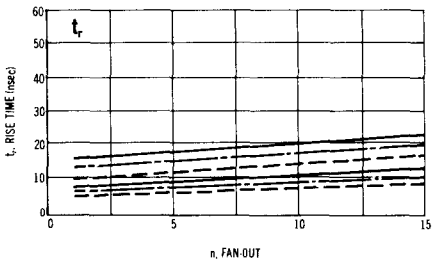


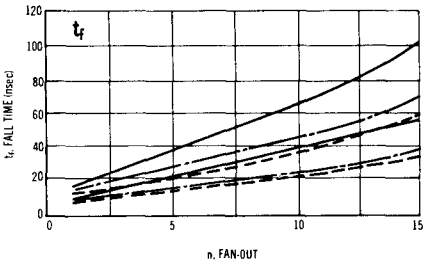


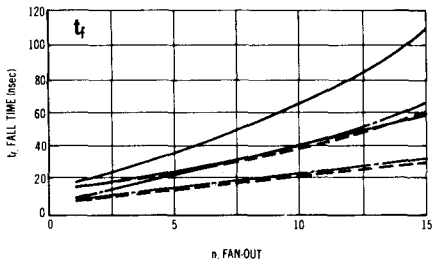












MC350 MECL series (continued)

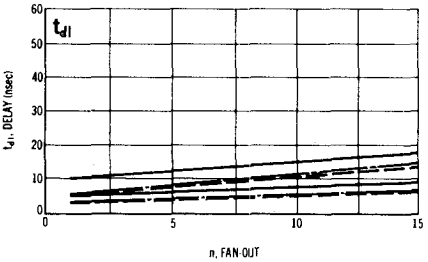
LOGIC GATES (CONTINUED)

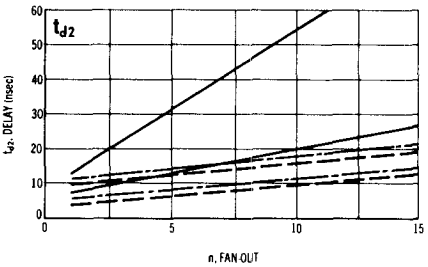
SWITCHING CHARACTERISTICS

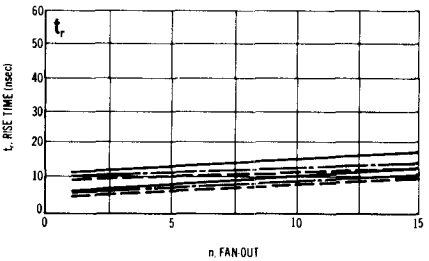
(10% to 90% distribution)

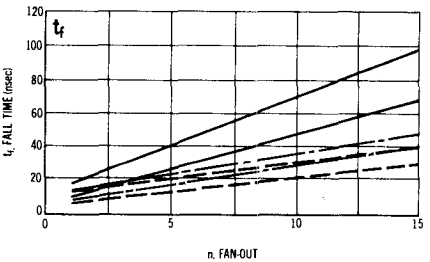
"NOR"
MC359, MC360, MC361,
and MC353 "OR" and "CARRY"

+75°C
+25°C
0°C

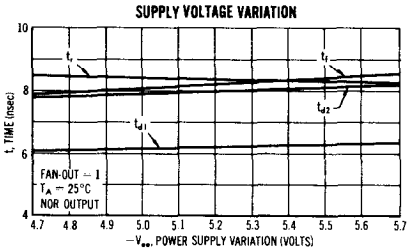


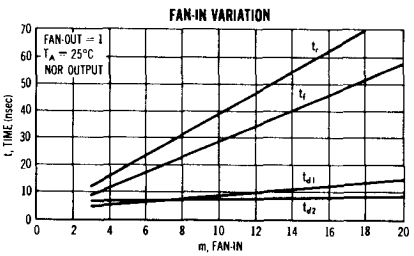


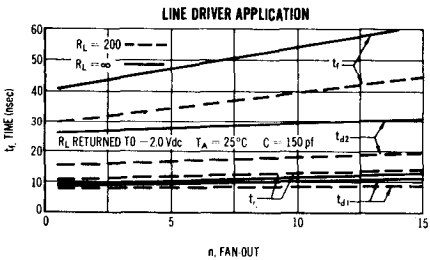


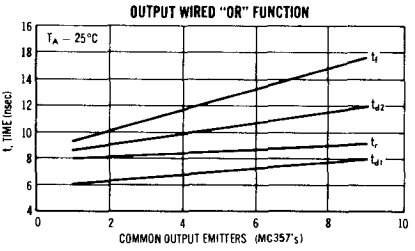


TYPICAL SWITCHING TIME VARIATIONS MC356









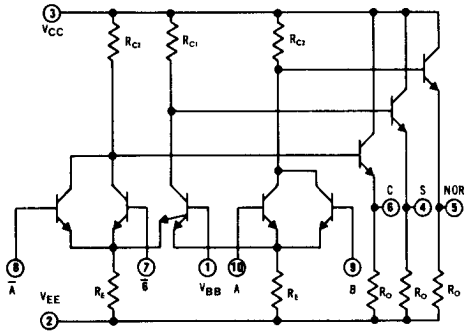
MC350 MECL series (continued)

MC353

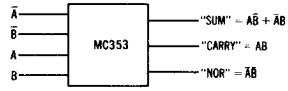
HALF-ADDER

- Provides the "SUM," "CARRY," and "NOR" Outputs for Use in Digital Computer Circuits over a Temperature Range of 0 to +75°C.
- Average Propagation Delay — 6 nsec

CIRCUIT SCHEMATIC



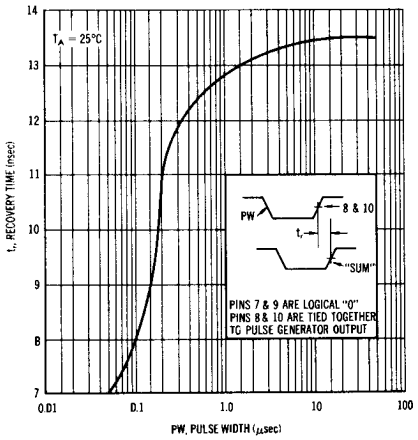
LOGIC SPECIFICATIONS



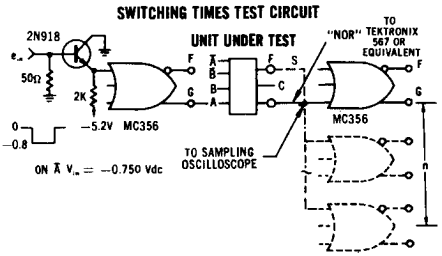
The "NOR" and "CARRY" outputs can be tied together to provide the "SUM" function.

If complement inputs are not used an undefined state can occur. When all inputs are at a logical "0" R_{C1} has two R_t currents which saturates the V_{BB} transistor. The "SUM" output goes to −2.3 Volts. The recovery time characteristics are shown in the curve below.

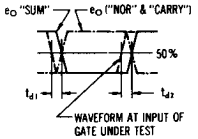
RECOVERY CHARACTERISTICS WITH SIMULTANEOUS "0" ON ALL INPUTS



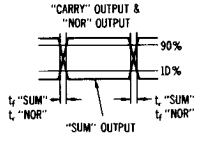
SWITCHING TIMES TEST CIRCUIT



PROPAGATION DELAY TIME



RISE AND FALL TIMES



(RISE TIME = t0% to 90% POINT OF POSITIVE GOING WAVEFORMS
FALL TIME = 90% to 10% POINT OF NEGATIVE GOING WAVEFORMS.)

MC350 MECL series (continued)

HALF-ADDER (CONTINUED)

ELECTRICAL CHARACTERISTICS: $V_{EE} = -5.2$ Vdc ±1%, $V_{CC} = 0$ $V_{BB} = -1.18$ Vdc @ 0°C
$V_{BB} = -1.15$ Vdc @ +25°C
$V_{BB} = -1.08$ Vdc @ +75°C

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
DC CHARACTERISTICS									
"NOR" Logical "1" Output Voltage	V_{in} = -1.350 Vdc each input	V_1	0.715	0.850	0.670	0.795	0.590	0.725	Vdc
"NOR" Saturation Breakpoint Voltage	$\frac{dV\ "NOR"}{dV_{in}} = 0$	V_3	—	0.510	—	0.550	—	0.630	Vdc
"NOR" Logical "0" Output Voltage	Each Input: V_{in} = -0.850 Vdc @ 0°C V_{in} = -0.795 Vdc @ 25°C V_{in} = -0.725 Vdc @ 75°C	V_4	 1.570 — —	 1.830 — —	 — 1.465 —	 — 1.700 —	 — — 1.395	 — — 1.680	Vdc
"SUM" Logical "1" Output Voltage	Each Input: V_{in} = -0.850 Vdc @ 0°C V_{in} = -0.785 Vdc @ 25°C V_{in} = -0.725 Vdc @ 75°C	V_5	 0.715 — —	 0.850 — —	 — 0.670 —	 — 0.785 —	 — — 0.590	 — — 0.725	Vdc
"SUM" Logical "0" Output Voltage	V_{in} = -1.350 Vdc each input	V_2	1.570	1.830	1.465	1.700	1.395	1.680	
Transition Region Slope	Between: $V_{"SUM"}$ = -1.000 and -1.400 Vdc @ 8°C $V_{"SUM"}$ = -0.950 and -1.350 Vdc @ 25°C $V_{"SUM"}$ = -8.858 and -1.250 Vdc @ 75°C	ΔV	 — — —	 0.085 — —	 — — —	 — 0.895 —	 — — —	 — — 0.105	Vdc
"CARRY" Logical "1" Output Voltage	V_{in} = -1.350 Vdc each input	V_1	0.715	0.850	0.670	0.795	0.590	0.725	Vdc
"CARRY" Logical "0" Output Voltage	Each Input: V_{in} = -0.850 Vdc @ 0°C V_{in} = -0.795 Vdc @ 25°C V_{in} = -8.725 Vdc @ 75°C	V_4	 1.578 — —	 1.830 — —	 — 1.485 —	 — 1.700 —	 — — 1.395	 — — 1.680	Vdc
"CARRY" Saturation Breakpoint Voltage	$\frac{dV\ "CARRY"}{dV_{in}} = 0$	V_3	—	8.510	—	0.550	—	8.830	Vdc
Total Unit Power Supply Current	All Inputs Open	I_E	—	15.9	—	15.30	—	14.10	mAdc
LOADING CHARACTERISTICS									
"NOR" Output Voltage Change Between No Load and Full Load Conditions	All Inputs open No load = 8 Current (pin 5) Full load = 2.5 mAdc (pin 5)	ΔV_1	—	0.855	—	0.055	—	0.875	Vdc
"CARRY" Output Voltage Change Between No Load and Full Load Conditions	All Inputs open No load = 0 current (pin 6) Full load = 2.5 mAdc (pin 6)	ΔV_1	—	0.855	—	0.055	—	0.075	Vdc
"SUM" Output Vsitage Change Between No Load and Full Load Conditions	No lsad = 8 current (pin 4) Full load = 2.5 mAdc (pin 4) Input (pin 9): V_{in} = -0.850 Vdc @ 0°C V_{in} = -0.795 Vdc @ 25°C V_{in} = -0.725 Vdc @ 75°C	ΔV_5	 — — —	 0.855 — —	 — — —	 — 0.055 —	 — — —	 — — 0.075	Vdc

SWITCHING CHARACTERISTICS

The stray capacitance introduced by the test jig was:
$C_t = (n + 12)$ pf where n = number of fan-outs.

$V_{in} = -0.790$ Vdc, $V_L = -1.640$ Vdc @ 0°C
$V_{in} = -0.750$ Vdc, $V_L = -1.550$ Vdc @ +25°C
$V_{in} = -0.675$ Vdc, $V_L = -1.500$ Vdc @ +75°C

Propagation Delay Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	3.0	12.0	4.0	12.0	5.0	17.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	3.0	8.5	3.0	9.0	4.8	12.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_{d1}	3.0	8.5	3.0	9.0	4.0	12.0	
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	8.0	3.0	8.5	4.0	12.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	8.0	4.0	10.5	5.0	14.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_{d2}	3.0	9.0	4.0	10.5	5.0	14.0	
Rise Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_r	3.0	18.0	4.0	10.5	5.0	t5.0	
"NOR" Output	Fan-In = 1, Fan-Out = t	t_r	3.0	9.8	4.0	10.8	4.0	15.0	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_r	3.0	9.8	4.0	10.8	4.8	15.0	
Fall Time									nsec
"SUM" Output	Fan-In = 1, Fan-Out = 1	t_f	3.0	12.0	4.0	14.8	5.0	18.0	
"NOR" Output	Fan-In = 1, Fan-Out = 1	t_f	3.0	12.0	4.0	14.0	5.0	17.8	
"CARRY" Output	Fan-In = 1, Fan-Out = 1	t_f	3.0	12.0	4.0	14.0	5.0	17.0	

MC350 MECL series (continued)

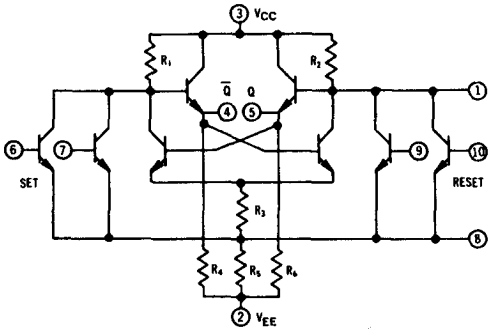
FLIP-FLOPS

MC352

DC R-S FLIP-FLOP

Performs the Binary Function of "Q" and "$\overline{Q}$" Outputs at High Speeds over a Temperature Range of 0 to +75°C.

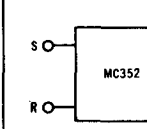
CIRCUIT SCHEMATIC



NOTE: Any unused inputs can normally be left open-circuited. In cases where there may be external leakage to the unused inputs they should be connected to V_{EE}.

LOGIC SPECIFICATIONS

When V_H is defined as a logical "1" and V_L as a logical "0", the function is as follows:



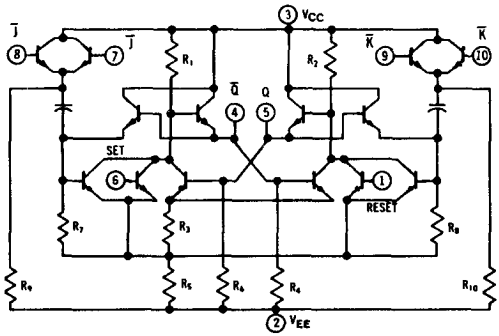
R	S	Q^{n+1}
0	1	1
1	0	0
0	0	Q^n
1	1	N.D.

MC358

J-K FLIP-FLOP

Performs the Single Phase Binary Function of "Q" and "$\overline{Q}$" Outputs at High Speeds over a Temperature Range of 0 to +75°C.

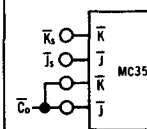
CIRCUIT SCHEMATIC



NOTE: Any unused inputs can normally be left open-circuited. In cases where there may be external leakage to the unused inputs they should be connected to V_{EE}.

LOGIC SPECIFICATIONS

When V_H is defined as a logical "1" and V_L as a logical "0", the function is as follows:



Clocked JK Operation

$\overline{J}_s$	$\overline{K}_s$	$\overline{C}_o$	Q^{n+1}
ϕ	ϕ	0	Q^n
0	0	1	$\overline{Q}^n$
0	1	1	1
1	0	1	0
1	1	1	Q^n

The $\overline{J}_s$ and $\overline{K}_s$ inputs refer to logic levels while the $\overline{C}_o$ input refers to dynamic logic swings. The $\overline{J}_s$ and $\overline{K}_s$ inputs would be changed to a logical "1" only while the $\overline{C}_o$ input is in a logic "1" state.

Set-Reset operation is the same as the MC352.

MC350 MECL series (continued)

FLIP-FLOPS (CONTINUED)

MC352, MC358

ELECTRICAL CHARACTERISTICS: $V_{EE} = -5.2$ Vdc ±1%, $V_{CC} = 0$

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
DC CHARACTERISTICS									
"Q" or "$\bar{Q}$" Logical "1" Output Voltage	Each Input: V_{in} = -1.350 Vdc	V_1	0.715	0.850	0.670	0.795	0.590	0.725	Vdc
"Q" or "$\bar{Q}$" Logical "0" Output Voltage	Each Input: V_{in} = -1.350 Vdc	V_2	1.570	1.830	1.465	1.700	1.395	1.680	Vdc
"Q" or "$\bar{Q}$" Saturation Breakpoint Voltage	dV "Q"/dV_{in} = 0; dV "$\bar{Q}$"/dV_{in} = 0	V_3	—	0.61	—	0.65	—	0.73	Vdc
"Q" or "$\bar{Q}$" Latch Voltage (MC352)	$dV_1/dV_{in} \approx \infty$	V_L	1.11	1.34	1.09	1.30	1.02	1.23	Vdc
(MC358)	$dV_1/dV_{in} \approx \infty$	V_L	1.11	1.25	1.09	1.21	1.02	1.14	Vdc
Total Power Supply Current	All Inputs Open	I_E	—	9.3	—	8.90	—	8.30	mAdc
LOADING CHARACTERISTICS									
"Q" Output Voltage Change	All Inputs Open, measured between no load and full load V_{in} (pin 6) = -0.850 Vdc @ 0°C V_{in} (pin 6) = -0.795 Vdc @ 25°C V_{in} (pin 6) = -0.725 Vdc @ 75°C No load = 0 current (pin 5) Full load = 2.5 mAdc ± 5% (pin 5)	ΔV_1	— — —	0.075 — —	— — —	— 0.075 —	— — —	— — 0.085	Vdc
"$\bar{Q}$" Output Voltage Change	All Inputs Open, measured between no load and Full load, V_{in} at pin 10 for MC352, pin 1 for MC358 V_{in} = -0.850 Vdc @ 0°C V_{in} = -0.795 Vdc @ 25°C V_{in} = -0.725 Vdc @ 72°C No load = 0 current (pin 4) Full load = 2.5 mAdc ± 5% (pin 4)	ΔV_1	— — —	0.075 — —	— — —	— 0.075 —	— — —	— — 0.085	Vdc
Output Voltage at Max I_{in}	Set "Q" to upper state: V_{in} = -0.850 Vdc (pin 8) @ 0°C V_{in} = -0.795 Vdc (pin 6) @ 25°C V_{in} = -0.725 Vdc (pin 6) @ 75°C Remove V_{in}, Then Input = 120 µAdc ±1% @ 0°C 100 µAdc ±1% @ 25°C and 75°C	V_1	0.715 — —	0.850 — —	— 0.670 —	— 0.795 —	— — 0.590	— — 0.725	Vdc

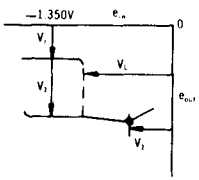
MC352:

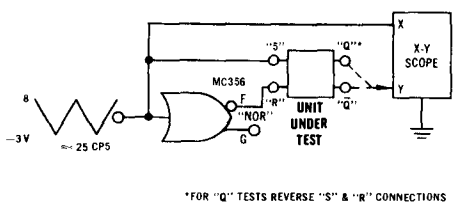
Input	Output
1. Pin 9	Pin 4 ("$\bar{Q}$")
2. Pin 7	Pin 5 ("$\bar{Q}$")
3. Pin 10	Pin 4 ("Q")
4. Pin 6	Pin 5 ("Q")

MC358:

Input	Output
1. Pin 1	Pin 4 ("$\bar{Q}$")
2. Pin 6	Pin 5 ("Q")

TRANSFER CHARACTERISTICS





*FOR "Q" TESTS REVERSE "S" & "R" CONNECTIONS

MC350 MECL series (continued)

FLIP-FLOPS (CONTINUED)

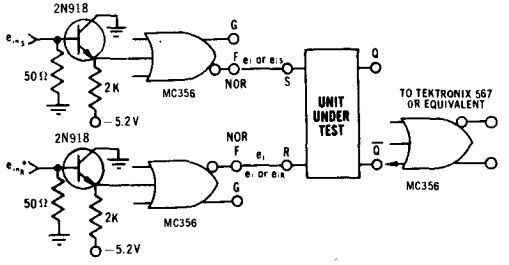
MC352

SWITCHING CHARACTERISTICS: V_{CC} = 0, V_{EE} = −5.2 Volts, (all ± 1%), V_H = −0.790 Vdc, V_L = −1.640 Vdc @ 0°C
V_H = −0.750 Vdc, V_L = −1.550 Vdc @ +25°C
V_H = −0.675 Vdc, V_L = −1.500 Vdc @ +75°C

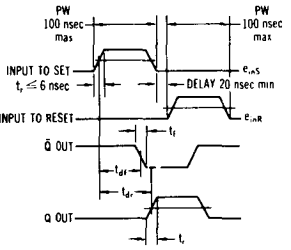
The stray capacitance introduced by the test jig was;
C_S = (n + 12) pf where n = number of fan-outs.

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
Propagation Delay Time	Either Output (Fan-In = 1, Fan-Out = 1) Either Output (Fan-In = 1, Fan-Out = 1)	t_{dr} t_{df}	4.0 4.0	10.0 14.0	5.0 5.0	11.0 15.0	6.0 6.0	17.0 17.0	nsec
Rise Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_r	4.0	16.0	5.0	17.0	6.0	18.0	nsec
Fall Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_f	4.0	16.0	5.0	18.0	6.0	21.0	nsec

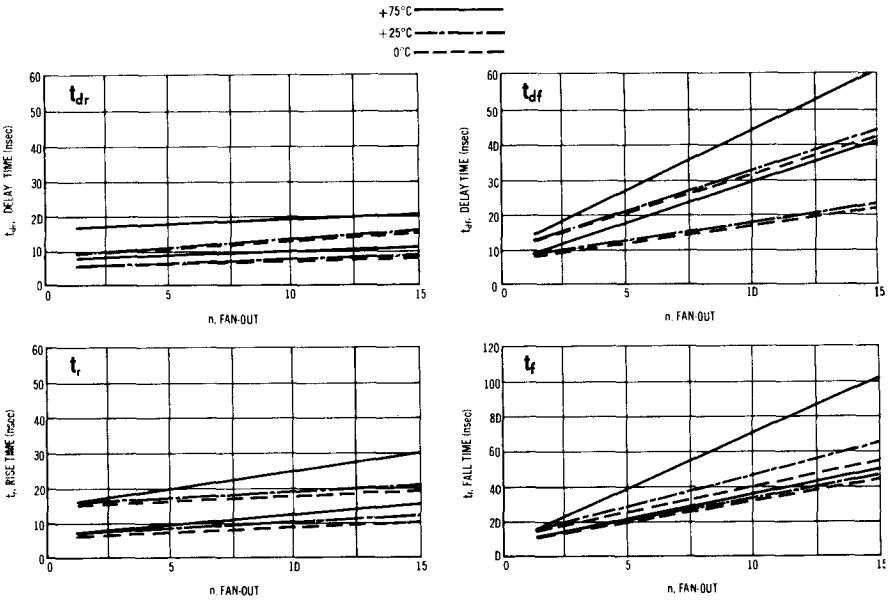
SWITCHING TIME TEST CIRCUIT



SWITCHING TIME TEST PROCEDURE



SWITCHING CHARACTERISTICS
(10% to 90% distribution)



MC350 MECL series (continued)

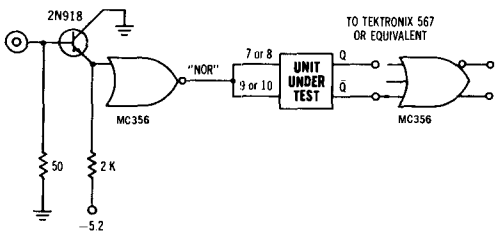
FLIP-FLOPS (CONTINUED)

MC358

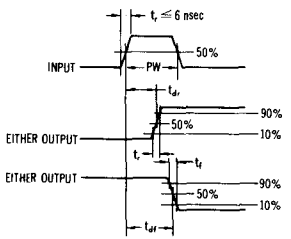
SWITCHING CHARACTERISTICS: $V_{CC} = 0$, $V_{EE} = -5.2$ Volts, (all ±1%). $V_{IH} = -0.790$ Vdc, $V_{IL} = -1.640$ Vdc @ 0°C
The stray capacitance introduced by the test jig was; $V_{IH} = -0.750$ Vdc, $V_{IL} = -1.550$ Vdc @ +25°C
$C_s = (n + 12)$ pf where n = number of fan-outs. $V_{IH} = -0.675$ Vdc, $V_{IL} = -1.500$ Vdc @ +75°C

Test	Conditions	Symbol	0°C		25°C		75°C		Units
			min	max	min	max	min	max	
Propagation Delay Time	Either Output (Fan-In = 1, Fan-Out = 1) Either Output (Fan-In = 1, Fan-Out = 1)	t_{dr} t_{df}	4.0 4.0	11.0 13.0	5.0 5.0	15.0 16.0	6.0 6.0	30.0 18.0	nsec nsec
Rise Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_r	4.0	15.0	5.0	15.0	6.0	27.0	nsec
Fall Time	Either Output (Fan-In = 1, Fan-Out = 1)	t_f	4.0	16.0	5.0	16.0	6.0	35.0	nsec

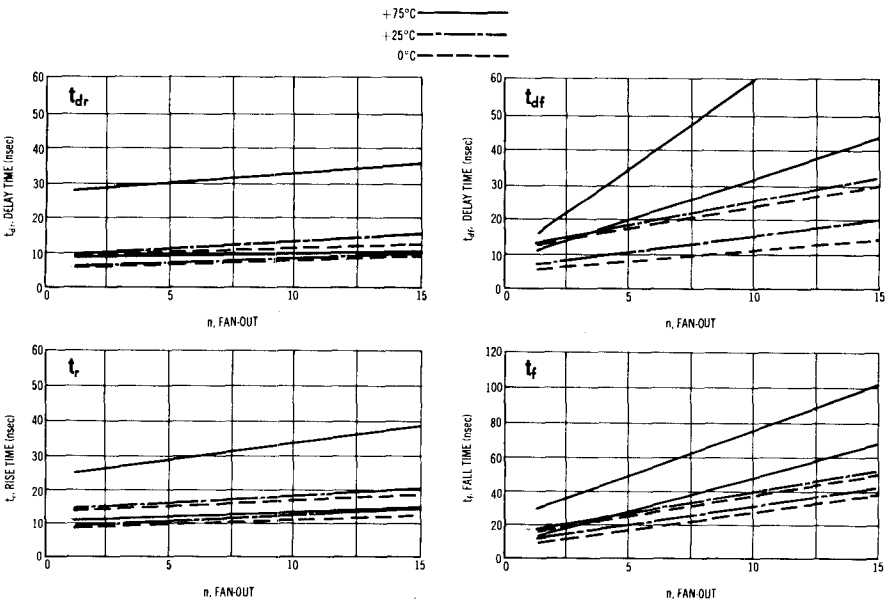
SWITCHING TIME TEST CIRCUIT



SWITCHING WAVEFORMS



SWITCHING CHARACTERISTICS
(10% to 90% distribution)



MC350 MECL series (continued)

MC355

GATE EXPANDER

Designed primarily for use in conjunction With the MC356 and MC357 "MECL" 3-INPUT LOGIC GATES. Each expander unit increases the fan-in of the basic gate by five.

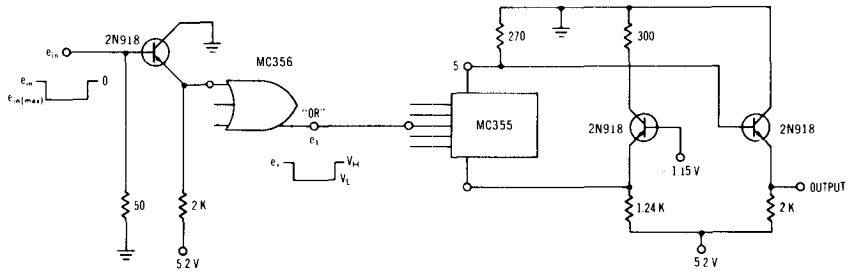
ELECTRICAL CHARACTERISTICS

Test	Conditions	Symbol	0°C min	0°C max	25°C min	25°C max	75°C min	75°C max	Units
Base Leakage Current	V_{EE} = -2.0 Vdc, V_{CC} = 0, V_{BB} = -5.2 Vdc	I_{BL}	—	0.5	—	0.5	—	2.0	μAdc
Input Voltage	V_{CB} = -0.7 Vdc, V_B = 0, I_E = -1.33 mAdc	V_{BE}	0.730	0.770	0.680	0.720	0.580	0.620	Vdc
Collector Leakage Current	V_{CC} = -2 Vdc, V_{BE} = 0.3 Vdc (All inputs), V_{EE} = 0	I_{CEX}	—	1.0	—	1.0	—	15.0	μAdc

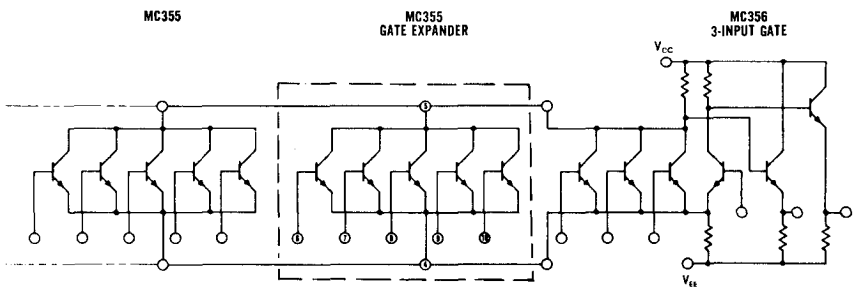
SWITCHING CHARACTERISTICS

Propagation Delay		t_{d1} t_{d2}	3.0 3.0	8.0 11.0	3.0 4.0	9.0 11.0	4.0 5.0	11.0 13.0	nsec
Rise Time		t_r	3.0	12.0	4.0	13.0	5.0	15.0	nsec
Fall Time		t_f	3.0	13.0	4.0	14.0	5.0	16.0	nsec

SWITCHING TIME TEST CIRCUIT



CIRCUIT SCHEMATIC AND INTERCONNECTION TO MC356 3-INPUT GATE



NOTE: Any unused inputs can normally be left open-circuited. In cases where there may be external leakage to the unused inputs they should be connected to V_{EE}.

MC650 VTL series

DIGITAL CIRCUIT SERIES

MC650G
DUAL 3-INPUT GATE

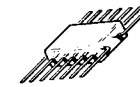
MC651F
DUAL 4-INPUT GATE

Variable Threshold Logic provides a means for varying noise immunity characteristics by varying the external supply voltage. This series provides input noise immunity as high as 5 volts with logic swings as great as 10 volts.



12 PIN
(MC650G ONLY)

CASE 98



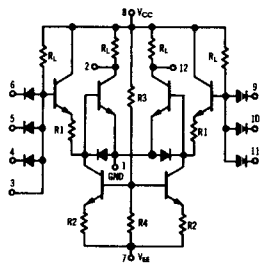
14 PIN FLAT PACKAGE
(MC651F ONLY)

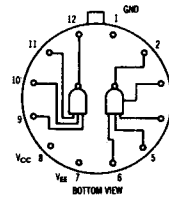
CASE 72

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

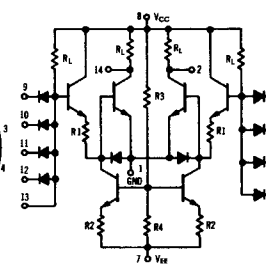
Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	+12	Vdc
Power Supply Voltage	V_{EE}	-12	Vdc
Input Voltage	V_{in}	+12	Vdc
Current (All Pins)	—	30	mAdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

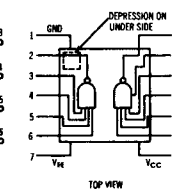
CIRCUIT SCHEMATIC AND LOGIC DIAGRAMS





MC650G





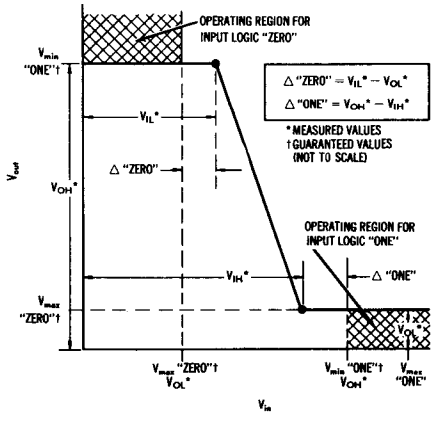
MC651F

MC650G, MC651F (continued)

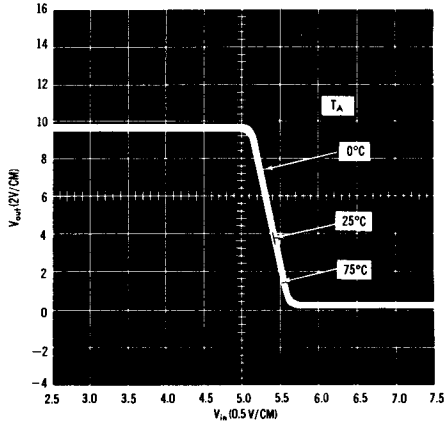
ELECTRICAL CHARACTERISTICS (V_{CC} = 10 Vdc, V_{EE} = −10 Vdc, T_A = 0 to +75° unless otherwise noted)

Characteristic	Figure No.	Symbol	Min	Typ	Max	Unit
Output Saturation Voltage (I_{out} = 15 mA, All Inputs to V_{CC})		V_{max} "0"	—	—	0.725	Vdc
Output High Voltage (I_{out} = -25 μA, All Inputs to ground)		V_{min} "1"	9.65	—	—	Vdc
Input Leakage Current (V_{in} = +10 V)		I_R	—	—	5.0	μAdc
Input Down Current (Inputs individually to ground)		I_F	—	—	3.0	mAdc
TRANSFER CHARACTERISTICS	1					
Output Voltage ($V_{IL(min)}$ = 4.3 V, I_{out} = -25 μA)		V_{out}	9.55	—	—	Vdc
($V_{IH(max)}$ = 6.5 V, I_{out} = 15 mA)			—	—	0.750	
Ground DC Noise Immunity (Fan-Out = 5)	9	V_{NG}	—	3.7	—	Vdc
SWITCHING TIME	16					
Propagation Delay (Fan-Out = 5)		t_{d2}	—	45	—	nsec
Propagation Delay (Fan-Out = 1)		t_{d1}	—	55	—	nsec
Output Capacitance (f = 100 kc, input pins grounded)		C_{out}	—	11	—	pf
Input Capacitance (f = 100 kc, input bias = 0 V, unused pins grounded)		C_{in}	—	4	—	pf
Supply Current - Both Gates						
Inputs Open		I_{CC}	—	—	19	mAdc
		I_{EE}	—	—	7.5	mAdc
Inputs Ground		I_{CC}	—	—	10.0	mAdc
		I_{EE}	—	—	7.5	mAdc
Fan-Out		n	—	—	5	—

TRANSFER CHARACTERISTIC DEFINITIONS



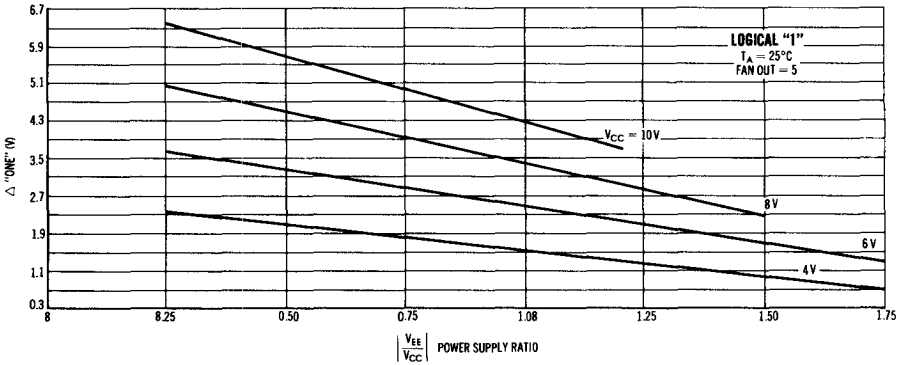
INPUT/OUTPUT TRANSFER CHARACTERISTIC VARIATIONS WITH TEMPERATURE

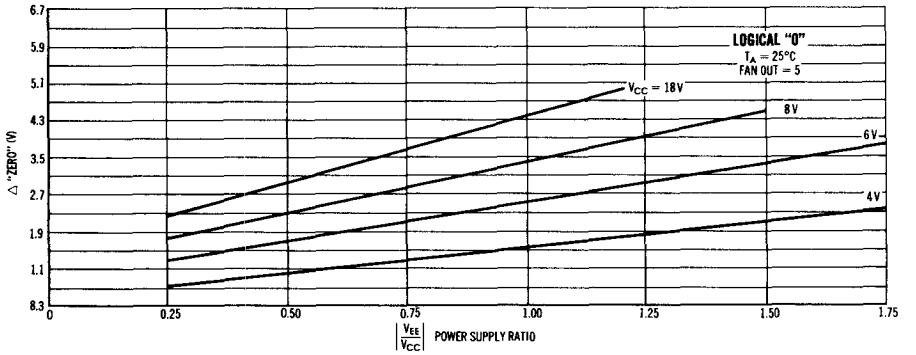


MC650G, MC651F (continued)

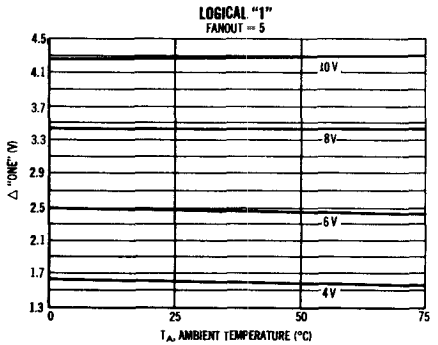
TYPICAL CHARACTERISTIC CURVES

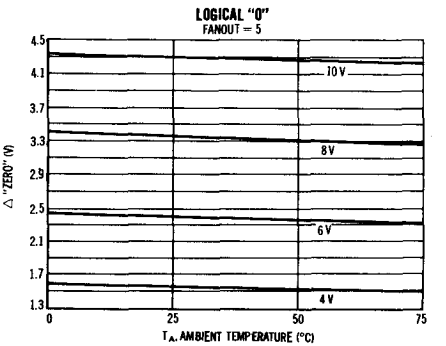
INPUT DC NOISE MARGIN versus POWER SUPPLY RATIO





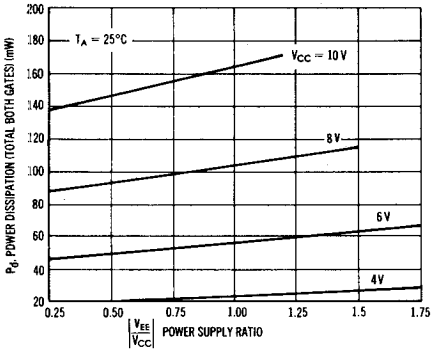
INPUT DC NOISE MARGIN versus TEMPERATURE



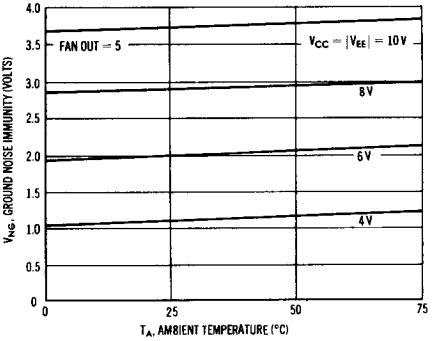


MC650G, MC651F (continued)

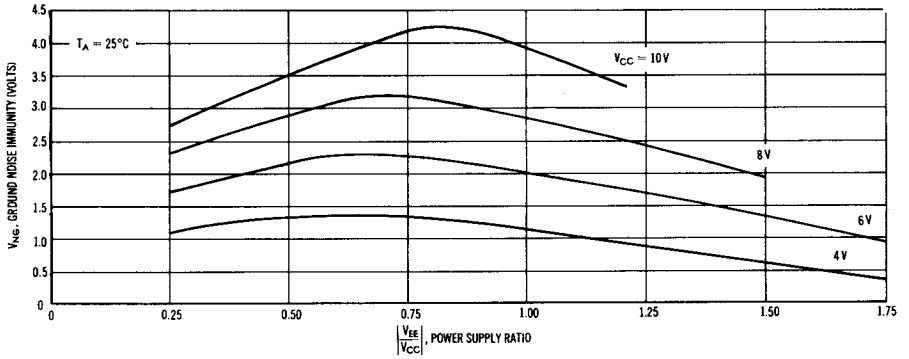
POWER DISSIPATION versus POWER SUPPLY RATIO



GROUND NOISE IMMUNITY versus TEMPERATURE

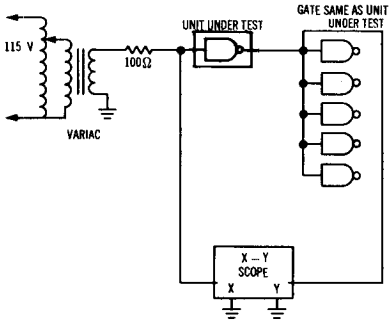


GROUND NOISE IMMUNITY versus POWER SUPPLY RATIO

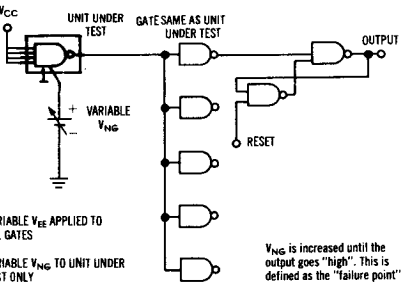


TEST CIRCUITS

INPUT NOISE MARGIN



GROUND NOISE IMMUNITY

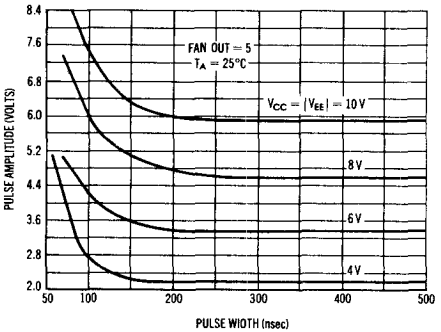


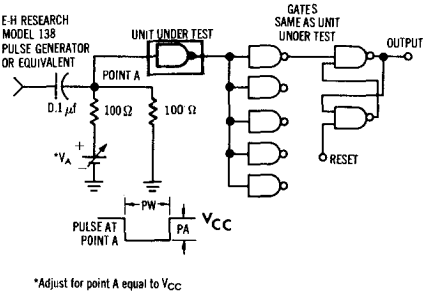
MC650G, MC651F (continued)

PULSE NOISE TESTS

For a given pulse width, the pulse amplitude is increased until the output goes "high". This is defined as the "Failure Point".

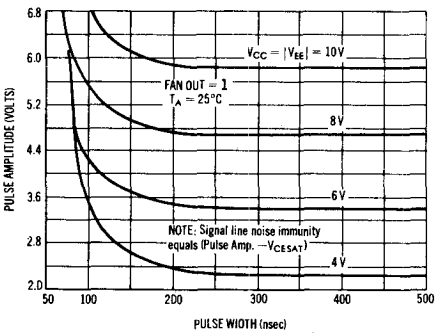
SIGNAL-LINE NEGATIVE PULSE AMPLITUDE versus PULSE WIDTH

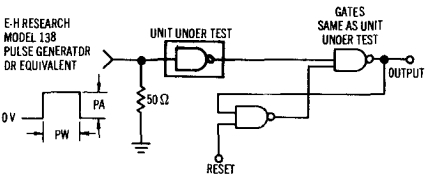




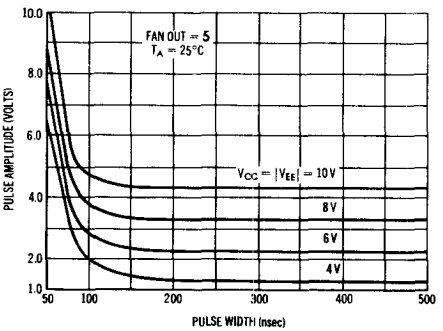
*Adjust for point A equal to V_{CC}

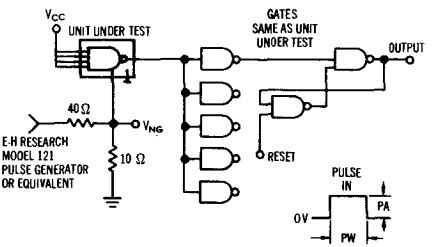
SIGNAL-LINE POSITIVE PULSE AMPLITUDE versus PULSE WIDTH





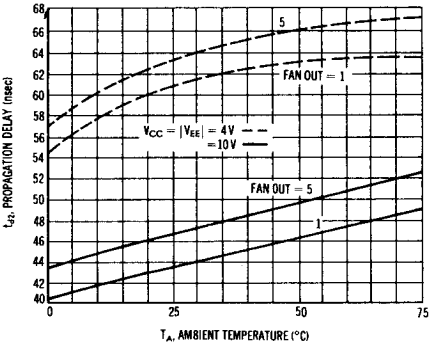
GROUND-LINE POSITIVE PULSE AMPLITUDE versus PULSE WIDTH



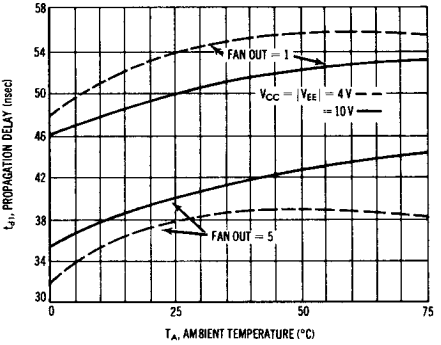


MC650G, MC651F (continued)

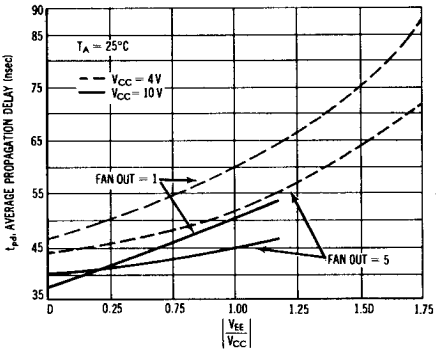
t_{d2} PROPAGATION DELAY versus TEMPERATURE



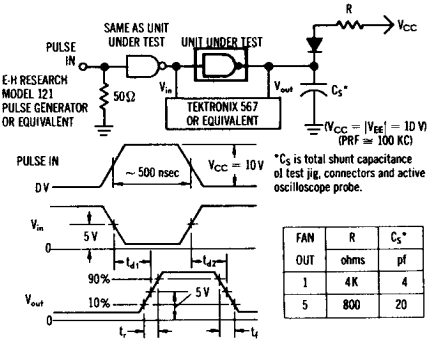
t_{d1} PROPAGATION DELAY versus TEMPERATURE



AVERAGE PROPAGATION DELAY versus POWER SUPPLY RATIO

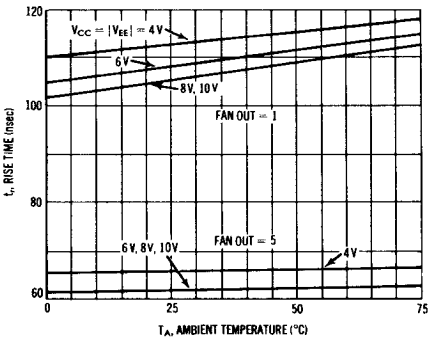


SWITCHING TIME TEST CIRCUIT

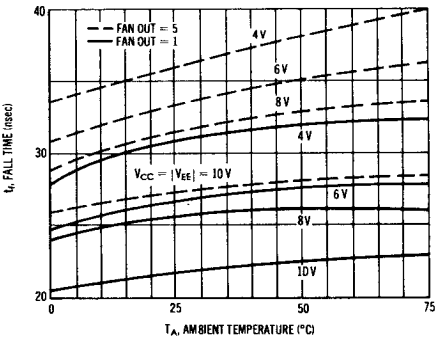


FAN OUT	R ohms	C_S* pf
1	4K	4
5	800	20

RISE TIME versus TEMPERATURE



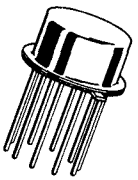
FALL TIME versus TEMPERATURE



MC652F
MC652G



CASE 83
(14-pin flat package)



CASE 98
(12-pin)

This VTL R-S flip-flop has two set and two reset inputs, a feature which allows logic operations to be performed while generating the set and reset functions. A shift register may be fabricated from two MC652 units.

ELECTRICAL CHARACTERISTICS V_{CC} = 10 Vdc, V_{EE} = −10 Vdc, T_A = 0 to +75°C unless otherwise noted

Characteristic	Symbol	Min	Typ	Max	Unit
Output "LOW" Voltage I_Q = 12 mA, R_1 and R_2 = V_{CC} $I_{\bar{Q}}$ = 12 mA, S_1 and S_2 = V_{CC}	Q $\bar{Q}$	— —	— —	0.725 0.725	Vdc Vdc
Output "HIGH" Voltage I_Q = -25 μA, S_1 and S_2 = V_{CC} $I_{\bar{Q}}$ = -25 μA, R_1 and R_2 = V_{CC}	Q $\bar{Q}$	9.65 9.65	— —	— —	Vdc Vdc
Input Leakage Current (V_{in} = +10 Vdc)	I_R	—	—	5.0	μAdc
Input "DOWN" Current Inputs individually to ground	I_F	—	—	3.0	mAdc
Ground DC Noise Immunity Voltage (Fan-Out = 4)	V_{NG}	—	3.7	—	Vdc
Switching Times, Figure 2 and 3 (Fan-Out = 1) Set-Reset Mode DC $\overline{\text{Set}}$-$\overline{\text{Reset}}$ Mode	t_{d1} t_{d2} t_{d1} t_{d2}	— — — —	40 75 40 70	— — — —	nsec nsec nsec nsec
Supply Current (All Inputs Open)	I_{CC} I_{EE}	— —	— —	23.0 7.5	mAdc mAdc
Input Capacitance (f = 100 kc, Input Bias = 0, unused pins grounded)	C_{in}	—	3	—	pf
Output Capacitance (f = 100 kc, Input pins grounded)	C_{out}	—	14	—	pf
Fan-Out	n	—	—	4	—

MC652F, MC652G (continued)

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC} V_{EE}	12 -12	Vdc
Input Voltage	V_{in}	12	Vdc
Current (all pins)	—	30	mAdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

NOTE: To assure correct biasing apply negative voltage to V_{EE} pin ONLY.

CIRCUIT SCHEMATIC

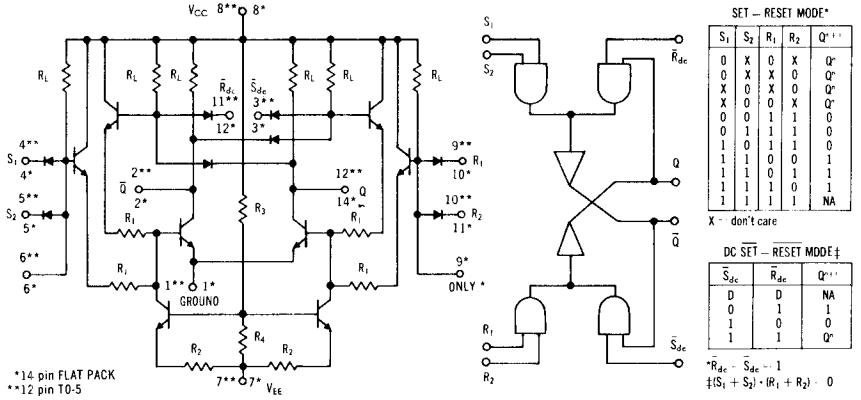
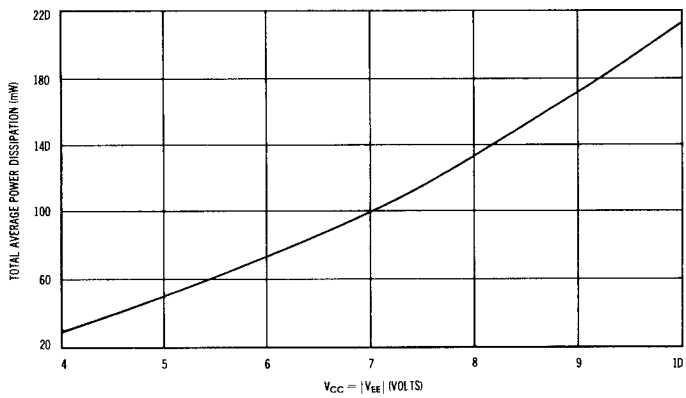


FIGURE 1 – AVERAGE POWER DISSIPATION versus POWER SUPPLY VOLTAGE



MC652F, MC652G (continued)

FIGURE 2 — PROPAGATION DELAY versus TEMPERATURE

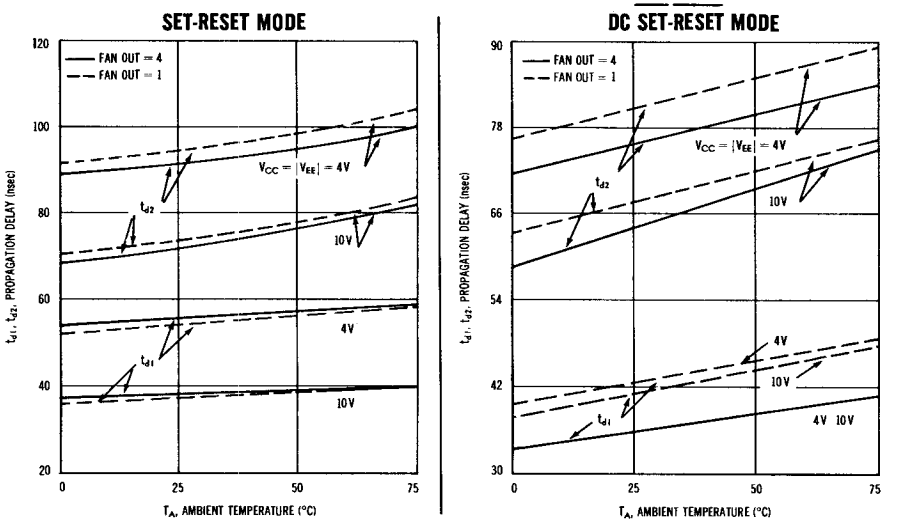
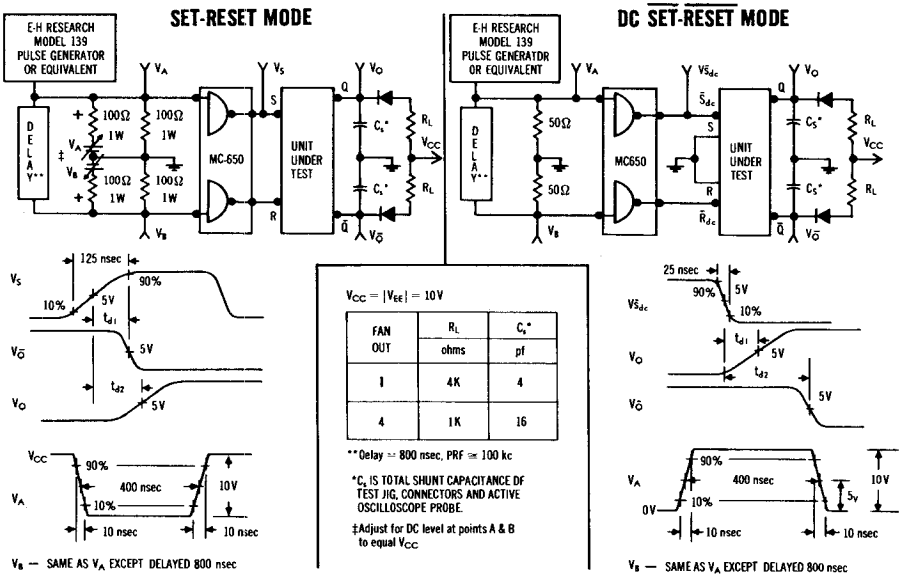


FIGURE 3 — TEST CIRCUIT PROPAGATION DELAY



$V_{CC} = |V_{EE}| = 10V$

FAN OUT	R_L ohms	C_L* pf
1	4K	4
4	1K	16

**Delay ≈ 800 nsec, PRF ≈ 100 kc

*C_L IS TOTAL SHUNT CAPACITANCE OF TEST JIG, CONNECTORS AND ACTIVE OSCILLOSCOPE PROBE.

‡Adjust for DC level at points A & B to equal V_{CC}

V_B — SAME AS V_A EXCEPT DELAYED 800 nsec

V_B — SAME AS V_A EXCEPT DELAYED 800 nsec

MC652F, MC652G (continued)

FIGURE 4 — "SET" PULSE AMPLITUDE versus PULSE WIDTH

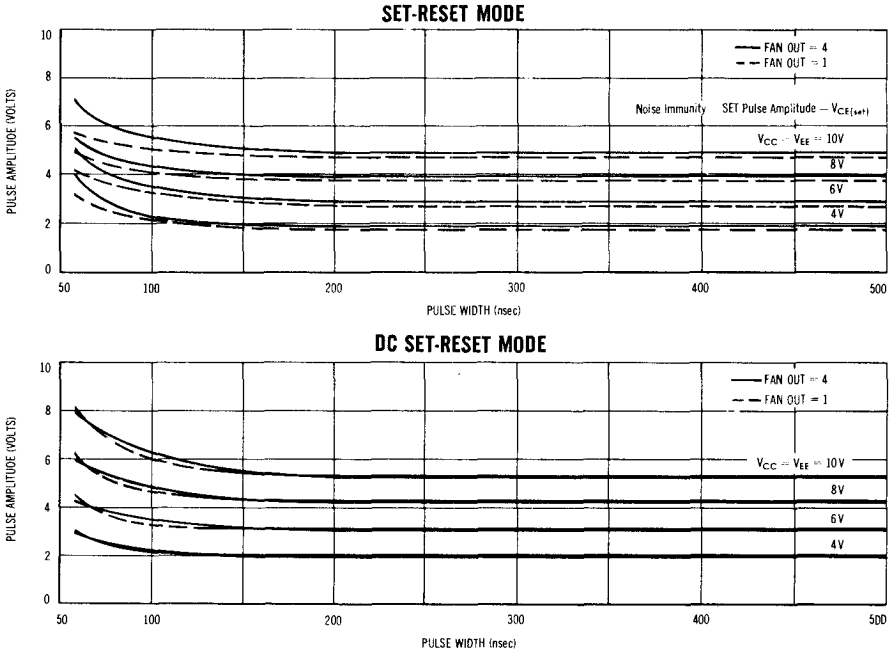
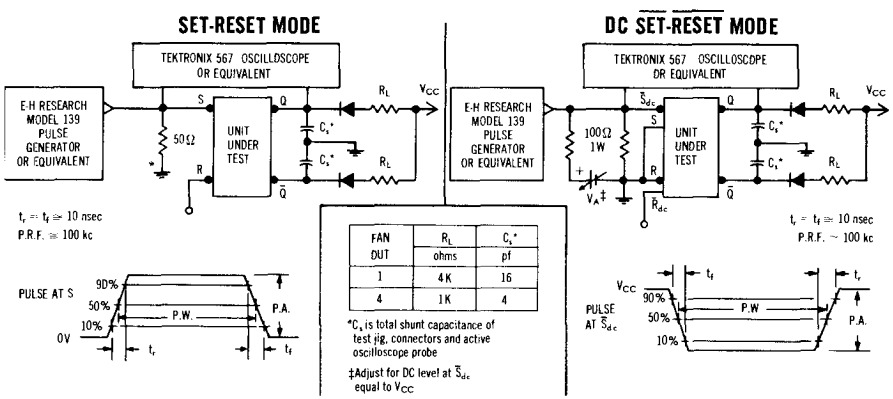


FIGURE 5 — "SET" PULSE AMPLITUDE versus PULSE WIDTH TEST CIRCUITS



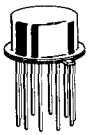
MC700G RTL Series

INDUSTRIAL/COMMERCIAL RTL INTEGRATED CIRCUITS

The Commercial/Industrial RTL line consists of a combination of Milliwatt RTL (low power) and RTL (medium power) devices, and is intended for use in commercial/industrial applications. The loading diagrams are guaranteed over a temperature range of +15°C to +55°C by utilizing a worst-case specification.



CASE 96



CASE 96A

MC715G, MC718G, MC726G, MC727G, MC799G ONLY

MILLIWATT RTL — LOW POWER

ADDER		MC708G
BUFFER		MC709G
LOGIC GATES		
DUAL 2-INPUT GATE		MC710G
4-INPUT GATE		MC711G
DUAL 3-INPUT GATE		MC718G
5-INPUT GATE		MC728G
HALF-ADDER		MC712G
FLIP-FLOP	MC713G	MC720G
GATE EXPANDER		MC721G

RTL — MEDIUM POWER

BUFFER		MC700G
DUAL BUFFER		MC799G
COUNTER ADAPTER		MC701G
FLIP-FLOPS	MC726G MC702G	MC723G
LOGIC GATES		
3-INPUT GATE		MC703G
4-INPUT GATE		MC707G
5-INPUT GATE		MC729G
DUAL 2-INPUT GATE		MC714G
DUAL 3-INPUT GATE		MC715G
HALF-ADDER		MC704G
HALF-SHIFT REGISTERS	MC705G,	MC706G
QUAD INVERTER		MC727G

TYPICAL DESIGN CHARACTERISTICS ($T_A = 25°C$)

Characteristic	Rating	Unit
Power Dissipation		mW/node
Milliwatt RTL (Low Power)	3	
RTL (Medium Power)	20	
Noise Immunity	300	mV
Average Propagation Delay		nsec
MC713G	70	
MC720G	60	
MC723G	25	
MC726G	40	
Average Propagation Delay (Ring Oscillator Operation)		nsec
MC700G	15	
MC701G	20	
MC702G	10	
MC702G	10	
MC704G	10	
MC705G	20	
MC706G	20	
MC707G	10	
MC708G	50	
MC709G	25	
MC710G	25	
MC711G	25	
MC712G	50	
MC714G	10	
MC715G	10	
MC718G	25	
MC721G	25	
MC727G	10	
MC728G	25	
MC729G	10	
MC799G	15	

MC700G (continued)

GENERAL RULES

The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.

All unused inputs should be returned to ground.

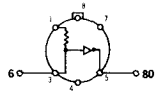
The MC721G is essentially the same as the MC710G with the omission of node resistors, and is intended only for use with the MC710G, MC711G, and MC718G.

Vcc is applied to Pin 8 with Pin 4 grounded except on the MC715G and MC718G, where Vcc is applied to Pin 10 with Pin 5 grounded.

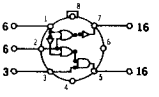
Loading diagrams are intended for use when mixing Milliwatt RTL and RTL in system applications.

LOADING DIAGRAMS

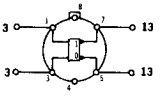
Valid from +15°C to +55°C with $V_{cc} = 3.6\ V \pm 10\%$



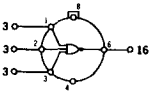
MC700G



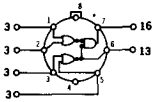
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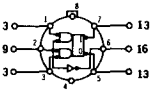
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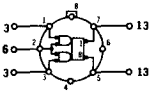
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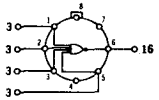
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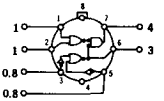
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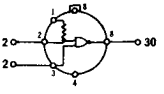
MC706G



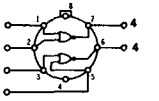
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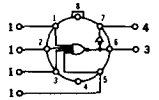
MC708G



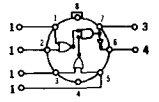
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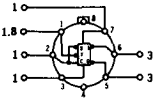
MC710G



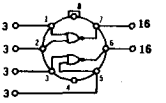
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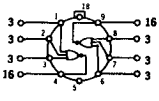
MC712G



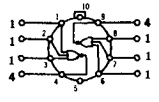
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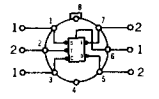
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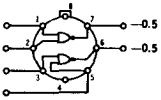
MC715G



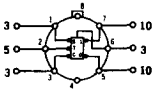
MC718G



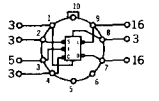
MC720G



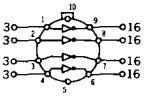
MC721G



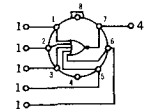
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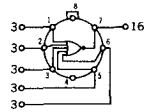
MC726G



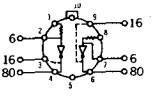
MC727G



MC728G



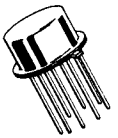
MC729G



MC799G

MC900G / MC800G RTL Series

MC900G SERIES / MC800G SERIES RTL INTEGRATED CIRCUITS



The RTL line consists of monolithic, integrated Resistor-Transistor Logic Circuits. The MC900G series and MC800G series are designed for use over the temperature range of −55°C to +125°C and 0°C to +100°C, respectively.

BUFFERS

MC900G, MC800G
MC999G, MC899G

COUNTER ADAPTERS

MC901G, MC801G

HALF-ADDERS

MC904G, MC804G

LOGIC GATES

3-INPUT GATES
MC903G, MC803G

4-INPUT GATES
MC929G, MC829G

5-INPUT GATES
MC929G, MC829G

DUAL 2-INPUT GATES
MC914G, MC814G

DUAL 3-INPUT GATES
MC915G, MC815G

HALF-SHIFT REGISTERS

MC905G, MC805G
MC906G, MC806G

FLIP-FLOPS

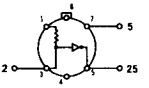
MC902G, MC802G
MC916G, MC816G
MC927G, MC827G

INVERTERS

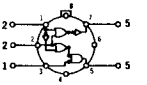
MC927G, MC827G

LOADING DIAGRAMS

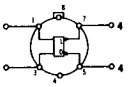
Valid for V_{CC} = 3.0V ±10%; Temperature Range = −55 to +125°C for MC900G series
0 to +100°C for MC800G series



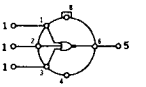
MC900G, MC800G



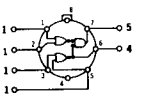
MC901G, MC881G



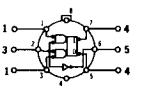
MC902G, MC802G



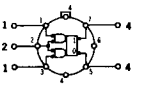
MC903G, MC803G



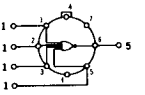
MC984G, MC804G



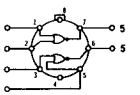
MC905G, MC805G



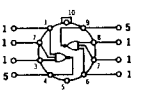
MC906G, MC806G



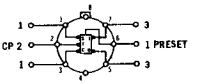
MC987G, MC807G



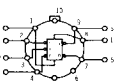
MC914G, MC814G



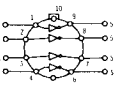
MC915G, MC815G



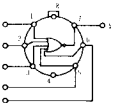
MC916G, MC816G



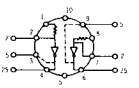
MC926G, MC826G



MC927G, MC827G



MC929G, MC829G



MC999G, MC899G

MC900G / MC800G series (continued)

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic		Symbol	Rating	Unit
Logic Input Voltage		—	±4	Vdc
Power Supply Voltage		—	+12	Vdc
Operating Temperature Range	MC900G Series MC800G Series	T_A	-55 to +125 0 to +100	°C
Storage Temperature Range		T_{stg}	-65 to +150	°C
Power Dissipation		P_D	500	mW

TEST CONDITION TOLERANCES

$V_{BOT} = \pm 10$ mV $V_{CC} = \pm 10$ mV $V_{in} = \pm 2$ mV $V_{on} = \pm 2$ mV $V_{off} = \pm 2$ mV

GENERAL RULES

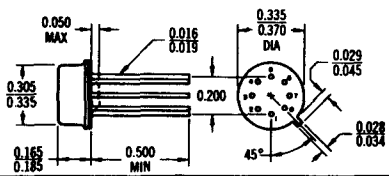
- The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.
- A gate output connected in parallel with another output reduces the drive capability by ½ load. (Paralleling gate circuits requires a V_{CC} connection to only one of the gates.)
- Any number of gates may be paralleled if the input loading is increased by ¼ load.
- If the counter adapter is paralleled with another circuit, the output drive capability must be reduced by 2 loads. The reason for this drive reduction is the 1280-ohm resistance that connects the output terminals on the counter adapter.
- All unused inputs should be returned to ground.

DEFINITIONS

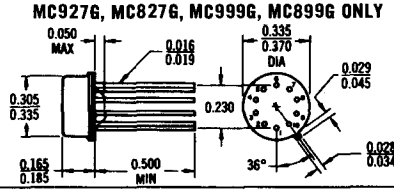
I_{A3}, I_{A4}, I_{A5}	Minimum available output current for outputs with a loading factor of 3, 4, and 5 respectively
I_{AB}	Minimum available output current from the MC900G Buffer
I_{CEX}	Output leakage current
I_{in}	Maximum input current, with V_{in} applied and a fan-in greater than one
$2I_{in}$, $3I_{in}$	Maximum input current for 2 or 3 bases, respectively, with V_{in} applied
V_{BOT}	Maximum input voltage
V_{CC}	Supply voltage
V_{CE}	Maximum saturation voltage, V_{in} applied to input
V_{in}	Minimum high-level voltage
V_{off}	Maximum input voltage that will not turn on the transistor
V_{on}	Minimum turn-on voltage
V_{out}	Maximum output voltage, V_{on} applied to input
V_R	Resistor connection to V_{CC} for output voltage reading

OUTLINE DIMENSIONS

8 LEAD PACKAGE



10-LEAD PACKAGE
MC915G, MC815G, MC926G, MC826G, MC927G, MC827G, MC999G, MC899G ONLY



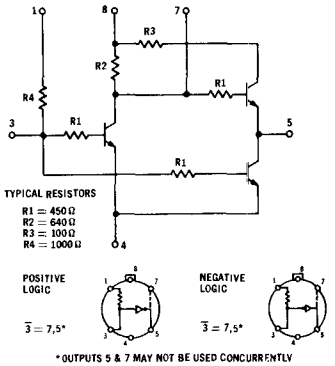
MC900G / MC800G series (continued)

BUFFERS

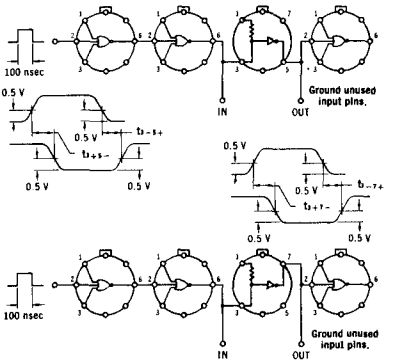
MC900G
MC800G

The buffer is designed to drive a greater number of load circuits than the basic RTL circuit. Because this circuit has a very low output impedance the rise times of output waveforms are maintained when driving capacitive loads. A resistor which is internally connected to the input allows for capacitive coupling to the input, the differentiation of input waveforms, and various multivibrator applications.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS

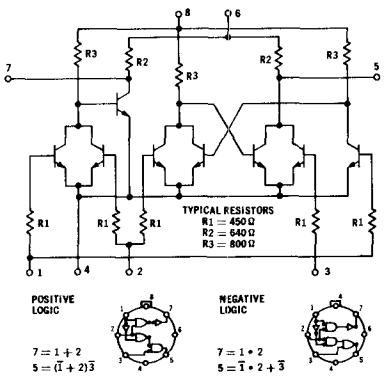


COUNTER ADAPTERS

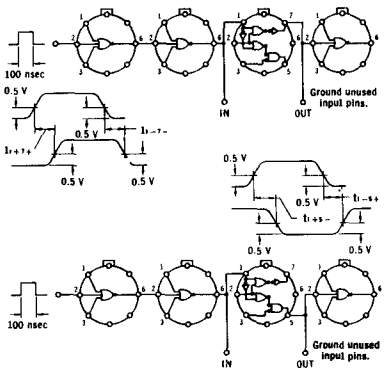
MC901G
MC801G

This device provides the true output at Pin 7 and the complement output at Pin 5 for an input applied to Pin 1. A positive gating signal may be applied to Pin 2 to inhibit both outputs. A positive signal applied to Pin 3 will hold output Pin 5 at near-ground potential. The output nodes are returned separately to the power supply so that the outputs might be paralleled with other circuits.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS



MC900G / MC800G series (continued)

BUFFERS

ELECTRICAL CHARACTERISTICS

MC900G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	Volts V_{on} Pin No.	Volts V_{BOT} Pin No.	Volts V_{off} Pin No.	Volts V_{CC} Pin No.	Ohms V_R Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00	680*
+25°C	0.844	0.815	1.50	0.565	3.00	680*
+125°C	0.674	0.674	1.50	0.320	3.00	820*

Power Dissipation @ T_A = 25°C: Input High: 16 mW typical, 24 mW maximum
Input Low: 45 mW typical, 52 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_R Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	3	—	—	—	8	—	4	1, 5, 7	$2\ I_{in}(3)$	—	990	—	870	—	940	μAdc
Output Current	—	7	—	3	8	—	4	1, 5	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
	—	5	—	3	8	—	4	1, 7	$I_{AB}(5)$	12.4	—	12.7	—	11.8	—	mAdc
Output Voltage	—	3	—	—	8	5	4	1, 7	$V_{out}(5)$	—	710	—	300	—	320	mVdc
	—	3	—	—	8	—	4	1, 5, 7	$V_{out}(7)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	3	—	8	5	4	1, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	3	—	8	—	4	1, 5, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
	—	—	—	—	1, 8	—	4	3, 5, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out														
	3	5	—	—	8	—	4	1, 7	t_{3+5-}	—	—	—	30	—	—	nsec
	3	5	—	—	8	—	4	1, 7	t_{3-5+}	—	—	—	30	—	—	nsec
	3	7	—	—	8	—	4	1, 5	t_{3+7-}	—	—	—	28	—	—	nsec
	3	7	—	—	8	—	4	1, 5	t_{3-7+}	—	—	—	32	—	—	nsec

Pins 2 and 6 omitted. *Resistor Value to V_{CC}

COUNTER ADAPTERS

ELECTRICAL CHARACTERISTICS

MC901G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	Volts V_{on} Pin No.	Volts V_{BOT} Pin No.	Volts V_{off} Pin No.	Volts V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 55 mW typical, 70 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	6, 8	4	3, 5, 7	$2\ I_{in}(1)$	—	990	—	870	—	940	μAdc
	2	—	1	—	6, 8	4	3, 5, 7	$2\ I_{in}(2)$	—	990	—	870	—	940	μAdc
	2	—	—	—	6, 8	4	1, 3, 5, 7	$2\ I_{in}(2)$	—	990	—	870	—	940	μAdc
	3	—	1	—	6, 8	4	2, 5, 7	$I_{in}(3)$	—	495	—	435	—	470	μAdc
Output Current	—	5	—	1, 3	6, 8	4	2, 7	$I_{A5}(5)$	2.47	—	2.54	—	2.35	—	mAdc
	—	2, 5	1	3	6, 8	4	7	$I_{A5}(5)$	2.47	—	2.54	—	2.35	—	mAdc
	—	1, 7	—	—	6, 8	4	2, 3, 5	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
	—	2, 7	—	—	6, 8	4	1, 3, 5	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
Output Voltage	—	3	2	—	6, 8	4	1, 5, 7	$V_{out}(5)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	1	—	2	6, 8	4	3, 5, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	2, 3	—	6, 8	4	1, 5, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	—	1, 2	6, 8	4	3, 5, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	1	5	—	—	6, 8	4	2, 3, 7	t_{1+5-}	—	—	—	42	—	—	nsec
	1	5	—	—	6, 8	4	2, 3, 7	t_{1-5+}	—	—	—	42	—	—	nsec
	1	7	—	—	6, 8	4	2, 3, 5	t_{1+7+}	—	—	—	38	—	—	nsec
	1	7	—	—	6, 8	4	2, 3, 5	t_{1-7-}	—	—	—	36	—	—	nsec

MC900G / MC800G series (continued)

BUFFERS

ELECTRICAL CHARACTERISTICS — MC800G

Power Dissipation @ T_A = 25°C: Input High: 16 mW typical, 24 mW maximum; Input Low: 45 mW typical, 52 mW maximum

@ Test Temperature	Test Conditions: V_{in} Pin No. (Volts)	V_{on} Pin No. (Volts)	V_{IBOT} Pin No. (Volts)	V_{off} Pin No. (Volts)	V_{CC} Pin No. (Volts)	V_R^* Pin No. (Ohms)
0°C	0.909	0.909	1.50	0.574	3.00	680°
+25°C	0.844	0.844	1.50	0.554	3.00	680°
+100°C	0.710	0.710	1.50	0.370	3.00	880°

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{IBOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_R^* Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	3	—	—	—	8	—	4	1, 5, 7	$2\ I_{in}(3)$	—	1.81	—	8.90	—	0.90	mAdc
Output Current	—	7	—	3	8	—	4	1, 5	$I_{A5}(7)$	2.52	—	2.38	—	2.25	—	mAdc
	—	5	—	3	8	—	4	1, 7	$I_{AB}(5)$	12.6	—	11.8	—	11.25	—	mAdc
Output Voltage	—	3	—	—	8	5	4	1, 7	$V_{out}(5)$	—	574	—	400	—	378	mVdc
	—	3	—	—	8	—	4	1, 5, 7	$V_{out}(7)$	—	574	—	400	—	378	mVdc
Saturation Voltage	—	—	3	—	8	5	4	1, 7	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	1	—	8	—	4	1, 5, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	—	—	1, 8	—	4	3, 5, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out														
	3	5	—	—	8	—	4	1, 7	t_{3+5-}	—	—	—	30	—	—	nsec
	3	5	—	—	8	—	4	1, 7	t_{3-5+}	—	—	—	30	—	—	nsec
	3	7	—	—	8	—	4	1, 5	t_{3+7-}	—	—	—	28	—	—	nsec
	3	7	—	—	8	—	4	1, 5	t_{3-7+}	—	—	—	32	—	—	nsec

Pins 2 and 6 omitted. *Resistor Value to V_{CC}

COUNTER ADAPTERS

ELECTRICAL CHARACTERISTICS — MC801G

Power Dissipation @ T_A = 25°C: 55 mW typical, 70 mW maximum

@ Test Temperature	Test Conditions: V_{in} Pin No. (Volts)	V_{on} Pin No. (Volts)	V_{IBOT} Pin No. (Volts)	V_{off} Pin No. (Volts)	V_{CC} Pin No. (Volts)
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{IBOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2	—	6, 8	4	3, 5, 7	$2\ I_{in}(1)$	—	1.81	—	0.90	—	0.90	mAdc
	2	—	1	—	6, 8	4	3, 5, 7	$2\ I_{in}(2)$	—	1.81	—	8.90	—	8.90	mAdc
	2	—	—	—	8, 8	4	1, 3, 5, 7	$2\ I_{in}(2)$	—	1.81	—	8.90	—	8.90	mAdc
	2	—	1	—	8, 8	4	2, 5, 7	$I_{in}(3)$	—	504	—	450	—	450	μAdc
Output Current	—	5	—	1, 3	8, 8	4	2, 7	$I_{A5}(5)$	2.52	—	2.38	—	2.25	—	mAdc
	—	2, 5	1	3	6, 8	4	7	$I_{A5}(5)$	2.52	—	2.38	—	2.25	—	mAdc
	—	1, 7	—	—	8, 8	4	2, 3, 5	$I_{A5}(7)$	2.52	—	2.38	—	2.25	—	mAdc
	—	2, 7	—	—	6, 8	4	1, 3, 5	$I_{A5}(7)$	3.52	—	2.38	—	3.25	—	mAdc
Output Voltage	—	3	2	—	6, 8	4	1, 5, 7	$V_{out}(5)$	—	574	—	400	—	378	mVdc
Saturation Voltage	—	1	—	2	6, 8	4	3, 5, 7	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	2, 3	—	8, 6	4	1, 5, 7	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	—	1, 2	6, 8	4	3, 5, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	1	5	—	—	8, 6	4	2, 3, 7	t_{1+5-}	—	—	—	42	—	—	nsec
	1	5	—	—	6, 8	4	2, 3, 7	t_{1-5+}	—	—	—	42	—	—	nsec
	1	7	—	—	6, 8	4	2, 3, 5	t_{1+7+}	—	—	—	38	—	—	nsec
	1	7	—	—	6, 6	4	2, 3, 5	t_{1-7-}	—	—	—	38	—	—	nsec

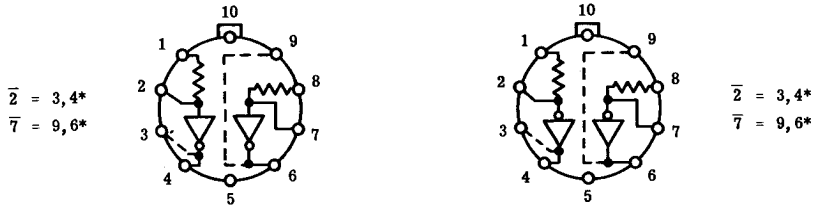
MC900G / MC800G series (continued)

The dual buffer is designed to drive a greater number of load circuits than the basic RTL circuit. Because this circuit has a very low output impedance the rise times of output waveforms are maintained when driving capacitive loads. A resistor which is internally connected to the input allows for capacitive coupling to the input, the differentiation of input waveforms and various multivibrator applications.

RTL DUAL BUFFER

MC999G MC899G

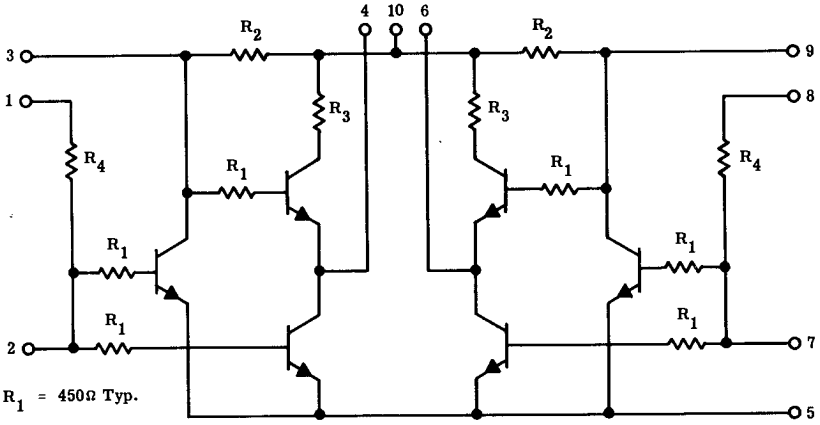
LOGIC SYMBOLS AND FUNCTIONS



*Outputs 3 & 4 or 9 & 6 may not be used concurrently.

POSITIVE LOGIC NEGATIVE LOGIC

CIRCUIT DIAGRAM



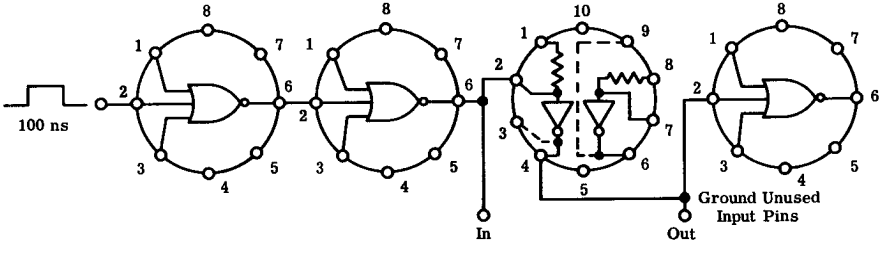
R_1 = 450Ω Typ.

R_2 = 640Ω Typ.

R_3 = 100Ω Typ.

R_4 = 1000Ω Typ.

SWITCHING TIME TEST CIRCUIT



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

DUAL BUFFERS

MC999G

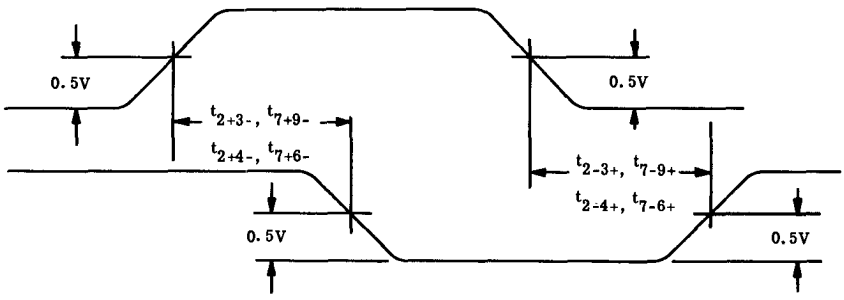
@ Test Temperature	Test Conditions		Volts			Ohms
−55°C	1.014	1.014	1.50	0.710	3.00	680*
+25°C	0.844	0.815	1.50	0.565	3.00	680*
+125°C	0.674	0.674	1.50	0.320	3.00	820*

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_R* Pin No.	Grounded Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	2				10		5	$2I_{IN}(2)$	---	990	---	870	---	940	μAdc
	7				10		5	$2I_{IN}(7)$	---	990	---	870	---	940	μAdc
Output Current		3		2	10		5	$I_{A5}(3)$	2.47	---	2.54	---	2.35	---	mAdc
		9		7	10		5	$I_{A5}(9)$	2.47	---	2.54	---	2.35	---	mAdc
		4		2	10		5	$I_{AB}(4)$	12.4	---	12.7	---	11.8	---	mAdc
		6		7	10		5	$I_{AB}(6)$	12.4	---	12.7	---	11.8	---	mAdc
Output Voltage		2			10	4	5	$V_{OUT}(4)$	---	710	---	300	---	320	mVdc
		7			10	6	5	$V_{OUT}(8)$	---	710	---	300	---	320	mVdc
		2			10		5	$V_{OUT}(3)$	---	710	---	300	---	320	mVdc
		7			10		5	$V_{OUT}(9)$	---	710	---	300	---	320	mVdc
Saturation Voltage			2		10	4	5	$V_{CE}(4)$	---	200	---	210	---	280	mVdc
			7		10	6	5	$V_{CE}(6)$	---	200	---	210	---	280	mVdc
			2		10		5	$V_{CE}(3)$	---	200	---	210	---	280	mVdc
			7		10		5	$V_{CE}(9)$	---	200	---	210	---	280	mVdc
					1, 10		5	$V_{CE}(3)$	---	200	---	210	---	280	mVdc
					8, 10		5	$V_{CE}(9)$	---	200	---	210	---	280	mVdc
Switching Time	Pulse in	Pulse out													
	2	4			10		5	t_{2+4-}	---	---	---	30	---	---	nsec
	2	4			10		5	t_{2-4+}	---	---	---	30	---	---	nsec
	2	3			10		5	t_{2+3-}	---	---	---	28	---	---	nsec
	2	3			10		5	t_{2-3+}	---	---	---	32	---	---	nsec
	7	6			10		5	t_{7+6-}	---	---	---	30	---	---	nsec
	7	6			10		5	t_{7-6+}	---	---	---	30	---	---	nsec
	7	9			10		5	t_{7+9-}	---	---	---	28	---	---	nsec
	7	9			10		5	t_{7-9+}	---	---	---	32	---	---	nsec

Pins not referenced are open.

*Resistor to V_{CC}

SWITCHING TIME WAVEFORM



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

DUAL BUFFERS

MC899G

	Test Conditions Volts					Ohms												
@ Test Temperature 0°C	0.909	0.909	1.50	0.574	3.00	680*												
@ Test Temperature +25°C	0.844	0.844	1.50	0.554	3.00	680*												
@ Test Temperature +100°C	0.710	0.710	1.50	0.370	3.00	850*												
Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_R* Pin No.	Grounded Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	2				10		5	$2I_{IN}(2)$	---	1.01	---	0.90	---	0.90	mAdc
	7				10		5	$2I_{IN}(7)$	---	1.01	---	0.90	---	0.90	mAdc
Output Current		3		2	10		5	$I_{A5}(3)$	2.52	---	2.38	---	2.25	---	mAdc
		9		7	10		5	$I_{A5}(9)$	2.52	---	2.38	---	2.25	---	mAdc
		4		2	10		5	$I_{AB}(4)$	12.6	---	11.9	---	11.25	---	mAdc
		6		7	10		5	$I_{AB}(6)$	12.6	---	11.9	---	11.25	---	mAdc
Output Voltage		2			10	4	5	$V_{OUT}(4)$	---	574	---	400	---	370	mVdc
		7			10	6	5	$V_{OUT}(6)$	---	574	---	400	---	370	mVdc
		2			10		5	$V_{OUT}(3)$	---	574	---	400	---	370	mVdc
		7			10		5	$V_{OUT}(9)$	---	574	---	400	---	370	mVdc
Saturation Voltage			2		10	4	5	$V_{CE}(4)$	---	290	---	260	---	340	mVdc
			7		10	6	5	$V_{CE}(6)$	---	290	---	260	---	340	mVdc
			2		10		5	$V_{CE}(3)$	---	290	---	260	---	340	mVdc
			7		10		5	$V_{CE}(9)$	---	290	---	260	---	340	mVdc
					1, 10		5	$V_{CE}(3)$	---	290	---	260	---	340	mVdc
					8, 10		5	$V_{CE}(9)$	---	290	---	260	---	340	mVdc
Switching Time	Pulse in	Pulse out													
	2	4			10		5	t_{2+4-}	---	---	---	30	---	---	nsec
	2	4			10		5	t_{2-4+}	---	---	---	30	---	---	nsec
	2	3			10		5	t_{2+3-}	---	---	---	28	---	---	nsec
	2	3			10		5	t_{2-3+}	---	---	---	32	---	---	nsec
	7	6			10		5	t_{7+6-}	---	---	---	30	---	---	nsec
	7	6			10		5	t_{7-6+}	---	---	---	30	---	---	nsec
	7	9			10		5	t_{7+9-}	---	---	---	28	---	---	nsec
	7	9			10		5	t_{7-9+}	---	---	---	32	---	---	nsec

Pins not referenced are open.

* Resistor to V_{CC}

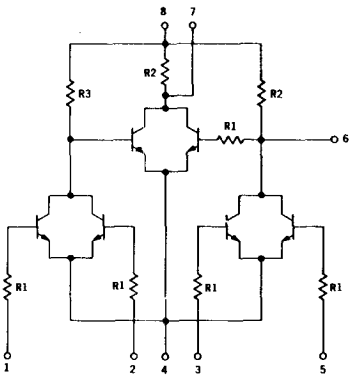
MC900G / MC800G series (continued)

HALF-ADDERS

MC904G
MC804G

This half-adder device can be used to supply the "SUM" and "CARRY" operations on two input signals. If the inputs are applied to Pins 1 and 2, and their complements to Pins 3 and 5, the "SUM" of the inputs appears on Pin 7 while the "CARRY" appears on Pin 6. This circuit also performs the exclusive "OR" function.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



TYPICAL RESISTORS
R1 = 450Ω
R2 = 640Ω
R3 = 800Ω

POSITIVE LOGIC

$6 = \overline{3 + 5}$
$7 = (1 + 2)(3 + 5)$
IF: $3 = \overline{1}$, & $5 = \overline{2}$
THEN: $6 = 1 \cdot 2$
$7 = 1 \cdot \overline{2} + \overline{1} \cdot 2$

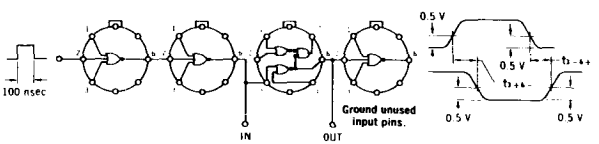


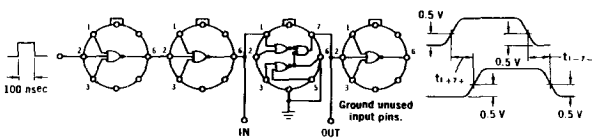
NEGATIVE LOGIC

$6 = \overline{3 \cdot 5}$
$7 = 1 \cdot 2 + 3 \cdot 5$
IF: $3 = \overline{1}$, & $5 = \overline{2}$
THEN:
$6 = 1 + 2$
$7 = 1 \cdot 2 + \overline{1} \cdot \overline{2}$



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS





ELECTRICAL CHARACTERISTICS — MC904G

@ Test Temperature	Test Conditions Volts				
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 45 mW typical, 53 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	2	—	1	—	8	4	3, 5, 6, 7	$I_{in}(2)$	—	495	—	435	—	470	μAdc
	3	—	5	—	8	4	1, 2, 8, 7	$I_{in}(3)$	—	495	—	435	—	470	μAdc
	5	—	3	—	8	4	1, 2, 6, 7	$I_{in}(5)$	—	495	—	435	—	478	μAdc
Output Current	—	6	—	3, 5	8	4	1, 2, 7	$I_{A4}(6)$	1.96	—	2.19	—	1.88	—	mAdc
	—	1, 3, 7	—	—	8	4	2, 5, 6	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
	—	2, 5, 7	—	—	8	4	1, 3, 8	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
Output Voltage	—	3	—	—	8	4	1, 2, 5, 8, 7	$V_{out}(8)$	—	710	—	300	—	320	mVdc
	—	5	—	—	8	4	1, 2, 3, 8, 7	$V_{out}(6)$	—	718	—	300	—	320	mVdc
	—	6	1, 2	—	8	4	3, 5, 7	$V_{out}(7)$	—	718	—	300	—	320	mVdc
Saturation Voltage	—	—	3	—	8	4	1, 2, 5, 6, 7	$V_{CE}(8)$	—	200	—	210	—	280	mVdc
	—	—	5	—	6	4	1, 2, 3, 8, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	1, 2	3, 5	6	4	8, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
	—	—	3, 5	1, 2	8	4	6, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	3	8	—	—	8	4	1, 2, 5, 7	t_{3+8-}	—	—	—	20	—	—	nsec
	3	6	—	—	6	4	1, 2, 5, 7	t_{3-6+}	—	—	—	30	—	—	nsec
	1	7	—	—	8	4, 6	2, 3, 5	t_{1+7+}	—	—	—	36	—	—	nsec
	1	7	—	—	8	4, 6	2, 3, 5	t_{1-7-}	—	—	—	36	—	—	nsec

ELECTRICAL CHARACTERISTICS — MC804G

@ Test Temperature	Test Conditions Volts				
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: 45 mW typical, 53 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	504	—	450	—	458	μAdc
	2	—	1	—	8	4	3, 5, 6, 7	$I_{in}(2)$	—	504	—	450	—	450	μAdc
	3	—	5	—	6	4	1, 2, 6, 7	$I_{in}(3)$	—	504	—	450	—	450	μAdc
	5	—	3	—	8	4	1, 2, 8, 7	$I_{in}(5)$	—	504	—	450	—	450	μAdc
Output Current	—	6	—	3, 5	8	4	1, 2, 7	$I_{A4}(8)$	2.02	—	2.05	—	1.80	—	mAdc
	—	1, 3, 7	—	—	8	4	2, 5, 6	$I_{A5}(7)$	2.52	—	2.38	—	2.25	—	mAdc
	—	2, 5, 7	—	—	6	4	1, 3, 6	$I_{A5}(7)$	2.52	—	2.38	—	2.25	—	mAdc
Output Voltage	—	3	—	—	8	4	1, 2, 5, 6, 7	$V_{out}(6)$	—	574	—	400	—	370	mVdc
	—	5	—	—	8	4	1, 2, 3, 6, 7	$V_{out}(6)$	—	574	—	400	—	370	mVdc
	—	6	1, 2	—	8	4	3, 5, 7	$V_{out}(7)$	—	574	—	400	—	378	mVdc
Saturation Voltage	—	—	3	—	8	4	1, 2, 5, 8, 7	$V_{CE}(6)$	—	290	—	260	—	340	mVdc
	—	—	5	—	8	4	1, 2, 3, 5, 7	$V_{CE}(6)$	—	290	—	260	—	340	mVdc
	—	—	1, 2	3, 5	8	4	6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	3, 5	1, 2	6	4	6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	3	6	—	—	8	4	1, 2, 5, 7	t_{3+6-}	—	—	—	30	—	—	nsec
	3	6	—	—	8	4	1, 2, 5, 7	t_{3-5+}	—	—	—	30	—	—	nsec
	1	7	—	—	8	4	2, 3, 5	t_{1+7+}	—	—	—	36	—	—	nsec
	1	7	—	—	8	4	2, 3, 5	t_{1-7-}	—	—	—	36	—	—	nsec

MC900G / MC800G series (continued)

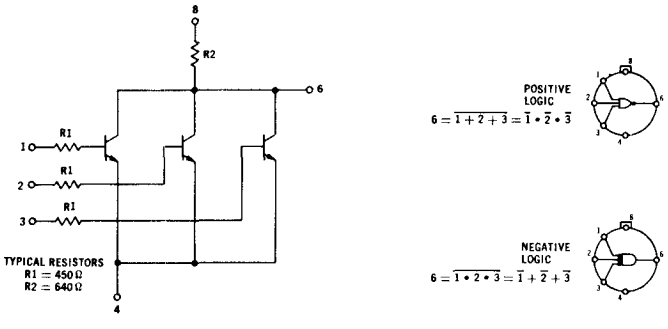
LOGIC GATES

MC903G
MC803G

This device provides the "NAND/NOR" function on Pin 6. Individual gate elements may be paralleled or used with other logic elements for increasing the number of inputs (subject to loading rules).

3-INPUT "NAND/NOR" GATES

CIRCUIT DIAGRAM AND LOGIC SYMBOLS

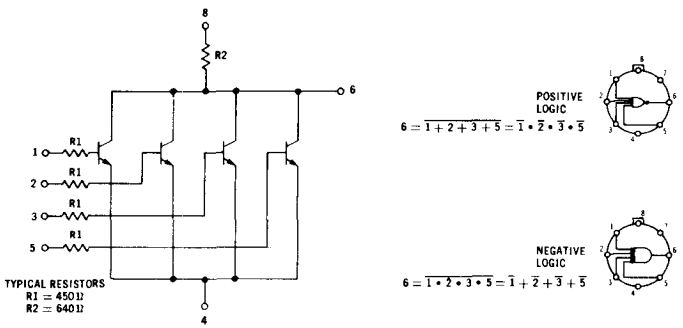


MC907G
MC807G

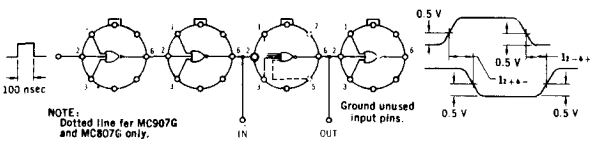
This device provides the "NAND/NOR" function on Pin 6. Individual gate elements may be paralleled or used with other logic elements for increasing the number of inputs (subject to loading rules).

4-INPUT "NAND/NOR" GATES

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS (For All Types)



MC900G / MC800G series (continued)

LOGIC GATES

ELECTRICAL CHARACTERISTICS — MC903G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: Input High: 19 mW typical, 27 mW maximum
Input Low: 5 mW typical, 9 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2, 3	—	8	4	6	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	2	—	1, 3	—	8	4	6	$I_{in}(2)$	—	495	—	435	—	470	μAdc
	3	—	1, 2	—	8	4	6	$I_{in}(3)$	—	495	—	435	—	470	μAdc
Output Current	—	6	—	1, 2, 3	8	4	—	$I_{AS}(6)$	2.47	—	2.54	—	2.35	—	mAdc
Output Leakage Current	6	—	—	1, 2, 3	—	4	8	$I_{CEX}(6)$	—	100	—	218	—	235	μAdc
Output Voltage	—	1	—	—	8	4	2, 3, 6	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	2	—	—	8	4	1, 3, 6	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	3	—	—	8	4	1, 2, 6	$V_{out}(6)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	1	—	8	4	2, 3, 6	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	2	—	8	4	1, 3, 6	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	3	—	8	4	1, 2, 6	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	2	6	—	—	8	4	1, 3	t_{2+6-}	—	—	—	20	—	—	nsec
	2	6	—	—	8	4	1, 3	t_{2-6+}	—	—	—	28	—	—	nsec

Pins 5 and 7 omitted

ELECTRICAL CHARACTERISTICS — MC907G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: Input High: 19 mW typical, 27 mW maximum
Input Low: 5 mW typical, 9 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2, 3, 5	—	8	4	6, 7	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	2	—	1, 3, 5	—	8	4	6, 7	$I_{in}(2)$	—	495	—	435	—	470	μAdc
	3	—	1, 2, 5	—	8	4	6, 7	$I_{in}(3)$	—	495	—	435	—	470	μAdc
	5	—	1, 2, 3	—	8	4	6, 7	$I_{in}(5)$	—	495	—	435	—	470	μAdc
Output Current	—	6	—	1, 2, 3, 5	8	4	7	$I_{AS}(6)$	2.47	—	2.54	—	2.35	—	mAdc
Output Leakage Current	6	—	—	1, 2, 3, 5	—	4	7, 8	$I_{CEX}(6)$	—	100	—	218	—	235	μAdc
Output Voltage	—	1	—	—	8	4	2, 3, 5, 6, 7	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	2	—	—	8	4	1, 3, 5, 6, 7	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	3	—	—	8	4	1, 2, 5, 6, 7	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	5	—	—	8	4	1, 2, 3, 6, 7	$V_{out}(6)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	1	—	8	4	2, 3, 5, 6, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	2	—	8	4	1, 3, 5, 6, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	3	—	8	4	1, 2, 5, 6, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	5	—	8	4	1, 2, 3, 6, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	2	6	—	—	8	4	1, 3, 5, 7	t_{2+6-}	—	—	—	20	—	—	nsec
	2	6	—	—	8	4	1, 3, 5, 7	t_{2-6+}	—	—	—	28	—	—	nsec

MC900G / MC800G series (continued)

LOGIC GATES

ELECTRICAL CHARACTERISTICS — MC803G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: Input High: 19 mW typical, 27 mW maximum
Input Low: 5 mW typical, 9 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2, 3	—	8	4	6	I_{in}(1)	—	504	—	450	—	450	μAdc
	2	—	1, 3	—	8	4	6	I_{in}(2)	—	504	—	450	—	450	μAdc
	3	—	1, 2	—	8	4	6	I_{in}(3)	—	504	—	450	—	450	μAdc
Output Current	—	6	—	1, 2, 3	8	4	—	I_{A5}(6)	2.52	—	2.38	—	2.25	—	mAdc
Output Leakage Current	6	—	—	1, 2, 3	—	4	8	I_{CEX}(6)	—	100	—	225	—	225	μAdc
Output Voltage	—	1	—	—	8	4	2, 3, 6	V_{out}(6)	—	574	—	400	—	370	mVdc
	—	2	—	—	8	4	1, 3, 6	V_{out}(6)	—	574	—	400	—	370	mVdc
	—	3	—	—	8	4	1, 2, 6	V_{out}(6)	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1	—	8	4	2, 3, 6	V_{CE}(6)	—	290	—	260	—	340	mVdc
	—	—	2	—	8	4	1, 3, 6	V_{CE}(6)	—	290	—	260	—	340	mVdc
	—	—	3	—	8	4	1, 2, 6	V_{CE}(6)	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	2	6	—	—	8	4	1, 3	t_{2+6-}	—	—	—	20	—	—	nsec
	2	6	—	—	8	4	1, 3	t_{2-6+}	—	—	—	28	—	—	nsec

Pins 5 and 7 omitted

ELECTRICAL CHARACTERISTICS — MC807G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: Input High: 19 mW typical, 27 mW maximum
Input Low: 5 mW typical, 9 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2, 3, 5	—	8	4	6, 7	I_{in}(1)	—	504	—	450	—	450	μAdc
	2	—	1, 3, 5	—	6	4	6, 7	I_{in}(2)	—	504	—	450	—	450	μAdc
	3	—	1, 2, 5	—	6	4	6, 7	I_{in}(3)	—	504	—	450	—	450	μAdc
	5	—	1, 2, 3	—	6	4	6, 7	I_{in}(5)	—	504	—	450	—	450	μAdc
Output Current	—	6	—	1, 2, 3, 5	6	4	7	I_{A5}(6)	2.52	—	2.36	—	2.25	—	mAdc
Output Leakage Current	6	—	—	1, 2, 3, 5	—	4	7, 8	I_{CEX}(6)	—	100	—	225	—	225	μAdc
Output Voltage	—	1	—	—	8	4	2, 3, 5, 6, 7	V_{out}(6)	—	574	—	400	—	370	mVdc
	—	2	—	—	8	4	1, 3, 5, 6, 7	V_{out}(6)	—	574	—	400	—	370	mVdc
	—	3	—	—	8	4	1, 2, 5, 6, 7	V_{out}(6)	—	574	—	400	—	370	mVdc
	—	5	—	—	8	4	1, 2, 3, 6, 7	V_{out}(6)	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1	—	8	4	2, 3, 5, 6, 7	V_{CE}(6)	—	290	—	260	—	340	mVdc
	—	—	2	—	8	4	1, 3, 5, 6, 7	V_{CE}(6)	—	290	—	260	—	340	mVdc
	—	—	3	—	8	4	1, 2, 5, 6, 7	V_{CE}(6)	—	290	—	260	—	340	mVdc
	—	—	5	—	9	4	1, 2, 3, 6, 7	V_{CE}(6)	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	2	6	—	—	6	4	1, 3, 5, 7	t_{2+6-}	—	—	—	20	—	—	nsec
	2	6	—	—	8	4	1, 3, 5, 7	t_{2-6+}	—	—	—	28	—	—	nsec

MC900G/MC800G series (continued)

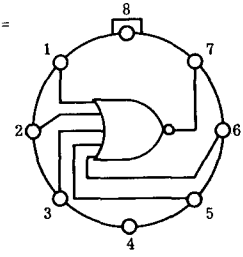
RTL
5-INPUT GATE

MC929G
MC829G

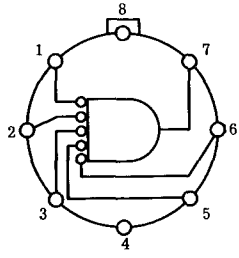
These devices provide the NAND/NOR function on pin 7. Individual gates may be paralleled with other logic elements for increasing the number of inputs (subject to loading rules). The MC929G is designed for operation over the full military range of −55°C to +125°C while the MC829G is guaranteed over a temperature range of 0°C to +100°C.

LOGIC SYMBOLS AND FUNCTIONS (PER MIL-STD-806B)

$7 = \overline{1+2+3+5+6} = \bar{1}\cdot\bar{2}\cdot\bar{3}\cdot\bar{5}\cdot\bar{6}$



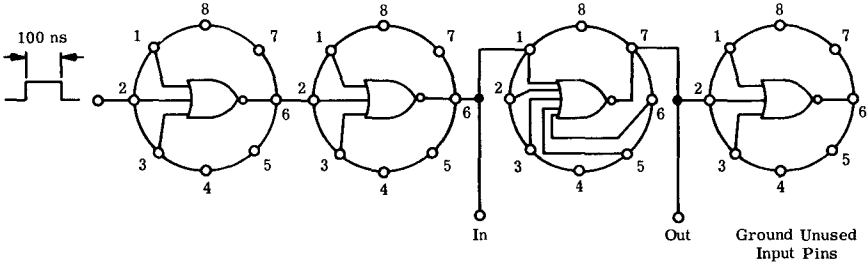
POSITIVE LOGIC



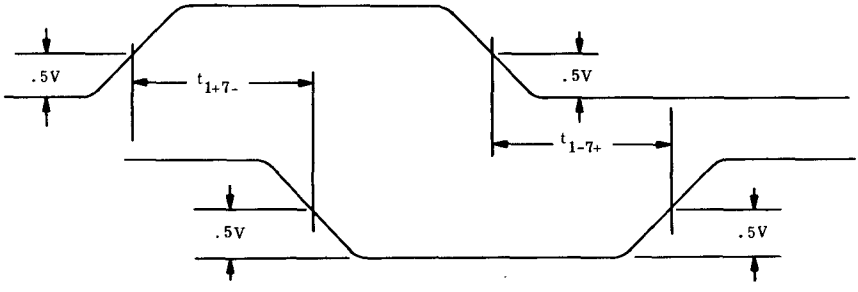
NEGATIVE LOGIC

$7 = \overline{1\cdot2\cdot3\cdot5\cdot6} = \bar{1}+\bar{2}+\bar{3}+\bar{5}+\bar{6}$

SWITCHING TIME TEST CIRCUIT



SWITCHING TIME WAVEFORM



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

5-INPUT GATES

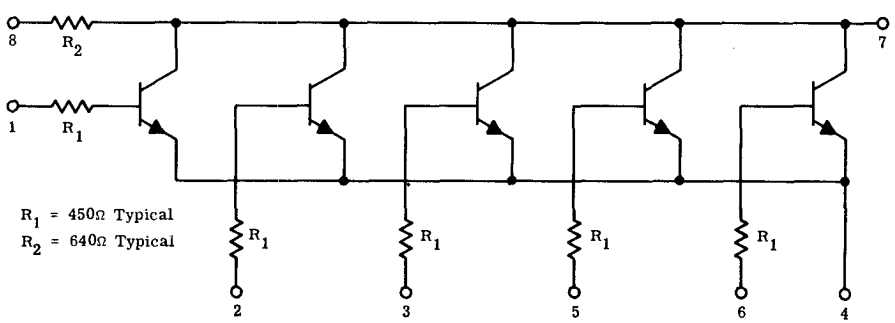
MC929G

@ Test Temperature	Test Conditions Volts				
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1		2, 3, 5, 6		8	4	$I_{IN}(1)$	---	495	---	435	---	470	μAdc
	2		1, 3, 5, 6		8	4	$I_{IN}(2)$	---	495	---	435	---	470	μAdc
	3		1, 2, 5, 6		8	4	$I_{IN}(3)$	---	495	---	435	---	470	μAdc
	5		1, 2, 3, 6		8	4	$I_{IN}(5)$	---	495	---	435	---	470	μAdc
	6		1, 2, 3, 5		8	4	$I_{IN}(6)$	---	495	---	435	---	470	μAdc
Output Current		7		1, 2, 3, 5, 6	8	4	$I_{A5}(7)$	2.47	---	2.54	---	2.35	---	mAdc
Output Leakage Current	7			1, 2, 3, 5, 6		4	$I_{CEX}(7)$	---	100	---	218	---	235	μAdc
Output Voltage		1			8	4	$V_{OUT}(7)$	---	710	---	300	---	320	mVdc
		2			8	4	$V_{OUT}(7)$	---	710	---	300	---	320	mVdc
		3			8	4	$V_{OUT}(7)$	---	710	---	300	---	320	mVdc
		5			8	4	$V_{OUT}(7)$	---	710	---	300	---	320	mVdc
		6			8	4	$V_{OUT}(7)$	---	710	---	300	---	320	mVdc
Saturation Voltage			1		8	4	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
			2		8	4	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
			3		8	4	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
			5		8	4	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
			6		8	4	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
Switching Time	Pulse in	Pulse out												
	1	7			8	2, 3, 4, 5, 6	t_{1+7-}	---	---	---	20	---	---	nsec
	1	7			8	2, 3, 4, 5, 6	t_{1-7+}	---	---	---	28	---	---	nsec

Pins not referenced are open

CIRCUIT DIAGRAM



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

5-INPUT GATES

MC829G

@ Test Temperature	Test Conditions Volts				
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1		2, 3, 5, 6		8	4	$I_{IN}(1)$	---	504	---	450	---	450	μAdc
	2		1, 3, 5, 6		8	4	$I_{IN}(2)$	---	504	---	450	---	450	μAdc
	3		1, 2, 5, 6		8	4	$I_{IN}(3)$	---	504	---	450	---	450	μAdc
	5		1, 2, 3, 6		8	4	$I_{IN}(5)$	---	504	---	450	---	450	μAdc
	6		1, 2, 3, 5		8	4	$I_{IN}(6)$	---	504	---	450	---	450	μAdc
Output Current		7		1, 2, 3, 5,6	8	4	$I_{A5}(7)$	2.52	---	2.38	---	2.25	---	mAdc
Output Leakage Current	7			1, 2, 3, 5,6		4	$I_{CEX}(7)$	---	100	---	225	---	225	μAdc
Output Voltage		1			8	4	$V_{OUT}(7)$	---	574	---	400	---	370	mVdc
		2			8	4	$V_{OUT}(7)$	---	574	---	400	---	370	mVdc
		3			8	4	$V_{OUT}(7)$	---	574	---	400	---	370	mVdc
		5			8	4	$V_{OUT}(7)$	---	574	---	400	---	370	mVdc
		6			8	4	$V_{OUT}(7)$	---	574	---	400	---	370	mVdc
Saturation Voltage			1		8	4	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
			2		8	4	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
			3		8	4	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
			5		8	4	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
			6		8	4	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
Switching Time	Pulse in	Pulse out												
	1	7			8	2, 3, 4, 5,6	t_{1+7-}	---	---	---	20	---	---	nsec
	1	7			8	2, 3, 4, 5,6	t_{1-7+}	---	---	---	28	---	---	nsec

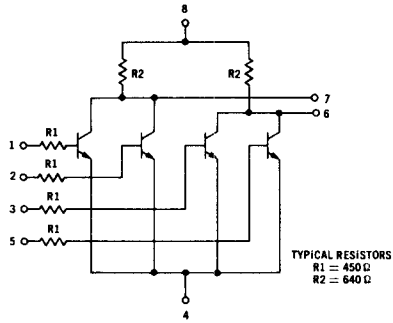
Pins not referenced are open.

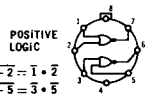
MC914G
MC814G

DUAL 2-INPUT "NAND/NOR" GATES

This gate element consists of two "NAND/NOR" gate circuits that can be used in the same manner as the other gate elements. Other applications of this circuit include cross-connecting to form a bistable multivibrator, or a two-input noninverting gate.

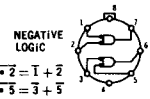
CIRCUIT DIAGRAM AND LOGIC SYMBOLS





$7 = \overline{1+2} = \bar{1} \cdot \bar{2}$

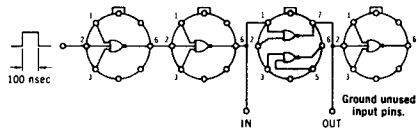
$6 = \overline{3+5} = \bar{3} \cdot \bar{5}$

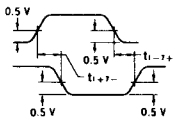


$7 = \overline{1 \cdot 2} = \bar{1} + \bar{2}$

$6 = \overline{3 \cdot 5} = \bar{3} + \bar{5}$

SWITCHING TIME TEST CIRCUITS AND WAVEFORMS



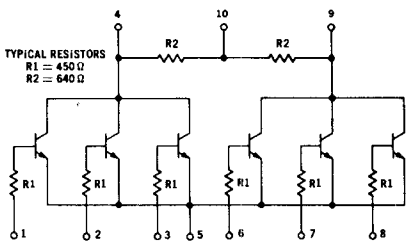


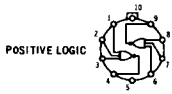
MC915G
MC815G

DUAL 3-INPUT "NAND/NOR" GATES

This gate element consists of two "NAND/NOR" gate circuits that can be used in the same manner as the other gate elements. Other applications of this circuit include cross-connecting to form a bistable multivibrator with two "SET" and two "RESET" inputs, or as a three-input noninverting gate.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS





$4 = \overline{1+2+3} = \bar{1} \cdot \bar{2} \cdot \bar{3}$

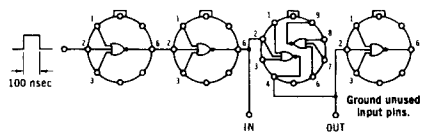
$9 = \overline{6+7+8} = \bar{6} \cdot \bar{7} \cdot \bar{8}$

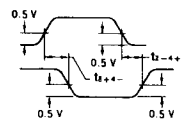


$4 = \overline{1 \cdot 2 \cdot 3} = \bar{1} + \bar{2} + \bar{3}$

$9 = \overline{6 \cdot 7 \cdot 8} = \bar{6} + \bar{7} + \bar{8}$

SWITCHING TIME TEST CIRCUITS AND WAVEFORMS





MC900G / MC800G series (continued)

LOGIC GATES

ELECTRICAL CHARACTERISTICS — MC914G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{en} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.80	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.90	0.320	3.00

Power Dissipation @ T_A = 25°C: Inputs High: 38 mW typical, 54 mW maximum; Inputs Low: 10 mW typical, 18 mW maximum

Characteristic	V_{in} Pin No.	V_{en} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	485	—	435	—	470	µAdc
	2	—	1	—	8	4	3, 5, 8, 7	$I_{in}(2)$	—	495	—	435	—	470	µAdc
	3	—	5	—	8	4	1, 2, 8, 7	$I_{in}(3)$	—	485	—	435	—	470	µAdc
	5	—	3	—	8	4	1, 2, 8, 7	$I_{in}(5)$	—	485	—	435	—	470	µAdc
Output Current	—	7	—	1, 2	8	4	3, 5, 8	$I_{A5}(7)$	2.47	—	2.54	—	2.35	—	mAdc
	—	8	—	3, 5	8	4	1, 2, 7	$I_{A5}(8)$	2.47	—	2.54	—	2.35	—	mAdc
Output Leakage Current	8	—	—	3, 5	—	4	1, 2, 7, 8	$I_{CEX}(8)$	—	100	—	218	—	235	µAdc
	7	—	—	1, 2	—	4	3, 5, 8, 8	$I_{CEX}(7)$	—	100	—	218	—	235	µAdc
Output Voltage	—	1	—	—	8	4	2, 3, 5, 6, 7	$V_{out}(7)$	—	710	—	300	—	329	mVdc
	—	2	—	—	8	4	1, 3, 5, 6, 7	$V_{out}(7)$	—	710	—	300	—	328	mVdc
	—	3	—	—	8	4	1, 2, 5, 6, 7	$V_{out}(8)$	—	710	—	300	—	329	mVdc
	—	5	—	—	8	4	1, 3, 3, 8, 7	$V_{out}(8)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	1	—	8	4	2, 3, 5, 6, 7	$V_{CE}(7)$	—	200	—	210	—	380	mVdc
	—	—	2	—	8	4	1, 3, 5, 8, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
	—	—	3	—	8	4	1, 2, 5, 8, 7	$V_{CE}(8)$	—	200	—	210	—	280	mVdc
	—	—	5	—	8	4	1, 2, 3, 6, 7	$V_{CE}(8)$	—	300	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4	2, 3, 5, 6	t_{1+7-}	—	—	—	20	—	—	nsec
	1	7	—	—	8	4	2, 3, 5, 8	t_{1-7+}	—	—	—	28	—	—	nsec

ELECTRICAL CHARACTERISTICS — MC915G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{en} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: Inputs High: 38 mW typical, 54 mW maximum; Inputs Low: 10 mW typical, 18 mW maximum

Characteristic	V_{in} Pin No.	V_{en} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2, 5	—	18	5	4, 8, 7, 8, 8	$I_{in}(1)$	—	485	—	435	—	470	µAdc
	2	—	1, 3	—	10	5	4, 8, 7, 8, 8	$I_{in}(2)$	—	485	—	435	—	470	µAdc
	3	—	1, 3	—	10	5	4, 8, 7, 8, 9	$I_{in}(3)$	—	485	—	435	—	470	µAdc
	6	—	7, 8	—	10	5	1, 2, 3, 4, 8	$I_{in}(8)$	—	485	—	435	—	470	µAdc
	7	—	6, 8	—	10	5	1, 2, 3, 4, 8	$I_{in}(7)$	—	485	—	435	—	470	µAdc
	8	—	6, 7	—	10	5	1, 2, 3, 4, 8	$I_{in}(8)$	—	488	—	435	—	470	µAdc
Output Current	—	4	—	1, 2, 3	10	5	8, 7, 8, 8	$I_{A5}(4)$	2.47	—	2.54	—	2.38	—	mAdc
	—	8	—	6, 7, 8	10	5	1, 2, 3, 4	$I_{A5}(8)$	2.47	—	2.54	—	2.36	—	mAdc
Output Leakage Current	4	—	—	1, 2, 3	—	5	6, 7, 8, 9, 10	$I_{CEX}(4)$	—	100	—	218	—	235	µAdc
	9	—	—	8, 7, 6	—	5	1, 2, 2, 4, 18	$I_{CEX}(8)$	—	100	—	218	—	235	µAdc
Output Voltage	—	1	7	—	18	5	2, 3, 4, 6, 8, 8	$V_{out}(4)$	—	718	—	300	—	320	mVdc
	—	2	7	—	10	5	1, 3, 4, 6, 8, 8	$V_{out}(4)$	—	710	—	300	—	328	mVdc
	—	3	7	—	10	5	1, 2, 4, 6, 8, 9	$V_{out}(4)$	—	710	—	300	—	320	mVdc
	—	8	2	—	10	5	1, 3, 4, 7, 8, 9	$V_{out}(8)$	—	710	—	308	—	320	mVdc
	—	7	2	—	10	5	1, 3, 4, 8, 8, 8	$V_{out}(9)$	—	710	—	300	—	320	mVdc
	—	9	2	—	10	5	1, 3, 4, 8, 7, 8	$V_{out}(9)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	1, 6	—	10	5	2, 3, 4, 7, 8, 8	$V_{CE}(4)$	—	200	—	210	—	290	mVdc
	—	—	2, 6	—	10	5	1, 3, 4, 7, 8, 8	$V_{CE}(4)$	—	300	—	210	—	390	mVdc
	—	—	3, 8	—	18	5	1, 2, 4, 7, 8, 8	$V_{CE}(4)$	—	300	—	210	—	380	mVdc
	—	—	1, 8	—	18	2	2, 3, 4, 7, 8, 9	$V_{CE}(8)$	—	200	—	210	—	380	mVdc
	—	—	1, 7	—	10	5	2, 3, 4, 8, 8, 9	$V_{CE}(8)$	—	200	—	210	—	280	mVdc
	—	—	1, 8	—	10	5	3, 3, 4, 6, 7, 8	$V_{CE}(8)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	2	4	—	—	10	5	1, 3, 6, 7, 9, 8	t_{2+4-}	—	—	—	20	—	—	nsec
	2	4	—	—	10	5	1, 3, 8, 7, 9, 8	t_{2-4+}	—	—	—	38	—	—	nsec

ELECTRICAL CHARACTERISTICS — MC814G

@ Test Temperature	Test Conditions Volts				
	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: Inputs High: 38 mW typical, 54 mW maximum; Inputs Low: 10 mW typical, 18 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	504	—	450	—	450	µAdc
	2	—	1	—	8	4	3, 5, 6, 7	$I_{in}(2)$	—	504	—	450	—	450	µAdc
	3	—	5	—	8	4	1, 2, 6, 7	$I_{in}(3)$	—	504	—	450	—	450	µAdc
	5	—	3	—	8	4	1, 2, 6, 7	$I_{in}(5)$	—	504	—	450	—	450	µAdc
Output Current	—	7	—	1, 2	8	4	3, 5, 6	$I_{AS}(7)$	2.52	—	2.38	—	2.25	—	mAdc
	—	6	—	3, 5	8	4	1, 2, 7	$I_{AS}(6)$	3.53	—	2.38	—	3.35	—	mAdc
Output Leakage Current	6	—	—	3, 5	—	4	1, 2, 7, 6	$I_{CEX}(6)$	—	100	—	225	—	225	µAdc
	7	—	—	1, 2	—	4	3, 5, 6, 6	$I_{CEX}(7)$	—	100	—	225	—	325	µAdc
Output Voltage	—	1	—	—	6	4	2, 3, 5, 6, 7	$V_{out}(7)$	—	574	—	400	—	370	mVdc
	—	2	—	—	6	4	1, 3, 5, 6, 7	$V_{out}(7)$	—	574	—	400	—	370	mVdc
	—	3	—	—	6	4	1, 2, 5, 6, 7	$V_{out}(6)$	—	574	—	400	—	370	mVdc
	—	5	—	—	6	4	1, 2, 3, 6, 7	$V_{out}(6)$	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1	—	6	4	2, 3, 5, 6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	3	—	6	4	1, 3, 5, 6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	3	—	6	4	1, 2, 5, 6, 7	$V_{CE}(6)$	—	290	—	260	—	340	mVdc
	—	—	5	—	6	4	1, 2, 3, 6, 7	$V_{CE}(6)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	6	4	2, 3, 5, 6	t_{1+7-}	—	—	—	20	—	—	nsec
	1	7	—	—	6	4	2, 3, 5, 6	t_{1-7+}	—	—	—	28	—	—	nsec

ELECTRICAL CHARACTERISTICS — MC815G

@ Test Temperature	Test Conditions Volts				
	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+200°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: Inputs High: 38 mW typical, 54 mW maximum; Inputs Low: 10 mW typical, 28 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2, 3	—	18	5	4, 8, 7, 8, 8	$I_{in}(1)$	—	504	—	450	—	450	µAdc
	2	—	1, 3	—	10	5	4, 8, 7, 8, 9	$I_{in}(2)$	—	504	—	450	—	450	µAdc
	3	—	1, 2	—	10	5	4, 8, 7, 8, 5	$I_{in}(5)$	—	504	—	450	—	450	µAdc
	6	—	7, 6	—	18	5	1, 2, 3, 4, 9	$I_{in}(6)$	—	504	—	450	—	450	µAdc
	7	—	6, 8	—	10	5	1, 2, 3, 4, 9	$I_{in}(7)$	—	504	—	450	—	450	µAdc
	8	—	5, 7	—	10	5	1, 2, 3, 4, 8	$I_{in}(8)$	—	504	—	450	—	450	µAdc
Output Current	—	4	—	1, 2, 3	10	5	9, 7, 6, 9	$I_{AS}(4)$	2.52	—	2.36	—	2.25	—	mAdc
	—	9	—	6, 7, 8	10	5	1, 3, 3, 4	$I_{AS}(8)$	2.53	—	2.38	—	2.25	—	mAdc
Output Leakage Current	4	—	—	1, 2, 3	—	5	9, 7, 8, 9, 18	$I_{CEX}(4)$	—	190	—	225	—	225	µAdc
	3	—	—	8, 7, 8	—	5	1, 2, 5, 4, 18	$I_{CEX}(8)$	—	190	—	325	—	225	µAdc
Output Voltage	—	1	7	—	10	5	2, 3, 4, 8, 8, 9	$V_{out}(4)$	—	574	—	400	—	370	mVdc
	—	3	7	—	10	5	1, 3, 4, 5, 8, 9	$V_{out}(4)$	—	574	—	400	—	370	mVdc
	—	3	7	—	10	5	1, 2, 4, 8, 8, 9	$V_{out}(4)$	—	574	—	400	—	378	mVdc
	—	6	2	—	10	5	1, 3, 4, 7, 8, 9	$V_{out}(8)$	—	574	—	400	—	378	mVdc
	—	7	2	—	10	5	1, 3, 4, 6, 8, 9	$V_{out}(9)$	—	574	—	400	—	370	mVdc
	—	8	2	—	10	5	1, 3, 4, 8, 7, 9	$V_{out}(8)$	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1, 8	—	10	5	2, 3, 6, 7, 8, 9	$V_{CE}(4)$	—	290	—	260	—	340	mVdc
	—	—	2, 8	—	10	5	1, 5, 4, 7, 8, 8	$V_{CE}(4)$	—	250	—	160	—	348	mVdc
	—	—	3, 8	—	10	5	1, 3, 4, 7, 8, 9	$V_{CE}(4)$	—	290	—	260	—	340	mVdc
	—	—	1, 8	—	10	5	2, 3, 4, 7, 8, 9	$V_{CE}(9)$	—	290	—	260	—	340	mVdc
	—	—	1, 7	—	10	8	2, 3, 4, 6, 8, 9	$V_{CE}(9)$	—	290	—	260	—	340	mVdc
	—	—	1, 8	—	10	8	2, 3, 4, 8, 7, 9	$V_{CE}(8)$	—	290	—	360	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	2	4	—	—	10	5	1, 3, 6, 7, 8, 8	t_{1+4-}	—	—	—	20	—	—	nsec
	2	4	—	—	10	5	1, 5, 6, 7, 8, 9	t_{2-4+}	—	—	—	35	—	—	nsec

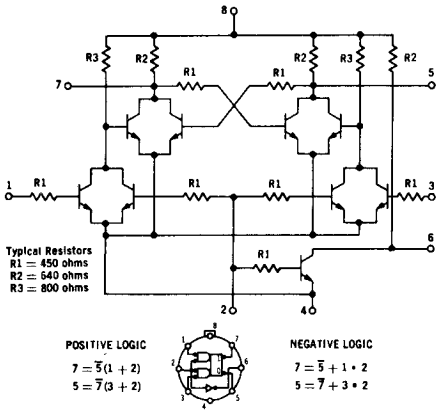
MC900G / MC800G series (continued)

HALF-SHIFT REGISTERS

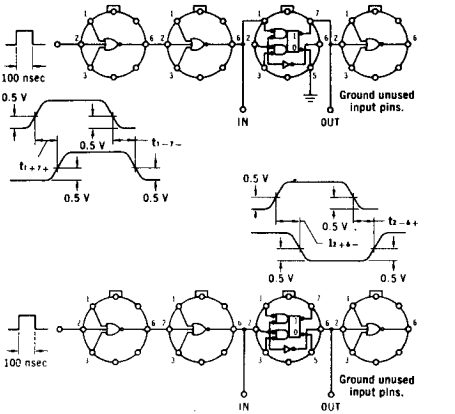
MC905G
MC805G

This half-shift register consists of three input RTL gate circuits and two output RTL gate circuits cross-connected to form a bistable storage unit. A gating signal is applied to the three input gate circuits. Logic inputs are supplied to Pins 1 and 3, with the gate signal on Pin 2 controlling these inputs. The complement of the gating signal is furnished at Pin 6. Information is shifted into the storage unit by applying near-ground logic levels at the inputs. For example, the logic levels appearing at Pins 1 and 3 will be transferred to Pins 7 and 5 respectively when the gate signal on Pin 2 goes to the condition of near-ground potential. Low logic levels on all three inputs will cause low logic levels at both outputs.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



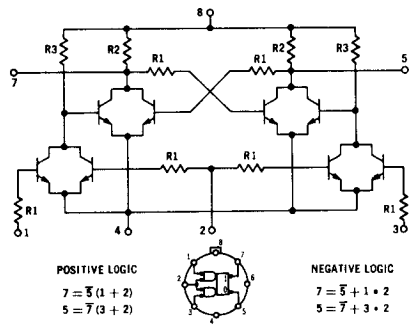
SWITCHING TIME TEST CIRCUITS AND WAVEFORMS



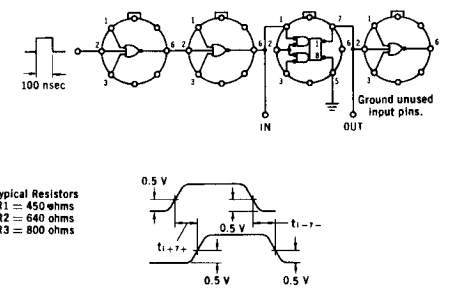
MC906G
MC806G
(WITHOUT INVERTER)

This half-shift register consists of two input RTL gate circuits and two output RTL gate circuits cross-connected to form a bistable storage unit. A gating signal is applied to the two input gate circuits. Logic inputs are supplied to Pins 1 and 3, with the gate signal on Pin 2 controlling these inputs. Information is shifted into the storage unit by applying near-ground logic levels at the inputs. For example, the logic levels appearing at Pins 1 and 3 will be transferred to Pins 7 and 5 respectively when the gate signal on Pin 2 goes to the condition of near-ground potential. Low logic levels on all three inputs will cause low logic levels at both outputs.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS



HALF-SHIFT REGISTERS

ELECTRICAL CHARACTERISTICS — MC905G

@ Test Temperature	Test Conditions Volts				
	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 53 mW typical, 64 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	2	—	1, 3	—	8	4	5, 6, 7	$3\ I_{in}(2)$	—	1.48	—	1.30	—	1.41	mAdc
	3	—	2	—	8	4	1, 5, 6, 7	$I_{in}(3)$	—	485	—	435	—	470	μAdc
Output Current	—	2, 5	—	—	8	4, 7 †	1, 3, 6	$I_{A4}(5)$	1.98	—	2.19	—	1.88	—	mAdc
	—	3, 5	—	—	8	4	1, 2, 6, 7	$I_{A4}(5)$	1.98	—	2.19	—	1.88	—	mAdc
	—	8	—	2	8	4	1, 3, 5, 7	$I_{A5}(6)$	2.47	—	2.54	—	2.35	—	mAdc
	—	2, 7	—	—	8	4, 5 †	1, 3, 8	$I_{A4}(7)$	1.98	—	2.19	—	1.88	—	mAdc
	—	1, 7	—	—	8	4	2, 3, 5, 6	$I_{A4}(7)$	1.98	—	2.19	—	1.88	—	mAdc
Output Voltage	—	7	2, 3	—	8	4	1, 5, 6	$V_{out}(5)$	—	710	—	300	—	320	mVdc
	—	2	—	—	8	4	1, 3, 5, 6, 7	$V_{out}(6)$	—	710	—	300	—	320	mVdc
	—	5	1, 2	—	8	4	3, 8, 7	$V_{out}(7)$	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	1, 2, 3	—	8	4, 5 †	6, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	—	2, 3	8	4, 7	1, 5, 6	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	2	—	8	4	1, 3, 5, 6, 7	$V_{CE}(6)$	—	200	—	210	—	280	mVdc
	—	—	1, 2, 3	—	8	4, 7 †	5, 6	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
	—	—	—	1, 2	8	4, 5	3, 6, 7	$V_{CE}(7)$	—	200	—	210	—	288	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4, 5	2, 3, 8	t_{1+7+}	—	—	—	40	—	—	nsec
	1	7	—	—	8	4, 5	2, 3, 6	t_{1-7-}	—	—	—	40	—	—	nsec
	2	6	—	—	8	4	1, 3, 5, 7	t_{2+6-}	—	—	—	28	—	—	nsec
	2	6	—	—	8	4	1, 3, 5, 7	t_{2-6+}	—	—	—	24	—	—	nsec

† Silicon Diode to Ground

ELECTRICAL CHARACTERISTICS — MC906G

@ Test Temperature	Test Conditions Volts				
	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 36 mW typical, 43 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	2	—	1, 3	—	8	4	5, 8, 7	$2\ I_{in}(2)$	—	990	—	870	—	940	μAdc
	3	—	2	—	8	4	1, 5, 6, 7	$I_{in}(3)$	—	495	—	435	—	470	μAdc
Output Current	—	2, 5	—	—	8	4, 7 †	1, 3, 8	$I_{A4}(5)$	1.88	—	2.19	—	1.88	—	mAdc
	—	3, 5	—	—	8	4	1, 2, 8, 7	$I_{A4}(5)$	1.98	—	2.19	—	1.88	—	mAdc
	—	2, 7	—	—	8	4, 5 †	1, 3, 8	$I_{A4}(7)$	1.88	—	2.19	—	1.88	—	mAdc
	—	1, 7	—	—	8	4	2, 3, 5, 8	$I_{A4}(7)$	1.98	—	2.19	—	1.88	—	mAdc
Output Voltage	—	7	2, 3	—	8	4	1, 5, 6	$V_{out}(5)$	—	710	—	300	—	328	mVdc
	—	5	1, 2	—	8	4	3, 8, 7	$V_{out}(7)$	—	710	—	300	—	328	mVdc
Saturation Voltage	—	—	1, 2, 3	—	8	4, 5 †	6, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	—	2, 3	8	4, 7	1, 5, 8	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	1, 2, 3	—	8	4, 7 †	5, 8	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
	—	—	—	1, 2	8	4, 5	3, 8, 7	$V_{CE}(7)$	—	200	—	210	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4, 5	2, 3, 8	t_{1+7+}	—	—	—	40	—	—	nsec
	1	7	—	—	8	4, 5	2, 3, 8	t_{1-7-}	—	—	—	40	—	—	nsec

† Silicon Diode To Ground

MC900G / MC800G series (continued)

HALF-SHIFT REGISTERS

ELECTRICAL CHARACTERISTICS — MC805G

@ Test Temperature	Test Conditions Volts				
	V_{in}	V_{on}	V_{BOT}	V_{off}	V_{CC}
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: 53 mW typical, 64 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	504	—	450	—	450	μAdc
	2	—	1, 3	—	8	4	5, 6, 7	$3\ I_{in}(2)$	—	1.51	—	1.35	—	1.35	mAdc
	3	—	2	—	8	4	1, 5, 6, 7	$I_{in}(3)$	—	504	—	450	—	450	μAdc
Output Current	—	2, 5	—	—	8	4, 7 †	1, 3, 6	$I_{A4}(5)$	2.02	—	2.05	—	1.80	—	mAdc
	—	3, 5	—	—	8	4	1, 2, 6, 7	$I_{A4}(5)$	2.02	—	2.05	—	1.80	—	mAdc
	—	6	—	2	8	4	1, 3, 5, 7	$I_{A5}(6)$	2.52	—	2.38	—	2.25	—	mAdc
	—	2, 7	—	—	8	4, 5 †	1, 3, 6	$I_{A4}(7)$	2.02	—	2.05	—	1.80	—	mAdc
	—	1, 7	—	—	8	4	2, 3, 5, 6	$I_{A5}(7)$	2.02	—	2.05	—	1.80	—	mAdc
Output Voltage	—	7	2, 3	—	8	4	1, 5, 6	$V_{out}(5)$	—	574	—	400	—	370	mVdc
	—	2	—	—	8	4	1, 3, 5, 6, 7	$V_{out}(6)$	—	574	—	400	—	370	mVdc
	—	5	1, 2	—	8	4	3, 6, 7	$V_{out}(7)$	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1, 2, 3	—	8	4, 5 †	6, 7	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	—	2, 3	8	4, 7	1, 5, 6	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	2	—	8	4	1, 3, 5, 6, 7	$V_{CE}(6)$	—	280	—	260	—	340	mVdc
	—	—	1, 2, 3	—	8	4, 7 †	5, 6	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	—	1, 2	8	4, 5	3, 6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4, 5	2, 3, 6	t_{1+7+}	—	—	—	40	—	—	nsec
	1	7	—	—	8	4, 5	2, 3, 6	t_{1-7-}	—	—	—	40	—	—	nsec
	2	8	—	—	8	4	1, 3, 5, 7	t_{2+6-}	—	—	—	28	—	—	nsec
	2	6	—	—	8	4	1, 3, 5, 7	t_{2-6+}	—	—	—	24	—	—	nsec

† Silicon Diode to Ground

ELECTRICAL CHARACTERISTICS — MC806G

@ Test Temperature	Test Conditions Volts				
	V_{in}	V_{on}	V_{BOT}	V_{off}	V_{CC}
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: 36 mW typical, 43 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	2	—	8	4	3, 5, 6, 7	$I_{in}(1)$	—	504	—	450	—	450	μAdc
	2	—	1, 3	—	8	4	5, 6, 7	$2\ I_{in}(2)$	—	1010	—	900	—	900	μAdc
	3	—	2	—	8	4	1, 5, 6, 7	$I_{in}(3)$	—	504	—	450	—	450	μAdc
Output Current	—	2, 5	—	—	8	4, 7 †	1, 3, 6	$I_{A4}(5)$	2.02	—	2.05	—	1.80	—	mAdc
	—	3, 5	—	—	8	4	1, 2, 6, 7	$I_{A5}(5)$	2.02	—	2.05	—	1.80	—	mAdc
	—	2, 7	—	—	8	4, 5 †	1, 3, 6	$I_{A4}(7)$	2.02	—	2.05	—	1.80	—	mAdc
	—	1, 7	—	—	8	4	2, 3, 5, 6	$I_{A4}(7)$	2.02	—	2.05	—	1.80	—	nAdc
Output Voltage	—	7	2, 3	—	8	4	1, 5, 6	$V_{out}(5)$	—	574	—	400	—	370	mVdc
	—	5	1, 2	—	8	4	3, 8, 7	$V_{out}(7)$	—	574	—	400	—	370	mVdc
Saturation Voltage	—	—	1, 2, 3	—	8	4, 5 †	6, 7	$V_{CE}(5)$	—	290	—	280	—	340	mVdc
	—	—	—	2, 3	8	4, 7	1, 5, 6	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
	—	—	1, 2, 3	—	8	4, 7 †	5, 8	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	—	1, 2	8	4, 5	3, 6, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4, 5	2, 3, 6	t_{1+7+}	—	—	—	40	—	—	nsec
	1	7	—	—	8	4, 5	2, 3, 6	t_{1-7-}	—	—	—	40	—	—	nsec

† Silicon Diode to Ground

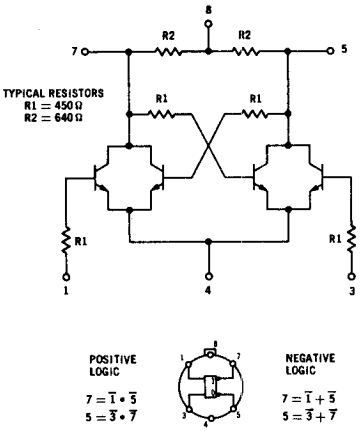
MC900G / MC800G series (continued)

FLIP-FLOPS

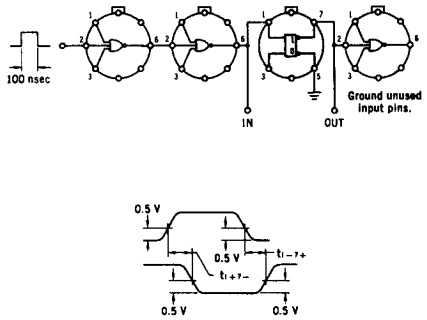
MC902G
MC802G

This flip-flop is formed by internally cross-coupling two basic RTL "NOR" gates. This bistable storage element can be set to one of its stable states by applying a high logic level on one of the inputs. High logic levels on both inputs will result in simultaneous low levels at both outputs.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUITS AND WAVEFORMS



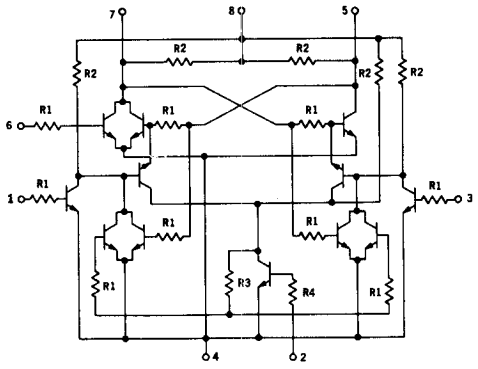
MC916G
MC816G

J-K FLIP-FLOP

The JK Flip-Flop has no undefined state in its operational truth table. The output state of this flip-flop is predictable for any combination of inputs.

The versatile JK Flip-Flop is suitable for use in counters, shift registers, or any other control type application. This flip-flop can be operated in the toggling mode. Simultaneous logic ONE pulses applied to the SET and CLEAR terminals cause the output state to reverse. A PRESET input allows asynchronous entry for presetting counters, inserting parallel data into registers, and other similar applications.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



TYPICAL RESISTORS
R1 = 450 ohms
R2 = 640 ohms
R3 = 510 ohms
R4 = 225 ohms



H is more positive than L.
X is the output state at time n.

PIN 1 SET	PIN 3 CLEAR t = n	PIN 7 "1" OUTPUT t = n + 1
H	H	X^*
H	L	H
L	H	L
L	L	$\overline{X}^*$

For switching specifications see back cover.

MC900G / MC800G series (continued)

FLIP-FLOPS

ELECTRICAL CHARACTERISTICS — MC902G

@ Test Temperature	Test Conditions Volts				
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 22 mW typical, 28 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	5	—	8	4	3, 7	$I_{in}(1)$	—	495	—	435	—	470	μAdc
	3	—	7	—	8	4	1, 5	$I_{in}(3)$	—	495	—	435	—	470	μAdc
Output Current	—	5	1	3	8	4	7	$I_{A4}(5)$	1.98	—	2.19	—	1.88	—	mAdc
	—	7	3	1	8	4	5	$I_{A4}(7)$	1.98	—	2.19	—	1.88	—	mAdc
Output Voltage	—	3	1	—	8	4	5, 7	$V_{out}(5)$	—	718	—	300	—	228	mVdc
	—	7	—	—	8	4	1, 3, 5	$V_{out}(5)$	—	718	—	308	—	328	mVdc
	—	1	3	—	8	4	5, 7	$V_{out}(7)$	—	710	—	308	—	320	mVdc
	—	5	—	—	8	4	1, 3, 7	$V_{out}(7)$	—	718	—	300	—	320	mVdc
Saturation Voltage	—	—	1, 3	—	8	4	5, 7	$V_{CE}(5)$	—	200	—	210	—	288	mVdc
	—	—	—	1	8	4, 5†	3, 7	$V_{CE}(5)$	—	200	—	210	—	280	mVdc
	—	—	1, 3	—	8	4	5, 7	$V_{CE}(7)$	—	208	—	210	—	280	mVdc
	—	—	—	3	8	4, 7†	1, 5	$V_{CE}(7)$	—	208	—	218	—	280	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4	3, 5	t_{1+7-}	—	—	—	28	—	—	nsec
	1	7	—	—	8	4	3, 5	t_{1-7+}	—	—	—	30	—	—	nsec

Pins 2 and 6 omitted

†Silicon Diode to Ground

ELECTRICAL CHARACTERISTICS — MC916G

@ Test Temperature	Test Conditions Volts				
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Power Dissipation @ T_A = 25°C: 54 mW typical

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	5	—	8	4	2, 3, 6, 7	$I_{in}(1)$	—	495	—	435	—	478	μAdc
	2	—	1, 3,	—	8	4	5, 6, 7	$2\,I_{in}(2)$	—	990	—	870	—	948	μAdc
	3	—	7	—	8	4	1, 2, 5, 8	$I_{in}(3)$	—	495	—	435	—	478	μAdc
	6	—	5	—	8	4	1, 2, 3, 7	$I_{in}(6)$	—	495	—	435	—	478	μAdc
Output Current	—	5	1, 6	—	8	4	2, 3, 7	$I_{A3}(5)$	1.48	—	1.52	—	1.41	—	mAdc
	—	7	3	6	8	4, 5†	1, 2	$I_{A3}(7)$	1.48	—	1.52	—	1.41	—	mAdc
	—	5, 6	1	—	8	4	2, 3, 7	$I_{A3}(5)$	1.48	—	1.52	—	1.41	—	mAdc
Output Voltage	—	6	—	—	8	4, 5	1, 2, 3, 7	$V_{out}(7)$	—	718	—	380	—	320	mVdc
	—	1, 3	—	—	8	4, 6	5	$V_{out}(7)$‡#	—	718	—	388	—	328	mVdc
	—	3	—	1	8	4, 8	5, 7	$V_{out}(7)$‡	—	718	—	308	—	320	mVdc
	—	—	—	1, 3	8	4, 6	7	$V_{out}(7)$‡§	—	710	—	300	—	320	mVdc
Saturation Voltage	—	—	6	—	8	4, 5	1, 2, 3, 7	$V_{CE}(7)$	—	200	—	218	—	280	mVdc
	—	—	—	—	8	4, 7†	1, 2, 3, 5, 6	$V_{CE}(7)$	—	208	—	210	—	280	mVdc
	—	—	—	6	8	4, 5†	1, 2, 3, 7	$V_{CE}(5)$	—	200	—	218	—	280	mVdc
Turn-On Voltage	—	1, 3	—	—	8	4, 6	7*	$V_{on}(7)$‡§	1814	—	815	—	674	—	mVdc
	—	1	—	3	8	4, 6	5, 7*	$V_{on}(7)$‡	1014	—	815	—	674	—	mVdc
	—	—	—	1, 3	8	4, 6	5	$V_{on}(7)$‡#*	1014	—	815	—	674	—	mVdc

†Silicon Diode to Ground

*Pin 7 Loaded by: 1.52 mAdc (+25°C)
1.48 mAdc (−55°C)
1.41 mAdc (+125°C)

‡Pin 2 = ⌐

§Pin 5 = LOW
#Pin 7 = LOW
} Set by a momentary ground prior to the application of the negative-going Clock Pulse.

MC900G / MC800G series (continued)

FLIP-FLOPS

ELECTRICAL CHARACTERISTICS — MC802G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: 22 mW typical, 28 mW maximum

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	5	—	8	4	3, 7	$I_{in}(1)$	—	504	—	450	—	450	μAdc
	3	—	7	—	8	4	1, 5	$I_{in}(3)$	—	584	—	450	—	450	μAdc
Output Current	—	5	1	3	8	4	7	$I_{A4}(5)$	2.02	—	2.05	—	1.80	—	mAdc
	—	7	3	1	8	4	5	$I_{A4}(7)$	2.82	—	2.85	—	1.80	—	mAdc
Output Voltage	—	3	1	—	8	4	5, 7	$V_{out}(5)$	—	574	—	400	—	370	mVdc
	—	7	—	—	8	4	1, 3, 5	$V_{out}(5)$	—	574	—	480	—	378	mVdc
	—	1	3	—	8	4	5, 7	$V_{out}(7)$	—	574	—	408	—	378	mVdc
	—	5	—	—	8	4	1, 3, 7	$V_{out}(7)$	—	574	—	400	—	378	mVdc
Saturation Voltage	—	—	1, 3	—	8	4	5, 7	$V_{CE}(5)$	—	290	—	260	—	348	mVdc
	—	—	—	1	8	4, 5†	3, 7	$V_{CE}(5)$	—	290	—	260	—	348	mVdc
	—	—	1, 3	—	8	4	5, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	—	3	8	4, 7†	1, 5	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
Switching Time	Pulse In	Pulse Out													
	1	7	—	—	8	4	3, 5	t_{1+7-}	—	—	—	28	—	—	nsec
	1	7	—	—	8	4	3, 5	t_{1-7+}	—	—	—	30	—	—	nsec

Pins 2 and 6 omitted † Silicon Diode to Ground

ELECTRICAL CHARACTERISTICS — MC816G

@ Test Temperature	Test Conditions Volts V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Power Dissipation @ T_A = 25°C: 54 mW typical

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	—	5	—	8	4	2, 3, 6, 7	$I_{in}(1)$	—	504	—	450	—	450	μAdc
	2	—	1, 3,	—	8	4	5, 8, 7	$2\,I_{in}(2)$	—	1010	—	900	—	900	μAdc
	3	—	7	—	8	4	1, 2, 5, 6	$I_{in}(3)$	—	504	—	450	—	450	μAdc
	6	—	5	—	8	4	1, 2, 3, 7	$I_{in}(8)$	—	504	—	450	—	458	μAdc
Output Current	—	5	1, 6	—	8	4	2, 3, 7	$I_{A3}(5)$	1.51	—	1.43	—	1.35	—	mAdc
	—	7	3	8	8	4, 5†	1, 2	$I_{A3}(7)$	1.51	—	1.43	—	1.35	—	mAdc
	—	5, 6	1	—	8	4	2, 3, 7	$I_{A3}(5)$	1.51	—	1.43	—	1.35	—	mAdc
Output Voltage	—	8	—	—	8	4, 5	1, 2, 3, 7	$V_{out}(7)$	—	574	—	400	—	370	mVdc
	—	1, 3	—	—	8	4, 8	5	$V_{out}(7)$‡#	—	574	—	400	—	370	mVdc
	—	3	—	1	8	4, 8	5, 7	$V_{out}(7)$‡	—	574	—	400	—	370	mVdc
	—	—	—	1, 3	8	4, 6	7	$V_{out}(7)$†§	—	574	—	400	—	378	mVdc
Saturation Voltage	—	—	8	—	8	4, 5	1, 2, 3, 7	$V_{CE}(7)$	—	290	—	260	—	340	mVdc
	—	—	—	—	8	4, 7†	1, 2, 3, 5, 8	$V_{CE}(7)$	—	290	—	260	—	348	mVdc
	—	—	—	8	8	4, 5†	1, 2, 3, 7	$V_{CE}(5)$	—	290	—	260	—	340	mVdc
Turn-On Voltage	—	1, 3	—	—	8	4, 6	7*	$V_{on}(7)$‡§	909	—	844	—	710	—	mVdc
	—	1	—	3	8	4, 8	5, 7*	$V_{on}(7)$‡	909	—	844	—	710	—	mVdc
	—	—	—	1, 3	8	4, 8	5	$V_{on}(7)$‡#*	909	—	844	—	710	—	mVdc

† Silicon Diode to Ground

*Pin 7 loaded by: 1.43 mAdc (+25°C)
1.51 mAdc (8°C)
1.35 mAdc (+100°C)

‡ Pin 2 = ⊓

§ Pin 5 = LOW
Pin 7 = LOW
} Set by a momentary ground prior to the application of the negative-going Clock Pulse.

MC900G / MC800G series (continued)

FLIP-FLOPS

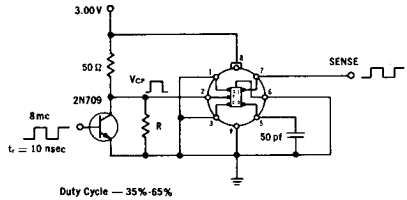
SWITCHING TIMES — MC916G, MC816G

Test	Figure No.	Maximum @ 25°C only	Maximum Over full temperature range	Unit
CP above V_{on} + 50 mV	—	—	60 min	nsec
t_{2-7-}	1	40	60	nsec
t_{2-5-}	1	40	60	nsec
t_{2-7+}	1	80	100	nsec
t_{2-5+}	1	80	100	nsec
t_{1+2-}	2	—	50	nsec
t_{3+2-}	2	—	50	nsec
t_{1-2-}	2	—	50	nsec
t_{3-2-}	2	—	58	nsec
t_{6+7-}	3	—	50	nsec
t_{6+5+}	3	—	90	nsec

NOTES:
1. Change of state occurs on trailing edge of clock pulse.
2. With a high level on Pin 6, and with the proper SET and CLEAR inputs for a low level at Pin 5, Pin 5 will be high except for a short period after the negative-going edge of a clock pulse. Pin 5 will go low for up to 50 nsec, and then return to a high level within 100 nsec after a negative clock transition.

TOGGLE CHARACTERISTICS

	Min	Max	Unit
Toggle Frequency	8	—	mc
Output Load (clock frequency = 8 mc)	—	50	pf
Output Load (clock frequency ≤ 4 mc)	—	100	pf



Duty Cycle — 35%-65%

MC916G — V_{CP} Magnitude = 1.2 V @ −55°C, R = 50 ohms
= 0.9 V @ +125°C, R = 33 ohms

MC816G — V_{CP} Magnitude = 1.0 V @ 0°C, R = 39 ohms
= 0.9 V @ 100°C, R = 33 ohms

V_{CP} will rise above V_{on} since the input current, pin 2, is typically 1.4 I_{in}.

Pin 4 = ground; Pin 8 = V_{CC} = 3.00 V;
ratings valid from -55 to +125°C for MC916G
0 to +100°C for MC816G

SWITCHING TIME TEST CIRCUITS AND WAVEFORMS

FIGURE 1

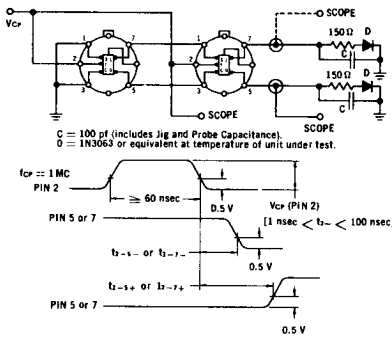


FIGURE 2

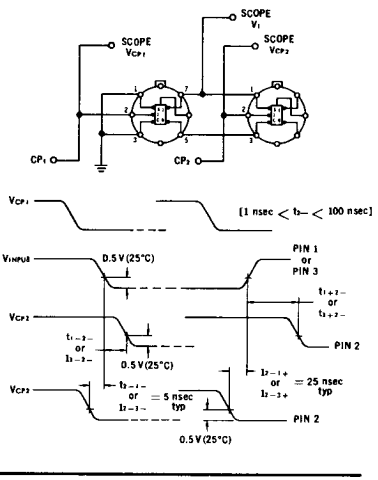
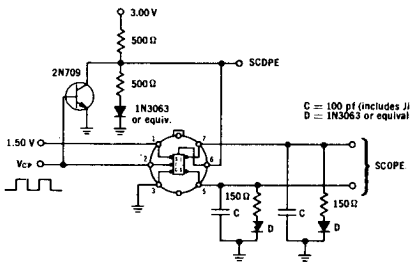
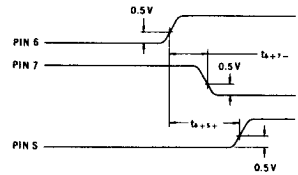


FIGURE 3





MC900G/MC800G series (continued)

The JK Flip-Flop has the unique advantage over the conventional binary element in that no ambiguous output state can result with any combination of data input signals. A simultaneous low level set and clear input will cause the output state to reverse. Whereas, high levels on both set and clear inputs prevent the output state from changing.

The versatile JK Flip-Flop storage element can be used to advantage in shift registers, binary counters, and other control functions where JK logic minimizes the logic structure of the unit.

Preset and preclear inputs are available for presetting counters, for asynchronous entry of data into registers, and other similar applications. A high level on the preset input causes the Q output of the flip-flop to assume the low logic state. A high level on the preclear input sets the Q output to the high logic state.

The MC926G is designed for operation over the full military temperature range of −55°C to +125°C. The MC826G is guaranteed over a temperature range of 0°C to +100°C.

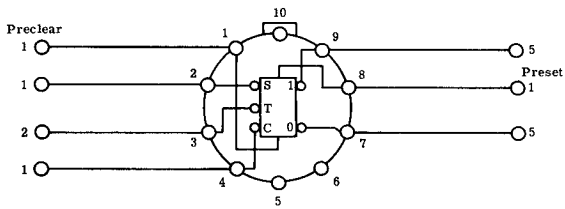
JK FLIP-FLOP

MC926G
MC826G

t = n		t = n+1
Set (2)	Clear (4)	Output (9)
H	H	X^n
H	L	H
L	H	L
L	L	$X^{\overline{n}}$

H is more positive than L

X is output state at time n



LOGIC SYMBOL AND LOADING DIAGRAM

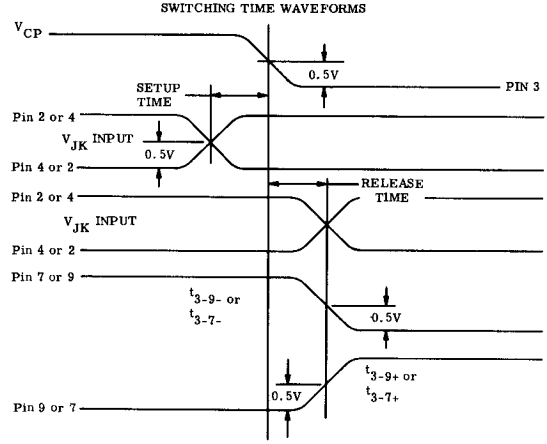
SWITCHING TIMES

TEST	MAXIMUM @ 25°C Only	MAXIMUM Over Full Temperature Range	Unit
t_{3-9-}	60	90	nsec
t_{3-7-}	60	90	nsec
t_{3-9+}	60	90	nsec
t_{3-7+}	60	90	nsec
t_{2+3-}	--	50	nsec
t_{4+3-}	--	50	nsec
t_{2-3-}	--	30	nsec
t_{4-3-}	--	30	nsec
t_{3-2-}	--	+5*	nsec
t_{3-4-}	--	+5*	nsec
t_{3-2+}	--	0*	nsec
t_{3-4+}	--	0*	nsec
$t_{1 \text{ or } 8+ \text{ to output } -}$	--	90	nsec
$t_{1 \text{ or } 8+ \text{ to output } +}$	--	70	nsec
t_{3-9-}	--	25 (Min) #	nsec
t_{3-7-}	--	25 (Min) #	nsec
t_{3-9+}	--	25 (Min) #	nsec
t_{3-7+}	--	25 (Min) #	nsec

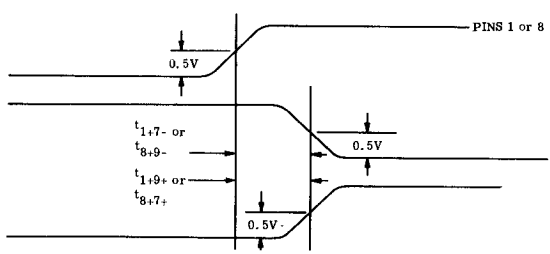
* Negative switching time means the inputs can momentarily change before the clock pulse transition.

\# Lightly loaded

SWITCHING TIME WAVEFORMS



SWITCHING TIME WAVEFORMS



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

FLIP-FLOPS

MC926G

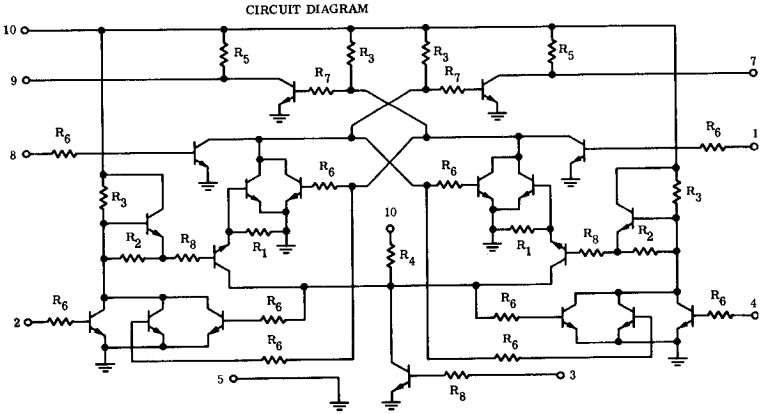
@ Test Temperature	Test Conditions	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C		1.014	1.014	1.50	0.710	3.00
+25°C		0.844	0.815	1.50	0.565	3.00
+125°C		0.674	0.674	1.50	0.320	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1				10	5	2, 3, 4, 6, 7, 8, 9	$I_{IN}(1)$	---	495	---	435	---	470	μAdc
	2		8		10	5	1, 3, 4, 6, 7, 9	$I_{IN}(2)$	---	495	---	435	---	470	μAdc
	3		2, 4		10	5	1, 6, 7, 8, 9	$2I_{IN}(3)$	---	990	---	870	---	940	μAdc
	4		1		10	5	2, 3, 6, 7, 8, 9	$I_{IN}(4)$	---	495	---	435	---	470	μAdc
	8				10	5	1, 2, 3, 4, 6, 7, 9	$I_{IN}(8)$	---	495	---	435	---	470	μAdc
Output Current		1, 9	8		10	5	2, 3, 4, 6, 7	$I_{A5}(9)$	2.47	---	2.54	---	2.35	---	mAdc
		7, 8	1		10	5	2, 3, 4, 6, 9	$I_{A5}(7)$	2.47	---	2.54	---	2.35	---	mAdc
Saturation Voltage		1		8	10	5	2, 3, 4, 6, 7, 9	$V_{CE}(7)$	---	200	---	210	---	280	mVdc
		8		1	10	5	2, 3, 4, 6, 7, 9	$V_{CE}(9)$	---	200	---	210	---	280	mVdc
		2		4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(7)$*△	---	200	---	210	---	280	mVdc
		4		2	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$§△	---	200	---	210	---	280	mVdc
		2, 4			10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$*△	---	200	---	210	---	280	mVdc
				2, 4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(7)$*△	---	200	---	210	---	280	mVdc
				2, 4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$§△	---	200	---	210	---	280	mVdc
		2, 4			10	5	1, 3, 6 7, 8, 9	$V_{CE}(7)$§△	---	200	---	210	---	280	mVdc

§ Pin 1 = Hi
* Pin 8 = Hi
△ Pin 3 = ⌐¯|_

Set by a momentary application of V_{BOT} prior to the application of the negative going clock pulse.

CIRCUIT DIAGRAM



Typical Resistors:

R_1 = 3KΩ
R_2 = 2KΩ
R_3 = 900Ω
R_4 = 700Ω
R_5 = 640Ω
R_6 = 600Ω
R_7 = 550Ω
R_8 = 300Ω

MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

FLIP-FLOPS

MC826G

@ Test Temperature	Test Conditions Volts				
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

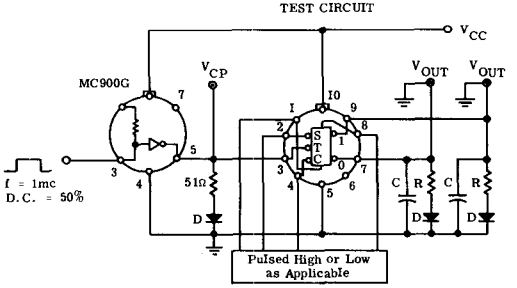
Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	I				10	5	2, 3, 4, 6, 7, 8, 9	$I_{IN}(1)$	---	504	---	450	---	450	μAdc
	2		8		10	5	1, 3, 4, 6, 7, 9	$I_{IN}(2)$	---	504	---	450	---	450	μAdc
	3		2, 4		10	5	1, 6, 7, 8, 9	$2I_{IN}(3)$	---	101	---	0.9	---	0.9	mAdc
	4		1		10	5	2, 3, 6, 7, 8, 9	$I_{IN}(4)$	---	504	---	450	---	450	μAdc
	8				10	5	1, 2, 3, 4, 6, 7, 9	$I_{IN}(8)$	---	504	---	450	---	450	μAdc
Output Current		1, 9	8		10	5	2, 3, 4, 6, 7	$I_{A5}(9)$	2.52	---	2.38	---	2.25	---	mAdc
		7, 8	1		10	5	2, 3, 4, 6, 9	$I_{A5}(7)$	2.52	---	2.38	---	2.25	---	mAdc
Saturation Voltage		I		8	10	5	2, 3, 4, 6, 7, 9	$V_{CE}(7)$	---	290	---	260	---	340	mVdc
		8		1	10	5	2, 3, 4, 6, 7, 9	$V_{CE}(9)$	---	290	---	260	---	340	mVdc
		2		4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(7)$*Δ	---	290	---	260	---	340	mVdc
		4		2	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$§Δ	---	290	---	260	---	340	mVdc
		2, 4			10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$*Δ	---	290	---	260	---	340	mVdc
				2, 4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(7)$*Δ	---	290	---	260	---	340	mVdc
				2, 4	10	5	1, 3, 6, 7, 8, 9	$V_{CE}(9)$§Δ	---	290	---	260	---	340	mVdc
		2, 4			10	5	1, 3, 6, 7, 8, 9	$V_{CE}(7)$§Δ	---	290	---	260	---	340	mVdc

§ Pin I = Hi
* Pin 8 = Hi

Set by a momentary application of V_{BOT} prior to the application of the negative going clock pulse.

Δ Pin 3 = ⌐¯¯¯¯¯¯¬_

TEST CIRCUIT



f = 1mc
D.C. = 50%

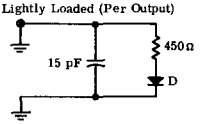
(1 nsec < t_{3-} < 200 nsec)

C= 100 pF (includes jig and probe capacitance)

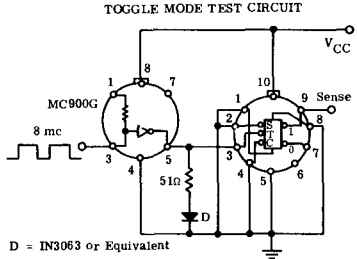
D= IN3063 or equivalent at temperature of unit under test

R= 90 ohms

Lightly Loaded (Per Output)



TOGGLE MODE TEST CIRCUIT



D = IN3063 or Equivalent

TOGGLE CHARACTERISTIC

	Min	Max	Unit
Toggle Frequency	8	---	mc
Clock Pulse Duty Cycle (8mc)	25	75	%
Capacitive Load/Output	--	Unlimited	pF

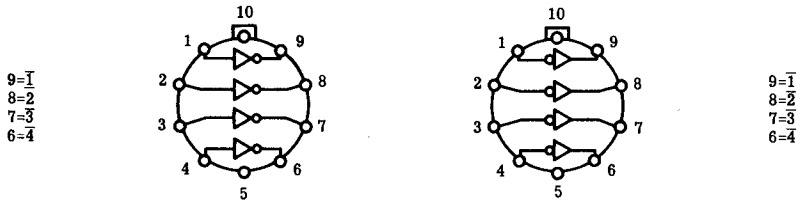
MC900G/MC800G series (continued)

RTL
QUAD INVERTER

MC927G
MC827G

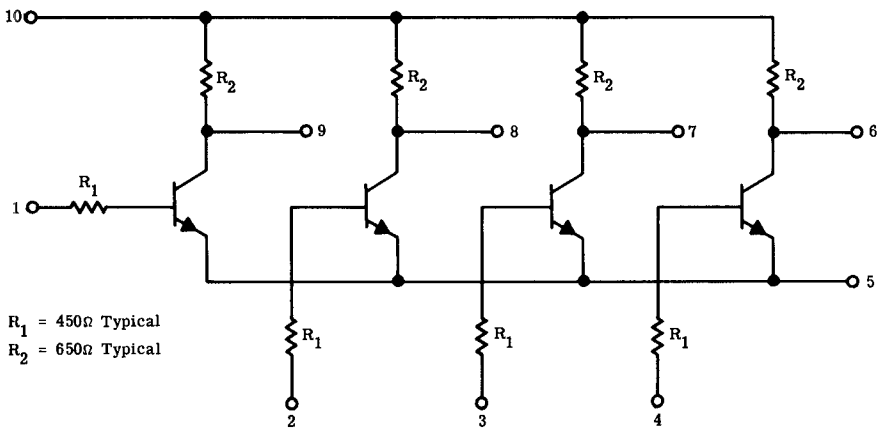
These devices perform the simple inversion function. The MC927G is designed for operation over the full military temperature range of −55°C to +125°C. The MC827G is guaranteed over a temperature range of 0°C to +100°C.

LOGIC SYMBOLS AND FUNCTIONS (PER MIL-STD-806B)

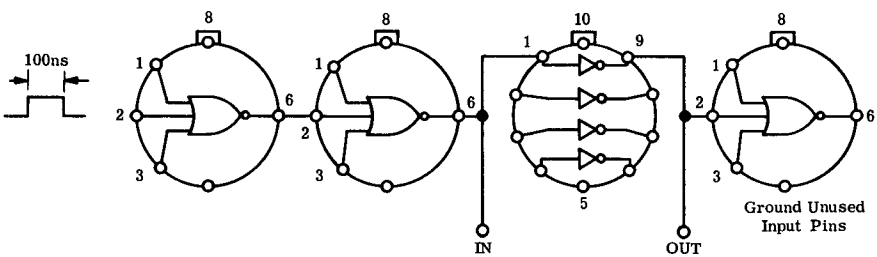


POSITIVE LOGIC NEGATIVE LOGIC

CIRCUIT DIAGRAM



SWITCHING TIME TEST CIRCUIT



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

QUAD INVERTERS

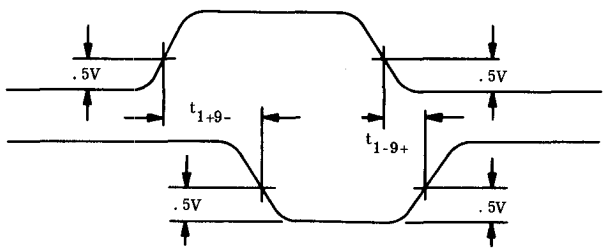
MC927G

@ Test Temperature	Test Conditions		Volts		
−55°C	1.014	1.014	1.50	0.710	3.00
+25°C	0.844	0.815	1.50	0.565	3.00
+125°C	0.674	0.674	1.50	0.320	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	--	2	--	10	5	3, 4, 6, 7	$I_{in}(1)$*	--	495	--	435	--	470	μAdc
	2	--	1	--	10	5	3, 4, 6, 7	$I_{in}(2)$*	--	495	--	435	--	470	μAdc
	3	--	4	--	10	5	1, 2, 8, 9	$I_{in}(3)$**	--	495	--	435	--	470	μAdc
	4	--	3	--	10	5	1, 2, 8, 9	$I_{in}(4)$**	--	495	--	435	--	470	μAdc
Output Current	--	6	--	4	10	5	1, 2, 3, 7, 8, 9	$I_{A5}(6)$	2.47	--	2.54	--	2.35	--	mAdc
	--	7	--	3	10	5	1, 2, 4, 6, 8, 9	$I_{A5}(7)$	2.47	--	2.54	--	2.35	--	mAdc
	--	8	--	2	10	5	1, 3, 4, 6, 7, 9	$I_{A5}(8)$	2.47	--	2.54	--	2.35	--	mAdc
	--	9	--	1	10	5	2, 3, 4, 6, 7, 8	$I_{A5}(9)$	2.47	--	2.54	--	2.35	--	mAdc
Output Leakage Current	6	--	--	4	--	5	1, 2, 3, 7, 8, 9, 10	$I_{CEX}(6)$	--	100	--	218	--	235	μAdc
	7	--	--	3	--	5	1, 2, 4, 6, 8, 9, 10	$I_{CEX}(7)$	--	100	--	218	--	235	μAdc
	8	--	--	2	--	5	1, 3, 4, 6, 7, 9, 10	$I_{CEX}(8)$	--	100	--	218	--	235	μAdc
	9	--	--	1	--	5	2, 3, 4, 6, 7, 8, 10	$I_{CEX}(9)$	--	100	--	218	--	235	μAdc
Output Voltage	--	4	1, 2, 3	--	10	5	6, 7, 8, 9	$V_{OUT}(6)$	--	710	--	300	--	320	mVdc
	--	3	1, 2, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(7)$	--	710	--	300	--	320	mVdc
	--	2	1, 3, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(8)$	--	710	--	300	--	320	mVdc
	--	1	2, 3, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(9)$	--	710	--	300	--	320	mVdc
Saturation Voltage	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(6)$	--	200	--	210	--	280	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(7)$	--	200	--	210	--	280	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(8)$	--	200	--	210	--	280	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(9)$	--	200	--	210	--	280	mVdc
Switching Time	Pulse in	Pulse out													
	1	9	---	--	10	5	2, 3, 4, 6, 7, 8	t_{1+9-}	--	--	--	20	--	--	nsec
	1	9	---	--	10	5	2, 3, 4, 6, 7, 8	t_{1-9+}	--	--	--	28	--	--	nsec

* Pin 8 connected to Pin 9
** Pin 6 connected to Pin 7

SWITCHING TIME WAVEFORM



MC900G/MC800G series (continued)

ELECTRICAL CHARACTERISTICS

QUAD INVERTERS

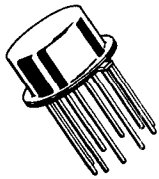
MC827G

@ Test Temperature	Test Conditions Volts				
0°C	0.909	0.909	1.50	0.574	3.00
+25°C	0.844	0.844	1.50	0.554	3.00
+100°C	0.710	0.710	1.50	0.370	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+100°C Min	+100°C Max	Unit
Input Current	1	--	2	--	10	5	3, 4, 6, 7	$I_{in}(1)$*	--	504	--	450	--	450	μAdc
	2	--	1	--	10	5	3, 4, 6, 7	$I_{in}(2)$*	--	504	--	450	--	450	μAdc
	3	--	4	--	10	5	1, 2, 8, 9	$I_{in}(3)$**	--	504	--	450	--	450	μAdc
	4	--	3	--	10	5	1, 2, 8, 9	$I_{in}(4)$**	--	504	--	450	--	450	μAdc
Output Current	--	6	--	4	10	5	1, 2, 3, 7, 8, 9	$I_{A5}(6)$	2.52	--	2.38	--	2.25	--	mAdc
	--	7	--	3	10	5	1, 2, 4, 6, 8, 9	$I_{A5}(7)$	2.52	--	2.38	--	2.25	--	mAdc
	--	8	--	2	10	5	1, 3, 4, 6, 7, 9	$I_{A5}(8)$	2.52	--	2.38	--	2.25	--	mAdc
	--	9	--	1	10	5	2, 3, 4, 6, 7, 8	$I_{A5}(9)$	2.52	--	2.38	--	2.25	--	mAdc
Output Leakage	6	--	--	4	--	5	1, 2, 3, 7, 8, 9, 10	$I_{CEX}(8)$	--	100	--	225	--	225	μAdc
	7	--	--	3	--	5	1, 2, 4, 6, 8, 9, 10	$I_{CEX}(7)$	--	100	--	225	--	225	μAdc
	8	--	--	2	--	5	1, 3, 4, 6, 7, 9, 10	$I_{CEX}(8)$	--	100	--	225	--	225	μAdc
	9	--	--	1	--	5	2, 3, 4, 6, 7, 8, 10	$I_{CEX}(9)$	--	100	--	225	--	225	μAdc
Output Voltage	--	4	1, 2, 3	--	10	5	6, 7, 8, 9	$V_{OUT}(6)$	--	574	--	400	--	370	mVdc
	--	3	1, 2, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(7)$	--	574	--	400	--	370	mVdc
	--	2	1, 3, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(8)$	--	574	--	400	--	370	mVdc
	--	1	2, 3, 4	--	10	5	6, 7, 8, 9	$V_{OUT}(9)$	--	574	--	400	--	370	mVdc
Saturation Voltage	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(6)$	--	290	--	260	--	340	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(7)$	--	290	--	260	--	340	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(8)$	--	290	--	260	--	340	mVdc
	--	--	1, 2, 3, 4	--	10	5	6, 7, 8, 9	$V_{CE}(9)$	--	290	--	260	--	340	mVdc
Switching Time	Pulse in	Pulse out													
	1	9	--	--	10	5	2, 3, 4, 6, 7, 8	t_{1+9-}	--	--	--	20	--	--	nsec
	1	9	--	--	10	5	2, 3, 4, 6, 7, 8	t_{1-9+}	--	--	--	28	--	--	nsec

* Pin 8 connected to Pin 9
** Pin 6 connected to Pin 7

MC908G MILLIWATT RTL SERIES



The Milliwatt RTL Line consists of eight monolithic, integrated Resistor-Transistor Logic circuits. These devices are designed for use over the full military temperature range of −55 to +125°C.

ADDER
MC908G

BUFFER
MC909G

LOGIC GATES
DUAL 2-INPUT GATE
MC910G

4-INPUT GATE
MC911G

5-INPUT GATE
MC928G

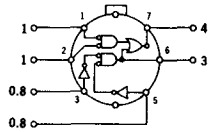
DUAL 3-INPUT GATE
MC918G

FLIP-FLOP
MC913G
MC920G

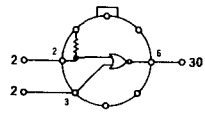
HALF-ADDER
MC912G

GATE EXPANDER
MC921G

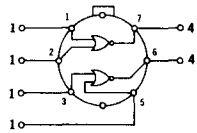
LOADING DIAGRAMS
Valid from −55°C to +125°C with V_{cc} = 3.00 V ± 10%



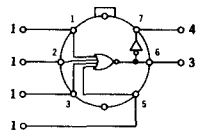
MC908G



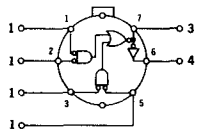
MC909G



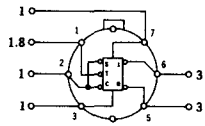
MC910G



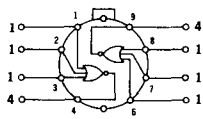
MC911G



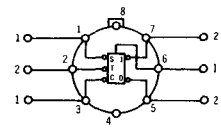
MC912G



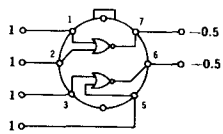
MC913G



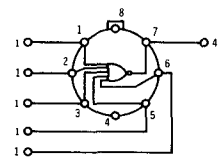
MC918G



MC920G



MC921G



MC928G

MC908G RTL SERIES (continued)

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Rating	Unit
Maximum Applied Voltage to pin 8 (pulsed, ≤ 1sec)	12	Vdc
Maximum Applied Voltage to pin 8 (continuous)	8	Vdc
Maximum Applied Voltage to any input	±4	Vdc
Operating Temperature Range	-55 to +125	°C
Storage Temperature Range	-65 to +150	°C
Maximum Power Dissipation	250	mW

TEST CONDITION TOLERANCES

$V_{CC} = \pm 10$ mV
$V_{BOT} = \pm 10$ mV
$V_{in} = \pm 2$ mV
$V_{on} = \pm 2$ mV
$V_{off} = \pm 2$ mV
$V_{LL} = \pm 2$ mV
$V_{RL} = \pm 1\%$
$V_{RH} = \pm 1\%$

GENERAL RULES

- The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.
- All unused inputs should be returned to ground.

DEFINITIONS

I_{A3} Minimum available output current for outputs with loading factor of 3

I_{A4} Minimum available output current for outputs with loading factor of 4

I_{AB} Minimum available output current from the MC909G (Buffer)

I_{AM} Maximum available gate output current

I_{CEX} Output Leakage Current

I_{in} Maximum input current with V_{in} applied and a fan-in of two or greater

I_L Leakage current

V_{BOT} Maximum input voltage

V_{CC} Supply voltage

V_{CE} Maximum saturation voltage (V_{in} applied to input)

V_{in} Minimum high level voltage

V_{LL} A supply voltage low enough to allow flow of leakage currents only

V_{off} Maximum input voltage that will not turn on the transistor

V_{on} Minimum turn-on voltage

V_{out} Maximum output voltage (V_{on} applied to input)

V_{RH} Voltage drop across resistor connected to V_{CC}, representing the highest node resistor value of Milliwatt RTL

V_{RL} Voltage drop across resistor connected to V_{CC} representing the lowest node resistor value of Milliwatt RTL

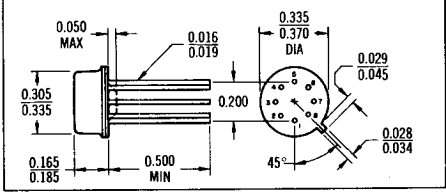
$0.8\ I_{in}$ Maximum input current with V_{in} applied and a fan-in equal to one

$1.8\ I_{in}$ Current drawn from the V_{in} supply by pin 1 of the MC913G (Flip-Flop)

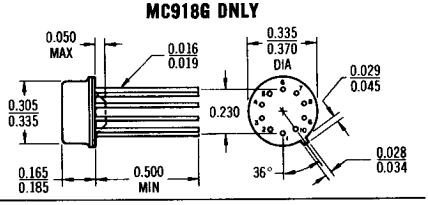
$2\ I_{in}$ Current drawn from the V_{in} supply by an input of the MC909G (Buffer)

OUTLINE DIMENSIONS

8-LEAD PACKAGE



10-LEAD PACKAGE
MC918G ONLY



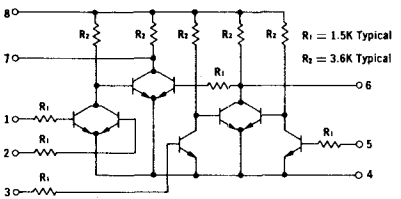
MC908G SERIES (continued)

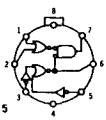
MC908G

ADDER

The MC908G is an RTL Adder. The binary half-adder function can be performed by connecting pin 1 to pin 3 and pin 2 to pin 5. The "SUM" is available on pin 7 while the "CARRY" is available on pin 6. The device may also be used as a data selector by connecting pin 1 to pin 3 and using pins 2 and 5 as data inputs. A full adder can be made utilizing two MC908Gs and one MC911G.

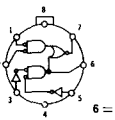
CIRCUIT DIAGRAM AND LOGIC SYMBOLS





$6 = \overline{(\overline{3+5})} = 3 \cdot 5$

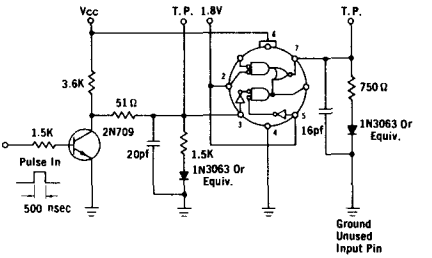
$7 = (1+2)(\overline{3}+\overline{5})$ POSITIVE LOGIC



$6 = (\overline{3 \cdot 5}) = 3 + 5$

NEGATIVE LOGIC $7 = 1 \cdot 2 + \overline{3} \cdot \overline{5}$

SWITCHING TIME TEST CIRCUIT AND WAVEFORM



ELECTRICAL CHARACTERISTICS

		Test Conditions Volts						
@ Test Temperature	−55°C	0.970	0.935	1.8	0.650	3.00	0.500
	+25°C	0.805	0.750	1.8	0.450	3.00	0.400
	+125°C	0.590	0.555	1.8	0.260	3.00	0.300

Average Power Dissipation = 10 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{LL} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	—	3, 4, 5	6, 7	I_{in}(1)	—	125	—	130	—	110	μAdc
	2	—	1	—	8	—	3, 4, 5	6, 7	I_{in}(2)	—	125	—	130	—	110	μAdc
	3	—	—	—	8	—	1, 2, 4, 5	6, 7	0.8 I_{in}(3)	—	100	—	104	—	88	μAdc
	5	—	—	—	8	—	1, 2, 3, 4	6, 7	0.8 I_{in}(5)	—	100	—	104	—	88	μAdc
Output Current	6	3, 5	—	—	8	—	1, 2, 4	7	I_{A3}(6)	350	—	364	—	308	—	μAdc
	7	1	—	3, 5	8	—	2, 4	6	I_{A4}(7)	475	—	494	—	418	—	μAdc
	7	2	—	3, 5	8	—	1, 4	6	I_{A4}(7)	475	—	494	—	418	—	μAdc
Saturation Voltage	—	—	3	5	8	—	1, 2, 4	6, 7	V_{CE}(6)	—	220	—	220	—	220	mVdc
	—	—	5	3	8	—	1, 2, 4	6, 7	V_{CE}(6)	—	220	—	220	—	220	mVdc
	—	—	—	1, 2	8	—	3, 4, 5	6, 7	V_{CE}(7)	—	220	—	220	—	220	mVdc
	6	—	1, 2, 3, 5	—	8	—	4	7	V_{CE}(7)	—	220	—	220	—	220	mVdc
Output Voltage	—	6	1, 2, 3, 5	—	8	—	4	7	V_{out}(7)	—	620	—	300	—	230	mVdc
Leakage Current	—	—	—	—	—	8	1, 2, 3, 4, 5	6, 7	I_L(8)	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out														
Turn-On Delay	3	7	2, 5	—	8	—	1, 4	6	t_{3+7-}	—	—	—	100	—	—	nsec
Turn-Off Delay	3	7	2, 5	—	8	—	1, 4	6	t_{3-7+}	—	—	—	00	—	—	nsec

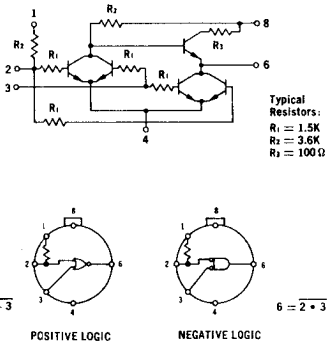
MC908G SERIES (continued)

MC909G

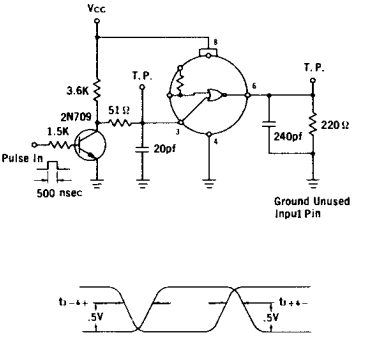
BUFFER

The MC909G RTL Buffer is designed to drive a greater number of loads than the basic Resistor Transistor Logic circuit. Returning an input resistor to V_{CC} allows for capacitive coupling in multivibrator and differentiator applications.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUIT AND WAVEFORM



ELECTRICAL CHARACTERISTICS

	Test Conditions															
	Volts					Ohms										
@ Test Temperature −55°C	0.970	0.935	1.8	0.650	3.00	4.27K*										
@ Test Temperature +25°C	6.805	0.750	1.8	0.450	3.00	4.3K*										
@ Test Temperature +125°C	0.590	0.555	1.8	0.260	3.00	5K*										

Average Power Dissipation = 10 mW @ T_A = 25°C, Duty Cycle = 50%

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{RH}* Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	2	—	3	—	8	—	4	1, 6	$2\ I_{in}(2)$	—	250	—	260	—	220	μAdc
	3	—	2	—	8	—	4	1, 6	$2\ I_{in}(3)$	—	250	—	260	—	220	μAdc
Output Current	6	—	—	2, 3	8	—	4	1	$I_{AB}(6)$	3.75	—	4.0	—	3.3	—	mAdc
Output Voltage	—	2	—	—	8	6	3, 4	1	$V_{out}(6)$	—	620	—	300	—	230	mVdc
	—	3	—	—	8	6	2, 4	1	$V_{out}(6)$	—	620	—	300	—	230	mVdc
Saturation Voltage	2	—	—	—	8	6	3, 4	1	$V_{CE}(6)$	—	220	—	220	—	220	mVdc
	3	—	—	—	8	6	2, 4	1	$V_{CE}(6)$	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	8	—	2, 3, 4	1, 6	$I_L(8)$	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out														
Turn-On Delay	3	6	—	—	8	—	2, 4	1	t_{3+6-}	—	—	—	90	—	—	nsec
Turn-Off Delay	3	6	—	—	8	—	2, 4	1	t_{3-6+}	—	—	—	70	—	—	nsec

*Resistor Value to V_{CC} Pins 5 and 7 omitted

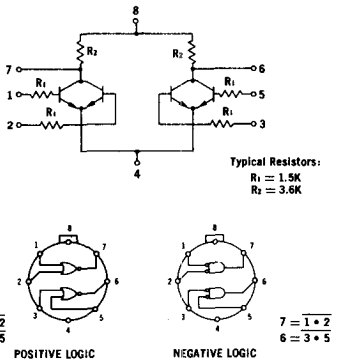
MC908G SERIES (continued)

MC910G — DUAL 2-INPUT "NOR" GATE

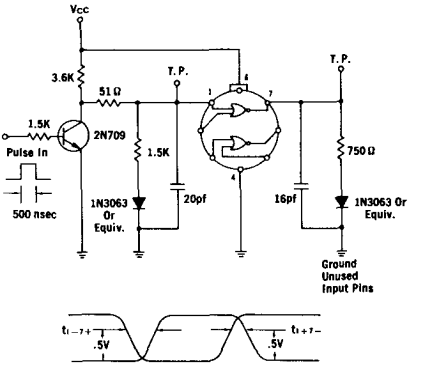
LOGIC GATES

The MC910G Dual (2-2) Input Gate consists of a pair of "NOR" Gates. It may also be used as a pair of inverters, a double inverter or as an R-S Flip-Flop.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUIT AND WAVEFORM



ELECTRICAL CHARACTERISTICS

		Test Conditions: Volts				
@ Test Temperature	−55°C	0.970	0.935	1.8	0.650	3.00
	+25°C	0.805	0.750	1.8	0.450	3.00
	+125°C	0.590	0.555	1.8	0.260	3.00

Average Power Dissipation = 4 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{en} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	8	3, 4, 5	6, 7	I_{in}(1)	—	125	—	130	—	110	μAdc
	2	—	1	—	8	3, 4, 5	6, 7	I_{in}(2)	—	125	—	130	—	110	μAdc
	3	—	5	—	8	1, 2, 4	6, 7	I_{in}(3)	—	125	—	130	—	110	μAdc
	5	—	3	—	8	1, 2, 4	6, 7	I_{in}(5)	—	125	—	130	—	110	μAdc
Output Current															
	7	—	3	1, 2	8	4, 5	6	I_{A4}/I_{AM}(7)	475	730	494	915	418	830	μAdc
	6	—	2	3, 5	8	1, 4	7	I_{A4}/I_{AM}(6)	475	730	494	815	418	830	μAdc
Output Voltage	—	1	—	—	8	2, 3, 4, 5	6, 7	V_{out}(7)	—	620	—	300	—	230	mVdc
	—	2	—	—	8	1, 3, 4, 5	6, 7	V_{out}(7)	—	620	—	300	—	230	mVdc
	—	3	—	—	8	1, 2, 4, 5	6, 7	V_{out}(6)	—	620	—	300	—	230	mVdc
	—	5	—	—	8	1, 2, 3, 4	6, 7	V_{out}(6)	—	620	—	300	—	230	mVdc
Saturation Voltage	1	—	—	—	8	2, 3, 4, 5	6, 7	V_{CE}(7)	—	220	—	220	—	220	mVdc
	2	—	—	—	8	1, 3, 4, 5	6, 7	V_{CE}(7)	—	220	—	220	—	220	mVdc
	3	—	—	—	8	1, 2, 4, 5	6, 7	V_{CE}(6)	—	220	—	220	—	220	mVdc
	5	—	—	—	8	1, 2, 3, 4	6, 7	V_{CE}(6)	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	8	1, 2, 3, 4, 5	6, 7	$I_{L(8)}$	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out													
Turn-On Delay	1	7	—	—	8	2, 3, 4, 5	8	t_{1+7-}	—	—	—	50	—	—	nsec
Turn-Off Delay	1	7	—	—	8	2, 3, 4, 5	6	t_{1-7+}	—	—	—	40	—	—	nsec

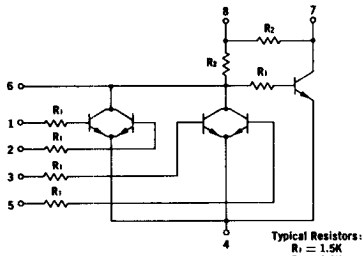
MC908G SERIES (continued)

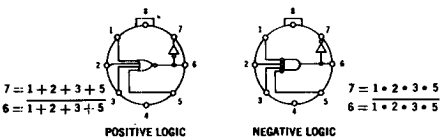
MC911G — 4-INPUT "OR/NOR" GATE

LOGIC GATES

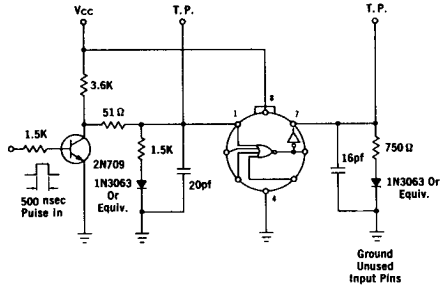
The MC911G 4-Input Gate provides the "NOR" function on pin 6 and the "OR" function on pin 7.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS





SWITCHING TIME TEST CIRCUIT AND WAVEFDRM



ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions Volts					
−55°C	0.970	0.935	1.8	0.650	3.00	0.500
+25°C	0.805	0.750	1.8	0.450	3.00	0.400
+125°C	0.590	0.555	1.8	0.260	3.00	0.300

Average Power Dissipation = 4 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{LL} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2, 3, 5	—	8	—	4	6, 7	I_{in}(1)	—	125	—	130	—	110	μAdc
	2	—	1, 3, 5	—	8	—	4	6, 7	I_{in}(2)	—	125	—	130	—	110	μAdc
	3	—	1, 2, 5	—	8	—	4	6, 7	I_{in}(3)	—	125	—	130	—	110	μAdc
	5	—	1, 2, 3	—	0	—	4	6, 7	I_{in}(5)	—	125	—	130	—	118	μAdc.
Output Current	6	—	—	1, 2, 3, 5	8	—	4	7	I_{A3}(0)	350	—	364	—	308	—	μAdc
	7	—	—	8	8	—	1, 2, 3, 4, 5	—	I_{A4}/I_{AM}(7)	475	730	494	615	416	830	μAdc
Output Voltage	—	1	—	—	8	—	2, 3, 4, 5	6, 7	V_{out}(6)	—	620	—	300	—	230	mVdc
	—	2	—	—	8	—	1, 3, 4, 5	6, 7	V_{out}(6)	—	620	—	300	—	238	mVdc
	—	3	—	—	8	—	1, 2, 4, 5	6, 7	V_{out}(6)	—	620	—	300	—	230	mVdc
	—	5	—	—	8	—	1, 2, 3, 4	8, 7	V_{out}(8)	—	620	—	300	—	230	mVdc
	—	6	—	—	8	—	1, 2, 3, 4, 5	7	V_{out}(7)	—	620	—	300	—	230	mVdc
Saturation Voltage	1	—	—	—	8	—	2, 3, 4, 5	6, 7	V_{CE}(8)	—	228	—	220	—	220	mVdc
	2	—	—	—	8	—	1, 3, 4, 5	6, 7	V_{CE}(6)	—	220	—	220	—	320	mVdc
	3	—	—	—	8	—	1, 2, 4, 5	6, 7	V_{CE}(6)	—	220	—	220	—	220	mVdc
	5	—	—	—	8	—	1, 2, 3, 4	6, 7	V_{CE}(8)	—	220	—	220	—	220	mVdc
	6	—	—	—	8	—	1, 2, 3, 4, 5	7	V_{CE}(7)	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	—	8	1, 2, 3, 4, 5	8, 7	I_L(8)	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out														
Turn-On Delay	1	7	—	—	6	—	2, 3, 4, 5	6	t_{1-7-}	—	—	—	70	—	—	nsec
Turn-Off Delay	1	7	—	—	8	—	2, 3, 4, 5	8	t_{1+7+}	—	—	—	90	—	—	nsec

MC908G series (continued)

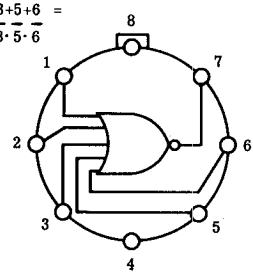
This device provides the NAND/NOR function on pin 7. Individual gates may be paralleled with other logic elements for increasing the number of inputs (subject to loading rules). The MC928G is designed for operation over the full military range of −55°C to +125°C.

MW RTL
5-INPUT GATE

MC928G

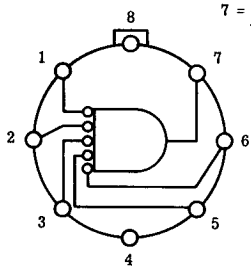
LOGIC SYMBOLS AND FUNCTIONS (PER MIL-STD-806B)

$7 = \overline{1+2+3+5+6} = \overline{1}\cdot\overline{2}\cdot\overline{3}\cdot\overline{5}\cdot\overline{6}$



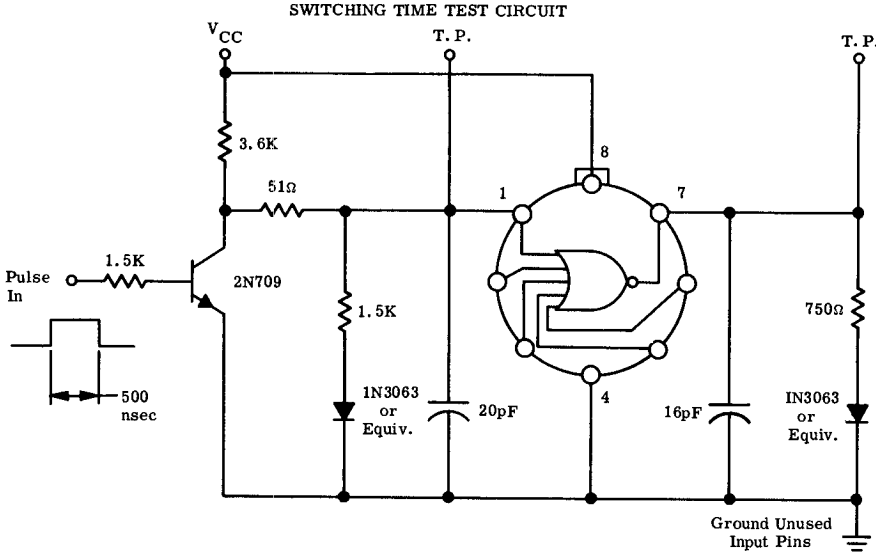
POSITIVE LOGIC

$7 = \overline{1\cdot2\cdot3\cdot5\cdot6} = \overline{1}+\overline{2}+\overline{3}+\overline{5}+\overline{6}$

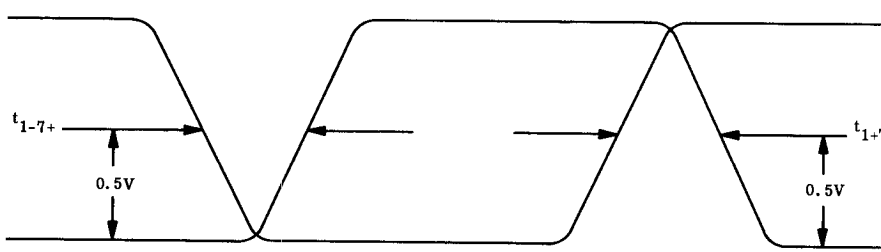


NEGATIVE LOGIC

SWITCHING TIME TEST CIRCUIT



SWITCHING TIME WAVEFORMS



MC908G series (continued)

ELECTRICAL CHARACTERISTICS

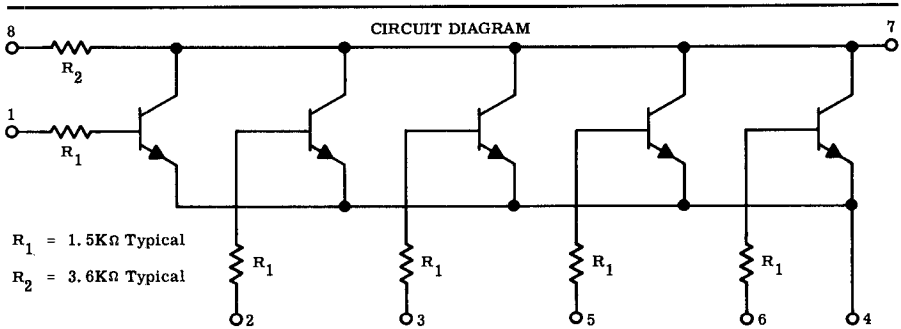
5-INPUT GATES

MC928G

@ Test Temperature	Test Conditions Volts				
−55°C	0.970	0.935	1.80	0.650	3.00
+25°C	0.805	0.750	1.80	0.450	3.00
+125°C	0.590	0.555	1.80	0.260	3.00

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1		2, 3, 5, 6		8	4	$I_{IN}(1)$	---	125	---	130	---	110	μAdc
	2		1, 3, 5, 6,		8	4	$I_{IN}(2)$	---	125	---	130	---	110	μAdc
	3		1, 2, 5, 6		8	4	$I_{IN}(3)$	---	125	---	130	---	110	μAdc
	5		1, 2, 3, 6		8	4	$I_{IN}(5)$	---	125	---	130	---	110	μAdc
	6		1, 2, 3, 5		8	4	$I_{IN}(6)$	---	125	---	130	---	110	μAdc
Output Current	7			1, 2, 3, 5, 6	8	4	$I_{A4}/I_{AM}(7)$	475	730	494	815	418	830	μAdc
Output Voltage		I			8	2, 3, 4, 5, 6	$V_{OUT}(7)$	---	620	---	300	---	230	mVdc
		2			8	1, 3, 4, 5, 6	$V_{OUT}(7)$	---	620	---	300	---	230	mVdc
		3			8	1, 2, 4, 5, 6	$V_{OUT}(7)$	---	620	---	300	---	230	mVdc
		5			8	1, 2, 3, 4, 6	$V_{OUT}(7)$	---	620	---	300	---	230	mVdc
		6			8	1, 2, 3, 4, 5	$V_{OUT}(7)$	---	620	---	300	---	230	mVdc
Saturation Voltage	1				8	2, 3, 4, 5, 6	$V_{CE}(7)$	---	220	---	220	---	220	mVdc
	2				6	1, 3, 4, 5, 6	$V_{CE}(7)$	---	220	---	220	---	220	mVdc
	3				8	1, 2, 4, 5, 6	$V_{CE}(7)$	---	220	---	220	---	220	mVdc
	5				8	1, 2, 3, 4, 6	$V_{CE}(7)$	---	220	---	220	---	220	mVdc
	6				8	1, 2, 3, 4, 5	$V_{CE}(7)$	---	220	---	220	---	220	mVdc
Leakage Current					8	1, 2, 3, 4, 5, 6	$I_L(8)$	---	100	---	100	---	100	μAdc
Switching Time	Pulse in	Pulse out												
	1	7			8	2, 3, 4, 5, 6	t_{1+7-}	---	---	---	50	---	---	nsec
	1	7			8	2, 3, 4, 5, 6	t_{1-7+}	---	---	---	60	---	---	nsec

CIRCUIT DIAGRAM



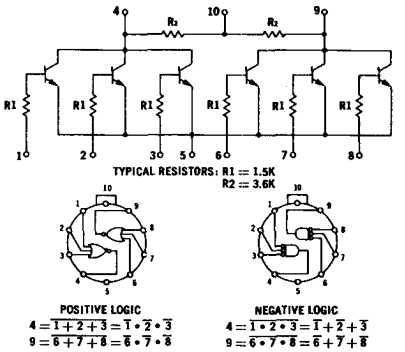
MC908G SERIES (continued)

MC918G — DUAL 3-INPUT "NOR" GATE

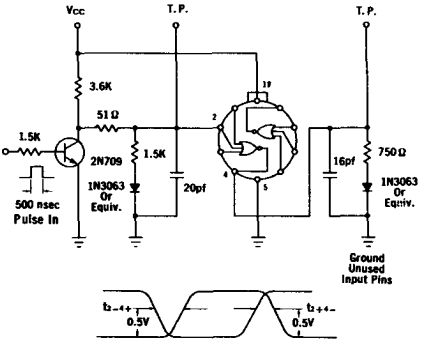
LOGIC GATES

This gate element consists of two "NAND/NOR" gate circuits that can be used in the same manner as the other gate elements. Other applications of this circuit include cross-connecting to form a bistable multivibrator with two set and two reset inputs, or as a three-input noninverting gate.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



SWITCHING TIME TEST CIRCUIT AND WAVEFORM



ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions Volts				
	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.
−55°C	0.970	0.935	1.8	0.650	3.00
+25°C	0.805	0.750	1.8	0.450	3.00
+125°C	0.590	0.555	1.8	0.260	3.00

Average Power Dissipation = 4 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2, 3	—	10	5, 6, 7, 8	4, 9	I_{in}(1)	—	125	—	130	—	110	μAdc
	2	—	1, 3	—	10	5, 6, 7, 8	4, 9	I_{in}(2)	—	125	—	130	—	118	μAdc
	3	—	1, 2	—	10	5, 6, 7, 8	4, 9	I_{in}(3)	—	125	—	130	—	110	μAdc
	6	—	7, 6	—	10	1, 2, 3, 5	4, 9	I_{in}(6)	—	125	—	130	—	110	μAdc
	7	—	6, 8	—	10	1, 2, 3, 5	4, 9	I_{in}(7)	—	125	—	130	—	110	μAdc
	8	—	6, 7	—	10	1, 2, 3, 5	4, 9	I_{in}(8)	—	125	—	139	—	110	μAdc
Output Current	4	—	7	1, 2, 3	10	5, 6, 8	9	I_{A4}/I_{AM}(4)	475	730	494	815	418	630	μAdc
	9	—	2	8, 7, 8	18	1, 3, 5	4	I_{A4}/I_{AM}(9)	475	730	494	815	416	638	μAdc
Output Voltage	—	1	—	—	19	2, 3, 5, 8, 7, 6	4, 8	V_{out}(4)	—	620	—	300	—	230	mVdc
	—	2	—	—	19	1, 3, 5, 6, 7, 8	4, 9	V_{out}(4)	—	620	—	300	—	230	mVdc
	—	3	—	—	10	1, 2, 5, 8, 7, 6	4, 8	V_{out}(4)	—	629	—	300	—	239	mVdc
	—	6	—	—	10	1, 2, 3, 5, 7, 8	4, 9	V_{out}(8)	—	620	—	300	—	230	mVdc
	—	7	—	—	10	1, 2, 3, 5, 6, 8	4, 9	V_{out}(9)	—	820	—	300	—	230	mVdc
	—	6	—	—	10	1, 2, 3, 5, 6, 7	4, 9	V_{out}(9)	—	620	—	300	—	230	mVdc
Saturation Voltage	1	—	—	—	10	2, 3, 5, 6, 7, 8	4, 8	V_{CE}(4)	—	220	—	220	—	228	mVdc
	2	—	—	—	10	1, 3, 5, 6, 7, 8	4, 9	V_{CE}(4)	—	220	—	220	—	220	mVdc
	3	—	—	—	10	1, 2, 5, 6, 7, 8	4, 9	V_{CE}(4)	—	220	—	220	—	220	mVdc
	6	—	—	—	10	1, 2, 3, 5, 7, 8	4, 9	V_{CE}(9)	—	220	—	220	—	228	mVdc
	7	—	—	—	10	1, 2, 3, 5, 6, 8	4, 9	V_{CE}(8)	—	220	—	220	—	220	mVdc
	8	—	—	—	10	1, 2, 3, 5, 6, 7	4, 9	V_{CE}(9)	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	10	1, 2, 3, 5, 8, 7, 8	4, 9	I_L(10)	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out													
Turn-On Delay	2	4	—	—	18	1, 3, 5, 6, 7, 8	9	t_{2+4-}	—	—	—	50	—	—	nsec
Turn-Off Delay	2	4	—	—	10	1, 3, 5, 6, 7, 6	9	t_{2-4+}	—	—	—	40	—	—	nsec

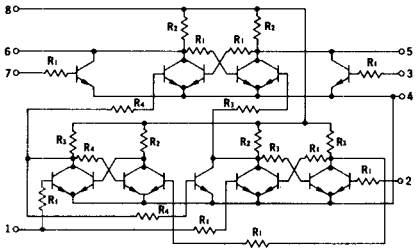
MC908G SERIES (continued)

MC913G

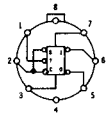
FLIP-FLOP

The MC913G RTL Type D Flip-Flop is a storage element that stores the state of pin 2 during negative transitions of pin 1. The flip-flop is not affected by changes of pin 2 during either the low or high state of the clock. Using pins 3 and 7 as inputs produces a standard R-S flip-flop.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



TYPICAL RESISTORS: $R_1 = 1.5K$ $R_3 = 180\Omega$
$R_2 = 3.6K$ $R_4 = 480\Omega$



DIRECT INPUT[1]

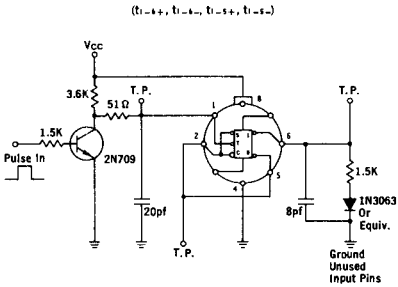
3	7	6	5
L	L	NC	NC[2]
L	H	L	H
H	L	H	L
H	H	L	L

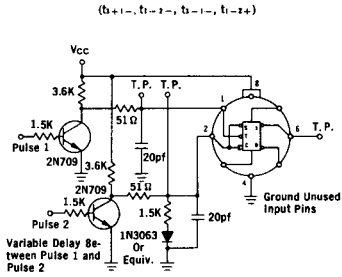
GATED INPUT[3]
$t = n$ $t = n + 1$

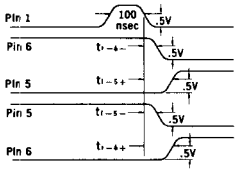
2	6	5
H	H	L
L	L	H

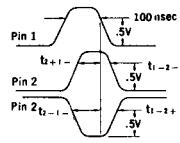
1. PIN 1 MUST BE HIGH
2. NC = NO CHANGE
3. PINS 3 AND 7 MUST BE LOW

SWITCHING TIME TEST CIRCUIT AND WAVEFORM









MC908G SERIES (continued)

MC913G

FLIP-FLOP

ELECTRICAL CHARACTERISTICS

	Test Conditions Volts					
@ Test Temperature −55°C	0.970	0.935	1.8	0.650	3.00	0.500
@ Test Temperature +25°C	0.805	0.750	1.8	0.450	3.00	0.400
@ Test Temperature +125°C	0.590	0.555	1.8	0.260	3.00	0.300

Average Power Dissipation = 12 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{LL} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	2	—	—	1*	8	—	3, 4, 7	5, 6	$I_{in}(2)$*	—	125	—	130	—	110	μAdc
	3	—	2	1*	8	—	4, 7	5, 6	$I_{in}(3)$*	—	125	—	130	—	110	μAdc
	7	—	—	1*	8	—	2, 3, 4	5, 6	$I_{in}(7)$*	—	125	—	130	—	110	μAdc
	1	—	—	—	8	—	2, 3, 4, 7	5, 6	$1.8\ I_{in}(1)$	—	225	—	234	—	198	μAdc
	1	—	2	—	8	—	3, 4, 7	5, 6	$1.8\ I_{in}(1)$	—	225	—	234	—	198	μAdc
Output Current																
	5	1	2, 7	3	8	—	4	6	$I_{A3}(5)$	350	—	364	—	308	—	μAdc
	6	1	3	7	8	—	2, 4	5	$I_{A3}(6)$	350	—	364	—	308	—	μAdc
	5	—	7	1*, 3	8	—	2, 4	6	$I_{A3}(5)$*	350	—	364	—	308	—	μAdc
	6	2	3	1*, 7	8	—	4	5	$I_{A3}(6)$*	350	—	364	—	308	—	μAdc
Output Voltage	—	3	1, 7	—	8	—	2, 4	5, 6	$V_{out}(5)$	—	620	—	300	—	230	mVdc
	—	7	1, 3	—	8	—	2, 4	5, 6	$V_{out}(6)$	—	620	—	300	—	230	mVdc
	—	6	1	—	8	—	2, 3, 4, 7	5	$V_{out}(5)$	—	820	—	300	—	230	mVdc
	—	5	1	—	8	—	2, 3, 4, 7	6	$V_{out}(6)$	—	620	—	300	—	230	mVdc
Saturation Voltage	3	—	1, 7	—	8	—	2, 4	5, 6	$V_{CE}(5)$	—	220	—	220	—	220	mVdc
	7	—	1, 3	—	8	—	2, 4	5, 6	$V_{CE}(6)$	—	220	—	220	—	220	mVdc
	6	—	1	—	8	—	2, 3, 4, 7	5	$V_{CE}(5)$	—	220	—	220	—	220	mVdc
	5	—	1	—	8	—	2, 3, 4, 7	6	$V_{CE}(6)$	—	220	—	220	—	220	mVdc
	—	2	7	1*	8	—	3, 4	5, 6	$V_{CE}(5)$*	—	220	—	220	—	220	mVdc
	—	—	3	1*, 2	8	—	4, 7	5, 6	$V_{CE}(6)$*	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	—	8	1, 2, 3, 4, 7	5, 6	$I_L(8)$	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out	Pulse 1 In	Pulse 2 In												
	1	6	—	—	8	—	3, 4, 7	5	t_{1-6-}**	—	—	—	80	—	—	nsec
	1	6	—	—	8	—	3, 4, 7	5	t_{1-6+}**	—	—	—	120	—	—	nsec
	1	5	—	—	8	—	3, 4, 7	6	t_{1-5-}**	—	—	—	80	—	—	nsec
	1	5	—	—	8	—	3, 4, 7	6	t_{1-5+}**	—	—	—	120	—	—	nsec
	—	6	1	2	8	—	3, 4, 7	5	t_{2+1-}	—	—	60	—	—	—	nsec
	—	6	1	2	8	—	3, 4, 7	5	t_{1-2-}	—	—	30	—	—	—	nsec
	—	6	1	2	8	—	3, 4, 7	5	t_{2-1-}	—	—	60	—	—	—	nsec
	—	6	1	2	8	—	3, 4, 7	5	t_{1-2+}	—	—	30	—	—	—	nsec

*Resistor to V_{CC}: V_{RL} @ −55°C = 2.8 Kohms
@ +25°C = 2.7 Kohms
@ +125°C = 3.0 Kohms

The voltage applied to Pin 1 must change from V_{RL} to V_{off} prior to making measurements

** Tie Pin 2 to Pin 5

MC908G series (continued)

The JK Flip-Flop has the unique advantage over the conventional binary element in that no ambiguous output state can result with any combination of data input signals. A simultaneous low level set and clear inputs will cause the output state to reverse, whereas, high levels on both set and clear inputs prevent the output state from changing.

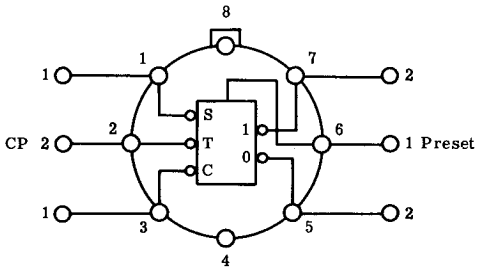
The versatile Flip-Flop storage element can be used to advantage in shift registers, binary counters, and other control functions where JK logic minimizes the logic structure of the unit.

A preset input is available for presetting counter and register stages. A high level on the preset input causes the Q output of the flip-flop to assume the low logic state.

mW RTL
JK FLIP-FLOP

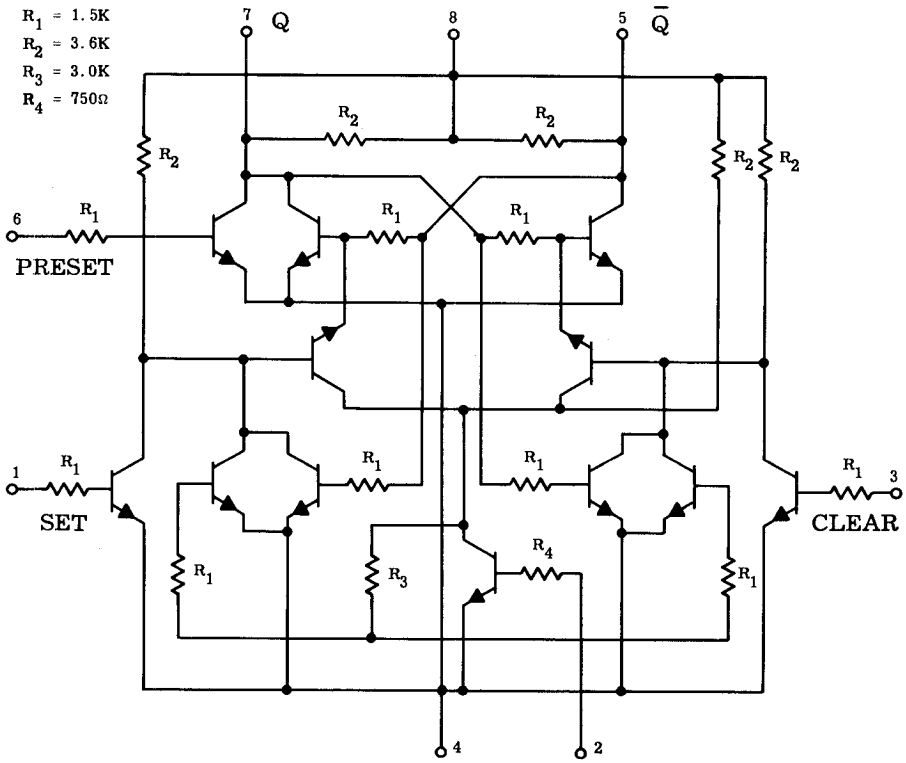
MC920G

H is more positive than L X is the output state at time n		
Pin 1 Set	Pin 3 Clear	Pin 7 "1" Output
t=n		t=n+1
H	H	X^n
H	L	H
L	H	L
L	L	$X^{\bar{n}}$



Typical Resistors
R_1 = 1.5K
R_2 = 3.6K
R_3 = 3.0K
R_4 = 750Ω

CIRCUIT DIAGRAM



MC908G series (continued)

ELECTRICAL CHARACTERISTICS

FLIP-FLOPS

MC920G

@ Test Temperature	Test Conditions Volts					
−55°C	0.970	0.935	1.30	0.650	3.00	0.500
+25°C	0.805	0.750	1.30	0.450	3.00	0.400
+125°C	0.590	0.555	1.30	0.260	3.00	0.300

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{SAT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{LL} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1		5		8		4	2, 3, 6, 7	$I_{IN}(1)$		125		130		110	μAdc
	2		1,3		8		4	5, 6, 7	$2I_{IN}(2)$		250		260		220	μAdc
	3		7		8		4	1, 2, 5, 6	$I_{IN}(3)$		125		130		110	μAdc
	6		5		8		4	1, 2, 3, 7	$I_{IN}(6)$		125		130		110	μAdc
Output Current		5	1,6		8		4	2, 3, 7	$I_{A2}(5)$	238		247		209		μAdc
		7	3	6	8		4, 5*	1, 2	$I_{A2}(7)$	238		247		209		μAdc
		5, 8	1		8		4	2, 3, 7	$I_{A2}(5)$	238		247		209		μAdc
Output Voltage		6			8		4, 5	1, 2, 3, 7	$V_{OUT}(7)$		620		300		230	mVdc
		7			8		4, 5*	1, 2, 3, 6	$V_{OUT}(5)$		620		300		230	mVdc
		5			8		4, 7*	1, 2, 3, 6	$V_{OUT}(7)$		620		300		230	mVdc
		1, 3			8		4, 6	2, 5, 7	$V_{OUT}(7)\triangle\#0$		620		300		230	mVdc
		3		1	8		4, 6	2, 5, 7	$V_{OUT}(7)\#0$		620		300		230	mVdc
				1,3	8		4, 6	2, 5, 7	$V_{OUT}(7)\#0\S$		620		300		230	mVdc
Saturation Voltage			6		8		4, 5	1, 2, 3, 7	$V_{CE}(7)$		220		220		220	mVdc
					8		4, 7*	1, 2, 3, 5, 6	$V_{CE}(7)$		220		220		220	mVdc
				6	8		4, 5*	1, 2, 3, 7	$V_{CE}(5)$		220		220		220	mVdc
Turn-on Voltage		1		3	8		4, 6	2, 5, 7	$V_{ON}(7)\#^{**}$	935		750		555		mVdc
		1, 3			8		4, 6.	2, 5, 7	$V_{ON}(7)\#\S^{**}$	935		750		555		mVdc
				1,3	8		4, 6	2, 5, 7	$V_{ON}(7)\#\triangle^{**}$	935		750		555		mVdc
Leakage Current						8	4	1, 2, 3, 5, 6, 7			100		100		100	μAdc

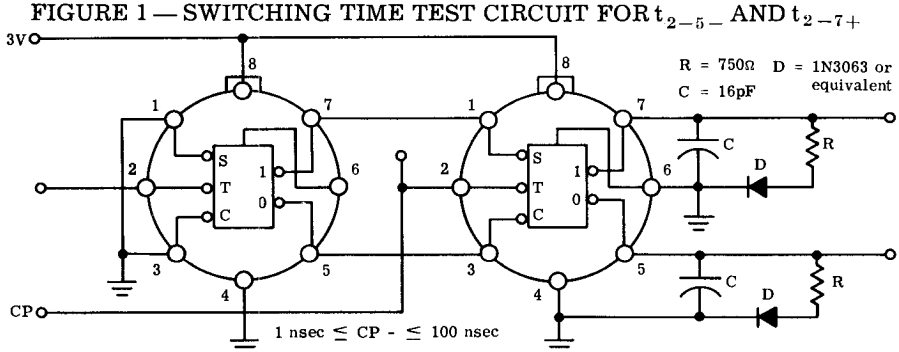
* Silicon Diode to Ground

** Pin 7 } Loaded by: 247 μAdc (+25°C)
0 Pin 5 } 238 μAdc (−55°C)
209 μAdc (+125°C)

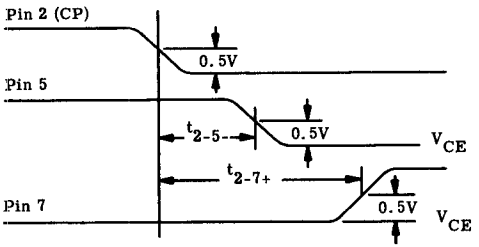
\# Pin 2 = ⌊

§ Pin 5 = LOW } Set by a momentary ground prior to the application of the negative-going Clock Pulse.
△ Pin 7 = LOW }

FIGURE 1 — SWITCHING TIME TEST CIRCUIT FOR t_{2-5-} AND t_{2-7+}



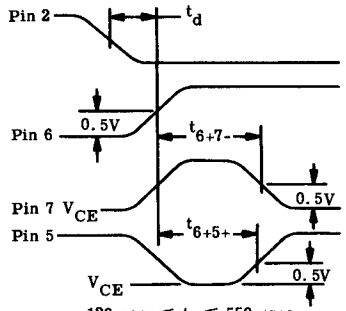
WAVEFORMS (SEE FIGURE 1)



Clock pulse must be delayed from that at pins 1 and 3

Test	Limit (25°C)		Units
	Min	Max	
t_{2-5-}	20	80	nsec
t_{2-7+}	--	120	nsec

WAVEFORMS (SEE FIGURE 2)



120 nsec $\leq t_d \leq$ 550 nsec

Test	Limit	Unit
t_{6+7-}	60 Max	nsec
t_{6+5+}	120 Max	nsec

FIGURE 2 — SWITCHING TIME TEST CIRCUIT FOR t_{6+7-} AND t_{6+5+}

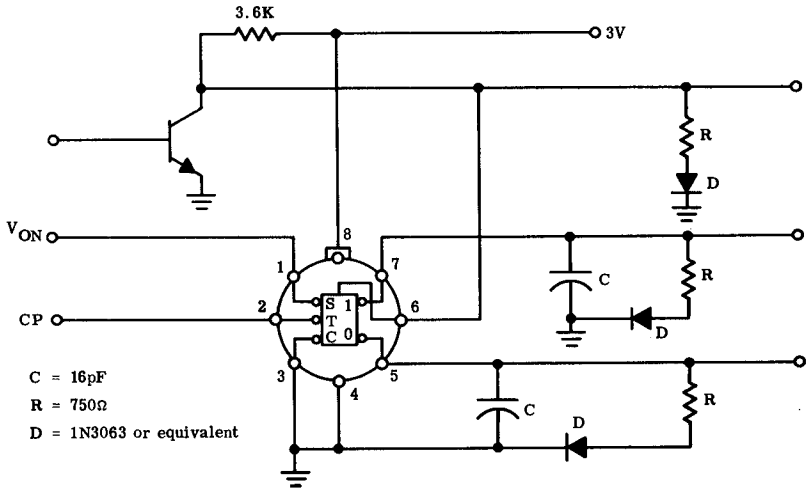
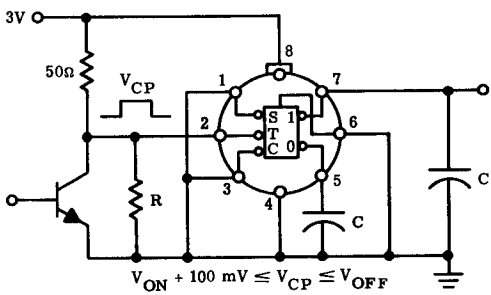


FIGURE 3 — TOGGLE TEST CIRCUIT

	Temperature (°C)	V (Volts)	R Ohms	C pF	Limit (mc)
Minimum Toggle Frequency:	25	1.0	39	24	3.0
	25	1.0	39	50	1.5
	-55	1.2	50	24	3.0
	-55	1.2	50	50	1.5
	+125	0.9	33	24	3.0
	+125	0.9	33	50	1.5



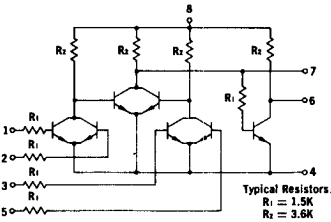
MC908G SERIES (continued)

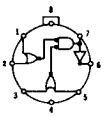
MC912G

HALF-ADDER

The MC912G is an RTL Half-Adder. By applying the complement of pins 1 and 2 to pins 3 and 5, the "SUM" and "NOT SUM" functions of a binary half-adder are produced on pin 7 and 6 respectively.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS

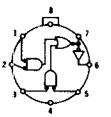




POSITIVE LOGIC

$7 = (1 + 2)(3 + 5)$

$6 = \overline{1} \cdot \overline{2} + \overline{3} \cdot \overline{5}$

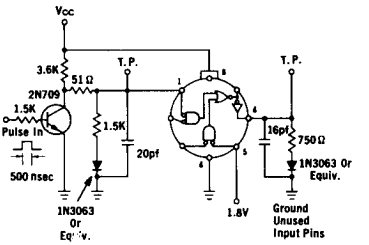


NEGATIVE LOGIC

$7 = 1 \cdot 2 + 3 \cdot 5$

$6 = (\overline{1} + \overline{2})(\overline{3} + \overline{5})$

SWITCHING TIME TEST CIRCUIT AND WAVEFORM





ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions Volts					
−55°C	0.970	0.935	1.8	0.650	3.00	0.500
+25°C	0.805	0.750	1.8	0.450	3.00	0.400
+125°C	0.590	0.555	1.8	0.260	3.00	0.300

Average Power Dissipation = 8 mW @ T_A = 25°C

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{LL} Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Input Current	1	—	2	—	6	—	3, 4, 5	6, 7	$I_{in}(1)$	—	125	—	130	—	110	μAdc
	2	—	1	—	6	—	3, 4, 5	6, 7	$I_{in}(2)$	—	125	—	130	—	110	μAdc
	3	—	5	—	6	—	1, 2, 4	6, 7	$I_{in}(3)$	—	125	—	130	—	110	μAdc
	5	—	3	—	8	—	1, 2, 4	6, 7	$I_{in}(5)$	—	125	—	130	—	110	μAdc
Output Current	7	1, 3	—	—	8	—	2, 4, 5	6	$I_{A3}(7)$	350	—	364	—	308	—	μAdc
	7	2, 5	—	—	8	—	1, 3, 4	6	$I_{A3}(7)$	350	—	364	—	308	—	μAdc
	6	—	—	—	6	—	1, 2, 3, 4, 5	7	$I_{A4}(6)$	475	—	494	—	416	—	μAdc
Output Voltage	—	7	1, 2, 3, 5	—	6	—	4	6	$V_{out}(6)$	—	620	—	300	—	230	mVdc
Saturation Voltage	7	—	1, 2, 3, 5	—	6	—	4	6	$V_{CE}(6)$	—	220	—	220	—	220	mVdc
	—	—	3, 5	1, 2	6	—	4	6, 7	$V_{CE}(7)$	—	220	—	220	—	220	mVdc
	—	—	1, 2	3, 5	6	—	4	6, 7	$V_{CE}(7)$	—	220	—	220	—	220	mVdc
Leakage Current	—	—	—	—	—	9	1, 2, 3, 4, 5	6, 7	$I_L(6)$	—	100	—	100	—	100	μAdc
Switching Time	Pulse In	Pulse Out														
Turn-On Delay	1	6	5	—	8	—	2, 3, 4	7	t_{1+6-}	—	—	—	100	—	—	nsec
Turn-Off Delay	1	6	5	—	8	—	2, 3, 4	7	t_{1-6+}	—	—	—	80	—	—	nsec

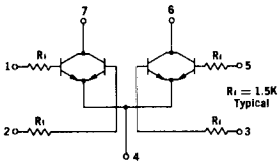
MC908G SERIES (continued)

MC921G

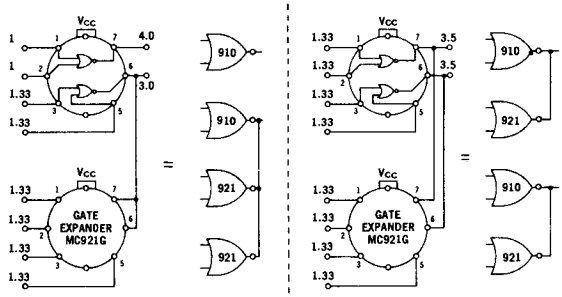
GATE EXPANDER

The MC921G Gate Expander is designed to increase the fan-in capability of the MC910G, MC911G, and MC918G Gates.

CIRCUIT DIAGRAM



USE OF GATE EXPANDER



NOTES FOR THE USE OF THE MC921G

1. The input loading factor of the expanded gate is 1.33.
2. Pin 8 of the MC921G must be connected to Vcc.
3. The output loading factor of the expanded gate is decreased 0.5 load for every added node.

ELECTRICAL CHARACTERISTICS

	Test Conditions							
	Volts					Ohms		
@ Test Temperature −55°C	0.970	0.935	1.8	0.650	3.00	4.27K*	2.8K*	
@ Test Temperature +25°C	0.805	0.750	1.0	0.450	3.00	4.3K*	2.7K*	
@ Test Temperature +125°C	0.590	0.555	1.8	0.260	3.00	5K*	3K*	

Average Power Dissipation — Negligible

Characteristic	V_{in} Pin No.	V_{on} Pin No.	V_{BOT} Pin No.	V_{off} Pin No.	V_{CC} Pin No.	V_{RH}* Pin No.	V_{RL}* Pin No.	Grounded Pin No.	Open Pin No.	Symbol Pin No. in ( )	Test Limits −55°C Max	Test Limits +25°C Max	Test Limits +125°C Max	Unit
Input Current	1	—	2	—	8	7	—	3, 4, 5	6	$I_{in}(1)$	125	130	110	μAdc
	2	—	1	—	8	7	—	3, 4, 5	6	$I_{in}(2)$	125	130	110	μAdc
	3	—	5	—	8	6	—	1, 2, 4	7	$I_{in}(3)$	125	130	110	μAdc
	5	—	3	—	8	6	—	1, 2, 4	7	$I_{in}(5)$	125	130	110	μAdc
Output Voltage	—	1	—	—	8	—	7	2, 3, 4, 5	6	$V_{out}(7)$	620	300	230	mVdc
	—	2	—	—	8	—	7	1, 3, 4, 5	6	$V_{out}(7)$	620	300	230	mVdc
	—	3	—	—	8	—	6	1, 2, 4, 5	7	$V_{out}(6)$	620	300	230	mVdc
	—	5	—	—	8	—	6	1, 2, 3, 4	7	$V_{out}(6)$	620	300	230	mVdc
Saturation Voltage	1	—	—	—	8	—	7	2, 3, 4, 5	8	$V_{CE}(7)$	220	220	220	mVdc
	2	—	—	—	8	—	7	1, 3, 4, 5	6	$V_{CE}(7)$	220	220	220	mVdc
	3	—	—	—	8	—	6	1, 2, 4, 5	7	$V_{CE}(6)$	220	220	220	mVdc
	5	—	—	—	8	—	8	1, 2, 3, 4	7	$V_{CE}(6)$	220	220	220	mVdc
Output Leakage Current	7	—	—	1, 2	8	—	—	3, 4, 5	6	$I_{CEX}(7)$	5	5	40	μAdc
	6	—	—	3, 5	8	—	—	1, 2, 4	7	$I_{CEX}(6)$	5	5	40	μAdc
Leakage Current	—	—	—	—	6, 7, 8	—	—	1, 2, 3, 4, 5	—	$I_L(6, 7, 6)$	100	100	100	μAdc

*Resistor Value to V_{CC}

MC930/ MC830 MDTL Series

MC930 SERIES/MC830 SERIES MDTL INTEGRATED CIRCUITS

The MDTL line consists of monolithic, modified, integrated Diode-Transistor Logic Circuits. The MC930 Series is designed for use over the temperature range of −55°C to +125°C, and the MC830 Series for use from 0°C to +75°C.

MAXIMUM RATINGS

Characteristic	Rating	Unit
Supply Voltage Continuous Pulsed, < 1 second	 +8 +12	Vdc
Output Current into Outputs MC932, MC832, MC944, MC844 - Continuous Pulsed, < 30 ms All other types	 150 300 30	mAdc
Input Forward Current	-10	mAdc
Input Reverse Current MC932, MC832, MC944, MC844 All other types	 5.0 1.0	mAdc
Operating Temperature Range MC930 Series MC830 Series	 -55 to +125 0 to +75	°C
Storage Temperature Range	-65 to +150	°C

GENERAL RULES

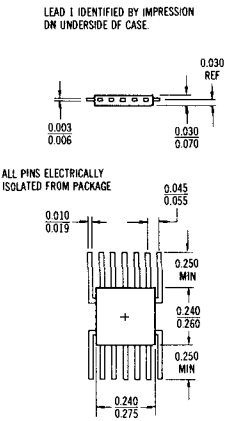
- The number of load circuits that may be driven from an output is determinated by the input loading factor. The summation of input loading should not exceed the drive capability of the output.
- The outputs of the Dual 4 input gate may be tied together to perform the wired-collector OR function. For each added gate subtract 1 unit fan-out. For six added gates only 5 unit loads need be subtracted.
- The outputs of the Dual Buffer may not be tied together
- The outputs of the Dual Power Gate may be tied together to perform the wired-collector OR function.
- An external load resistor should be utilized with the Dual Power Gate. At Vcc = 5.0 ±0.5 V, subtract the following output loads:

R
2 kΩ — 2 loads
1 kΩ — 4 loads
510 Ω — 8 loads

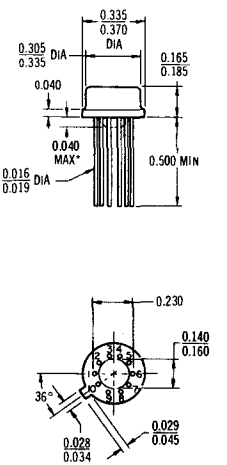
- For increased current capability, the inputs and outputs of ½ MC932 and ½ MC944 can be paralleled (up to and including 4 common outputs). The combined output will equal 100 loads while each combined input will equal 4 loads.

OUTLINE DIMENSIONS

TO-86



TO-100



MC930/MC830 (continued)

FLIP-FLOPS

MC931G, MC831G
MC945G, MC845G
MC948G, MC848G
MC931F, MC831F
MC945F, MC845F
MC948F, MC848F

GATE EXPANDERS

MC933G, MC833G
MC933F, MC833F

MULTIPLE GATES

DUAL 2-3 INPUT "NAND/NOR" GATES
MC930G, MC830G

DUAL 2-3 INPUT POWER GATES
MC944G, MC844G

DUAL 4-INPUT "NAND/NOR" GATES
MC930F, MC830F

DUAL 4-INPUT POWER GATES
MC944F, MC844F

TRIPLE 3-INPUT "NAND/NOR" GATES
MC962F, MC862F

QUAD 2-INPUT "NAND/NOR" GATES
MC946F, MC846F

DUAL BUFFERS

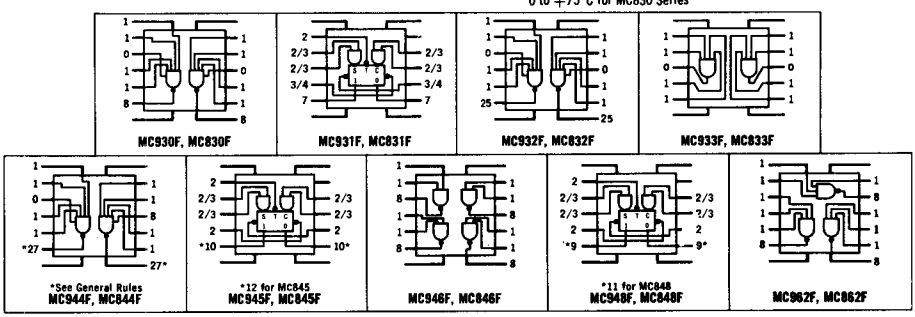
MC932G, MC832G
MC932F, MC832F

DEFINITIONS

I_{CEX}	Collector-to-emitter leakage of the output transistor
$\frac{2}{3} I_F$	Forward current of input diodes which are ⅔ of unit load
I_F	Forward current of input diodes for unit input load
$2 I_F$	Forward current of input diodes which are twice the unit load
I_{FCP}	Forward current of clock input diodes
I_{FD}	Forward current of dual expander diodes
I_{FS}	Forward current of set and clear input diodes
I_{max}	Maximum rated power supply current with V_{max} applied
I_{OH}	Output high current
I_{OL}	Output low current
I_{PDH}	Power supply drain with the inputs high
I_R	Reverse current of input diodes with V_R applied
I_{RCP}	Reverse current of clock input diodes
I_{SC}	Short circuit current obtained from device output when one or more inputs are low
V_{CC}	Power supply voltage
V_{CCH}	High power supply voltage
V_{CCL}	Low power supply voltage
V_{CEX}	Output transistor collector-to-emitter voltage
V_{CPTH}	Clock threshold voltage
V_F	Forward voltage of input diodes
V_{FD}	Forward voltage of dual expander diodes
V_{IH}	Voltage for high input voltage state
V_{IL}	Voltage for low input voltage state.
V_{ILS}	Voltage for low set and clear input voltage state.
V_{max}	Maximum rated power supply voltage (V_{CC})
V_{OH}	Output high voltage with I_{OH} flowing out of pin
V_{OL}	Output low voltage with I_{OL} flowing into pin
V_{PD}	Power supply voltage for power dissipation test.
V_R	Reverse voltage for input diode leakage test
V_X	Low voltage utilized in testing expander inputs

LOADING DIAGRAMS

Valid for $V_{CC} = 5.0\ V \pm 10\%$; Temperature Range = −55 to +125°C for MC930 Series
0 to +75°C for MC830 Series



Fan-out applies also to can package; refer to individual device drawing for applicable pin numbers.

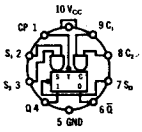
MC930/MC830 (continued)

FLIP-FLOPS

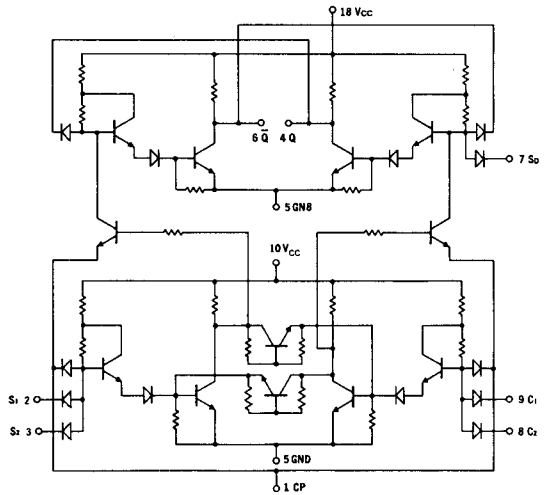
MC931G
MC831G

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



NOTE: For Clock Pulse waveforms and Propagation Delay Time test circuit and waveforms, see page 14.



ELECTRICAL CHARACTERISTICS — MC931G

@ Test Temperature	I_{OL} mA	I_{OH} mA	V_{IL} Volts	V_{IH} Volts	V_F Volts	V_R Volts	V_{CC} Volts	V_{CCL} Volts	V_{CCH} Volts	V_{PD} Volts	V_{max} Volts
−55°C	10.0	−0.12	1.46	2.10	0	4.00	—	4.50	5.50	—	—
+25°C	10.0	−0.12	1.10	2.00	0	4.00	5.00	4.50	5.50	5.00	6.00
+125°C	9.5	−0.12	0.98	2.00	0	4.00	—	4.50	5.50	—	—

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	① CP_a Pin No	② CP_b Pin No	③ CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	4	—	—	—	—	—	—	18	—	—	—	—	—	1	2,5,6⑤	V_{OL} (4)	—	0.48	—	0.48	—	0.45	Vdc
	6	—	—	—	—	—	—	10	—	—	—	—	—	1	4⑤,5,9	V_{OL} (6)	—	0.48	—	0.40	—	0.45	Vdc
	—	4①	9	2,3	—	—	—	10	—	—	—	1	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	4①	8	2,3	—	—	—	10	—	—	—	1	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	6①	2	8,9	—	—	—	10	—	—	—	1	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6①	3	8,9	—	—	—	18	—	—	—	1	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	7⑥	—	—	—	—	18	—	—	—	1	—	—	2,3,5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	2	—	—	18	—	—	—	—	—	1,5	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	3	—	—	18	—	—	—	—	—	1,5	I_R (3)	—	2.0	—	2.8	—	5.0	μAdc
	—	—	—	—	—	7	—	—	18	—	—	1	—	—	5,8,9	I_R (7)	—	2.8	—	2.8	—	5.8	μAdc
	—	—	—	—	—	8	—	—	18	—	—	—	—	—	1,5	I_R (8)	—	2.8	—	2.8	—	5.8	μAdc
	—	—	—	—	—	9	—	—	18	—	—	—	—	—	1,5	I_R (9)	—	2.8	—	2.0	—	5.8	μAdc
	—	—	—	—	—	1	—	—	18	—	—	—	—	—	2,3,5,8,9	I_{RCP} (1)	—	20	—	28	—	38	μAdc
Forward Current	—	—	—	—	2	—	—	—	18	—	—	—	—	—	5	$3I_F$ (2)	—	−1.87	—	−1.87	—	−1.80	mAdc
	—	—	—	—	3	—	—	—	18	—	—	—	—	—	5	$3I_F$ (3)	—	−1.07	—	−1.87	—	−1.80	mAdc
	—	—	—	—	8	—	—	—	10	—	—	—	—	—	5	$2I_F$ (8)	—	−1.87	—	−1.87	—	−1.80	mAdc
	—	—	—	—	9	—	—	—	18	—	—	—	—	—	5	$3I_F$ (9)	—	−1.07	—	−1.87	—	−1.80	mAdc
	—	—	3	—	—	—	—	—	18	—	—	—	1	—	5	I_{RCP} (1)	—	−3.28	—	−3.20	—	−3.08	mAdc
	—	—	8	—	—	—	—	—	10	—	—	—	1	—	5	I_{RCP} (1)	—	−3.28	—	−3.20	—	−3.08	mAdc
	—	—	—	—	7	—	—	—	18	—	—	—	—	—	4,5,8	I_{FS} (7)	—	−1.28	—	−1.20	—	−1.18	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	10	—	—	—	—	5	I_{PDH} (10)	—	—	—	ℰℰ.8	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	10	—	—	—	1,2,3,5,8,9	I_{max} (10)	—	—	—	14.5	—	—	mAdc
Switching Time (Pins 2 and 8 are connected, Pins 4 and 8 are connected)	Pulse In 1	Pulse Out 4	—	—	—	—	18	—	—	—	—	—	—	—	5	$t_{pd}+$	—	—	25	75	—	—	ns
	1	4	—	—	—	—	18	—	—	—	—	—	—	—	5	$t_{pd}-$	—	—	35	75	—	—	ns

Pins not listed are left open

① Momentarily ground this terminal before applying −0.12mA

① CP_a = Clock Pulse a, CP_b = Clock Pulse b, CP_c = Clock Pulse c } See page 14

⑤ Momentarily ground this terminal before applying I_{OL} to complementary terminal, i.e., terminal of opposite function

⑥ $V_{ILS} = V_{IL}$

MC930/MC830 (continued)

FLIP-FLOPS

MC931G
MC831G

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of this flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. The direct set (S_D) input is available.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 2	S_2 Pin 3	C_1 Pin 9	C_2 Pin 8	Q Pin 4
0	x	0	x	Q_n
8	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	8	1
1	1	1	1	U

J-K TRUTH TABLE

(Connect S_2 to $\overline{Q}$, C_2 to Q)

t_n		t_{n+1}
S_1 Pin 2	C_1 Pin 9	Q Pin 4
0	0	Q_n
1	8	1
0	1	0
1	1	$\overline{Q}_n$

8 — Low State (more negative)
1 — High State (more positive)
x — State of the input does not affect the state of the circuit.
U — Indeterminate State

ELECTRICAL CHARACTERISTICS — MC831G

@ Test Temperature	Test Conditions																															
	mA		Volts																													
0°C	10.5	−0.12	1.20	2.00	0.45	4.00	5.00	—	—																							
+25°C	18.5	−0.12	1.18	1.90	0.45	4.80	5.00	5.00	8.00																							
+75°C	10.2	−0.12	8.95	1.60	8.50	4.00	5.00	—	—																							

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{EE} Pin No	V_{max} Pin No	① CP_a Pin No	① CP_b Pin No	① CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	4	—	—	—	—	—	16	—	—	—	—	1	2, 5, 6⑥	V_{OL} (4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	—	—	—	10	—	—	—	—	1	4⑥, 5, 9	V_{OL} (6)	—	8.45	—	0.45	—	8.50	Vdc
	—	4①	9	2, 3	—	—	10	—	—	1	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4①	8	2, 3	—	—	10	—	—	1	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	6①	2	8, 9	—	—	16	—	—	1	—	—	5	V_{OH} (6)	2.60	—	2.60	—	2.58	—	Vdc
	—	6①	3	8, 9	—	—	10	—	—	1	—	—	5	V_{OH} (6)	2.68	—	2.60	—	2.50	—	Vdc
	—	4	7⑥	—	—	—	16	—	—	1	—	—	2, 3, 5	V_{OH} (4)	2.60	—	2.60	—	2.58	—	Vdc
Reverse Current	—	—	—	—	—	2	10	—	—	—	—	—	1, 5	I_R (2)	—	5.8	—	5.8	—	18	μAdc
	—	—	—	—	—	3	10	—	—	—	—	—	1, 5	I_R (3)	—	5.0	—	5.8	—	18	μAdc
	—	—	—	—	—	7	10	—	—	1	—	—	5, 8, 9	I_R (7)	—	5.8	—	5.0	—	10	μAdc
	—	—	—	—	—	8	10	—	—	—	—	—	1, 5	I_R (8)	—	5.8	—	5.8	—	18	μAdc
	—	—	—	—	—	9	10	—	—	—	—	—	1, 5	I_R (9)	—	5.0	—	5.0	—	18	μAdc
	—	—	—	—	—	1	16	—	—	—	—	—	2, 3, 5, 8, 9	I_{RCP} (1)	—	30	—	30	—	48	μAdc
Forward Current	—	—	—	—	2	—	16	—	—	—	—	—	5	$z_5 I_F$ (2)	—	−8.95	—	−8.95	—	−8.90	mAdc
	—	—	—	—	3	—	10	—	—	—	—	—	5	$z_5 I_F$ (3)	—	−0.95	—	−0.95	—	−8.98	mAdc
	—	—	—	—	8	—	16	—	—	—	—	—	5	$z_5 I_F$ (8)	—	−8.95	—	−0.95	—	−8.90	mAdc
	—	—	—	—	9	—	16	—	—	—	—	—	5	$z_5 I_F$ (9)	—	−8.95	—	−0.95	—	−0.98	mAdc
	—	—	3	—	—	—	16	—	—	—	1	—	5	I_{FCP} (1)	—	−2.80	—	−2.80	—	−2.87	mAdc
	—	—	8	—	—	—	16	—	—	—	1	—	5	I_{FCP} (1)	—	−2.88	—	−2.80	—	−2.67	mAdc
	—	—	—	—	7	—	10	—	—	—	—	—	4, 5, 8	I_{FS} (7)	—	−1.85	—	−1.05	—	−1.88	mAdc
Power Drain Current	—	—	—	—	—	—	—	10	—	—	—	—	5	I_{FDH} (10)	—	—	—	14.8	—	—	mAdc
	—	—	—	—	—	—	—	—	10	—	—	—	1, 2, 3, 5, 8, 9	I_{max} (18)	—	—	—	18.8	—	—	mAdc
Switching Time (Pins 2 and 6 are connected, Pins 4 and 8 are connected)	Pulse In 1	Pulse Out 4	—	—	—	—	10	—	—	—	—	—	5	$t_{pd}+$	—	—	25	75	—	—	ns
	1	4	—	—	—	—	10	—	—	—	—	—	5	$t_{pd}-$	—	—	35	75	—	—	ns

Pins not listed are left open

① Momentarily ground this terminal before applying −8.12 mA

② CP_a = Clock Pulse a
CP_b = Clock Pulse b
CP_c = Clock Pulse c

③ Momentarily ground this terminal before applying I_{OL} to complementary terminal, i.e., terminal of opposite function

④ $V_{ILS} = V_{IL}$

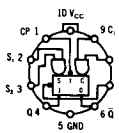
MC930/MC830 (continued)

FLIP-FLOPS

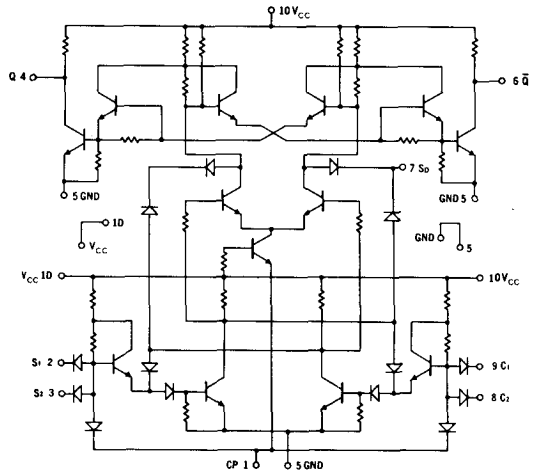
MC945G
MC845G

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



NOTE: For Clock Pulse Waveforms and Propagation Delay Time test circuit and circuit waveforms, see page 13-166.



ELECTRICAL CHARACTERISTICS — MC945G

	Test Conditions																							
	mA		Volts																					
@ Test Temperature −55°C	14.6	−0.12	1.40	2.10	0	4.00	—	4.50	5.50	—	—													
@ Test Temperature +25°C	15.2	−0.12	1.10	2.00	0	4.00	5.00	4.50	5.50	5.00	8.00													
@ Test Temperature +125°C	13.8	−0.12	0.85	2.00	0	4.00	—	4.50	5.50	—	—													
Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_S Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	⑤ CP_a Pin No	⑤ CP_c Pin No	**Grounded** Pin No	**Symbol** Pin No in ( )	**Test Limits** −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	**Unit**
Output Voltage	4	—	—	—	—	—	—	10	—	—	—	—	1	2,5	V_{OL} (4)	—	0.40	—	0.40	—	0.45	Vdc
	6	—	—	—	—	—	—	10	—	—	—	—	1	5, 9	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	—	4	0	2, 3	—	—	—	10	—	—	—	1	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	9	2, 3	—	—	—	10	—	—	—	1	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	2	0, 9	—	—	—	10	—	—	—	1	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	3	8, 9	—	—	—	10	—	—	—	1	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	7 ①	—	—	—	—	10	—	—	—	1	—	2,3,5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	2	—	—	10	—	—	—	—	1,5	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	3	—	—	10	—	—	—	—	1,5	I_R (3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	7	—	—	10	—	—	1	—	5,8,9	I_R (7)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	0	—	—	10	—	—	—	—	1,5	I_R (0)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	10	—	—	—	—	1,5	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	1, 10	—	—	—	—	—	—	—	2,3,5,0,9	I_{RCP} (1)	—	20	—	20	—	30	μAdc
Forward Current	—	—	—	—	2	—	—	—	10	—	—	—	—	5	$\frac{2}{3}I_F$ (2)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	3	—	—	—	10	—	—	—	—	5	$\frac{2}{3}I_F$ (3)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	8	—	—	—	10	—	—	—	—	5	$\frac{2}{3}I_F$ (8)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	9	—	—	—	10	—	—	—	—	5	$\frac{2}{3}I_F$ (9)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	7	—	—	—	—	—	10	—	—	—	—	1,5	I_{FCP} (1)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	7	—	—	—	10	—	—	—	—	2,5	I_{FS} (7)	—	−3.20	—	−3.20	—	−3.00	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	10	—	—	—	5	I_{PDH} (10)	—	—	—	11.0	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	10	—	—	1, 2, 3, 5, 8, 9	I_{max} (10)	—	—	—	14.5	—	—	mAdc
Switching Time (Pin 2 connected to Pin 6, Pin 4 connected to Pin 0)	Pulse In 1	Pulse Out 4																				
	1	4	—	—	—	—	10	—	—	—	—	—	—	5	$t_{pd}+$	—	—	25	100	—	—	ns
	1	4	—	—	—	—	10	—	—	—	—	—	—	5	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open

① $V_{IL3} = V_{IL}$

⑤ CP_a = Clock Pulse a
CP_c = Clock Pulse c

MC930/MC830 (continued)

FLIP-FLOPS

MC945G
MC845G

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of this flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. Asynchronous input, direct set (S_D), overrides the synchronous inputs. No matter what other inputs are applied to the flip-flop, the direct set input prevails.

The outputs of the MC945 and MC845 are buffered, thereby reducing the possibility of circuit disturbance from external line noise.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 2	S_2 Pin 3	C_1 Pin 9	C_2 Pin 8	Q Pin 4
0	x	0	x	Q_n
0	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	0	1
1	1	1	1	U

J-K TRUTH TABLE

(Connect S_2 to $\overline{Q}$, C_2 to Q)

t_n		t_{n+1}
S_1 Pin 2	C_1 Pin 9	Q Pin 4
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

0 — Low State (more negative)
1 — High State (more positive)
x — State of the input does not affect the state of the circuit.
U — Indeterminate State

ELECTRICAL CHARACTERISTICS — MC845G

@ Test Temperature	Test Conditions										
	mA		Volts								
0°C	16.8	−8.12	1.20	2.00	0.45	4.00	5.00	—	—		
+25°C	16.8	−8.12	1.10	1.90	0.45	4.00	5.00	5.00	6.00		
+75°C	16.0	−8.12	0.95	1.80	0.50	4.00	5.00	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{EO} Pin No	V_{max} Pin No	① CP_a Pin No	① CP_c Pin No	Grounded Pin No	Symbol Pin No in( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	4	—	—	—	—	—	10	—	—	—	1	2,5	V_{OL}(4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	—	—	—	10	—	—	—	1	5,9	V_{OL}(6)	—	0.45	—	0.45	—	0.50	Vdc
	—	4	8	2,3	—	—	10	—	—	1	—	5	V_{OH}(4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	9	2,3	—	—	10	—	—	1	—	5	V_{OH}(4)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	2	8,9	—	—	10	—	—	1	—	5	V_{OH}(6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	3	8,9	—	—	10	—	—	1	—	5	V_{OH}(6)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	7 ②	—	—	—	10	—	—	1	—	2,3,5	V_{OH}(4)	2.60	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	2	10	—	—	—	—	1,5	I_R(2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	3	10	—	—	—	—	1,5	I_R(3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	7	10	—	—	1	—	5,8,9	I_R(7)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	8	10	—	—	—	—	1,5	I_R(8)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	9	10	—	—	—	—	1,5	I_R(9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	1, 10	—	—	—	—	—	2, 3, 5, 8, 9	I_{RCP}(1)	—	30	—	30	—	40	μAdc
Forward Current	—	—	—	—	2	—	10	—	—	—	—	5	$2I_F$(2)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	3	—	10	—	—	—	—	5	$2I_F$(3)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	8	—	10	—	—	—	—	5	$2I_F$(8)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	9	—	10	—	—	—	—	5	$2I_F$(9)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	7	—	—	—	10	—	—	—	—	1,5	I_{FCP}(1)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	7	—	10	—	—	—	—	2,5	I_{FS}(7)	—	−2.80	—	−2.80	—	−2.67	mAdc
Power Drain Current	—	—	—	—	—	—	—	10	—	—	—	5	I_{PDH}(10)	—	—	—	14	—	—	mAdc
	—	—	—	—	—	—	—	—	10	—	—	1, 2, 3, 5, 8, 9	I_{max}(10)	—	—	—	18	—	—	mAdc
Switching Time (Pin 2 connected to Pin 6, Pin 4 connected to Pin 8)	Pulse In	Pulse Out																		
	1	4	—	—	—	—	10	—	—	—	—	5	$t_{pd}+$	—	—	25	100	—	—	ns
	1	4	—	—	—	—	10	—	—	—	—	5	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open
② $V_{EO} = V_{IL}$
① CP_a = Clock Pulse a
CP_c = Clock Pulse c

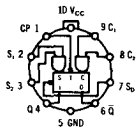
MC930/MC830 (continued)

FLIP-FLOPS

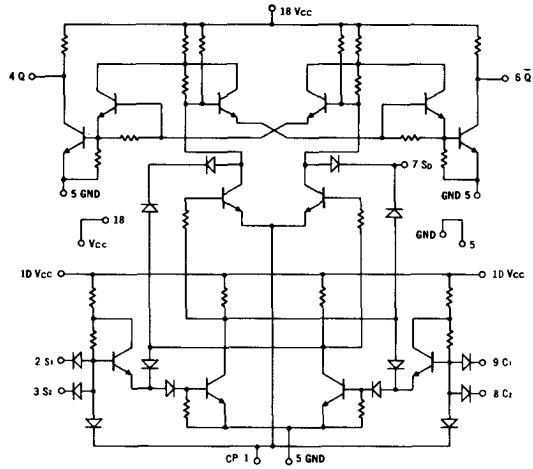
MC948G
MC848G

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



NOTE: For Clock Pulse Waveforms and Propagation Delay Time test circuit and circuit waveforms, see page 13-166.



ELECTRICAL CHARACTERISTICS — MC948G

@ Test Temperature	Test Conditions (mA) I_{OL}	I_{OH}	Volts V_{IL}	V_{IH}	V_P	V_R	V_{CC}	V_{CCL}	V_{CCH}	V_{PD}	V_{max}	CP_a	CP_c
−55°C	13.0	−0.12	1.40	2.10	0	4.00	—	4.50	5.50	—	—		
+25°C	13.6	−0.12	1.10	2.00	0	4.00	5.00	4.50	5.50	0.00	9.00		
+125°C	12.3	−0.12	0.60	2.00	0	4.00	—	4.50	5.50	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_P Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	② CP_a Pin No	② CP_c Pin No	Grounded Pin No	Symbol Pin No in( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	4	—	—	—	—	—	—	1D	—	—	—	—	1	2,5	V_{OL} (4)	—	0.40	—	0.40	—	0.45	Vdc
	6	—	—	—	—	—	—	1D	—	—	—	—	1	5,9	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	—	4	8	2,3	—	—	—	1D	—	—	—	1	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	9	2,3	—	—	—	1D	—	—	—	1	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	2	8,9	—	—	—	1D	—	—	—	1	—	5	V_{OH} (6)	2.50	—	2.60	—	2.58	—	Vdc
	—	6	3	8,9	—	—	—	1D	—	—	—	1	—	5	V_{OH} (6)	2.50	—	2.60	—	2.58	—	Vdc
	—	4	7 ①	—	—	—	—	1B	—	—	—	1	—	2,3,5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	2	—	—	1D	—	—	—	—	1,5	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	3	—	—	1D	—	—	—	—	1,5	I_R (3)	—	2.8	—	2.0	—	5.0	μAdc
	—	—	—	—	—	7	—	—	1D	—	—	1	—	5,8,9	I_R (7)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	8	—	—	1D	—	—	—	—	1,5	I_R (8)	—	2.8	—	2.0	—	5.0	μAdc
	—	—	—	—	—	9	—	—	1D	—	—	—	—	1,5	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	1	—	—	1D	—	—	—	—	2,3,5,8,9	I_{RCP} (1)	—	20	—	20	—	30	μAdc
Forward Current	—	—	—	—	2	—	—	—	1D	—	—	—	—	5	$2I_F$ (2)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	3	—	—	—	1D	—	—	—	—	5	$2I_F$ (3)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	8	—	—	—	1D	—	—	—	—	5	$2I_F$ (8)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	9	—	—	—	1D	—	—	—	—	5	$2I_F$ (9)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	7	—	—	—	—	—	1D	—	—	—	—	1,5	I_{FCP} (1)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	7	—	—	—	1D	—	—	—	—	2,5	I_{FS} (7)	—	−3.20	—	−3.20	—	−3.00	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	1D	—	—	—	5	I_{PDH} (10)	—	—	—	13.5	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	1B	—	—	1,2,3,5,8,9	I_{max} (10)	—	—	—	19.0	—	—	mAdc
Switching Time (Pin 2 connected to Pin 6, Pin 4 connected to Pin 8)	Pulse in 1	Pulse Out 4	—	—	—	—	1D	—	—	—	—	—	—	5	$t_{pd}+$	—	—	25	75	—	—	ns
	1	4	—	—	—	—	1D	—	—	—	—	—	—	5	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open

① $V_{AS} = V_{IL}$

② CP_a = Clock Pulse a
CP_c = Clock Pulse c

MC930/MC830 (continued)

FLIP-FLOPS

MC948G
MC848G

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of this flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. Asynchronous input, direct set (S_D), overrides the synchronous inputs. No matter what other inputs are applied to the flip-flop, the direct set input prevails.

The outputs of the MC948 and MC848 are buffered, thereby reducing the possibility of circuit disturbances from external line noise.

The output pull-up resistor has been changed from that utilized in the MC945 and MC845 in order to improve the propagation delay-versus-capacitance characteristics.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 2	S_2 Pin 3	C_1 Pin 9	C_2 Pin 8	Q Pin 4
0	x	0	x	Q_n
0	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	0	1
1	1	1	1	U

J-K TRUTH TABLE

(Connect S_2 to $\overline{Q}$, C_2 to Q)

t_n		t_{n+1}
S_1 Pin 2	C_1 Pin 9	Q Pin 4
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

0 — Low State (more negative)
1 — High State (more positive)
x — State of the input does not affect the state of the circuit.
U — Indeterminate State

ELECTRICAL CHARACTERISTICS — MC848G

	Test Conditions																						
	mA		Volts																				
@ Test Temperature 0°C	15.4	−0.12	1.20	2.00	0.45	4.00	5.00	—	—														
@ Test Temperature +25°C	15.4	−0.12	1.10	1.80	0.45	4.00	5.00	5.00	8.00														
@ Test Temperature +75°C	14.8	−0.12	0.95	1.80	0.50	4.00	5.00	—	—														

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	⑥ CP_2 Pin No	⑥ $\overline{CP}_2$ Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	4	—	—	—	—	—	10	—	—	—	1	2, 5	V_{OL} (4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	—	—	—	10	—	—	—	t	5, 9	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	—	4	8	2, 3	—	—	10	—	—	1	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	9	2, 3	—	—	10	—	—	t	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	2	8, 9	—	—	10	—	—	t	—	5	V_{OH} (5)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	3	8, 9	—	—	10	—	—	1	—	5	V_{OH} (5)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	7 ⑦	—	—	—	10	—	—	1	—	2, 3, 5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	2	10	—	—	—	—	1, 5	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	3	10	—	—	—	—	1, 5	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	7	10	—	—	1	—	5, 0, 9	I_R (7)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	8	10	—	—	—	—	1, 5	I_R (8)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	9	10	—	—	—	—	1, 5	I_R (9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	1	10	—	—	—	—	2, 3, 5, 8, 9	I_{RCF} (1)	—	30	—	30	—	40	μAdc
Forward Current	—	—	—	—	2	—	10	—	—	—	—	5	$\frac{1}{2}I_F$ (2)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	3	—	10	—	—	—	—	5	$\frac{1}{2}I_F$ (3)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	X	—	10	—	—	—	—	5	$\frac{1}{2}I_F$ (0)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	9	—	10	—	—	—	—	5	$\frac{1}{2}I_F$ (9)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	7	—	—	—	10	—	—	—	—	1, 5	I_{FCF} (1)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	7	—	10	—	—	—	—	2, 5	I_{FS} (7)	—	−2.80	—	−2.80	—	−2.67	mAdc
Power Drain Current	—	—	—	—	—	—	—	10	—	—	—	5	I_{PDH} (10)	—	—	—	17	—	—	mAdc
	—	—	—	—	—	—	—	10	—	—	—	1, 2, 3, 5, 0, 9	I_{PDL} (10)	—	—	—	22.5	—	—	mAdc
Switching Time (Pin 2 connected to Pin 5, Pin 4 connected to Pin 0)	Pulse In	Pulse Out																		
	1	4	—	—	—	—	10	—	—	—	—	5	$t_{pd}+$	—	—	25	75	—	—	ns
	1	4	—	—	—	—	10	—	—	—	—	5	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open
⑥ $V_{ck} = V_{IL}$
⑥ CP_2 = Clock Pulse a
CP_2 = Clock Pulse c

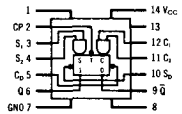
MC930/MC830 (continued)

FLIP-FLOPS

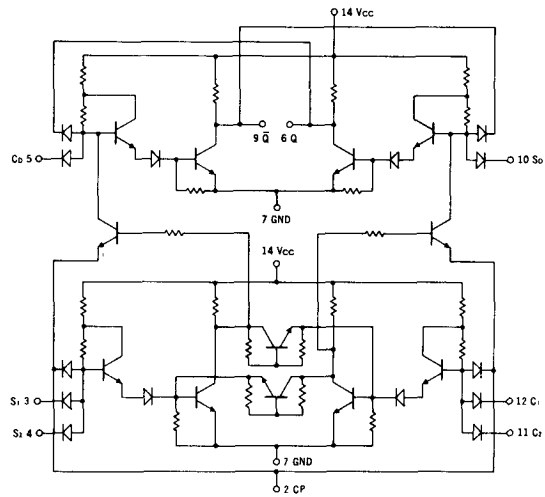
MC931F
MC831F

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



NOTE: For Clock Pulse Waveforms and Propagation Delay Time test circuit and circuit waveforms, see page 13-166.



ELECTRICAL CHARACTERISTICS — MC931F

	Test Conditions																									
	mA					Volts																				
@ Test Temperature −55°C	10.0	−0.12	1.40	2.10	⑥	4.00	—	4.50	5.50	—	—															
@ Test Temperature +25°C	10.6	−0.12	1.10	2.00	⑥	4.00	5.00	4.50	5.50	5.00	8.00															
@ Test Temperature +125°C	9.3	−0.12	0.80	2.00	⑥	4.00	—	4.50	5.50	—	—															

Characteristic	I_{OL} Pin No	I_{OHL} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{FO} Pin No	V_{max} Pin No	④ CP_a Pin No	⑤ CP_b Pin No	⑦ CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	—	—	—	—	14	—	—	—	—	—	2	3, 7, 9⑥	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	9	—	—	—	—	—	—	14	—	—	—	—	—	2	6⑥, 7, 12	V_{OL} (9)	—	0.40	—	0.40	—	0.45	Vdc
	—	6⑥	11	3, 4	—	—	—	14	—	—	—	2	—	—	7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6⑥	12	3, 4	—	—	—	14	—	—	—	2	—	—	7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	10⑥	5	—	—	—	14	—	—	—	2	—	—	3, 4, 7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	9⑥	3	11, 12	—	—	—	14	—	—	—	2	—	—	7	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
	—	9⑥	4	11, 12	—	—	—	14	—	—	—	2	—	—	7	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	5⑥	10	—	—	—	14	—	—	—	2	—	—	7, 11, 12	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	—	—	14	—	—	—	—	—	2, 7	I_R (3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	4	—	—	14	—	—	—	—	—	2, 7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	14	—	—	2	—	—	3, 4, 7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	10	—	—	14	—	—	2	—	—	7, 11, 12	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	11	—	—	14	—	—	—	—	—	2, 7	I_R (11)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	12	—	—	14	—	—	—	—	—	2, 7	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	2	—	—	14	—	—	—	—	—	3, 4, 7, 11, 12	I_{RCP} (2)	—	20	—	20	—	30	μAdc
Forward Current	—	—	—	—	3	—	—	—	14	—	—	—	—	—	7	$\frac{2}{3}I_F$ (3)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	4	—	—	—	14	—	—	—	—	—	7	$\frac{2}{3}I_F$ (4)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	11	—	—	—	14	—	—	—	—	—	7	$\frac{2}{3}I_F$ (11)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	12	—	—	—	14	—	—	—	—	—	7	$\frac{2}{3}I_F$ (12)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	4	—	—	—	—	—	14	—	—	—	—	2	7	I_{FCP} (2)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	11	—	—	—	—	—	14	—	—	—	—	2	7	I_{FCP} (2)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	5	—	—	—	14	—	—	—	—	—	4, 7, 9, 10	I_{FS} (5)	—	−1.20	—	−1.20	—	−1.10	mAdc
	—	—	—	—	10	—	—	—	14	—	—	—	—	—	5, 6, 7, 11	I_{FS} (10)	—	−1.20	—	−1.20	—	−1.10	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	—	—	—	7	I_{DRW}(14)	—	—	—	11.0	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	—	—	—	2, 3, 4, 7, 11, 12	I_{max} (14)	—	—	—	14.5	—	—	mAdc
Switching Time (Pins 3 and 9 are connected, Pins 6 and 11 are connected)	Pulse In 2	Pulse Out 6	—	—	—	—	14	—	—	—	—	—	—	—	7	$t_{pu}+$	—	—	25	75	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	—	—	—	7	$t_{pd}-$	—	—	35	75	—	—	ns

Pins not listed are left open

⑥ Momentarily ground this terminal before applying −0.12 mA

④ CP_a — Clock Pulse a
CP_b — Clock Pulse b
CP_c — Clock Pulse c

⑤ Momentarily ground this terminal before applying I_{OL} to complementary terminal, i.e., terminal of opposite function

⑦ $V_{ILS} = V_{IL}$

MC930/MC830 (continued)

FLIP-FLOPS

MC931F
MC831F

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of this flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. Direct set (S_D) and direct clear (C_D) inputs are available.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 3	S_2 Pin 4	C_1 Pin 12	C_2 Pin 11	Q Pin 6
0	x	0	x	Q_n
0	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	0	1
1	1	1	1	U

0 — Low State (more negative)

1 — High State (more positive)

x — State of the input does not affect the state of the circuit.

U — indeterminate State

ASYNCHRONOUS TRUTH TABLE

S_D Pin 10	C_D Pin 5	Q Pin 6	$\overline{Q}$ Pin 9
1	1	NC	NC
0	1	1	0
1	0	0	1
0	0	1	1

J-K TRUTH TABLE

(Connect S_2 to $\overline{Q}$, C_2 to Q)

t_n		t_{n+1}
S_1 Pin 3	C_1 Pin 12	Q Pin 6
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

Asynchronous inputs, direct set (S_D) and direct clear (C_D), override the synchronous inputs; they are independent of all other inputs.

ELECTRICAL CHARACTERISTICS — MC831F

@ Test Temperature	Test Conditions																										
	mA		Volts																								
0°C	10.5	−0.12	1.20	2.00	0.45	4.00	5.00	—	—																		
+25°C	10.5	−0.12	1.10	1.80	0.45	4.00	5.00	5.00	8.00																		
+75°C	10.2	−0.12	0.85	1.60	0.50	4.00	5.00	—	—																		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{FD} Pin No	V_{mod} Pin No	① CP_a Pin No	① CP_b Pin No	① CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	6	—	—	—	—	—	14	—	—	—	—	2	3,7,9⑥	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	9	—	—	—	—	—	14	—	—	—	—	2	6⑥,7,12	V_{OL} (9)	—	0.45	—	0.45	—	0.50	Vdc
	—	6①	11	3,4	—	—	14	—	—	2	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6①	12	3,4	—	—	14	—	—	2	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	10①	5	—	—	14	—	—	2	—	—	3,4,7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	9①	3	11,12	—	—	14	—	—	2	—	—	7	V_{OH}(9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9①	4	11,12	—	—	14	—	—	2	—	—	7	V_{OH}(9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	5①	10	—	—	14	—	—	2	—	—	7,11,12	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	14	—	—	—	—	—	2,7	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	4	14	—	—	—	—	—	2,7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	5	14	—	—	2	—	—	3,4,7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	10	14	—	—	2	—	—	7,11,12	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	11	14	—	—	—	—	—	2,7	I_R (11)	—	5.0	—	5.0	—	10	μA4c
	—	—	—	—	—	12	14	—	—	—	—	—	2,7	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	2	14	—	—	—	—	—	3,4,7,11,12	I_{RCP} (2)	—	30	—	30	—	40	μAdc
Forward Current	—	—	—	—	3	—	14	—	—	—	—	—	7	$\frac{2}{3} I_F$ (3)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	4	—	14	—	—	—	—	—	7	$\frac{2}{3} I_F$ (4)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	11	—	14	—	—	—	—	—	7	$\frac{2}{3} I_F$ (11)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	12	—	14	—	—	—	—	—	7	$\frac{2}{3} I_F$ (12)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	4	—	—	—	14	—	—	—	2	—	7	I_{RCP} (2)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	11	—	—	—	14	—	—	—	2	—	7	I_{RCP} (2)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	5	—	14	—	—	—	—	—	4,7,9,10	I_{FS} (5)	—	−1.05	—	−1.05	—	−1.00	mAdc
	—	—	—	—	10	—	14	—	—	—	—	—	5,6,7,11	I_{FS} (10)	—	−1.05	—	−1.05	—	−1.00	mAdc
Power Drain Current	—	—	—	—	—	—	—	14	—	—	—	—	7	I_{FDH} (14)	—	—	—	14.0	—	—	mAdc
	—	—	—	—	—	—	—	—	14	—	—	—	2,3,4,7,11,12	I_{mod} (14)	—	—	—	18.0	—	—	mAdc
Switching Time (Pins 3 and 9 are connected, Pins 6 and 11 are connected)	Pulse In	Pulse Out																			
	2	6	—	—	—	—	14	—	—	—	—	—		$t_{pd}+$	—	—	25	75	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	—		$t_{pd}-$	—	—	35	75	—	—	ns

Pins not listed are left open

① Momentarily ground this terminal before applying −0.12 mA

② CP_a — Clock Pulse a
CP_b — Clock Pulse b
CP_c — Clock Pulse c

③ Momentarily ground this terminal before applying I_{OL} to complementary terminal, i.e., terminal of opposite function

④ $V_{FLX} = V_{FL}$

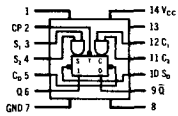
MC930/MC830 (continued)

FLIP-FLOPS

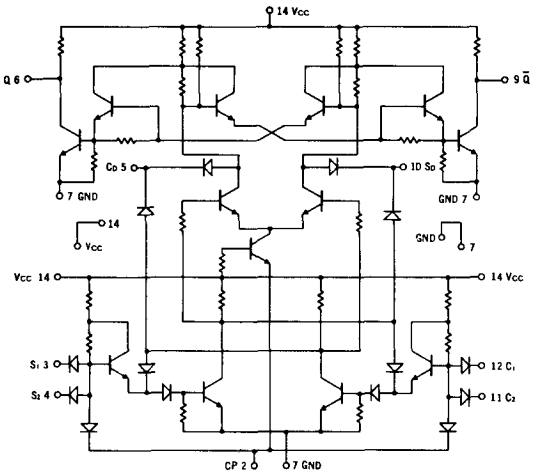
MC945F
MC845F

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



NOTE: For Clock Pulse Waveforms and Propagation Delay Time test circuit and circuit waveforms, see page 13-166.



ELECTRICAL CHARACTERISTICS — MC945F

@ Test Temperature	Test Conditions												
	mA		Volts										
−55°C	14.8	−0.12	1.40	2.10	0	4.00	—	4.50	5.50	—	—		
+25°C	15.2	−6.12	1.10	2.00	0	4.00	5.00	4.50	5.50	5.00	8.00		
+125°C	13.0	−0.12	0.90	2.00	0	4.00	—	4.50	5.50	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	⑤ CP_a Pin No	⑤ CP_c Pin No	Grounded Pin No	Symbol Pin No in( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	—	—	—	—	14	—	—	—	—	2	3,7	V_{OL} (6)	—	0.40	—	0.40	—	8.45	Vdc
	9	—	—	—	—	—	—	14	—	—	—	—	2	7,12	V_{OL} (9)	—	0.4D	—	0.4D	—	0.45	Vdc
	—	6	11	3,4	—	—	—	14	—	—	—	2	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	12	3,4	—	—	—	14	—	—	—	2	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	10⑥	5	—	—	—	14	—	—	—	2	—	3,4,7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	3	11,12	—	—	—	14	—	—	—	2	—	7	V_{OH} (9)	2.50	—	2.6D	—	2.50	—	Vdc
	—	9	4	11,12	—	—	—	14	—	—	—	2	—	7	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	5⑥	1D	—	—	—	14	—	—	—	2	—	7,11,12	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	—	—	14	—	—	—	—	2,7	I_R (3)	—	2.0	—	2.0	—	5.8	μAdc
	—	—	—	—	—	4	—	—	14	—	—	—	—	2,7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	14	—	—	2	—	3,4,7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	10	—	—	14	—	—	2	—	7,11,12	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	11	—	—	14	—	—	—	—	2,7	I_R (11)	—	2.0	—	2.0	—	5.8	μAdc
	—	—	—	—	—	12	—	—	14	—	—	—	—	2,7	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	2,14	—	—	—	—	—	—	—	3,4,7,11,12	I_{RCP} (2)	—	2D	—	20	—	30	μAdc
Forward Current	—	—	—	—	3	—	—	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (3)	—	−1.D7	—	−1.D7	—	−1.00	mAdc
	—	—	—	—	4	—	—	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (4)	—	−1.D7	—	−1.D7	—	−1.00	mAdc
	—	—	—	—	11	—	—	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (11)	—	−1.07	—	−1.D7	—	−1.DD	mAdc
	—	—	—	—	12	—	—	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (12)	—	−1.D7	—	−1.D7	—	−1.00	mAdc
	—	—	5	—	—	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−3.2D	—	−3.20	—	−3.DD	mAdc
	—	—	1D	—	—	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−3.2D	—	−3.20	—	−3.00	mAdc
	—	—	—	—	5	—	—	—	14	—	—	—	—	3,7,10,12	I_{FS} (5)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	10	—	—	—	14	—	—	—	—	4,5,7,11	I_{FS} (1D)	—	−3.20	—	−3.20	—	−3.00	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	—	—	7	I_{PDH} (14)	—	—	—	11.0	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	—	—	2,3,4,7,11,12	I_{max} (14)	—	—	—	14.5	—	—	mAdc
Switching Time (Pin 3 connected to Pin 9, Pin 6 connected to Pin 11)	Pulse In 2	Pulse Out 6	—	—	—	—	14	—	—	—	—	—	—	7	$t_{pd}+$	—	—	25	100	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	—	—	7	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open

⑤ $V_{CCL} = V_{IL}$

⑥ CP_a = Clock Pulse a
CP_c = Clock Pulse c

MC930/MC830 (continued)

FLIP-FLOPS

MC945F
MC845F

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of this flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. Asynchronous inputs, direct set (S_D) and direct clear (C_D), override the synchronous inputs. No matter what other inputs are applied to the flip-flop, the direct set and clear inputs prevail.

The outputs of the MC945 and MC845 are buffered, thereby reducing the possibility of circuit disturbance from external line noise.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 3	S_2 Pin 4	C_1 Pin 12	C_2 Pin 11	Q Pin 6
0	x	0	x	Q_n
0	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	0	1
1	1	1	1	U

0 — Low State (more negative)
1 — High State (more positive)
x — State of the input does not affect the state of the circuit.
U — Indeterminate State

ASYNCHRONOUS TRUTH TABLE

S_D Pin 10	C_D Pin 5	Q Pin 6	$\overline{Q}$ Pin 9
1	1	NC	NC
0	1	1	0
1	0	0	1
0	0	1	1

J-K TRUTH TABLE

(Connect S_2 to Q, C_2 to $\overline{Q}$)

t_n		t_{n+1}
S_1 Pin 3	C_1 Pin 12	Q Pin 6
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

Asynchronous inputs, direct set (S_D) and direct clear (C_D), override the synchronous inputs; they are independent of all other inputs.

ELECTRICAL CHARACTERISTICS — MC845F

		Test Conditions																			
		mA		Volts																	
@ Test Temperature	0°C	16.8	−0.12	1.20	2.00	0.45	4.00	5.00	—	—											
	+25°C	16.8	−0.12	1.10	1.90	0.45	4.00	5.00	5.00	8.80											
	+75°C	16.0	−0.12	0.95	1.80	0.50	4.00	5.00	—	—											

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{mm} Pin No	① CP_a Pin No	① CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	6	—	—	—	—	—	14	—	—	—	2	3,7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	9	—	—	—	—	—	14	—	—	—	2	7,12	V_{OL} (9)	—	0.45	—	0.45	—	0.50	Vdc
	—	6	11	3,4	—	—	14	—	—	2	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	12	3,4	—	—	14	—	—	2	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	10②	5	—	—	14	—	—	2	—	3,4,7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	3	11,12	—	—	14	—	—	2	—	7	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	4	11,12	—	—	14	—	—	2	—	7	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	5②	10	—	—	14	—	—	2	—	7,11,12	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	14	—	—	—	—	2,7	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	4	14	—	—	—	—	2,7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	5	14	—	—	2	—	3,4,7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	10	14	—	—	2	—	7,11,12	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	11	14	—	—	—	—	2,7	I_R (11)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	12	14	—	—	—	—	2,7	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	2,14	—	—	—	—	—	3,4,7,11,12	I_{RD} (2)	—	30	—	30	—	40	μAdc
Forward Current	—	—	—	—	3	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (3)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	4	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (4)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	11	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (11)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	12	—	14	—	—	—	—	7	$\frac{2}{3}I_F$ (12)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	5	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	10	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−2.00	—	−2.80	—	−2.67	mAdc
	—	—	—	—	5	—	14	—	—	—	—	3,7,10,12	I_{FS} (5)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	10	—	14	—	—	—	—	4,5,7,11	I_{FS} (10)	—	−2.00	—	−2.80	—	−2.67	mAdc
Power Drain Current	—	—	—	—	—	—	—	14	—	—	—	7	I_{PDH} (14)	—	—	—	14	—	—	mAdc
	—	—	—	—	—	—	—	—	14	—	—	2,3,4,7,11,12	I_{mm} (14)	—	—	—	10	—	—	mAdc
Switching Time (Pin 3 connected to Pin 9, Pin 6 connected to Pin 11)	Pulse in 2	Pulse Out 6	—	—	—	—	14	—	—	—	—	7	$t_{pd}+$	—	—	25	100	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	7	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open

① $V_{ILX} = V_{IL}$

① CP_a = Clock Pulse a
CP_c = Clock Pulse c

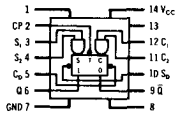
MC930/MC830 (continued)

FLIP-FLOPS

MC948F
MC848F

CLOCKED FLIP-FLOPS

CIRCUIT DIAGRAM AND LOGIC SYMBOLS

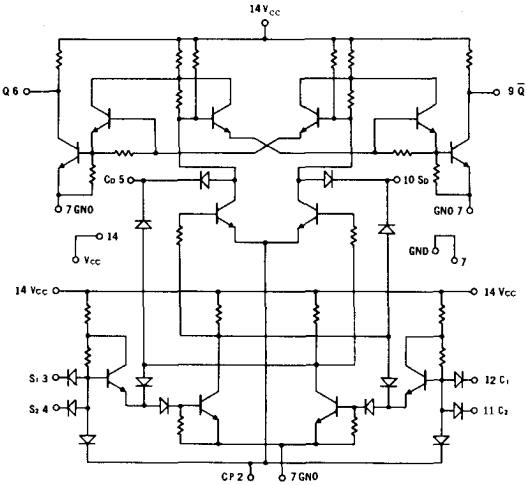


NOTE: For Clock Pulse Waveforms and Propagation Delay Time test circuit and circuit waveforms, see page 13-166.

SYNCHRONOUS TRUTH TABLE

t_n				t_{n+1}
S_1 Pin 3	S_2 Pin 4	C_1 Pin 12	C_2 Pin 11	Q Pin 6
0	x	0	x	Q_n
0	x	x	0	Q_n
x	0	0	x	Q_n
x	0	x	0	Q_n
0	x	1	1	0
x	0	1	1	0
1	1	0	x	1
1	1	x	0	1
1	1	1	1	U

0 — Low State (more negative)
1 — High State (more positive)
x — State of the input does not affect the state of the circuit.
U — Indeterminate State



ELECTRICAL CHARACTERISTICS — MC948F

	Test Conditions												
	mA		Volts										
@ Test Temperature −55°C	13.0	−0.12	1.40	2.10	0	4.00	—	4.50	5.50	—	—		
@ Test Temperature +25°C	13.0	−0.12	1.10	2.00	0	4.00	5.00	4.50	5.50	5.00	8.00		
@ Test Temperature +125°C	12.3	−0.12	0.88	2.00	0	4.00	—	4.50	5.50	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{PPM} Pin No	④ CP_n Pin No	④ CP_c Pin No	Grounded Pin No	Symbol Pin No in ( )	−55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	—	—	—	—	14	—	—	—	—	2	3,7	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	9	—	—	—	—	—	—	14	—	—	—	—	2	7,12	V_{O_1} (9)	—	0.48	—	0.40	—	0.45	Vdc
	—	6	11	3,4	—	—	—	14	—	—	—	2	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	12	3,4	—	—	—	14	—	—	—	2	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	10①	5	—	—	—	14	—	—	—	2	—	3,4,7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	3	11,12	—	—	—	14	—	—	—	2	—	7	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	4	11,12	—	—	—	14	—	—	—	2	—	7	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
	—	9	5①	10	—	—	—	14	—	—	—	2	—	7,11,12	V_{OH} (9)	2.50	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	—	—	14	—	—	—	—	2,7	I_R (3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	4	—	—	14	—	—	—	—	2,7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	14	—	—	2	—	3,4,7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	10	—	—	14	—	—	2	—	7,11,12	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	11	—	—	14	—	—	—	—	2,7	I_R (11)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	12	—	—	14	—	—	—	—	2,7	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	2	—	—	14	—	—	—	—	3,4,7,11,12	I_{CC} (2)	—	20	—	20	—	30	μAdc
Forward Current	—	—	—	—	3	—	—	—	14	—	—	—	—	7	$\Delta_5 I_F$ (3)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	4	—	—	—	14	—	—	—	—	7	$\Delta_5 I_F$ (4)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	11	—	—	—	14	—	—	—	—	7	$\Delta_5 I_F$ (11)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	—	—	12	—	—	—	14	—	—	—	—	7	$\Delta_5 I_F$ (12)	—	−1.07	—	−1.07	—	−1.00	mAdc
	—	—	5	—	—	—	—	—	14	—	—	—	—	2,7	I_{CCF} (2)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	10	—	—	—	—	—	14	—	—	—	—	2,7	I_{CCF} (2)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	5	—	—	—	14	—	—	—	—	3,7,10,12	I_{FS} (5)	—	−3.20	—	−3.20	—	−3.00	mAdc
	—	—	—	—	10	—	—	—	14	—	—	—	—	4,5,7,11	I_{FS} (10)	—	−3.20	—	−3.20	—	−3.00	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	—	—	7	I_{PDH} (14)	—	—	—	13.5	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	—	—	2,3,4,7,11,12	I_{PPM} (14)	—	—	—	19.0	—	—	mAdc
Switching Time (Pin 3 connected to Pin 9; Pin 6 connected to Pin 11)	Pulse In	Pulse Out																				
	2	6	—	—	—	—	14	—	—	—	—	—	—	7	$t_{pd}+$	—	—	25	75	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	—	—	7	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open
① $V_{IL3} = V_{IL}$
④ CP_n = Clock Pulse a
CP_c = Clock Pulse c

MC930/MC830 (continued)

FLIP-FLOPS

MC948F
MC848F

CLOCKED FLIP-FLOPS

This clocked flip-flop consists of two directly coupled flip-flops, operating on the familiar "master-slave" principle. Since operation depends only on voltage levels, the shape of the input clock becomes unimportant in determining the state of the flip-flop. When the clock voltage is high, the input information is stored in the "master" flip-flop, being transferred to the "slave" when the clock voltage is low.

This clocked flip-flop can be operated in either the R-S or J-K mode. For J-K operation the Q output is connected to a clear input, and the $\overline{Q}$ output is connected to a set input. Asynchronous inputs, direct set (S_D) and direct clear (C_D), override the synchronous inputs. No matter what other inputs are applied to the flip-flop, the direct set and clear inputs prevail.

The outputs of the MC948 and MC848 are buffered, thereby reducing the possibility of circuit disturbances from external line noise.

The output pull-up resistor has been changed from that utilized in the MC945 and MC845 in order to irnprove the propagation delay-versus-capacitance characteristics.

ASYNCHRONOUS TRUTH TABLE

S_D Pin 10	C_D Pin 5	Q Pin 6	$\overline{Q}$ Pin 9
1	1	NC	NC
0	1	1	0
1	0	0	1
0	0	1	1

J-K TRUTH TABLE

(Connect S_2 to $\overline{Q}$, C_2 to Q)

t_n		t_{n+1}
S_1 Pin 3	C_1 Pin 12	Q Pin 6
0	0	Q_n
1	0	1
0	1	0
1	1	$\overline{Q}_n$

Asynchronous inputs, direct set (S_D) and direct clear (C_D), override the synchronous inputs; they are independent of all other inputs.

ELECTRICAL CHARACTERISTICS — MC848F

@ Test Temperature	I_{OL} mA	I_{OH} mA	V_{IL} Volts	V_{IH} Volts	V_R Volts	V_R Volts	V_{CC} Volts	V_{PD} Volts	V_{max} Volts	① CP_a	① CP_c	Grounded	Symbol	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_R Pin No	V_R Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	CP_a Pin No	CP_c Pin No	Pin No	Pin No in ( )							
0°C	15.4	−0.12	1.20	2.00	0.45	4.00	5.00	—	—											
+25°C	15.4	−0.12	1.10	1.80	0.45	4.00	5.00	5.00	8.00											
+75°C	14.8	−0.12	0.95	1.80	0.50	4.00	5.00	—	—											
Output Voltage	6	—	—	—	—	—	14	—	—	—	2	3,7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	9	—	—	—	—	—	14	—	—	—	2	7,12	V_{OL} (9)	—	0.45	—	0.45	—	0.50	Vdc
	—	6	11	3,4	—	—	14	—	—	2	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	12	3,4	—	—	14	—	—	2	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	10②	5	—	—	14	—	—	2	—	3,4,7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	3	11,12	—	—	14	—	—	2	—	7	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	4	11,12	—	—	14	—	—	2	—	7	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
	—	9	5①	10	—	—	14	—	—	2	—	7,11,12	V_{OH} (9)	2.60	—	2.60	—	2.50	—	Vdc
Reverse Current	—	—	—	—	—	3	14	—	—	—	—	2,7	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	4	14	—	—	—	—	2,7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	5	14	—	—	2	—	3,4,7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	10	14	—	—	2	—	7,11,12	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	11	14	—	—	—	—	2,7	I_R (11)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	12	14	—	—	—	—	2,7	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	2	14	—	—	—	—	3,4,7,11,12	I_{RCP} (2)	—	30	—	30	—	40	μAdc
Forward Current	—	—	—	—	3	—	14	—	—	—	—	7	$\frac{2}{3}I_R$ (3)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	4	—	14	—	—	—	—	7	$\frac{2}{3}I_R$ (4)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	11	—	14	—	—	—	—	7	$\frac{2}{3}I_R$ (11)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	—	—	12	—	14	—	—	—	—	7	$\frac{2}{3}I_R$ (12)	—	−0.95	—	−0.95	—	−0.90	mAdc
	—	—	5	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	10	—	—	—	14	—	—	—	—	2,7	I_{FCP} (2)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	5	—	14	—	—	—	—	3,7,10,12	I_{FS} (5)	—	−2.80	—	−2.80	—	−2.67	mAdc
	—	—	—	—	10	—	14	—	—	—	—	4,5,7,11	I_{FS} (10)	—	−2.80	—	−2.80	—	−2.67	mAdc
Power Drain Current	—	—	—	—	—	—	—	14	—	—	—	7	I_{PDH} (14)	—	—	—	17	—	—	mAdc
	—	—	—	—	—	—	—	—	14	—	—	2,3,4,7,11,12	I_{PDH} (14)	—	—	—	22.5	—	—	mAdc
Switching Time (Pin 3 connected to Pin 9, Pin 6 connected to Pin 11)	Pulse In 2	Pulse Out 6	—	—	—	—	14	—	—	—	—	7	$t_{pd}+$	—	—	25	75	—	—	ns
	2	6	—	—	—	—	14	—	—	—	—	7	$t_{pd}-$	—	—	15	55	—	—	ns

Pins not listed are left open

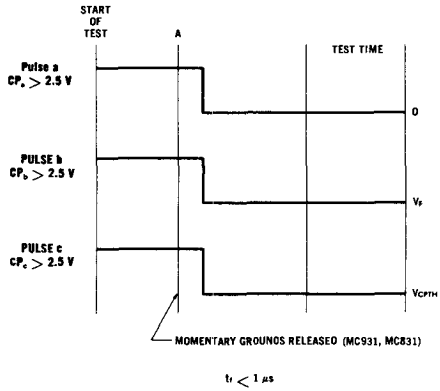
① $V_{ILa} = V_{IL}$

② CP_a = Clock Pulse a
CP_c = Clock Pulse c

MC930/MC830 (continued)

FLIP-FLOPS

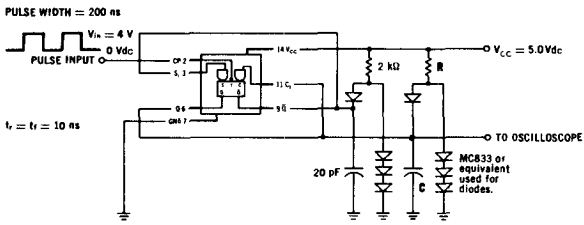
CLOCK PULSE WAVEFORMS



TEST CONDITIONS

T_A	V_{CPTH}		
	MC931	MC945	MC948
−55°C	1.10 V	1.15 V	1.30 V
+25°C	0.95 V	0.95 V	1.15 V
+125°C	0.75 V	0.65 V	0.85 V
	MC831	MC845	MC848
0°C	1.00 V	1.00 V	1.20 V
+25°C	0.95 V	0.95 V	1.15 V
+75°C	0.85 V	0.65 V	0.85 V

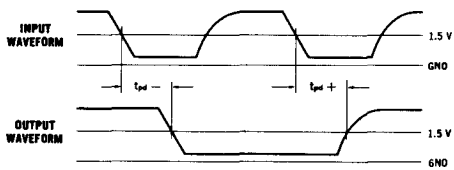
PROPAGATION DELAY TIME TEST CIRCUIT AND WAVEFORMS



For devices in the 10-pin can, the following connections apply:

CP = pin 1
S1 = pin 2
S2 = pin 3
CT = pin 9
C2 = pin 8
Q = pin 4
$\bar{Q}$ = pin 6
Vcc = pin 10
GND = pin 5

TEST	R	C
$t_{pd}+$	3.9 kohms	30 pF
$t_{pd}-$	400 ohms	30 pF



MC930/MC830 (continued)

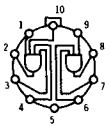
GATE EXPANDERS

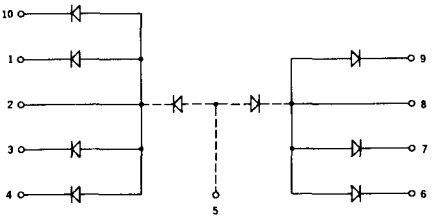
MC933G
MC833G

DUAL 3-4 INPUT
EXPANDERS

This dual expander consists of two independent diode networks with characteristics matched to the input diodes of the gate and buffer elements in this logic family. Its use increases the fan-in capability of other MDTL devices to a maximum of 20 while only slightly affecting performance.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



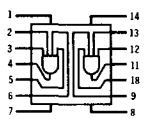


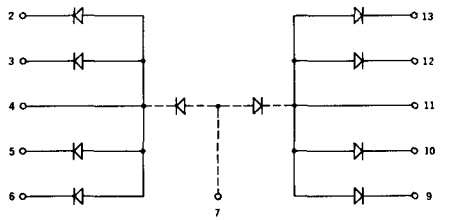
MC933F
MC833F

DUAL 4-INPUT
EXPANDERS

This dual expander consists of two independent diode networks with characteristics matched to the input diodes of the gate and buffer elements in this logic family. Its use increases the fan-in capability of other MDTL devices to a maximum of 20 while only slightly affecting performance.

CIRCUIT DIAGRAM AND LOGIC SYMBOLS





MC930/MC830 (continued)

GATE EXPANDERS

MC933G

DUAL 3-4 INPUT EXPANDERS

ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions mA	Test Conditions Volts
−55°C	2.00	4.00
+25°C	2.00	4.00
+125°C	2.00	4.00

Characteristic	I_{FO} Pin No	V_R Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Forward Voltage	2	—	1,5	V_{FO}(2)	—	0.98	—	8.82	—	8.65	Vdc
	2	—	3,5	V_{FO}(2)	—	0.98	—	0.82	—	0.65	Vdc
	2	—	4,5	V_{FO}(2)	—	0.98	—	0.82	—	0.65	Vdc
	2	—	5,10	V_{FO}(2)	—	0.98	—	0.82	—	0.65	Vdc
	2	—	1,3,4,5,10	V_{FO}(2)	8.85	—	0.70	—	0.50	—	Vdc
	8	—	5,6	V_{FO}(8)	—	0.98	—	8.82	—	0.65	Vdc
	8	—	5,7	V_{FO}(8)	—	0.98	—	0.82	—	0.65	Vdc
	8	—	5,9	V_{FO}(8)	—	0.98	—	0.82	—	0.65	Vdc
	8	—	5,6,7,9	V_{FO}(8)	0.85	—	0.70	—	0.50	—	Vdc
Reverse Current	—	1	3,4,5,10	I_R(1)	—	2.0	—	2.0	—	5.0	μAdc
	—	3	1,4,5,10	I_R(3)	—	2.0	—	2.0	—	5.0	μAdc
	—	4	1,3,5,10	I_R(4)	—	2.0	—	2.0	—	5.0	μAdc
	—	6	5,7,9	I_R(6)	—	2.0	—	2.0	—	5.0	μAdc
	—	7	5,6,9	I_R(7)	—	2.0	—	2.0	—	5.0	μAdc
	—	9	5,6,7	I_R(9)	—	2.0	—	2.0	—	5.0	μAdc
	—	10	1,3,4,5	I_R(10)	—	2.0	—	2.0	—	5.0	μAdc
	—	2	5	$5I_R$(2)	—	10	—	10	—	25	μAdc
	—	8	5	$5I_R$(8)	—	10	—	10	—	25	μAdc

Pins not listed are left open

MC933F

DUAL 4-INPUT EXPANDERS

ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditionx mA	Test Conditionx Voltx
−55°C	2.00	4.00
+25°C	2.00	4.00
+125°C	2.88	4.00

Chxracteristic	I_{FO} PinNo	V_R PinNo	Grounded PinNo	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Forward Voltage	4	—	2,7	V_{FO}(4)	—	0.98	—	0.82	—	0.65	Vdc
	4	—	3,7	V_{FO}(4)	—	0.98	—	0.82	—	0.65	Vdc
	4	—	5,7	V_{FO}(4)	—	0.98	—	0.82	—	0.65	Vdc
	4	—	6,7	V_{FO}(4)	—	0.98	—	0.82	—	0.65	Vdc
	4	—	2,3,5,6,7	V_{FO}(4)	0.85	—	0.70	—	0.50	—	Vdc
	11	—	7,9	V_{FO}(11)	—	0.98	—	0.82	—	0.65	Vdc
	11	—	7,10	V_{FO}(11)	—	0.98	—	0.82	—	0.65	Vdc
	11	—	7,12	V_{FO}(11)	—	0.98	—	0.82	—	0.65	Vdc
	11	—	7,13	V_{FO}(11)	—	0.98	—	0.82	—	0.65	Vdc
	11	—	7,9,10,12,13	V_{FO}(11)	0.85	—	0.70	—	0.50	—	Vdc
Reverse Current	—	2	3,5,6,7	I_R(2)	—	2.0	—	2.0	—	5.0	μAdc
	—	3	2,5,6,7	I_R(3)	—	2.0	—	2.0	—	5.0	μAdc
	—	5	2,3,6,7	I_R(5)	—	2.0	—	2.0	—	5.0	μAdc
	—	6	2,3,5,7	I_R(6)	—	2.0	—	2.0	—	5.0	μAdc
	—	9	7,10,12,13	I_R(9)	—	2.0	—	2.0	—	5.0	μAdc
	—	10	7,9,12,13	I_R(10)	—	2.0	—	2.0	—	5.0	μAdc
	—	12	7,9,10,13	I_R(12)	—	2.0	—	2.0	—	5.0	μAdc
	—	13	7,9,10,12	I_R(13)	—	2.0	—	2.0	—	5.0	μAdc
	—	4	7	$5I_R$(4)	—	10	—	10	—	25	μAdc
	—	11	7	$5I_R$(11)	—	10	—	10	—	25	μAdc

Pins not listed are left open

MC930/MC830 (continued)

GATE EXPANDERS

MC833G

DUAL 3-4 INPUT EXPANDERS

ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions mA	Test Conditions Volts
0°C	2.00	4.00
+25°C	2.00	4.00
+75°C	2.08	4.00

Characteristic	I_{FO} Pin No	V_R Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Forward Voltage	2	—	1, 5	V_{FD}(2)	—	0.90	—	0.82	—	0.75	Vdc
	2	—	3, 5	V_{FD}(2)	—	0.90	—	0.82	—	0.75	Vdc
	2	—	4, 5	V_{FD}(2)	—	0.90	—	0.82	—	0.75	Vdc
	2	—	5, 10	V_{FD}(2)	—	0.90	—	0.82	—	0.75	Vdc
	2	—	1, 3, 4, 5, 10	V_{FD}(2)	0.75	—	0.68	—	0.60	—	Vdc
	8	—	5, 6	V_{FD}(8)	—	0.98	—	0.82	—	0.75	Vdc
	8	—	5, 7	V_{FD}(8)	—	0.90	—	0.82	—	0.75	Vdc
	8	—	5, 9	V_{FD}(8)	—	0.90	—	0.82	—	0.75	Vdc
	8	—	5, 6, 7, 9	V_{FD}(8)	0.75	—	0.68	—	0.60	—	Vdc
Reverse Current	—	1	3, 4, 5, 10	I_R(1)	—	5.0	—	5.0	—	10	μAdc
	—	3	1, 4, 5, 10	I_R(3)	—	5.0	—	5.0	—	10	μAdc
	—	4	1, 3, 5, 10	I_R(4)	—	5.0	—	5.0	—	10	μAdc
	—	6	5, 7, 9	I_R(6)	—	5.0	—	5.0	—	10	μAdc
	—	7	5, 6, 9	I_R(7)	—	5.0	—	5.0	—	10	μAdc
	—	9	5, 6, 7	I_R(9)	—	5.0	—	5.0	—	10	μAdc
	—	10	1, 3, 4, 5	I_R(10)	—	5.0	—	5.0	—	18	μAdc
	—	2	5	$2I_R$(2)	—	—	—	10	—	—	μAdc
	—	8	5	$2I_R$(8)	—	—	—	10	—	—	μAdc

Pins not listed are left open

MC833F

DUAL 4-INPUT EXPANDERS

ELECTRICAL CHARACTERISTICS

@ Test Temperature	Test Conditions mA	Test Conditions Volts
0°C	2.88	4.00
+25°C	2.88	4.00
+75°C	2.80	4.00

Characteristic	I_{FO} Pin No	V_R Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Forward Voltage	4	—	2, 7	V_{FD}(4)	—	0.90	—	0.82	—	0.75	Vdc
	4	—	3, 7	V_{FD}(4)	—	0.90	—	0.82	—	0.75	Vdc
	4	—	5, 7	V_{FD}(4)	—	0.90	—	0.02	—	0.75	Vdc
	4	—	6, 7	V_{FD}(4)	—	0.90	—	0.82	—	0.75	Vdc
	4	—	2, 3, 5, 6, 7	V_{FD}(4)	0.75	—	0.60	—	0.60	—	Vdc
	11	—	7, 9	V_{FD}(11)	—	0.90	—	0.82	—	0.75	Vdc
	11	—	7, 10	V_{FD}(11)	—	0.90	—	0.82	—	0.75	Vdc
	11	—	7, 12	V_{FD}(11)	—	0.90	—	0.02	—	0.75	Vdc
	11	—	7, 13	V_{FD}(11)	—	0.90	—	0.82	—	0.75	Vdc
	11	—	7, 9, 10, 12, 13	V_{FD}(11)	0.75	—	0.68	—	0.60	—	Vdc
Reverse Current	—	2	3, 5, 6, 7	I_R(2)	—	5.0	—	5.0	—	10	μAdc
	—	3	2, 5, 6, 7	I_R(3)	—	5.0	—	5.0	—	10	μAdc
	—	5	2, 3, 6, 7	I_R(5)	—	5.0	—	5.0	—	10	μAdc
	—	6	2, 3, 5, 7	I_R(6)	—	5.0	—	5.0	—	10	μAdc
	—	9	7, 10, 12, 13	I_R(9)	—	5.0	—	5.0	—	10	μAdc
	—	10	7, 9, 12, 13	I_R(10)	—	5.0	—	5.0	—	10	μAdc
	—	12	7, 9, 10, 13	I_R(12)	—	5.0	—	5.0	—	10	μAdc
	—	13	7, 9, 10, 12	I_R(13)	—	5.0	—	5.0	—	10	μAdc
	—	4	7	$2I_R$(4)	—	—	—	10	—	—	μAdc
	—	11	7	$2I_R$(11)	—	—	—	10	—	—	μAdc

Pins not listed are left open

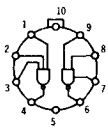
MC930/MC830 (continued)

LOGIC GATES

MC930G
MC830G

DUAL 2-3 INPUT
"NAND/NOR" GATES

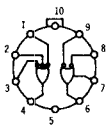
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$4 = \overline{1 \cdot 2 \cdot 3}$

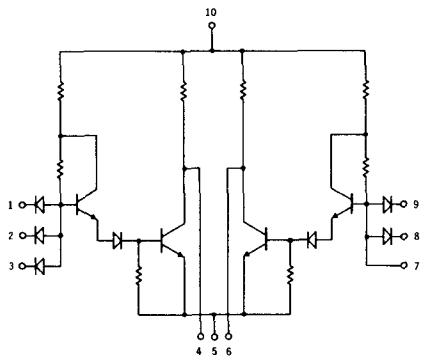
$6 = \overline{8 \cdot 9 \cdot (7)}$



NEGATIVE LOGIC

$4 = \overline{1 + 2 + 3}$

$6 = \overline{8 + 9 + (7)}$



ELECTRICAL CHARACTERISTICS — MC930G

	Test Conditions														
	mA		Volts												
@ Test Temperature −55°C	11.4	−0.12	1.40	2.10	—	0	4.00	—	—	4.50	5.50	—	—		
@ Test Temperature +25°C	12.0	−8.12	1.10	2.00	1.80	0	4.00	4.50	5.00	4.50	5.50	5.00	8.00		
@ Test Temperature +125°C	10.8	−0.12	0.80	2.00	—	0	4.00	—	—	4.50	5.50	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	4	—	—	1, 2, 3	—	—	—	—	—	10	—	—	—	5	V_{OL} (4)	—	0.40	—	0.40	—	0.45	Vdc
	6	—	—	8, 9	—	—	—	—	—	10	—	—	—	5	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	—	4	1	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	2	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	4	3	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	8	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	9	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	—	—	7	—	—	—	—	10	—	—	—	5	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	—	—	10	—	—	1, 4, 5	I_{SC} (4)	—	−1.34	—	−1.34	—	−1.30	mAdc
	—	—	—	—	—	—	—	—	—	—	10	—	—	5, 6, 8	I_{SC} (6)	—	−1.34	—	−1.34	—	−1.30	mAdc
Reverse Current	—	—	—	—	—	—	1	—	—	—	10	—	—	2, 3, 5	I_R (1)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	2	—	—	—	10	—	—	1, 3, 5	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	3	—	—	—	10	—	—	1, 2, 5	I_R (3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	8	—	—	—	10	—	—	5, 9	I_R (8)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	9	—	—	—	10	—	—	5, 8	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	—	—	—	—	—	4, 10	—	—	—	—	—	1, 5	I_{CEX} (4)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	—	6, 10	—	—	—	—	—	5, 8	I_{CEX} (6)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 3	—	—	—	10	—	—	5	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	2	1, 3	—	—	—	10	—	—	5	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	3	1, 2	—	—	—	10	—	—	5	I_F (3)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	8	9	—	—	—	10	—	—	5	I_F (8)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	9	8	—	—	—	10	—	—	5	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	—	10	—	5	I_{PDH} (10)	—	—	—	6.5	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	—	—	10	1, 5, 8	I_{max} (10)	—	—	—	5.5	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse In	Pulse Out																				
	3	6	—	—	—	—	—	—	10	—	—	—	—	5	$t_{pd}+$	—	—	25	80	—	—	ns
	3	6	—	—	—	—	—	—	10	—	—	—	—	5	$t_{pd}-$	—	—	10	30	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

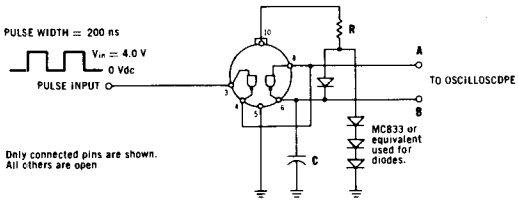
LOGIC GATES

MC930G
MC830G

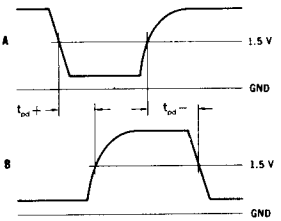
DUAL 2-3 INPUT
"NAND/NOR" GATES

This gate element consists of one 2-input and one 3-input "NAND/NOR" gate circuit. Other applications include cross-coupling to form a bistable multivibrator, or connecting the outputs in parallel to perform the logic "OR" function.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



TEST	R	C
$t_{pd}+$	3.9 kohms	30 pF
$t_{pd}-$	400 ohms	50 pF



ELECTRICAL CHARACTERISTICS — MC830G

		Test Conditions											
		mA		Volts									
@ Test Temperature	0°C	12.0	−0.12	1.20	2.00	—	0.45	4.00	—	5.00	—	—
	+25°C	12.0	−0.12	1.10	1.90	1.80	0.45	4.00	5.00	5.00	5.00	8.00
	+75°C	11.4	−0.12	0.95	1.88	—	0.50	4.00	—	5.00	—	—

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	4	—	—	1,2,3	—	—	—	—	10	—	—	5	V_{OL} (4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	8,9	—	—	—	—	10	—	—	5	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	—	4	1	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	2	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	3	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	8	—	—	—	—	—	10	—	—	5	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	9	—	—	—	—	—	10	—	—	5	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	—	—	7	—	—	—	10	—	—	5	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	10	—	—	1,4,5	I_{SC} (4)	—	−1.30	—	−1.30	—	−1.25	mAdc
	—	—	—	—	—	—	—	—	10	—	—	5,6,8	I_{SC} (6)	—	−1.30	—	−1.30	—	−1.25	mAdc
Reverse Current	—	—	—	—	—	—	1	—	10	—	—	2,3,5	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	10	—	—	1,3,5	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	3	—	10	—	—	1,2,5	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	8	—	10	—	—	5,9	I_R (8)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	10	—	—	5,8	I_R (9)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	—	4, 10	—	—	—	1,5	I_{CEX} (4)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	—	6, 10	—	—	—	5,8	I_{CEX} (6)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	—	1	2,3	—	10	—	—	5	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1,3	—	10	—	—	5	I_F (2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	3	1,2	—	10	—	—	5	I_F (3)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	8	9	—	10	—	—	5	I_F (8)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	8	—	10	—	—	5	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	10	—	5	I_{PDH} (10)	—	—	—	8.0	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	10	1,5,8	I_{max} (10)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse in	Pulse Out																		
	3	6	—	—	—	—	—	—	10	—	—	5	$t_{pd}+$	—	—	25	80	—	—	ns
	3	6	—	—	—	—	—	—	10	—	—	5	$t_{pd}-$	—	—	10	30	—	—	ns

Pins not listed are left open

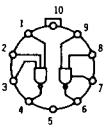
MC930/MC830 (continued)

LOGIC GATES

MC944G
MC844G

DUAL 2-3 INPUT
POWER GATES

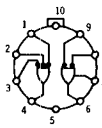
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$4 = \overline{1 \cdot 2 \cdot 3}$

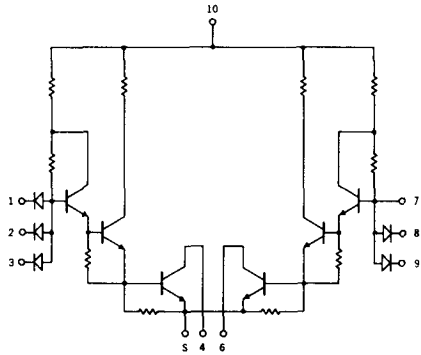
$6 = \overline{8 \cdot 9 \cdot (7)}$



NEGATIVE LOGIC

$4 = \overline{1 + 2 + 3}$

$6 = \overline{8 + 9 + (7)}$



ELECTRICAL CHARACTERISTICS — MC944G

			Test Conditions																	
			mA		Volts															
@ Test Temperature	−55°C		38.0	—	—	2.10	—	0	4.00	—	—	4.50	5.38	—	—					
	+25°C		40.8	5.00	1.18	2.00	1.60	0	4.00	4.58	5.00	4.50	5.58	5.80	8.00					
	+125°C		38.0	—	—	2.08	—	0	4.00	—	—	4.58	5.58	—	—					
Characteristic	I_{OL} Pin No	I_{CE} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	4	—	—	1,2,3	—	—	—	—	—	10	—	—	—	5	V_{OL}(4)	—	0.40	—	0.40	—	0.45	Vdc
	6	—	—	8,9	—	—	—	—	—	10	—	—	—	5	V_{OL}(6)	—	0.40	—	0.40	—	0.45	Vdc
Output Breakdown Voltage	—	4	—	—	—	—	—	—	—	—	10	—	—	1, 5	LV_{CE}(4)	—	—	6.0	—	—	—	Vdc
	—	6	—	—	—	—	—	—	—	—	10	—	—	5, 8	LV_{CE}(6)	—	—	6.0	—	—	—	Vdc
Reverse Current	—	—	—	—	—	—	1	—	—	—	10	—	—	2,3,5	I_R(1)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	2	—	—	—	10	—	—	1,3,5	I_R(2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	3	—	—	—	10	—	—	1,2,5	I_R(3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	8	—	—	—	10	—	—	5,9	I_R(8)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	9	—	—	—	10	—	—	5,8	I_R(9)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	1	—	—	—	—	4	—	—	10	—	—	5	I_{CEX}(4)	—	—	—	50	—	—	μAdc
	—	—	2	—	—	—	—	4	—	—	10	—	—	5	I_{CEX}(4)	—	—	—	50	—	—	μAdc
	—	—	3	—	—	—	—	4	—	—	10	—	—	5	I_{CEX}(4)	—	—	—	50	—	—	μAdc
	—	—	8	—	—	—	—	6	—	—	10	—	—	5	I_{CEX}(6)	—	—	—	50	—	—	μAdc
	—	—	9	—	—	—	—	6	—	—	10	—	—	5	I_{CEX}(6)	—	—	—	50	—	—	μAdc
	—	—	—	—	7	—	—	6	—	—	10	—	—	5	I_{CEX}(6)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	—	1	2,3	—	—	—	10	—	—	5	I_F(1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	2	1,3	—	—	—	10	—	—	5	I_F(2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	3	1,2	—	—	—	10	—	—	5	I_F(3)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	8	9	—	—	—	10	—	—	5	I_F(8)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	9	8	—	—	—	10	—	—	5	I_F(9)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	—	10	—	5	I_{PDH}(10)	—	—	—	20	—	—	mAdc
			—	—	—	—	—	—	—	—	—	—	10	1,5,8	I_{max}(10)	—	—	—	6.0	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse In	Pulse Out																			
	3	6	—	—	—	—	—	—	10	—	—	—	—	5	$t_{pd}+$	—	—	15	50	—	—	ns
	3	5	—	—	—	—	—	—	10	—	—	—	—	5	$t_{pd}-$	—	—	10	35	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

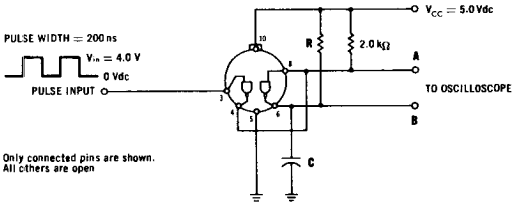
LOGIC GATES

MC944G
MC844G

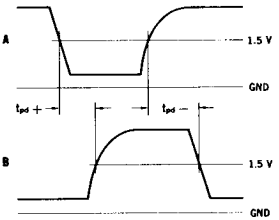
DUAL 2-3 INPUT
POWER GATES

This gate element consists of one 2-input and one 3-input power gate circuit, and is quite similar to the dual 2-3 input buffer (MC932G, MC832G). The power gate does not have the output pull-up emitter-follower as does the buffer element — its output being the open collector of a low saturation resistance transistor. The power gate may be used as a high fan-out gate, as a driver to interfacing circuits, or in other similar uses.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



TEST	R	C
$t_{pd}+$	510 ohms	20 pF
$t_{pd}-$	150 ohms	100 pF



ELECTRICAL CHARACTERISTICS — MC844G

	Test Conditions													Grounded Pin No	Symbol Pin No in ( )	Test Limits						Unit
	mA		Volts													0°C		+25°C		+75°C		
Characteristic	I_{OL} Pin No	I_{CE} Pin No	V_R Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No					Min	Max	Min	Max	Min	Max	
@ Test Temperature 0°C	40.0	—	—	2.00	—	0.45	4.00	—	5.00	—	—											
@ Test Temperature +25°C	40.0	5.00	1.10	1.90	1.88	0.45	4.00	5.00	5.00	5.00	8.00											
@ Test Temperature +75°C	30.0	—	—	1.90	—	0.50	4.00	—	5.00	—	—											
Output Voltage	4	—	—	1,2,3	—	—	—	—	10	—	—			5	V_{OL} (4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	8,9	—	—	—	—	10	—	—			5	V_{OL} (5)	—	0.45	—	0.45	—	0.50	Vdc
Output Breakdown Voltage	—	4	—	—	—	—	—	—	10	—	—			1,5	LV_{CE} (4)	—	—	6.0	—	—	—	Vdc
	—	6	—	—	—	—	—	—	10	—	—			5,8	LV_{CE} (6)	—	—	6.0	—	—	—	Vdc
Reverse Current	—	—	—	—	—	—	1	—	10	—	—			2,3,5	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	10	—	—			1,3,5	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	3	—	10	—	—			1,2,5	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	8	—	10	—	—			5,9	I_R (8)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	10	—	—			5,8	I_R (9)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	1	—	—	—	—	4	10	—	—			5	I_{CEX} (4)	—	—	—	100	—	—	μAdc
	—	—	2	—	—	—	—	4	10	—	—			5	I_{CEX} (4)	—	—	—	100	—	—	μAdc
	—	—	3	—	—	—	—	4	10	—	—			5	I_{CEX} (4)	—	—	—	100	—	—	μAdc
	—	—	8	—	—	—	—	6	10	—	—			5	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	9	—	—	—	—	6	10	—	—			5	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	—	—	7	—	—	6	10	—	—			5	I_{CEX} (6)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	—	1	2,3	—	10	—	—			5	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1,3	—	10	—	—			5	I_F (2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	3	1,2	—	10	—	—			5	I_F (3)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	8	9	—	10	—	—			5	I_F (8)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	8	—	10	—	—			5	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	10	—			5	I_{PDH} (10)	—	—	—	22.5	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	10			1,5,8	I_{max} (10)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse In	Pulse Out																				
	3	6	—	—	—	—	—	—	10	—	—			5	$t_{pd}+$	—	—	15	50	—	—	ns
	3	6	—	—	—	—	—	—	10	—	—			5	$t_{pd}-$	—	—	10	35	—	—	ns

Pins not listed are left open

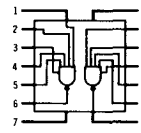
MC930/MC830 (continued)

LOGIC GATES

MC930F
MC830F

DUAL 4-INPUT
"NAND/NOR" GATES

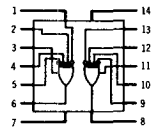
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$6 = \overline{1 \cdot 2 \cdot 4 \cdot 5 \cdot (3)}$

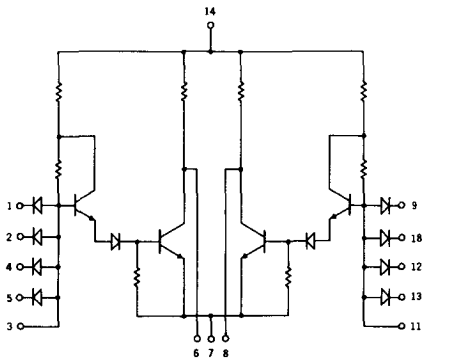
$8 = \overline{9 \cdot 10 \cdot 12 \cdot 13 \cdot (11)}$



NEGATIVE LOGIC

$6 = \overline{1 + 2 + 4 + 5 + (3)}$

$8 = \overline{9 + 10 + 12 + 13 + (11)}$



ELECTRICAL CHARACTERISTICS — MC930F

Characteristic	Test Conditions: @ Test Temperature	I_{OL} mA Pin No	I_{OH} mA Pin No	V_{IL} Volts Pin No	V_{IH} Volts Pin No	V_X Volts Pin No	V_S Volts Pin No	V_R Volts Pin No	V_{CEX} Volts Pin No	V_{CC} Volts Pin No	V_{CCL} Volts Pin No	V_{CCH} Volts Pin No	V_{PD} Volts Pin No	V_{max} Volts Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	−55°C	11.4	−0.12	1.40	2.10	—	0	4.00	—	—	4.50	5.50	—	—									
	+25°C	12.0	−8.12	1.10	2.00	1.80	0	4.88	4.50	5.00	4.50	5.50	5.00	6.00									
	+125°C	10.8	−0.12	0.80	2.00	—	0	4.00	—	—	4.50	5.50	—	—									
		6	—	—	1,2,4,5	—	—	—	—	—	14	—	—	—	7	V_{OL} (6)	—	8.40	—	0.40	—	0.45	Vdc
		8	—	—	9,10,12,13	—	—	—	—	—	14	—	—	—	7	V_{OL} (8)	—	0.40	—	0.40	—	8.45	Vdc
		—	6	1	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	2	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	4	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	5	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	—	3	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	9	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	18	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	12	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	13	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
		—	8	—	11	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
Short-Circuit Current		—	—	—	—	—	—	—	—	—	—	14	—	—	1,6,7	I_{SC} (6)	—	−1.34	—	−1.34	—	−1.30	mAdc
		—	—	—	—	—	—	—	—	—	—	14	—	—	7,8,9	I_{SC} (8)	—	−1.34	—	−1.34	—	−1.30	mAdc
Reverse Current		—	—	—	—	—	—	1	—	—	—	14	—	—	2,4,5,7	I_R (1)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	2	—	—	—	14	—	—	1,4,5,7	I_R (2)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	4	—	—	—	14	—	—	1,2,5,7	I_R (4)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	5	—	—	—	14	—	—	1,2,4,7	I_R (5)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	9	—	—	—	14	—	—	7,10,12,13	I_R (9)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	10	—	—	—	14	—	—	7,9,12,13	I_R (10)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	12	—	—	—	14	—	—	7,9,18,13	I_R (12)	—	2.0	—	2.8	—	5.8	μAdc
		—	—	—	—	—	—	13	—	—	—	14	—	—	7,9,10,12	I_R (13)	—	2.0	—	2.8	—	5.8	μAdc
Output Leakage Current		—	—	—	—	—	—	—	6, 14	—	—	—	—	—	1,7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
		—	—	—	—	—	—	—	8, 14	—	—	—	—	—	7,9	I_{CEX} (8)	—	—	—	50	—	—	μAdc
Forward Current		—	—	—	—	—	1	2,4,5	—	—	—	14	—	—	7	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	2	1,4,5	—	—	—	14	—	—	7	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	4	1,2,5	—	—	—	14	—	—	7	I_F (4)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	5	1,2,4	—	—	—	14	—	—	7	I_F (5)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	9	10,12,13	—	—	—	14	—	—	7	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	10	9,12,13	—	—	—	14	—	—	7	I_F (10)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	12	9,10,13	—	—	—	14	—	—	7	I_F (12)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	13	9,10,12	—	—	—	14	—	—	7	I_F (13)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current		—	—	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	6.50	—	—	mAdc
		—	—	—	—	—	—	—	—	—	—	—	—	14	1,7,9	I_{PDL} (14)	—	—	—	5.50	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In / Pulse Out																						
	5 / 8	—	—	—	—	—	—	—	14	—	—	—	—	—	7	t_{pd+}	—	—	25	80	—	—	ns
	5 / 8	—	—	—	—	—	—	—	14	—	—	—	—	—	7	t_{pd-}	—	—	10	30	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

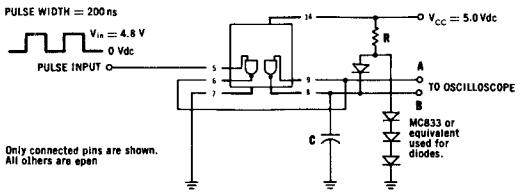
LOGIC GATES

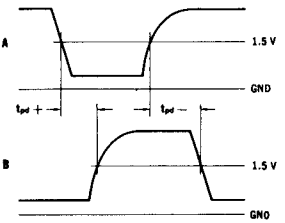
MC930F
MC830F

DUAL 4-INPUT
"NAND/NOR" GATES

This gate element consists of two 4-input "NAND/NOR" gate circuits. Other applications include cross-coupling to form a bistable multivibrator, or connecting the outputs in parallel to perform the logic "OR" function.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





TEST	R	C
$t_{pd}+$	3.9 kohms	30 pF
$t_{pd}-$	400 ohms	50 pF

ELECTRICAL CHARACTERISTICS — MC830F

	Test Conditions												
	mA		Volts										
@ Test Temperature 0°C	12.8	−0.12	1.20	2.00	—	0.45	4.00	—	5.00	—	—		
@ Test Temperature +25°C	12.8	−0.12	1.10	1.90	1.80	0.45	4.00	5.00	5.00	5.00	8.00		
@ Test Temperature +75°C	11.4	−0.12	0.85	1.90	—	0.50	4.00	—	5.00	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_R Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	6	—	—	1,2,4,5	—	—	—	—	14	—	—	7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	0	—	—	9,10,12,13	—	—	—	—	14	—	—	7	V_{OL} (8)	—	0.45	—	0.45	—	0.50	Vdc
	—	6	1	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	2	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	—	—	3	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	9	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	12	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	13	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	0	—	—	11	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	14	—	—	1, 6, 7	I_{SC} (6)	—	−1.30	—	−1.30	—	−1.25	mAdc
	—	—	—	—	—	—	—	—	14	—	—	7, 8, 9	I_{SC} (8)	—	−1.30	—	−1.38	—	−1.25	mAdc
Reverse Current	—	—	—	—	—	—	1	—	14	—	—	2, 4, 5, 7	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	14	—	—	1, 4, 5, 7	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	4	—	14	—	—	1, 2, 5, 7	I_R (4)	—	5.8	—	5.0	—	10	μAdc
	—	—	—	—	—	—	5	—	14	—	—	1, 2, 4, 7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	14	—	—	7, 10, 12, 13	I_R (9)	—	5.0	—	5.0	—	18	μAdc
	—	—	—	—	—	—	18	—	14	—	—	7, 9, 12, 13	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	12	—	14	—	—	7, 9, 10, 13	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	13	—	14	—	—	7, 9, 10, 12	I_R (13)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	—	6, 14	—	—	—	1, 7	I_{CEX} (6)	—	—	—	180	—	—	μAdc
	—	—	—	—	—	—	—	8, 14	—	—	—	7, 9	I_{CEX} (8)	—	—	—	180	—	—	μAdc
Forward Current	—	—	—	—	—	1	2,4,5	—	14	—	—	7	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1,4,5	—	14	—	—	7	I_F (2)	—	−1.40	—	−1.48	—	−1.33	mAdc
	—	—	—	—	—	4	1,2,5	—	14	—	—	7	I_F (4)	—	−1.40	—	−1.48	—	−1.33	mAdc
	—	—	—	—	—	5	1,2,4	—	14	—	—	7	I_F (5)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	18,12,13	—	14	—	—	7	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	10	9,12,13	—	14	—	—	7	I_F (10)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	12	9,10,13	—	14	—	—	7	I_F (12)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	13	9,10,12	—	14	—	—	7	I_F (13)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	8.0	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	1, 7, 9	I_{max} (14)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9) Pulse In 5	0	—	—	—	—	—	—	—	14	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
Pulse Out 5	8	—	—	—	—	—	—	—	14	—	—	7	$t_{pd}-$	—	—	18	30	—	—	ns

Pins not listed are left open

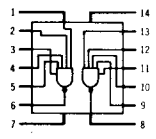
MC930/MC830 (continued)

LOGIC GATES

MC944F
MC844F

DUAL 4-INPUT
POWER GATES

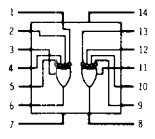
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$6 = \overline{1 \cdot 2 \cdot 4 \cdot 5 \cdot (3)}$

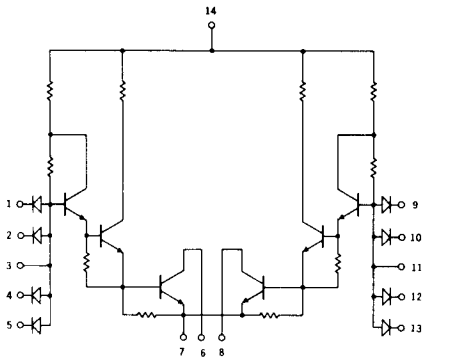
$8 = \overline{9 \cdot 10 \cdot 12 \cdot 13 \cdot (11)}$



NEGATIVE LOGIC

$6 = \overline{1 + 2 + 4 + 5 + (3)}$

$8 = \overline{9 + 10 + 12 + 13 + (11)}$



ELECTRICAL CHARACTERISTICS — MC944F

			Test Conditions																			
			mA		Volts																	
@ Test Temperature	−55°C		36.6	—	—	2.10	—	6	4.00	—	—	4.50	5.50	—	—							
	+25°C		40.0	5.60	1.10	2.00	1.80	0	4.00	4.50	5.00	4.50	5.50	5.06	6.00							
	+125°C		36.0	—	—	2.00	—	0	4.00	—	—	4.50	5.50	—	—							
Characteristic	I_{OL} Pin No	I_{CE} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	−55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	1, 2, 4, 5	—	—	—	—	—	14	—	—	—	7	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	8	—	—	9, 10, 12, 13	—	—	—	—	—	14	—	—	—	7	V_{OL} (8)	—	0.40	—	0.40	—	0.45	Vdc
Output Breakdown Voltage	—	6	—	—	—	—	—	—	—	—	14	—	—	1, 7	LV_{CE} (6)	—	—	6.0	—	—	—	Vdc
	—	8	—	—	—	—	—	—	—	—	14	—	—	7, 9	LV_{CE} (8)	—	—	6.0	—	—	—	Vdc
Reverse Current	—	—	—	—	—	—	1	—	—	—	14	—	—	2, 4, 5, 7	I_R (1)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	2	—	—	—	14	—	—	1, 4, 5, 7	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	4	—	—	—	14	—	—	1, 2, 5, 7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	5	—	—	—	14	—	—	1, 2, 4, 7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	9	—	—	—	14	—	—	7, 10, 12, 13	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	10	—	—	—	14	—	—	7, 9, 12, 13	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	12	—	—	—	14	—	—	7, 9, 10, 13	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	13	—	—	—	14	—	—	7, 9, 10, 12	I_R (13)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	1	—	—	—	—	6	—	—	14	—	—	7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	2	—	—	—	—	6	—	—	14	—	—	7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	4	—	—	—	—	6	—	—	14	—	—	7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	5	—	—	—	—	6	—	—	14	—	—	7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	—	—	3	—	—	6	—	—	14	—	—	7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	9	—	—	—	—	8	—	—	14	—	—	7	I_{CEX} (8)	—	—	—	50	—	—	μAdc
	—	—	10	—	—	—	—	8	—	—	14	—	—	7	I_{CEX} (8)	—	—	—	50	—	—	μAdc
	—	—	12	—	—	—	—	8	—	—	14	—	—	7	I_{CEX} (8)	—	—	—	50	—	—	μAdc
	—	—	13	—	—	—	—	8	—	—	14	—	—	7	I_{CEX} (8)	—	—	—	50	—	—	μAdc
	—	—	—	—	11	—	—	8	—	—	14	—	—	7	I_{CEX} (8)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 4, 5	—	—	—	14	—	—	7	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	2	1, 4, 5	—	—	—	14	—	—	7	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	4	1, 2, 5	—	—	—	14	—	—	7	I_F (4)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	5	1, 2, 4	—	—	—	14	—	—	7	I_F (5)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	9	10, 12, 13	—	—	—	14	—	—	7	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	10	9, 12, 13	—	—	—	14	—	—	7	I_F (10)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	12	9, 10, 13	—	—	—	14	—	—	7	I_F (12)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	13	9, 10, 12	—	—	—	14	—	—	7	I_F (13)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	20	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	—	—	14	1, 7, 9	I_{PDL} (14)	—	—	—	6.0	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																				
	5	0	—	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}+$	—	—	15	50	—	—	ns
	5	6	—	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}-$	—	—	10	35	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

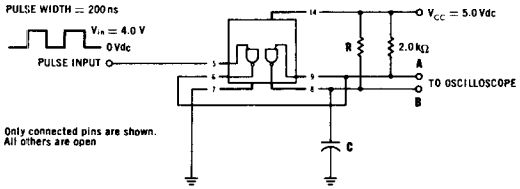
LOGIC GATES

MC944F
MC844F

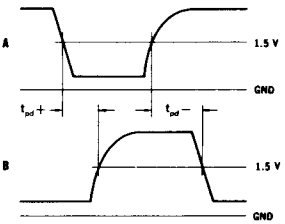
DUAL 4-INPUT POWER GATES

This element is a dual 4-input power gate, and is quite similar to the dual 4-input buffer, (MC932F, MC832F). The power gate does not have the output pull-up emitter-follower as does the buffer element — its output being the open collector of a low saturation resistance transistor. The power gate may be used as a high fan-out gate, as a driver to interfacing circuits, or in other similar uses.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



TEST	R	C
$t_{pd}+$	510 ohms	20 pF
$t_{pd}-$	150 ohms	100 pF



ELECTRICAL CHARACTERISTICS — MC844F

Characteristic	I_{OL} Pin No	I_{CE} Pin No	V_{RL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	6	—	—	—	—	—	—	—	14	—	—	7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	0	—	—	9, 10, 12, 13	—	—	—	—	14	—	—	7	V_{OL} (8)	—	0.45	—	0.45	—	0.50	Vdc
Output Breakdown Voltage	—	6	—	—	—	—	—	—	14	—	—	1, 7	LV_{CE} (6)	—	—	6.0	—	—	—	Vdc
	—	8	—	—	—	—	—	—	14	—	—	7, 9	LV_{CE} (8)	—	—	6.0	—	—	—	Vdc
Reverse Current	—	—	—	—	—	—	1	—	14	—	—	2, 4, 5, 7	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	14	—	—	1, 4, 5, 7	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	4	—	14	—	—	1, 2, 5, 7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	5	—	14	—	—	1, 2, 4, 7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	14	—	—	7, 10, 12, 13	I_R (9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	10	—	14	—	—	7, 9, 12, 13	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	12	—	14	—	—	7, 9, 10, 13	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	13	—	14	—	—	7, 9, 10, 12	I_R (13)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	1	—	—	—	—	6	14	—	—	7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	2	—	—	—	—	6	14	—	—	7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	4	—	—	—	—	6	14	—	—	7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	5	—	—	—	—	6	14	—	—	7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	—	—	3	—	—	6	14	—	—	7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	9	—	—	—	—	8	14	—	—	7	I_{CEX} (8)	—	—	—	100	—	—	μAdc
	—	—	10	—	—	—	—	8	14	—	—	7	I_{CEX} (8)	—	—	—	100	—	—	μAdc
	—	—	12	—	—	—	—	8	14	—	—	7	I_{CEX} (8)	—	—	—	100	—	—	μAdc
	—	—	13	—	—	—	—	8	14	—	—	7	I_{CEX} (8)	—	—	—	100	—	—	μAdc
	—	—	—	—	11	—	—	8	14	—	—	7	I_{CEX} (8)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 4, 5	—	14	—	—	7	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1, 4, 5	—	14	—	—	7	I_F (2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	4	1, 2, 5	—	14	—	—	7	I_F (4)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	5	1, 2, 4	—	14	—	—	7	I_F (5)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	10, 12, 13	—	14	—	—	7	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	10	9, 12, 13	—	14	—	—	7	I_F (10)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	12	9, 10, 13	—	14	—	—	7	I_F (12)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	13	9, 10, 12	—	14	—	—	7	I_F (13)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	22.5	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	1, 7, 9	I_{max} (14)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																		
	6	8	—	—	—	—	—	—	14	—	—	7	$t_{pd}+$	—	—	15	50	—	—	ns
	5	8	—	—	—	—	—	—	14	—	—	7	$t_{pd}-$	—	—	10	35	—	—	ns

Pins not listed are left open

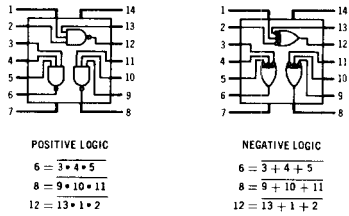
MC930/MC830 (continued)

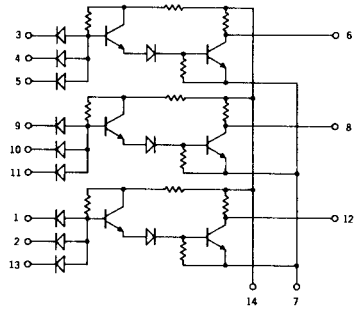
LOGIC GATES

MC962F
MC862F

TRIPLE 3-INPUT
"NAND/NOR" GATES

CIRCUIT DIAGRAM AND LOGIC SYMBOLS





ELECTRICAL CHARACTERISTICS — MC962F

	Test Conditions											
	mA		Volts									
@ Test Temperature −55°C	11.4	−0.12	1.40	2.10	0	4.00	—	—	4.50	5.50	—	—
@ Test Temperature +25°C	12.0	−0.12	1.10	2.00	0	4.00	4.50	5.00	4.50	5.50	5.00	8.00
@ Test Temperature +125°C	10.0	−8.12	0.08	2.80	0	4.00	—	—	4.50	5.50	—	—

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	3,4,5	—	—	—	—	14	—	—	—	7	V_{OL}(6)	—	0.40	—	0.40	—	0.45	Vdc
	8	—	—	9,10,11	—	—	—	—	14	—	—	—	7	V_{OL}(8)	—	0.40	—	0.40	—	0.45	Vdc
	12	—	—	1,2,13	—	—	—	—	14	—	—	—	7	V_{OL}(12)	—	0.40	—	0.40	—	0.45	Vdc
	—	6	3	—	—	—	—	—	14	—	—	—	7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	—	14	—	—	—	7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	—	14	—	—	—	7	V_{OH}(6)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	9	—	—	—	—	—	14	—	—	—	7	V_{OH}(8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	—	14	—	—	—	7	V_{OH}(8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	11	—	—	—	—	—	14	—	—	—	7	V_{OH}(8)	2.50	—	2.60	—	2.50	—	Vdc
	—	12	13	—	—	—	—	—	14	—	—	—	7	V_{OH}(12)	2.50	—	2.60	—	2.50	—	Vdc
	—	12	1	—	—	—	—	—	14	—	—	—	7	V_{OH}(12)	2.50	—	2.60	—	2.50	—	Vdc
	—	12	2	—	—	—	—	—	14	—	—	—	7	V_{OH}(12)	2.50	—	2.60	—	2.50	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	—	14	—	—	3,6,7	I_{SC}(6)	—	−1.34	—	−1.34	—	−1.30	mAdc
	—	—	—	—	—	—	—	—	—	14	—	—	7,8,9	I_{SC}(8)	—	−1.34	—	−1.34	—	−1.30	mAdc
	—	—	—	—	—	—	—	—	—	14	—	—	7,12,13	I_{SC}(12)	—	−1.34	—	−1.34	—	−1.30	mAdc
Reverse Current	—	—	—	—	—	1	—	—	—	14	—	—	2,7,13	I_R(1)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	2	—	—	—	14	—	—	1,7,13	I_R(2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	3	—	—	—	14	—	—	4,5,7	I_R(3)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	4	—	—	—	14	—	—	3,5,7	I_R(4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	—	14	—	—	3,4,7	I_R(5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	9	—	—	—	14	—	—	7,10,11	I_R(9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	10	—	—	—	14	—	—	7,9,11	I_R(10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	11	—	—	—	14	—	—	7,9,10	I_R(11)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	13	—	—	—	14	—	—	1,2,7	I_R(13)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	—	—	—	—	6,14	—	—	—	—	—	3,7	I_{CEX}(6)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	8,14	—	—	—	—	—	7,9	I_{CEX}(8)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	12,14	—	—	—	—	—	7,13	I_{CEX}(12)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	1	2,13	—	—	—	14	—	—	7	I_F(1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	2	1,13	—	—	—	14	—	—	7	I_F(2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	3	4,5	—	—	—	14	—	—	7	I_F(3)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	4	3,5	—	—	—	14	—	—	7	I_F(4)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	5	3,4	—	—	—	14	—	—	7	I_F(5)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	9	10,11	—	—	—	14	—	—	7	I_F(9)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	10	9,11	—	—	—	14	—	—	7	I_F(10)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	11	9,10	—	—	—	14	—	—	7	I_F(11)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	13	1,2	—	—	—	14	—	—	7	I_F(13)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH}(14)	—	—	—	9.75	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	—	14	3,7,9,13	I_{max}(14)	—	—	—	8.25	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																			
	5	0	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	0	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}-$	—	—	10	30	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

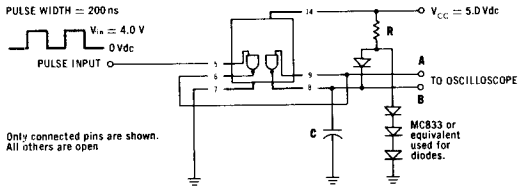
LOGIC GATES

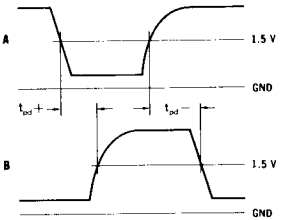
MC962F
MC862F

TRIPLE 3-INPUT
"NAND/NOR" GATES

This gate element consists of three 3-input "NAND/NOR" gate circuits.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





TEST	R	C
$t_{pd}+$	3.9 kohms	30 pF
$t_{pd}-$	400 ohms	50 pF

ELECTRICAL CHARACTERISTICS — MC862F

	Test Conditions									
	mA		Volts							
@ Test Temperature 0°C	12.0	−0.12	1.20	2.00	0.45	4.00	—	5.00	—	—
@ Test Temperature +25°C	12.8	−0.12	1.10	1.90	0.45	4.00	5.00	5.00	5.00	8.80
@ Test Temperature +75°C	11.4	−0.12	0.95	1.00	0.58	4.00	—	5.00	—	—

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	6	—	—	3,4,5	—	—	—	14	—	—	7	V_{OL}(6)	—	0.45	—	0.45	—	0.50	Vdc
	8	—	—	9,10,11	—	—	—	14	—	—	7	V_{OL}(8)	—	0.45	—	0.45	—	0.50	Vdc
	12	—	—	1,2,13	—	—	—	14	—	—	7	V_{OL}(12)	—	0.45	—	0.45	—	0.50	Vdc
	—	6	3	—	—	—	—	14	—	—	7	V_{OH}(6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	14	—	—	7	V_{OH}(6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	14	—	—	7	V_{OH}(6)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	9	—	—	—	—	14	—	—	7	V_{OH}(8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	14	—	—	7	V_{OH}(8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	11	—	—	—	—	14	—	—	7	V_{OH}(8)	2.60	—	2.60	—	2.50	—	Vdc
	—	12	13	—	—	—	—	14	—	—	7	V_{OH}(12)	2.60	—	2.60	—	2.50	—	Vdc
	—	12	1	—	—	—	—	14	—	—	7	V_{OH}(12)	2.60	—	2.60	—	2.50	—	Vdc
	—	12	2	—	—	—	—	14	—	—	7	V_{OH}(12)	2.60	—	2.60	—	2.50	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	14	—	—	3, 6, 7	I_{SC}(6)	—	−1.30	—	−1.30	—	−1.25	mAdc
	—	—	—	—	—	—	—	14	—	—	7, 8, 9	I_{SC}(8)	—	−1.30	—	−1.30	—	−1.25	mAdc
	—	—	—	—	—	—	—	14	—	—	7, 12, 13	I_{SC}(12)	—	−1.30	—	−1.30	—	−1.25	mAdc
Reverse Current	—	—	—	—	—	1	—	14	—	—	2, 7, 13	I_R(1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	2	—	14	—	—	1, 7, 13	I_R(2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	3	—	14	—	—	4, 5, 7	I_R(3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	4	—	14	—	—	3, 5, 7	I_R(4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	5	—	14	—	—	3, 4, 7	I_R(5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	9	—	14	—	—	7, 10, 11	I_R(9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	10	—	14	—	—	7, 9, 11	I_R(10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	11	—	14	—	—	7, 9, 10	I_R(11)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	13	—	14	—	—	1, 2, 7	I_R(13)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	6, 14	—	—	—	3, 7	I_{CEX}(6)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	8, 14	—	—	—	7, 9	I_{CEX}(8)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	12, 14	—	—	—	7, 13	I_{CEX}(12)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	1	2, 13	—	14	—	—	7	I_F(1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	2	1, 13	—	14	—	—	7	I_F(2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	3	4, 5	—	14	—	—	7	I_F(3)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	4	3, 5	—	14	—	—	7	I_F(4)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	5	3, 4	—	14	—	—	7	I_F(5)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	9	10, 11	—	14	—	—	7	I_F(9)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	10	9, 11	—	14	—	—	7	I_F(10)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	11	9, 10	—	14	—	—	7	I_F(11)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	13	1, 2	—	14	—	—	7	I_F(13)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	14	—	7	I_{PDH}(14)	—	—	—	12	—	—	mAdc
	—	—	—	—	—	—	—	—	—	14	3, 7, 9, 13	I_{max}(14)	—	—	—	12	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																	
	5	8	—	—	—	—	—	14	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	8	—	—	—	—	—	14	—	—	7	$t_{pd}-$	—	—	10	30	—	—	ns

Pins not listed are left open

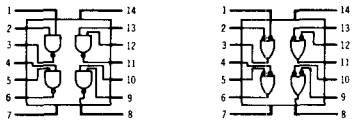
MC930/MC830 (continued)

LOGIC GATES

MC946F
MC846F

QUAD 2-INPUT
"NAND/NOR" GATES

CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$3 = \overline{1 \cdot 2}$

$6 = \overline{4 \cdot 5}$

$8 = \overline{9 \cdot 10}$

$11 = \overline{12 \cdot 13}$

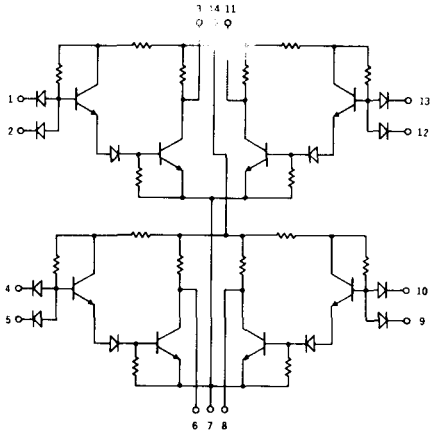
NEGATIVE LOGIC

$3 = \overline{1 + 2}$

$6 = \overline{4 + 5}$

$8 = \overline{9 + 10}$

$11 = \overline{12 + 13}$



ELECTRICAL CHARACTERISTICS — MC946F

	Test Conditions													
	mA		Volts											
@ Test Temperature −55°C	11.4	−8.12	1.48	2.18	0	4.08	—	—	4.50	5.50	—	—		
@ Test Temperature +25°C	12.0	−8.12	1.18	2.00	0	4.00	4.50	5.00	4.50	5.50	5.00	8.88		
@ Test Temperature +125°C	10.8	−0.12	0.80	2.00	0	4.00	—	—	4.38	5.58	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{FD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits −55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	3	—	—	1,2	—	—	—	—	14	—	—	—	7	V_{OL} (3)	—	0.40	—	0.40	—	0.45	Vdc
	6	—	—	4,5	—	—	—	—	14	—	—	—	7	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	8	—	—	9,10	—	—	—	—	14	—	—	—	7	V_{OL} (8)	—	0.40	—	0.40	—	0.45	Vdc
	11	—	—	12,13	—	—	—	—	14	—	—	—	7	V_{OL} (11)	—	0.40	—	0.40	—	0.45	Vdc
	—	3	1	—	—	—	—	—	14	—	—	—	7	V_{OH} (3)	2.50	—	2.60	—	2.50	—	Vdc
	—	3	2	—	—	—	—	—	14	—	—	—	7	V_{OH} (3)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	9	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	11	12	—	—	—	—	—	14	—	—	—	7	V_{OH} (11)	2.50	—	2.60	—	2.50	—	Vdc
	—	11	13	—	—	—	—	—	14	—	—	—	7	V_{OH} (11)	2.50	—	2.60	—	2.50	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	—	14	—	—	1,3,7	I_{SC} (3)	—	−1.34	—	−1.34	—	−1.30	mAdc
	—	—	—	—	—	—	—	—	—	14	—	—	4,6,7	I_{SC} (6)	—	−1.34	—	−1.34	—	−1.30	mAdc
	—	—	—	—	—	—	—	—	—	14	—	—	7,8,9	I_{SC} (8)	—	−1.34	—	−1.34	—	−1.38	mAdc
	—	—	—	—	—	—	—	—	—	14	—	—	7,11,12	I_{SC} (11)	—	−1.34	—	−1.34	—	−1.30	mAdc
Reverse Current	—	—	—	—	—	1	—	—	—	14	—	—	2,7	I_R (1)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	2	—	—	—	14	—	—	1,7	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	4	—	—	—	14	—	—	5,7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	5	—	—	—	14	—	—	4,7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	9	—	—	—	14	—	—	7,10	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	10	—	—	—	14	—	—	7,9	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	12	—	—	—	14	—	—	7,13	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	13	—	—	—	14	—	—	7,12	I_R (13)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	—	—	—	—	3,14	—	—	—	—	—	1,7	I_{CEX} (3)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	6,14	—	—	—	—	—	4,7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	8,14	—	—	—	—	—	7,9	I_{CEX} (8)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	11,14	—	—	—	—	—	7,12	I_{CEX} (11)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	3	2	—	—	—	14	—	—	7	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	2	1	—	—	—	14	—	—	7	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	4	5	—	—	—	14	—	—	7	I_F (4)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	5	4	—	—	—	14	—	—	7	I_F (5)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	9	10	—	—	—	14	—	—	7	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	10	9	—	—	—	14	—	—	7	I_F (10)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	12	13	—	—	—	14	—	—	7	I_F (12)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	13	12	—	—	—	14	—	—	7	I_F (13)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	14	—	7	I_{max} (14)	—	—	—	33	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	—	34	1,4,7,9,12	I_{max} (14)	—	—	—	11	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																			
	5	8	—	—	—	—	—	—	14	—	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	8	—	—	—	—	—	—	14	—	—	—	7	$t_{pd}-$	—	—	10	30	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

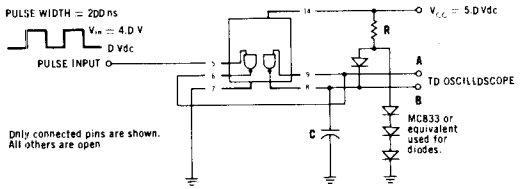
LOGIC GATES

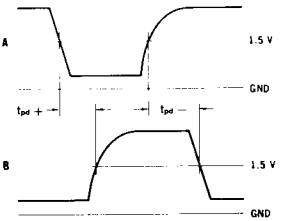
MC946F
MC846F

QUAD 2-INPUT
"NAND/NOR" GATES

This gate device consists of four 2-input "NAND/NOR" logic gate circuits. This element may be used as four inverter circuits, or as two bistable circuits by cross-coupling two dual 2-input gates. Among other applications, this device can be used as a dual 2-input non-inverting gate.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





TEST	R	C
$t_{pd}+$	3.9 kohms	30 pF
$t_{pd}-$	400 ohms	50 pF

ELECTRICAL CHARACTERISTICS — MC846F

		Test Conditions									
		mA		Volts							
@ Test Temperature	0°C	12.0	-0.12	1.20	2.00	0.45	4.00	—	5.00	—	—
	+25°C	12.0	-0.12	1.10	1.90	0.45	4.00	5.00	5.00	5.00	8.00
	+75°C	11.4	-0.12	0.95	1.00	0.50	4.00	—	5.00	—	—

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	3	—	—	1,2	—	—	—	14	—	—	7	V_{OL} (3)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	4,5	—	—	—	14	—	—	7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	8	—	—	9,10	—	—	—	14	—	—	7	V_{OL} (8)	—	0.45	—	0.45	—	0.50	Vdc
	11	—	—	12,13	—	—	—	14	—	—	7	V_{OL} (11)	—	0.45	—	0.45	—	0.50	Vdc
	—	3	1	—	—	—	—	14	—	—	7	V_{OH} (3)	2.60	—	2.60	—	2.50	—	Vdc
	—	3	2	—	—	—	—	14	—	—	7	V_{OH} (3)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	9	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	11	12	—	—	—	—	14	—	—	7	V_{OH} (11)	2.60	—	2.60	—	2.50	—	Vdc
	—	11	13	—	—	—	—	14	—	—	7	V_{OH} (11)	2.60	—	2.60	—	2.50	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	14	—	—	1,3,7	I_{SC} (3)	—	-1.30	—	-1.30	—	-1.25	mAdc
	—	—	—	—	—	—	—	14	—	—	4,6,7	I_{SC} (6)	—	-1.30	—	-1.30	—	-1.25	mAdc
	—	—	—	—	—	—	—	14	—	—	7,9,9	I_{SC} (8)	—	-1.30	—	-1.30	—	-1.25	mAdc
	—	—	—	—	—	—	—	14	—	—	7,11,12	I_{SC} (11)	—	-1.30	—	-1.30	—	-1.25	mAdc
Reverse Current	—	—	—	—	—	1	—	14	—	—	2,7	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	2	—	14	—	—	1,7	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	4	—	14	—	—	5,7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	5	—	14	—	—	4,7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	9	—	14	—	—	7,10	I_R (9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	10	—	14	—	—	7,9	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	12	—	14	—	—	7,13	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	13	—	14	—	—	7,12	I_R (13)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	3,14	—	—	—	1,7	I_{CEX} (3)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	6,14	—	—	—	4,7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	8,14	—	—	—	7,9	I_{CEX} (8)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	11,14	—	—	—	7,12	I_{CEX} (11)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	1	2	—	14	—	—	7	I_F (1)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	2	1	—	14	—	—	7	I_F (2)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	4	5	—	14	—	—	7	I_F (4)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	5	4	—	14	—	—	7	I_F (5)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	9	10	—	14	—	—	7	I_F (9)	—	-1.48	—	-1.40	—	-1.33	mAdc
	—	—	—	—	10	9	—	14	—	—	7	I_F (10)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	12	13	—	14	—	—	7	I_F (12)	—	-1.40	—	-1.40	—	-1.33	mAdc
	—	—	—	—	13	12	—	14	—	—	7	I_F (13)	—	-1.40	—	-1.48	—	-1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	t4	—	7	I_{PDH} (14)	—	—	—	16	—	—	mAdc
	—	—	—	—	—	—	—	—	—	t4	1,4,7,9,12	I_{PDL} (14)	—	—	—	16	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In 5	Pulse Out 8	—	—	—	—	—	14	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	8	—	—	—	—	—	14	—	—	7	$t_{pd}-$	—	—	10	38	—	—	ns

Pins not listed are left open

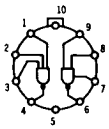
MC930/MC830 (continued)

BUFFERS

MC932G
MC832G

DUAL 2-3 INPUT BUFFERS

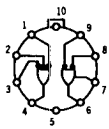
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$4 = \overline{1 \cdot 2 \cdot 3}$

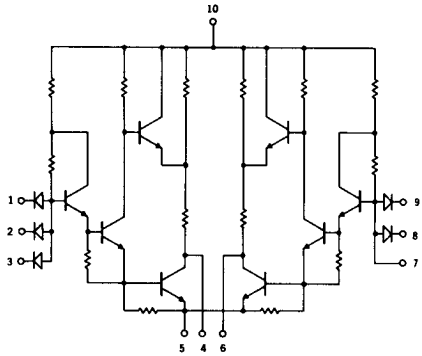
$6 = \overline{8 \cdot 9 \cdot (7)}$



NEGATIVE LOGIC

$4 = \overline{1 + 2 + 3}$

$6 = \overline{8 + 9 + (7)}$



ELECTRICAL CHARACTERISTICS — MC932G

		Test Conditions																							
		mA		Volts																					
@ Test Temperature	−55°C	34.0	−2.00	1.40	2.10	—	0	4.00	—	—	4.50	5.50	—	—											
	+25°C	36.0	−2.50	1.10	2.00	1.80	0	4.00	4.50	5.00	4.50	5.50	5.00	8.00											
	+125°C	32.0	−4.00	0.80	2.00	—	0	4.00	—	—	4.50	5.50	—	—											
Characteristic		I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_{X} Pin No	V_{F} Pin No	V_{R} Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{YD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	−55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage		4	—	—	1, 2, 3	—	—	—	—	—	10	—	—	—	5	V_{OL} (4)	—	0.40	—	0.40	—	0.45	Vdc
		6	—	—	8, 9	—	—	—	—	—	10	—	—	—	5	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
		—	4	1	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
		—	4	2	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
		—	4	3	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (4)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	8	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	9	—	—	—	—	—	—	10	—	—	—	5	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
		—	6	—	—	7	—	—	—	—	10	—	—	—	5	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current		—	—	—	—	—	—	—	—	—	—	10	—	—	1, 4, 5	I_{SC} (4)	−16	—	−18	—	−16	—	mAdc
		—	—	—	—	—	—	—	—	—	—	10	—	—	5, 6, 8	I_{SC} (6)	−16	—	−18	—	−16	—	mAdc
Reverse Current		—	—	—	—	—	—	1	—	—	—	10	—	—	2, 3, 5	I_R (1)	—	2.0	—	2.0	—	5.0	μAdc
		—	—	—	—	—	—	2	—	—	—	10	—	—	1, 3, 5	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
		—	—	—	—	—	—	3	—	—	—	10	—	—	1, 2, 5	I_R (3)	—	2.0	—	2.0	—	5.0	μAdc
		—	—	—	—	—	—	8	—	—	—	10	—	—	5, 9	I_R (8)	—	2.0	—	2.0	—	5.0	μAdc
		—	—	—	—	—	—	9	—	—	—	10	—	—	5, 8	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current		—	—	—	—	—	—	—	4, 10	—	—	—	—	—	1, 5	I_{CEX} (4)	—	—	—	50	—	—	μAdc
		—	—	—	—	—	—	—	6, 10	—	—	—	—	—	5, 8	I_{CEX} (6)	—	—	—	50	—	—	μAdc
Forward Current		—	—	—	—	—	1	2, 3	—	—	—	10	—	—	5	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	2	1, 3	—	—	—	10	—	—	5	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	3	1, 2	—	—	—	10	—	—	5	I_F (3)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	8	9	—	—	—	10	—	—	5	I_F (8)	—	−1.60	—	−1.60	—	−1.50	mAdc
		—	—	—	—	—	9	8	—	—	—	10	—	—	5	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
Power Drain Current		—	—	—	—	—	—	—	—	—	—	—	10	—	5	I_{DR} (10)	—	—	—	26.6	—	—	mAdc
		—	—	—	—	—	—	—	—	—	—	—	—	10	1, 5, 8	I_{DR} (10)	—	—	—	6.0	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse In	Pulse Out																							
	3	6	—	—	—	—	—	—	10	—	—	—	—	5		$t_{pd}+$	—	—	25	80	—	—	ns
	3	6	—	—	—	—	—	—	10	—	—	—	—	5		$t_{pd}-$	—	—	15	40	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

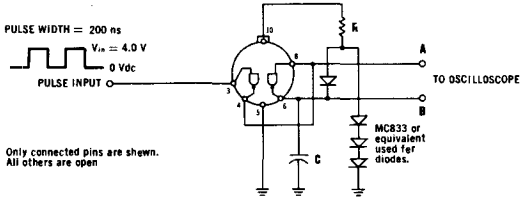
BUFFERS

MC932G
MC832G

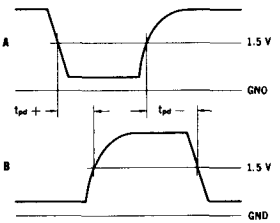
DUAL 2-3 INPUT BUFFERS

The dual buffer consists of one 2-input and one 3-input inverting driver designed especially for large capacitive loads at high speeds. An output emitter-follower in series with a 150-ohm resistor drives the output to the high voltage level. A low saturation resistance transitor is turned on, pulling the output down to the low voltage level and providing rapid discharge of capacitive loads.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS



TEST	R	C
$t_{pd}+$	510 ohms	500 pF
$t_{pd}-$	150 ohms	500 pF



ELECTRICAL CHARACTERISTICS — MC832G

	Test Conditions												
	mA		Volts										
@ Test Temperature 0°C	36.0	−2.00	1.28	2.88	—	0.45	4.00	—	5.00	—	—		
@ Test Temperature +25°C	36.0	−2.50	1.18	1.90	1.80	0.45	4.00	5.00	5.00	5.00	8.00		
@ Test Temperature +75°C	34.0	−3.00	0.95	1.80	—	0.50	4.00	—	5.00	—	—		

Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_Y Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{ID} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Test Limits 0°C Min	0°C Max	+25°C Min	+25°C Max	+75°C Min	+75°C Max	Unit
Output Voltage	4	—	—	1, 2, 3	—	—	—	—	10	—	—	5	V_{OL} (4)	—	0.45	—	0.45	—	0.50	Vdc
	6	—	—	8, 9	—	—	—	—	10	—	—	5	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	—	4	1	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	2	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	4	3	—	—	—	—	—	10	—	—	5	V_{OH} (4)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	0	—	—	—	—	—	10	—	—	5	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	9	—	—	—	—	—	10	—	—	5	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	—	—	7	—	—	—	10	—	—	5	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	10	—	—	1, 4, 5	I_{SC} (4)	−15	—	−16	—	−14	—	mAdc
	—	—	—	—	—	—	—	—	10	—	—	5, 6, 8	I_{SC} (6)	−15	—	−16	—	−14	—	mAdc
Reverse Current	—	—	—	—	—	—	1	—	10	—	—	2, 3, 5	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	10	—	—	1, 3, 5	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	3	—	10	—	—	1, 2, 5	I_R (3)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	0	—	10	—	—	5, 9	I_R (8)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	10	—	—	5, 8	I_R (9)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	—	4, 10	—	—	—	1, 5	I_{CEX} (4)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	—	6, 10	—	—	—	5, 0	I_{CEX} (6)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 3	—	10	—	—	5	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1, 3	—	10	—	—	5	I_F (2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	3	1, 2	—	10	—	—	5	I_F (3)	—	−1.40	—	−1.48	—	−1.33	mAdc
	—	—	—	—	—	8	9	—	10	—	—	5	I_F (8)	—	−1.48	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	8	—	10	—	—	5	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	10	—	5	I_{PDH} (10)	—	—	—	30	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	10	1, 5, 6	I_{max} (10)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 4 connected to Pin 8)	Pulse In	Pulse Out																		
	3	6	—	—	—	—	—	—	18	—	—	5	$t_{pd}+$	—	—	25	80	—	—	ns
	3	6	—	—	—	—	—	—	10	—	—	5	$t_{pd}-$	—	—	15	40	—	—	ns

Pins not listed are left open

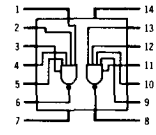
MC930/MC830 (continued)

BUFFERS

MC932F
MC832F

DUAL 4-INPUT BUFFERS

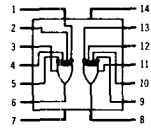
CIRCUIT DIAGRAM AND LOGIC SYMBOLS



POSITIVE LOGIC

$6 = \overline{1 \cdot 2 \cdot 4 \cdot 5 \cdot (3)}$

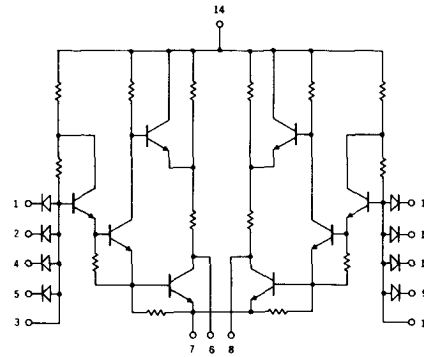
$8 = \overline{9 \cdot 10 \cdot 12 \cdot 13 \cdot (11)}$



NEGATIVE LOGIC

$6 = \overline{1 + 2 + 4 + 5 + (3)}$

$8 = \overline{9 + 10 + 12 + 13 + (11)}$



ELECTRICAL CHARACTERISTICS — MC932F

		Test Conditions																						
		mA		Volts																				
@ Test Temperature	−55°C	34.0	−2.80	1.40	2.10	—	0	4.00	—	—	4.50	5.50	—	—										
	+25°C	36.0	−2.50	1.10	2.00	1.80	0	4.00	4.50	5.00	4.50	5.50	5.00	8.00										
	+125°C	32.0	−4.00	8.80	2.00	—	0	4.00	—	—	4.50	5.50	—	—										
Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{CCL} Pin No	V_{CCH} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	−55°C Min	−55°C Max	+25°C Min	+25°C Max	+125°C Min	+125°C Max	Unit
Output Voltage	6	—	—	1, 2, 4, 5	—	—	—	—	—	14	—	—	—	7	V_{OL} (6)	—	0.40	—	0.40	—	0.45	Vdc
	8	—	—	9, 10, 12, 13	—	—	—	—	—	14	—	—	—	7	V_{OL} (8)	—	0.40	—	0.40	—	0.45	Vdc
	—	6	1	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	2	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (6)	2.50	—	2.60	—	2.50	—	Vdc
	—	6	—	—	3	—	—	—	—	14	—	—	—	7	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
	—	8	9	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	12	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	13	—	—	—	—	—	—	14	—	—	—	7	V_{OH} (8)	2.50	—	2.60	—	2.50	—	Vdc
	—	8	—	—	11	—	—	—	—	14	—	—	—	7	V_{OH} (0)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	—	—	14	—	—	1, 6, 7	I_{SC} (6)	−16	—	−18	—	−16	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	—	—	7, 0, 9	I_{SC} (8)	−16	—	−18	—	−16	—	mAdc
Reverse Current	—	—	—	—	—	—	1	—	—	—	14	—	—	2, 4, 5, 7	I_R (1)	—	2.0	—	2.0	—	5.8	μAdc
	—	—	—	—	—	—	2	—	—	—	14	—	—	1, 4, 5, 7	I_R (2)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	4	—	—	—	14	—	—	1, 2, 5, 7	I_R (4)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	5	—	—	—	14	—	—	1, 2, 4, 7	I_R (5)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	9	—	—	—	14	—	—	7, 10, 12, 13	I_R (9)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	10	—	—	—	14	—	—	7, 9, 12, 13	I_R (10)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	12	—	—	—	14	—	—	7, 9, 10, 13	I_R (12)	—	2.0	—	2.0	—	5.0	μAdc
	—	—	—	—	—	—	13	—	—	—	14	—	—	7, 9, 10, 12	I_R (13)	—	2.0	—	2.0	—	5.0	μAdc
Output Leakage Current	—	—	—	—	—	—	—	6, 14	—	—	—	—	—	1, 7	I_{CEX} (6)	—	—	—	50	—	—	μAdc
	—	—	—	—	—	—	—	8, 14	—	—	—	—	—	7, 9	I_{CEX} (8)	—	—	—	50	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 4, 5	—	—	—	14	—	—	7	I_F (1)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	2	1, 4, 5	—	—	—	14	—	—	7	I_F (2)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	4	1, 2, 5	—	—	—	14	—	—	7	I_F (4)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	5	1, 2, 4	—	—	—	14	—	—	7	I_F (5)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	9	10, 12, 13	—	—	—	14	—	—	7	I_F (9)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	10	9, 12, 13	—	—	—	14	—	—	7	I_F (10)	—	−1.60	—	−1.60	—	−1.50	mAdc
	—	—	—	—	—	12	9, 10, 13	—	—	—	14	—	—	7	I_F (12)	—	−1.60	—	−1.68	—	−1.50	mAdc
	—	—	—	—	—	13	9, 10, 12	—	—	—	14	—	—	7	I_F (13)	—	−1.60	—	−1.68	—	−1.50	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	26.6	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	—	—	14	1, 7, 9	I_{PDL} (14)	—	—	—	6.0	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																				
	5	8	—	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	8	—	—	—	—	—	—	14	—	—	—	—	7	$t_{pd}-$	—	—	15	40	—	—	ns

Pins not listed are left open

MC930/MC830 (continued)

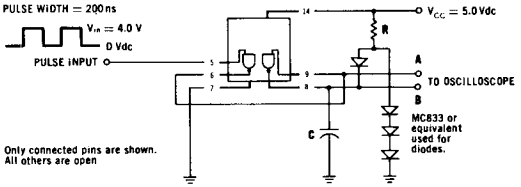
BUFFERS

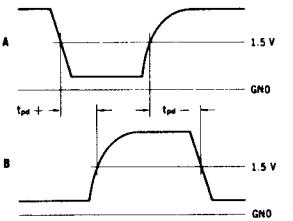
MC932F
MC832F

DUAL 4-INPUT BUFFERS

The dual buffer consists of two 4-input inverting drivers designed especially for driving large capacitive loads at high speeds. An output emitter-follower in series with a 150-ohm resistor drives the output to the high voltage level. A low saturation resistance transistor is turned on, pulling the output down to the low voltage level, and providing rapid discharge of capacitive loads.

SWITCHING TIME TEST CIRCUIT AND WAVEFORMS





TEST	R	C
$t_{pd}+$	510 ohms	500 pF
$t_{pd}-$	150 ohms	500 pF

ELECTRICAL CHARACTERISTICS — MC832F

	Test Conditions													Test Limits						
	mA		Volts											0°C		+25°C		+75°C		
@ Test Temperature 0°C	38.0	−2.00	1.20	2.00	—	0.45	4.00	—	5.00	—	—									
@ Test Temperature +25°C	30.0	−2.50	1.10	1.90	1.80	0.45	4.00	5.00	5.00	5.00	5.00									
@ Test Temperature +75°C	34.0	−3.00	0.95	1.80	—	0.50	4.00	—	5.00	—	—									
Characteristic	I_{OL} Pin No	I_{OH} Pin No	V_{IL} Pin No	V_{IH} Pin No	V_X Pin No	V_F Pin No	V_R Pin No	V_{CEX} Pin No	V_{CC} Pin No	V_{PD} Pin No	V_{max} Pin No	Grounded Pin No	Symbol Pin No in ( )	Min	Max	Min	Max	Min	Max	Unit
Output Voltage	6	—	—	1, 2, 4, 5	—	—	—	—	14	—	—	7	V_{OL} (6)	—	0.45	—	0.45	—	0.50	Vdc
	X	—	—	9, 10, 12, 13	—	—	—	—	14	—	—	7	V_{OL} (8)	—	0.45	—	0.45	—	0.50	Vdc
	—	6	1	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	2	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	4	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	5	—	—	—	—	—	14	—	—	7	V_{OH} (6)	2.60	—	2.60	—	2.50	—	Vdc
	—	6	—	—	3	—	—	—	14	—	—	7	V_{OH} (6)	—	—	2.60	—	—	—	Vdc
	—	X	9	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	10	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	12	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	13	—	—	—	—	—	14	—	—	7	V_{OH} (8)	2.60	—	2.60	—	2.50	—	Vdc
	—	8	—	—	11	—	—	—	14	—	—	7	V_{OH} (8)	—	—	2.60	—	—	—	Vdc
Short-Circuit Current	—	—	—	—	—	—	—	—	14	—	—	1, 6, 7	I_{SC} (6)	−15	—	−16	—	−14	—	mAdc
	—	—	—	—	—	—	—	—	14	—	—	7, 8, 9	I_{SC} (8)	−15	—	−16	—	−14	—	mAdc
Reverse Current	—	—	—	—	—	—	1	—	14	—	—	2, 4, 5, 7	I_R (1)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	2	—	14	—	—	1, 4, 5, 7	I_R (2)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	4	—	14	—	—	1, 2, 5, 7	I_R (4)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	5	—	14	—	—	1, 2, 4, 7	I_R (5)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	9	—	14	—	—	7, 10, 12, 13	I_R (9)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	10	—	14	—	—	7, 9, 12, 13	I_R (10)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	12	—	14	—	—	7, 9, 10, 13	I_R (12)	—	5.0	—	5.0	—	10	μAdc
	—	—	—	—	—	—	13	—	14	—	—	7, 9, 10, 12	I_R (13)	—	5.0	—	5.0	—	10	μAdc
Output Leakage Current	—	—	—	—	—	—	—	6, 14	—	—	—	1, 7	I_{CEX} (6)	—	—	—	100	—	—	μAdc
	—	—	—	—	—	—	—	8, 14	—	—	—	7, 9	I_{CEX} (8)	—	—	—	100	—	—	μAdc
Forward Current	—	—	—	—	—	1	2, 4, 5	—	14	—	—	7	I_F (1)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	2	1, 4, 5	—	14	—	—	7	I_F (2)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	4	1, 2, 5	—	14	—	—	7	I_F (4)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	5	1, 2, 4	—	14	—	—	7	I_F (5)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	9	10, 12, 13	—	14	—	—	7	I_F (9)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	10	9, 12, 13	—	14	—	—	7	I_F (10)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	12	9, 10, 13	—	14	—	—	7	I_F (12)	—	−1.40	—	−1.40	—	−1.33	mAdc
	—	—	—	—	—	13	9, 10, 12	—	14	—	—	7	I_F (13)	—	−1.40	—	−1.40	—	−1.33	mAdc
Power Drain Current	—	—	—	—	—	—	—	—	—	14	—	7	I_{PDH} (14)	—	—	—	30	—	—	mAdc
	—	—	—	—	—	—	—	—	—	—	14	1, 7, 9	I_{max} (14)	—	—	—	8.0	—	—	mAdc
Switching Time (Pin 6 connected to Pin 9)	Pulse In	Pulse Out																		
	5	X	—	—	—	—	—	—	14	—	—	7	$t_{pd}+$	—	—	25	80	—	—	ns
	5	8	—	—	—	—	—	—	14	—	—	7	$t_{pd}-$	—	—	15	40	—	—	ns

Pins not listed are left open

MC1050F
MC1051F
MC1052F

MCML

MC1050F Dual-4 Input Gate

The MC1050F is a monolithic Integrated Circuit Current Mode Logic Dual 4 Input Gate element. This gate element provides the positive logic "OR/NOR" function. A bias driver is "built-in" to the circuit, eliminating the necessity for any external biasing.

MC1051F Dual-4 Input Gate with "Wired-Or" Capability

The MC1051F is a monolithic Integrated Circuit, Current Mode Logic, Dual 4 Input Gate element, with the capability of operation in the "Wired-OR" condiguration. This gate element provides the positive logic "OR/NOR" function. A bias driver is "built-in" to the circuit, eliminating the necessity for any external biasing.

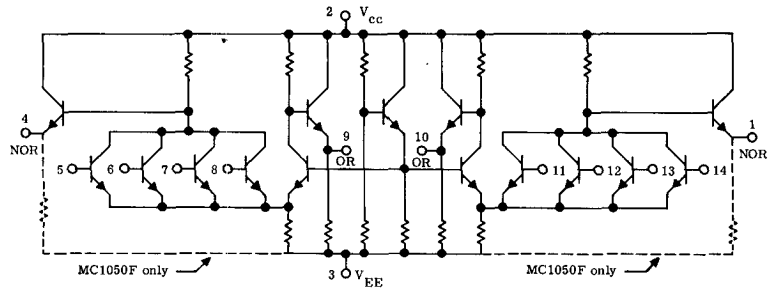
MC1052F Single-8 Input Gate

The MC1052F is a monolithic Integrated Circuit, Current Mode Logic, Single 8 Input Gate element. This gate element provides the positive logic "OR/NOR" function. A bias driver is "built-in" to the circuit, eliminating the necessity for any external biasing.

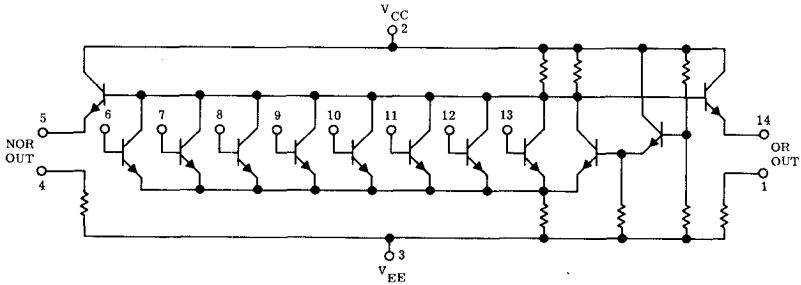
MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Logic input voltage (Pins 5, 6, 7, 8, 11, 12, 13 & 14)	—	5	Volts
Power Supply Voltage	—	10	Volts
Operating Temperature Range	T_A	0 to 70	°C
Storage Temperature Range	T_{stg}	-65 to 150	°C

FIGURE 1 — CIRCUIT SCHEMATICS



MC1050F, MC1051F



MC1052F

MC1050F, MC1051F, MC1052F (continued)

ELECTRICAL CHARACTERISTICS: $V_{CC} = 0$, $V_{EE} = -5.2$ Vdc, $T_A = 25°C$ unless otherwise noted
Unused inputs connected to V_{EE}.
MC1051F — Pins 1 and 4 connected to V_{EE} thru external 500-ohm resistor.
MC1052F — Connect pin 4 to pin 5 and pin 1 to pin 14 for all tests.

Characteristic	Symbol	Min	Max	Unit
DC CHARACTERISTICS				
"NOR" Logical "1" Output Voltage (Figure 1) (V_{in} = -1.35 Vdc each input)	V_1	-0.650	-0.825	Vdc
"NOR" Logical "0" Output Voltage (Figure 1) (V_{in} = -1.000 Vdc each input)	V_4	-1.530	-1.800	Vdc
"NOR" Saturation Breakpoint Voltage (Figure 1) (dv "NOR"/dV_{in} = 0)	V_3	—	-0.60	Vdc
"OR" Logical "1" Output Voltage (Figure 1) (V_{in} = -1000 Vdc each input)	V_5	-0.650	-0.825	Vdc
"OR" Logical "0" Output Voltage (Figure 1) (V_{in} = -1.35 Vdc each input)	V_2	-1.530	-1.800	Vdc
		Typ	Max	
Total Unit Power Supply Current Drain MC1050F MC1051F (Disconnect external 500-ohm resistor) MC1052F (Remove connections to pins 5 and 14)	I_E	 45 35 25	 60 50 35	mAdc
Input Current (V_1 = -0.800 Vdc each input)	I_{in}	—	200	μAdc
Fan-Out	n	—	10	—

SWITCHING CHARACTERISTICS: V_H = -0.740 Vdc, V_L = -1.630 Vdc, Fan-In = 1 (Figure 2)

Propagation Delay Time - Fan-Out = 1 "NOR" Output "OR" Output "NOR" Output "OR" Output	 t_{d1} t_{d1} t_{d2} t_{d2}	 — — — —	 **4.0** 5.0 5.0 4.0	ns
Rise Time - Fan-Out = 1	t_r	—	5.0	ns
Fall Time - Fan-Out = 1	t_f	—	4.0	ns

FIGURE 2 —
TRANSFER CHARACTERISTICS and METHOD OF TEST

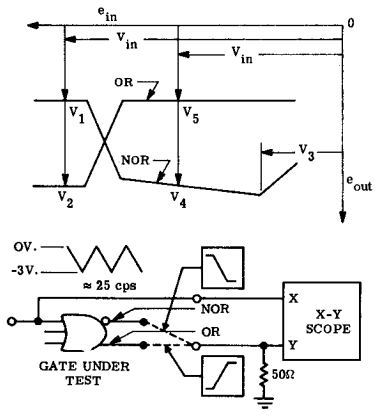
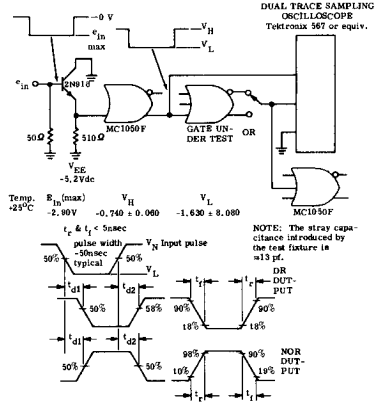


FIGURE 3 —
SWITCHING TEST CIRCUIT and WAVEFORMS



ADDITIONS AND MODIFICATIONS

LINEAR CIRCUITS

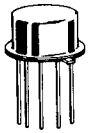
Linear Integrated Circuits

MC1110	Emitter-Coupled Amplifier
MC1519	Wideband Differential Amplifier
MC1524	1 W Power Amplifier
MC1530	Operational Amplifier
MC1531	Operational Amplifier — Darlington Input

MC1110

LINEAR CIRCUIT SERIES

G_T = 22 db @ 100 Mc
NF = 6 db @ 100 Mc

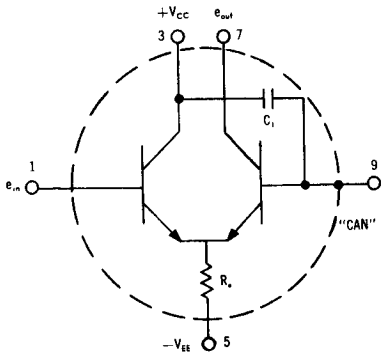


CASE 89

Emitter-coupled, integrated circuit linear amplifier for IF and RF applications. Frequency range is DC to 300 MC.

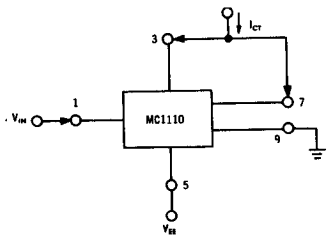
MAXIMUM RATINGS (at 25°C ambient)

Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	10	Vdc
Power Supply Voltage	V_{EE}	14	Vdc
Total Power Dissipation (Derate 5 mW/°C above T_A = 25°C)	P_D	0.5	Watt
Operating Temperature Range	T_j	-55 to+125	°C
Storage Temperature Range	T_{stg}	-65 to+200	°C
Maximum Input Level (RMS)	V_{in}	2	V (RMS)

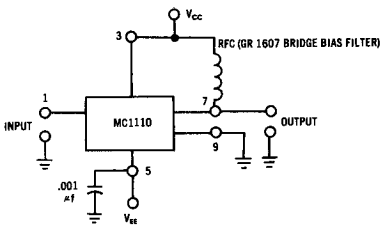


CIRCUIT SCHEMATIC

DC CHARACTERISTICS TEST CIRCUIT



SHORT CIRCUIT ADMITTANCE TEST CIRCUIT
(GENERAL RADIO 1607 A BRIDGE)



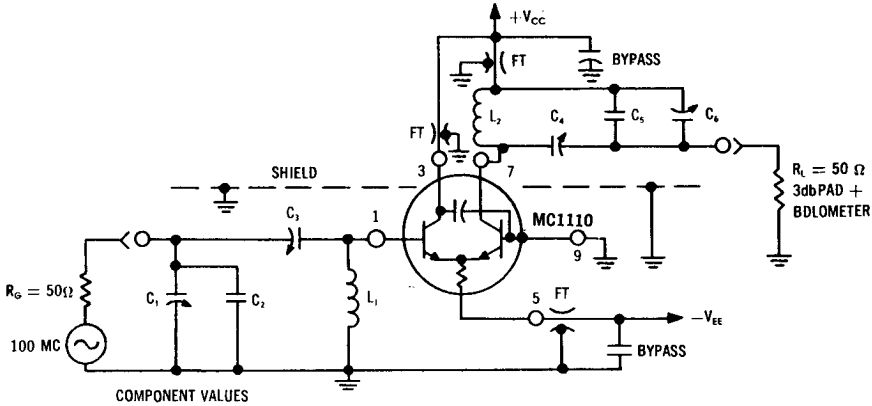
MC1110 (continued)

ELECTRICAL CHARACTERISTICS (At T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Typ	Max	Unit
DC CHARACTERISTICS						
Input Leakage Current (V_3 = 5 Vdc; I_5, I_7, I_9 = 0)		I_1	---	---	10	nAdc
Output Leakage Current (V_7 = 5 Vdc; I_1, I_3, I_5 = 0)		I_9	---	---	10	nAdc
Operating Current (V_{CC} = 5 Vdc, V_{EE} = -4.7 Vdc, V_{in} = 0)	Figure 1	I_{CT}	3.8	4	4.2	mAdc
Input Operating Current (V_{CC} = 5 Vdc, V_{EE} = -10 Vdc, V_{in} = 0)	Figure 2	I_1	---	---	250	μAdc
Reference Operating Current (V_{CC} = 5 Vdc, V_{EE} = -10 Vdc, V_{in} = 0)	Figure 1	I_9	---	---	250	μAdc
Current Balance (V_{CC} = 5 Vdc, V_{EE} = -10 Vdc, V_{in} = 0)	Figure 1	I_3/I_7	0.90	---	1.10	---
(V_{CC} = 5 Vdc, V_{EE} = -1 Vdc, V_{in} = 0)	Figure 1		0.90	---	1.10	
Large Signal Transconductance (V_{CC} = 5 Vdc, V_{EE} = -4 Vdc, ΔV_{in} = 50 mV)		G_{21}	26	28	---	m-mhos
SMALL SIGNAL CHARACTERISTICS						
Small Signal Current Gain (V_{CC} = 5 V, I_E = -4 mA, f = 100 mc)		h_{21}	6.0	9.0	---	---
Short Circuit Admittances (V_{CC} = 5 V, V_{EE} = -4V, f = 100 mc)	Figure 1	---				m-mhos
Input Admittance		$\lvert y_{11}\rvert$	---	2.0	---	
Reverse Transfer Admittance		$\lvert y_{12}\rvert$	---	0.064	---	
Forward Transfer Admittance		$\lvert y_{21}\rvert$	---	16.3	---	
Output Admittance		$\lvert y_{22}\rvert$	---	1.2	---	
Transducer Power Gain (V_{CC} = 5V, V_{EE} = -4V, f = 100 mc, BW = 3 mc)	Figure 20	G_T	22	26	---	db
(V_{CC} = 5V, V_{EE} = -4V, f = 200 mc, BW = 6 mc)	Figure 21		15	18	---	
Noise Figure (V_{CC} = 5V, V_{EE} = -4V, f = 100 mc, R_g = R_{SO})		NF	---	4	6	db

MC1110 (continued)

100 MC POWER GAIN TEST SET

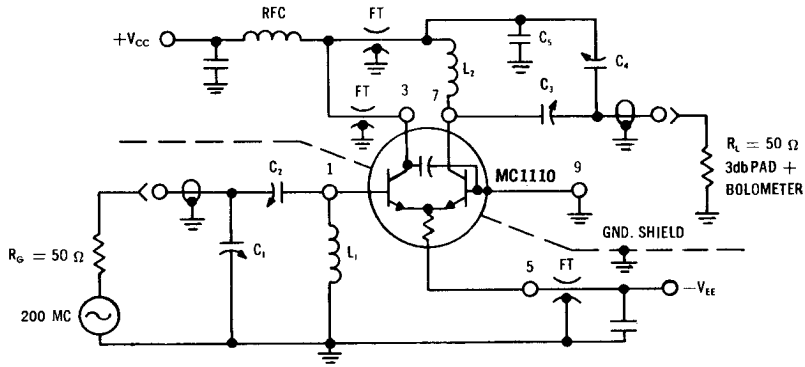


COMPONENT VALUES

C_1, C_6	VARIABLE CERAMIC CAPACITOR	9-35 $\mu\mu$f
C_3	VARIABLE CERAMIC CAPACITOR	5.5-18 $\mu\mu$f
C_4	VARIABLE CERAMIC CAPACITOR	2-8 $\mu\mu$f
C_2, C_5	FIXED MICA CAPACITOR	50 $\mu\mu$f
FT ALL	FEED THROUGH CAPACITORS	1200 $\mu\mu$f
Bypass	CAPACITORS, DISC CERAMIC	0.1 μf, 75 Vdc
L_1	INPUT INDUCTOR, 0.15 μh Q > 50	
L_2	OUTPUT INDUCTOR, 0.25 μh Q > 50	

V_{CC} = 5.0 Vdc
V_{EE} = −4 VOLTS

200 MC POWER GAIN TEST SET



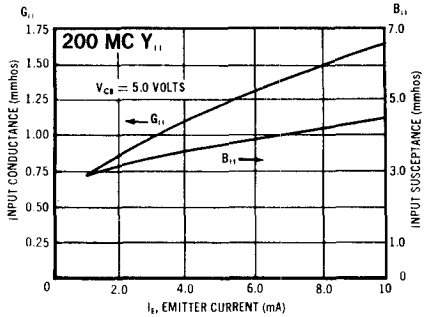
COMPONENT VALUES

C_1, C_4	VARIABLE CERAMIC CAPACITOR	5.5-18 $\mu\mu$f
C_2, C_3	VARIABLE CERAMIC CAPACITOR	2-8 $\mu\mu$f
C_5	FIXED MICA CAPACITOR	300 $\mu\mu$f
FT ALL	FEED THROUGH CAPACITORS	1200 $\mu\mu$f
BYPASS	CAPACITORS, DISC CERAMIC	0.1 μf, 75 Vdc
L_1	INPUT INDUCTOR	30 nhy Q > 100, 2T #16 AWG ¼" FORM
L_2	OUTPUT INDUCTOR	50 nhy Q > 100, 4T #16 AWG ¼" FORM
RFC	JEFFERS MOLDED CHOKE	0.68 μh

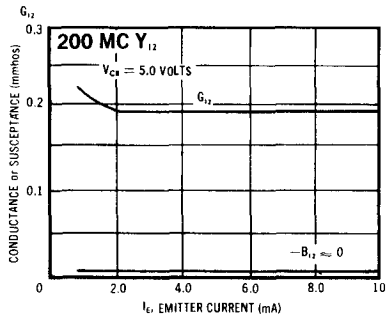
V_{CC} = 5.0 Vdc
V_{EE} = −4 VOLTS

MC1110 (continued)

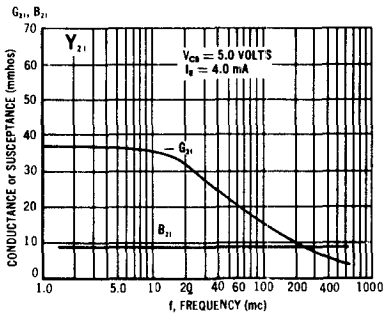
INPUT ADMITTANCE versus EMITTER CURRENT



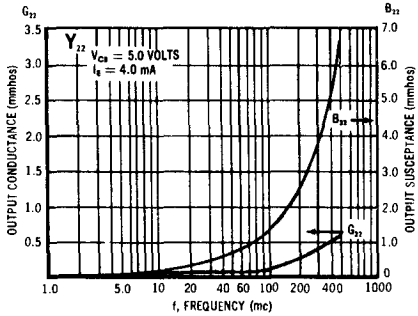
REVERSE TRANSFER ADMITTANCE versus EMITTER CURRENT



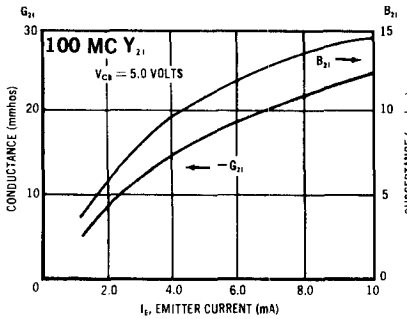
FORWARD TRANSFER ADMITTANCE versus FREQUENCY



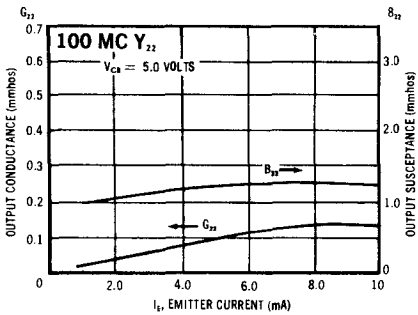
OUTPUT ADMITTANCE versus FREQUENCY,



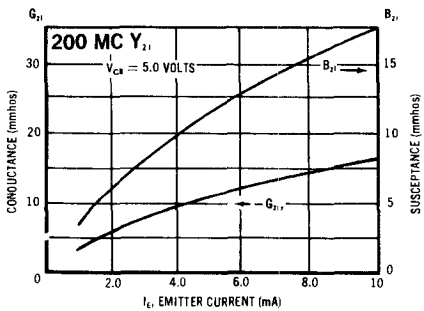
FORWARD TRANSFER ADMITTANCE versus EMITTER CURRENT



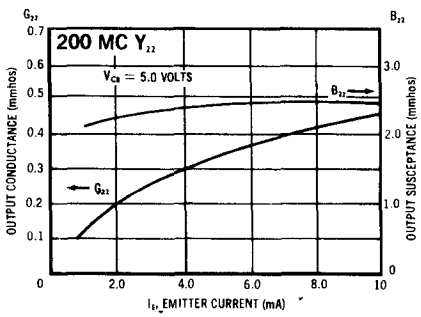
DUTPUT ADMITTANCE versus EMITTER CURRENT



FORWARD TRANSFER ADMITTANCE versus EMITTER CURRENT

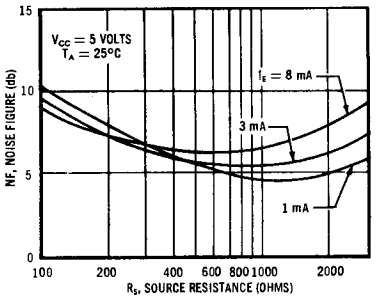


OUTPUT ADMITTANCE versus EMITTER CURRENT

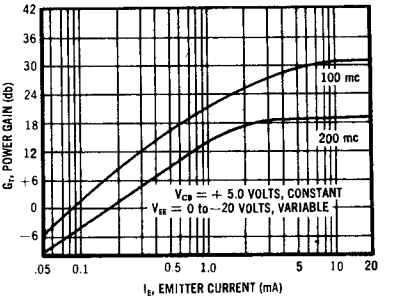


MC1110 (continued)

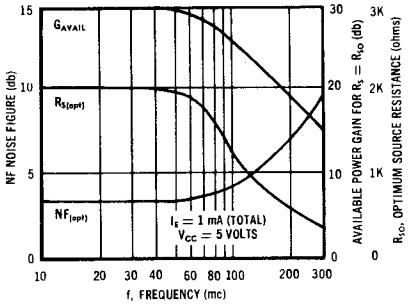
100 MC NOISE FIGURE vs. SOURCE RESISTANCE



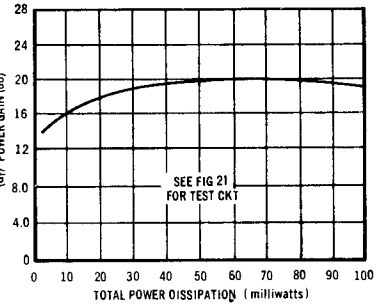
GAIN CONTROL CHARACTERISTICS



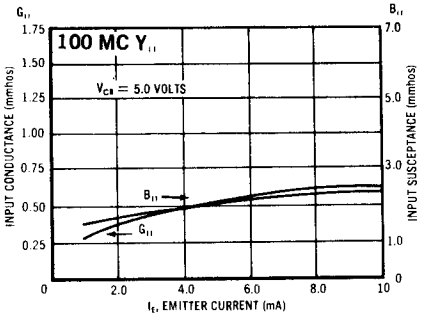
OPTIMUM NOISE FIGURE, OPTIMUM SOURCE RESISTANCE AND AVAILABLE POWER GAIN versus FREQUENCY



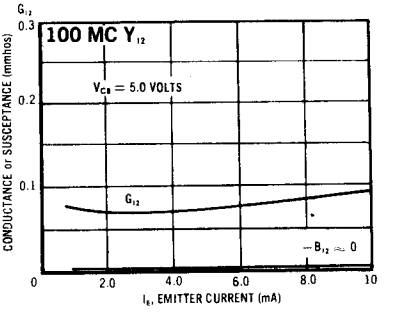
200 MC TRANSDUCER POWER GAIN (G_T) versus POWER DISSIPATION



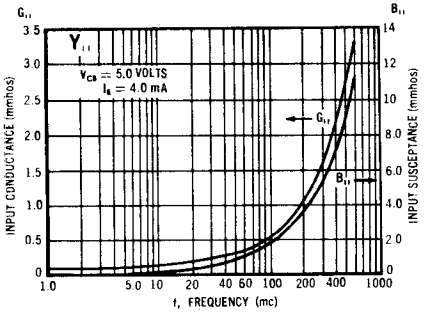
INPUT ADMITTANCE versus EMITTER CURRENT



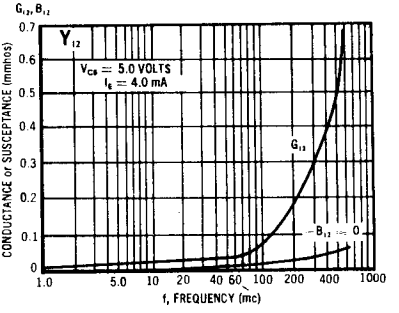
REVERSE TRANSFER ADMITTANCE versus EMITTER CURRENT



INPUT ADMITTANCE versus FREQUENCY



REVERSE TRANSFER ADMITTANCE versus FREQUENCY



MC1519

LINEAR CIRCUIT SERIES

A_{dd} = 67 db
V_{IO} = 6 mV
CMR = 89 db
BW = 0.7 Mc



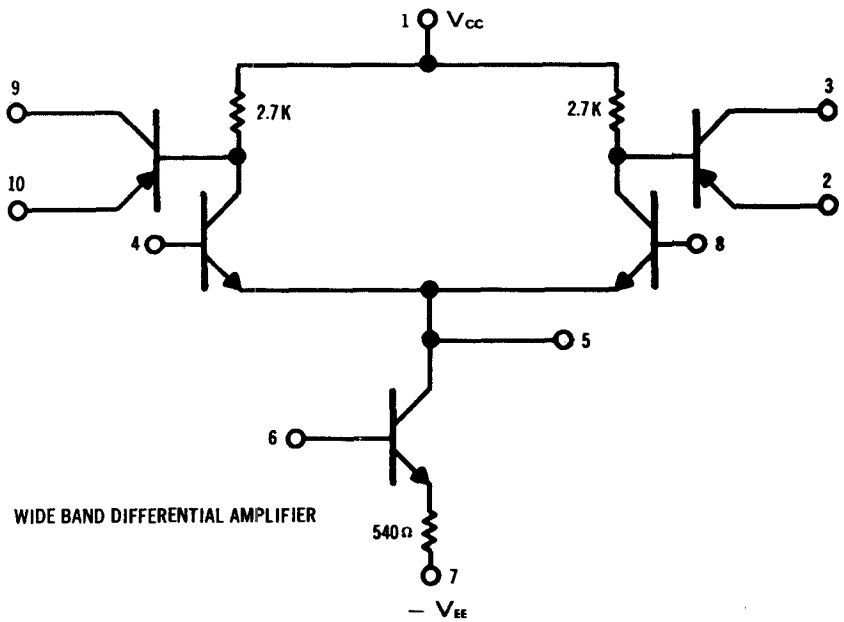
CASE 71

Integrated circuit wideband differential amplifier featuring NPN inputs and PNP outputs.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	+14	Vdc
Power Supply Voltage	V_{EE}	-14	Vdc
Differential Input Signal	V_{in}	±5	Vdc
Total Power Dissipation Derate above 25°C	P_D	300 2.0	mW mW/°C
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATIC



WIDE BAND DIFFERENTIAL AMPLIFIER

MC1519 (continued)

ELECTRICAL CHARACTERISTICS

($V_{CC} = +12$ Vdc, $V_{EE} = -12$ Vdc, $T_A = 25°C$ unless otherwise noted)

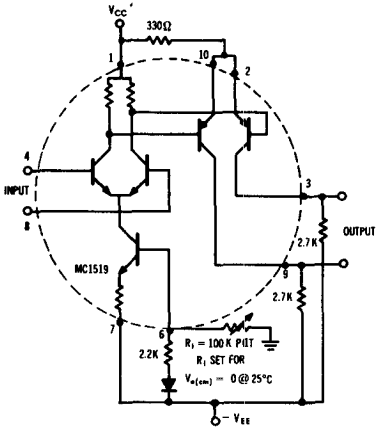
Characteristic	Figure No.	Symbol	Min	Typ	Max	Unit
Differential Voltage Gain	3, 8	A_{dd}				db
Circuit A (CE)			67	73	79	
Circuit B (CC)			40	45	50	
Single Ended Voltage Gain	3	A_V				db
Circuit A (CE)			—	67	—	
Circuit B (CC)			—	38	—	
Maximum Output Swing	4	V_O				$V_{(p-p)}$
Circuit A (CE)			12.0	14.0	—	
Circuit B (CC)			8.0	10.0	—	
Input Offset Voltage	5, 9	V_{IO}				mVdc
Circuit A (CE)			—	2.0	6.0	
Circuit B (CC)			—	2.0	6.0	
Input Offset Voltage Drift	5, 9	V_{IOD}				$\mu V/^oC$
Circuit A (CE)			—	5.0	—	
Circuit B (CC)			—	5.0	—	
Input Offset Current	6, 10	I_{IO}				μAdc
Circuit A (CE)			—	1.0	4.0	
Circuit B (CC)			—	2.0	8.0	
Input Current	6, 11	I_i				μAdc
Circuit A (CE)			—	40.0	70.0	
Circuit B (CC)			—	60.0	90.0	
Common Mode Rejection	7	CM_{Rej}				db
Circuit A (CE)			—	89.0	—	
Circuit B (CC)			—	86.0	—	
Bandwidth - 3 db	3, 12	BW				mc
Circuit A (CE)			0.70	1.0	—	
Circuit B (CC)			5.0	8.0	—	
Differential Input Impedance	2	Z_{in}				kohms
Circuit A (CE)			1.8	2.6	—	
Circuit B (CC)			—	1.2	—	
Single Ended Output Impedance	2	Z_{out}				kohms
Circuit A (CE)			—	2.7	—	
Circuit B (CC)			—	0.048	0.120	

MC1519 (continued)

TEST CIRCUITS

FIGURE 1

CIRCUIT A — COMMON EMITTER OUTPUT



CIRCUIT B — COMMON COLLECTOR OUTPUT

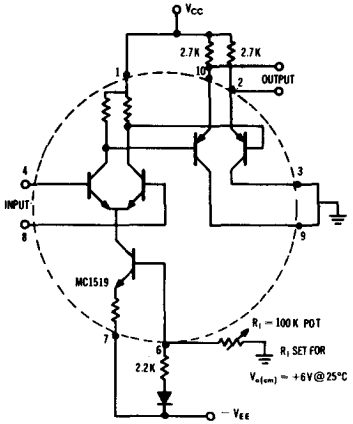
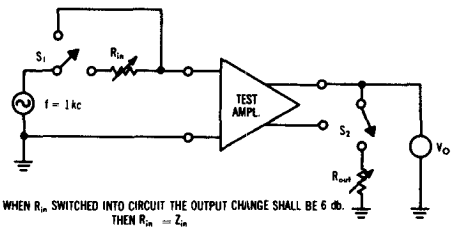


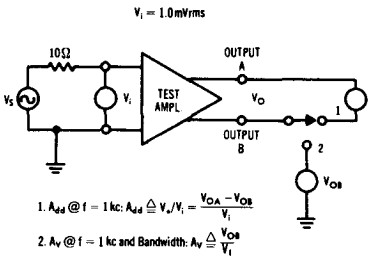
FIGURE 2 — DIFFERENTIAL INPUT IMPEDANCE and SINGLE-ENDED OUTPUT IMPEDANCE



Z_{in}: WHEN R_{in} SWITCHED INTO CIRCUIT THE OUTPUT CHANGE SHALL BE 6 db. THEN $R_{in} = Z_{in}$

Z_{out}: WHEN R_{out} SWITCHED INTO CIRCUIT THE OUTPUT CHANGE SHALL BE 6 db. THEN $R_{out} = Z_{out}$

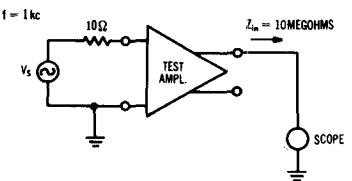
FIGURE 3 — DIFFERENTIAL VOLTAGE GAIN, SINGLE-ENDED VOLTAGE GAIN, and BANDWIDTH



1. A_{dd} @ f = 1 kc: $A_{dd} \triangleq V_o/V_i = \frac{V_{OA} - V_{OB}}{V_i}$

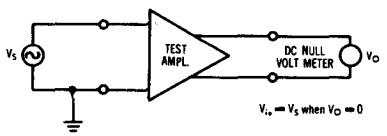
2. A_V @ f = 1 kc and Bandwidth: $A_V \triangleq \frac{V_{OB}}{V_i}$

FIGURE 4 — MAXIMUM OUTPUT SWING



V_S INCREASED UNTIL V_O REACHES FULL CUTOFF.

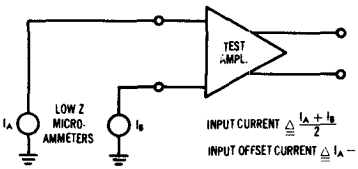
FIGURE 5 — INPUT OFFSET VOLTAGE



$V_{io} = V_S$ when $V_O = 0$

V_S IS CALIBRATED VARIABLE DC MILLIVOLT SOURCE WITH OUTPUT IMPEDANCE OF 10Ω

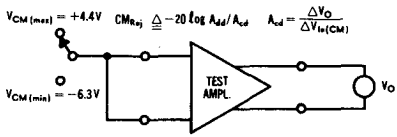
FIGURE 6 — INPUT OFFSET CURRENT and INPUT CURRENT



INPUT CURRENT $\triangleq \frac{I_A + I_B}{2}$

INPUT OFFSET CURRENT $\triangleq I_A - I_B$

FIGURE 7 — COMMON MODE REJECTION



ΔV_O RECORDED FOR A CHANGE IN THE COMMON MODE INPUT BIAS FROM +4.4 TO −6.3V

MC1519 (continued)

EFFECT OF TEMPERATURE ON CIRCUIT B CHARACTERISTICS
R_1 SET FOR $V_{O(CM)} = +6$ V AT +25°C

FIGURE 8 — DIFFERENTIAL MODE GAIN

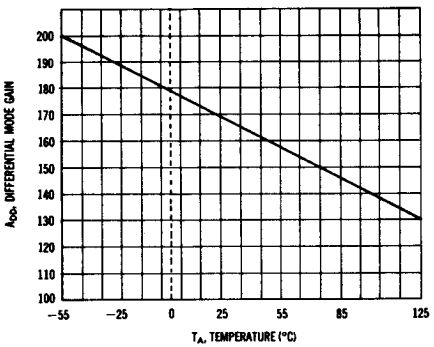


FIGURE 9 — INPUT OFFSET VOLTAGE

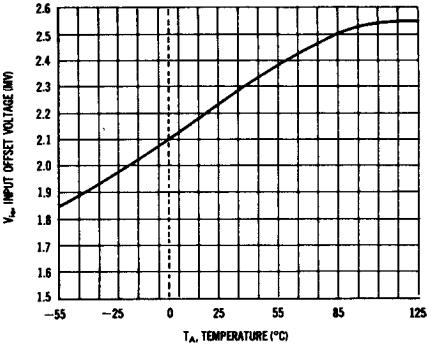


FIGURE 10 — INPUT OFFSET CURRENT

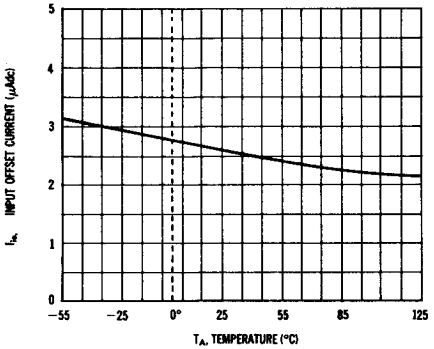


FIGURE 11 — INPUT CURRENT

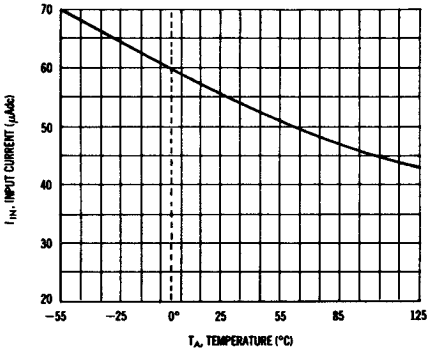


FIGURE 12 — CIRCUIT A BANDWIDTH

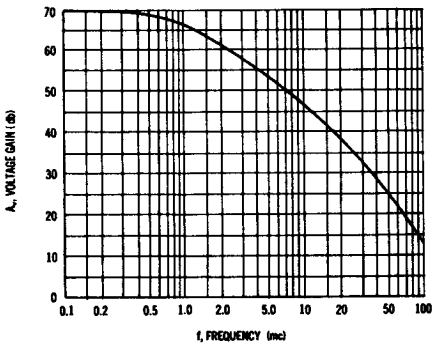
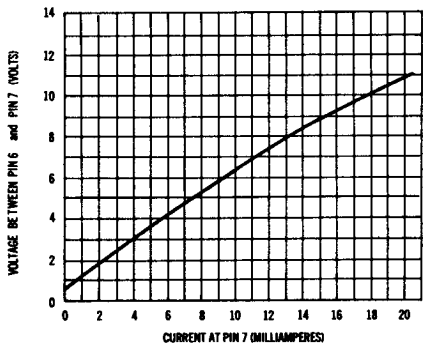


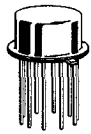
FIGURE 13 — CURRENT SOURCE BIASING



MC1524

LINEAR CIRCUIT SERIES

Z_L = 16 – 100Ω
THD = 0.6% Typ
A_V = 10, 20 or 30



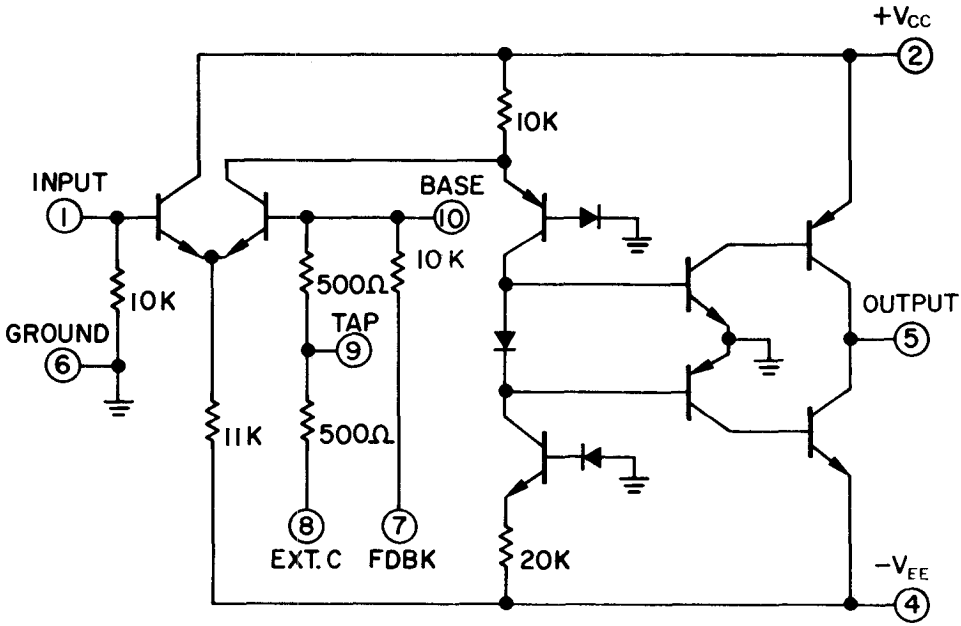
CASE 71

Integrated circuit 1-W audio power amplifier.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristics	Symbol	Ratings	Unit
Power Supply Voltage	V_{CC}	12	Vdc
Power Supply Voltage	V_{EE}	-12	Vdc
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C
Maximum Audio Output Power (T_A = -55°C to +125°C)	$P_{out(max)}$	1.0	Watt

LINEAR POWER AMPLIFIER CIRCUIT SCHEMATIC



MC1524 (continued)

ELECTRICAL CHARACTERISTICS ($V_{CC} = +6V, V_{EE} = -6V, T_A = 25°C.$)

Characteristic	Load Impedance ohms	Feedback Tap ohms	Symbol	Min	Typ	Max	Units
Maximum Peak-to-Peak Output Voltage for THD < 3% @ 1 kc	16	1000	V_{Omax}	9.0	10.0	—	$V_{(P-P)}$
Voltage Gain @ 1 kc	16	250	A_V	—	37.9	—	—
		500		—	20.0	—	
		1000		10.0	11.5	12.5	
	100	250		—	41.2	—	
		500		—	21.3	—	
		1000		11.0	12.3	13.5	
Input Impedance @ 1 kc	—	1000	Z_{in}	6.0	8.5	—	kohms
Output Impedance @ 1 kc	—	1000	Z_{out}	—	8.58	0.80	ohms
Bandwidth	18	250	BW	—	350	—	kc
		500		—	480	—	
		1000		250	770	—	
	40	250		—	340	—	
		500		—	480	—	
		1000		—	790	—	
	100	250		—	320	—	
		500		—	480	—	
		1000		—	810	—	
Zero Signal Current Drain (Each Supply)	16	1000	I_S	—	1.5	4.0	mA
Low Level Total Harmonic Distortion @ 1 kc (50 mVrms in)	18	1000	THD	—	0.6	2.0	%

FIGURE 1 — AC COUPLED CIRCUIT

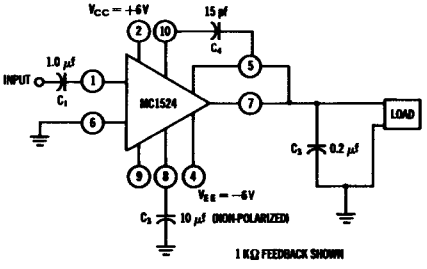
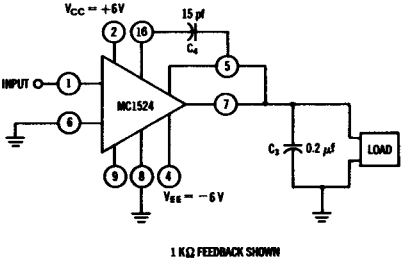


FIGURE 2 — DC COUPLED CIRCUIT



MC1524 (continued)

RECOMMENDED OPERATING CONDITIONS

1) DC load resistance (R_L) should be greater than 5 ohms for DC stability.

2) Power supplies should be balanced, have low source impedances, and should be turned on and off simultaneously. (See Fig. 6 for Standby Current vs. Supply Unbalance.)

3) Capacitors C_3 and C_4 provide high-frequency stability. For most loads, at temperatures below 70°C, C_4 may be omitted.

4) Low frequency rolloff of AC coupled circuit is determined by C_1 and C_2. Fig 1 is recommended for loudspeaker loads because of DC stability introduced by C_2.

5) Open loop operation is not recommended. Feedback taps are connected as follows:

Feedback Tap	Pin Connection
1 KΩ	8 to C_2 (AC) or ground (DC)
500Ω	9 to C_2 (AC) or ground (DC)
250Ω	8 to 10; 9 to C_2 (AC) or ground (DC)

FIGURE 3 — MAXIMUM AVAILABLE OUTPUT POWER

(BEFORE CLIPPING — RESISTIVE LOAD)

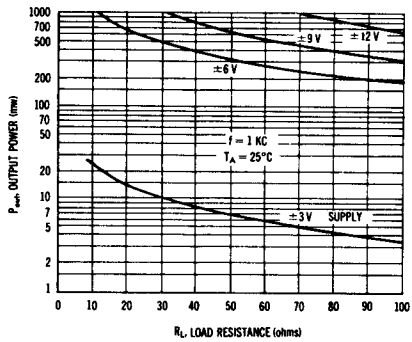


FIGURE 4 — TOTAL HARMONIC DISTORTION

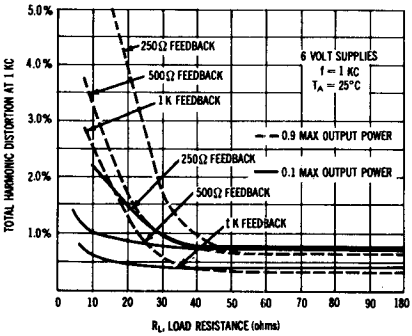


FIGURE 5 — AC COUPLED FREQUENCY RESPONSE

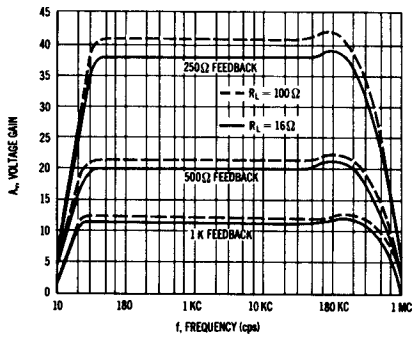
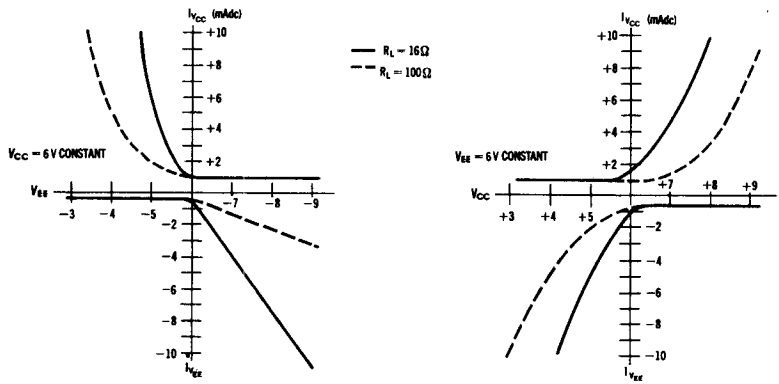


FIGURE 6 — STANDBY CURRENT VARIATION DUE TO SUPPLY UNBALANCE



MC1524 (continued)

FIGURE 7 — DC TRANSFER CHARACTERISTICS

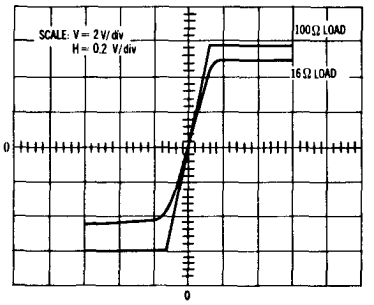
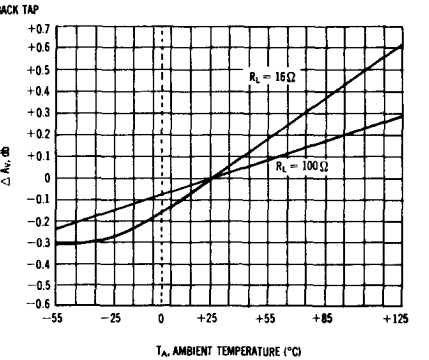
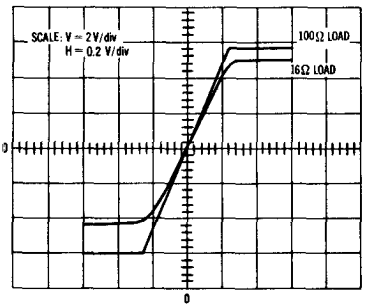
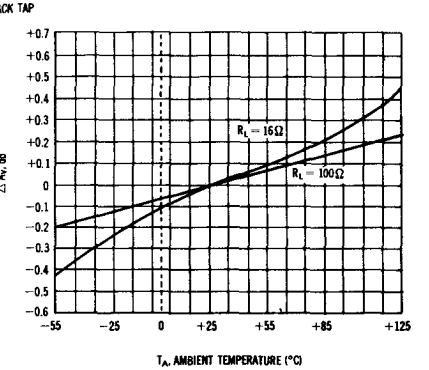
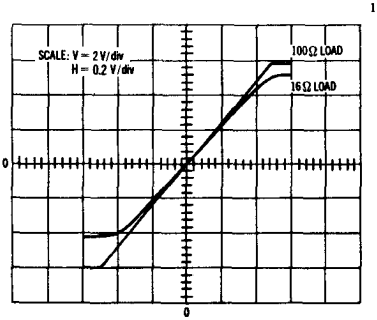


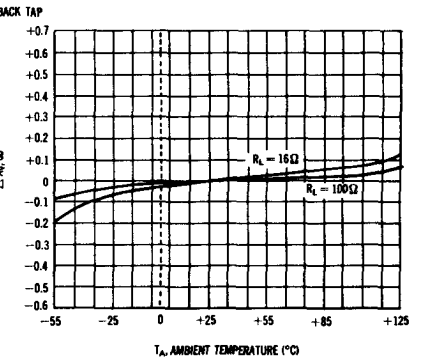
FIGURE 8 — VOLTAGE GAIN versus TEMPERATURE











MC1530
MC1531

LINEAR CIRCUITS



Monolithic Operational Amplifier, designed for use as a summing amplifier, integrator, or amplifier with operating characteristics that can be varied by means of external feedback components.

CASE 71

MAXIMUM RATINGS ($T_A = 25°C$ unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	+9	Vdc
Power Supply Voltage	V_{EE}	-9	Vdc
Differential Input Signal	V_{in}	±5	Vdc
Load Current	I_L	10	mA
Total Power Dissipation Derate above 25°C	P_D	600 4.0	mW mW/°C
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C

CIRCUIT SCHEMATICS

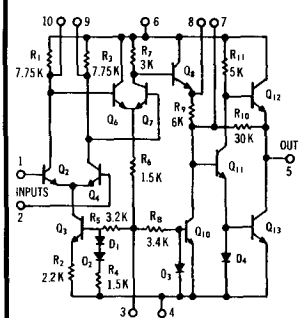


FIGURE 1 – MC1530 (STANDARD INPUT)

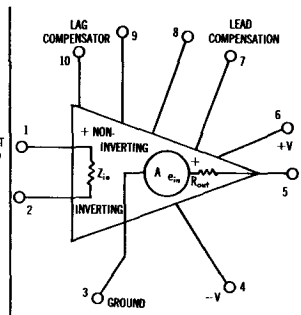


FIGURE 2 – EQUIVALENT CIRCUIT BOTH TYPES

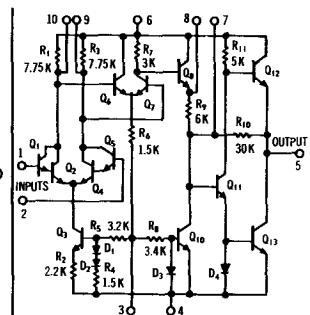
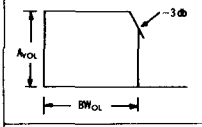
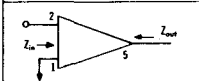
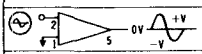
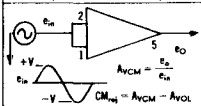
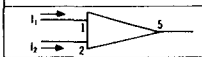
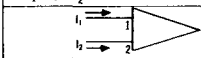
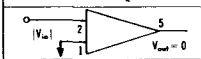
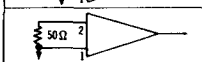
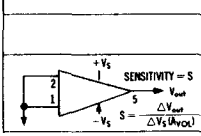


FIGURE 3 – MC1531 (DARLINGTON INPUT)

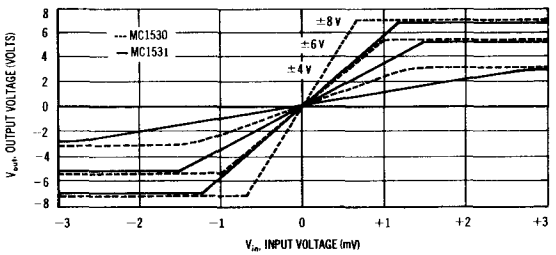
MC1530, MC1531 (continued)

ELECTRICAL CHARACTERISTICS (V_{CC} = +6 Vdc, V_{EE} = −6 Vdc, T_A = 25°C unless otherwise noted)

Characteristic Definitions *	Fig. No.	Characteristic		Symbol	Min	Typ	Max	Unit
	8	Open Loop Voltage Gain	MC1530	A_{VOL}	73	74	82	db
			MC1531		68	71	77	
			MC1530		4500	5000	12500	—
			MC1531		2500	3500	7000	—
		Open Loop Bandwidth (no roll-off capacitance)	MC1530	BW_{OL}	1	1.2	—	mc
			MC1531		0.20	0.4	—	
	-	Output Impedance (f = 20 cps)	MC1530, MC1531	Z_{out}	—	25	50	ohms
	15	Input Impedance (f = 20 cps)	MC1530	Z_{in}	10K	20 K	—	ohms
			MC1531		1 M	2 M	—	
	-	Output Voltage Swing (1 Kohm Load)	MC1530, MC1531	V_O	±4.5	±5.2	—	V_{peak}
	-	Input Common Mode Voltage Swing	MC1530	V_{iCM}	±2	±2.7	—	V_{peak}
			MC1531		±2	±2.4	—	
	-	Common Mode Rejection Ratio	MC1530	CM_{Rej}	70	75	—	db
			MC1531		65	75	—	
	16	Input Bias Current ($I_b = \frac{I_1 + I_2}{2}$)	MC1530	I_b	—	3	10	μA
			MC1531		—	0.025	0.150	
	17	Input Offset Current $I_{io} = I_1 - I_2$	MC1530	I_{io}	—	0.200	2	μA
			MC1531		—	0.003	0.025	
	14	Input Offset Voltage	MC1530	$\lvert V_{io} \rvert$	—	1	5	mV
			MC1531		—	3	10	
	10	Input Noise Voltage (Open Loop, 50 ohm source, BW_{OL} = 5 mc)	MC1530	$V_{N(in)}$	—	10	—	μV_{rms}
			MC1531		—	20	—	
	14	Average Temperature Coefficient of Input Offset Voltage		TC_{Vio}				$\mu V/^oC$
		25°C to +125°C	MC1530		—	3.8	—	
		-55°C to+ 25°C			—	8	—	
		25°C to +125°C	MC1531		—	11	—	
		-55°C to+ 25°C			—	20	—	
	11	D.C. Power Dissipation (Power Supply = ±6 V, V_O = 0)		P_D	—	110	150	mW
	-	Positive Supply Sensitivity (-V constant)		S_+	—	100	—	μV/V
	-	Negative Supply Sensitivity (+V constant)		S_-	—	100	—	μV/V

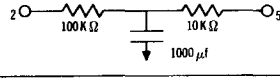
*All definitions imply linear operation (V_{io} = 0)

FIGURE 4 — NORMALIZED DC OPEN LOOP TRANSFER CHARACTERISTICS



RECOMMENDED OPERATING CONDITIONS

1. For High Slew Rate use Circuit A, Figure 12
2. For Minimum Noise use Circuit 8, Figure 12
3. For operational stability Power Supply decoupling should be employed at all times.
4. Self Biasing network used to hold output voltage less than ± 1 volt d.c. (quiescent)



MC1530, MC1531 (continued)

FIGURE 5 — VOLTAGE GAIN versus FREQUENCY

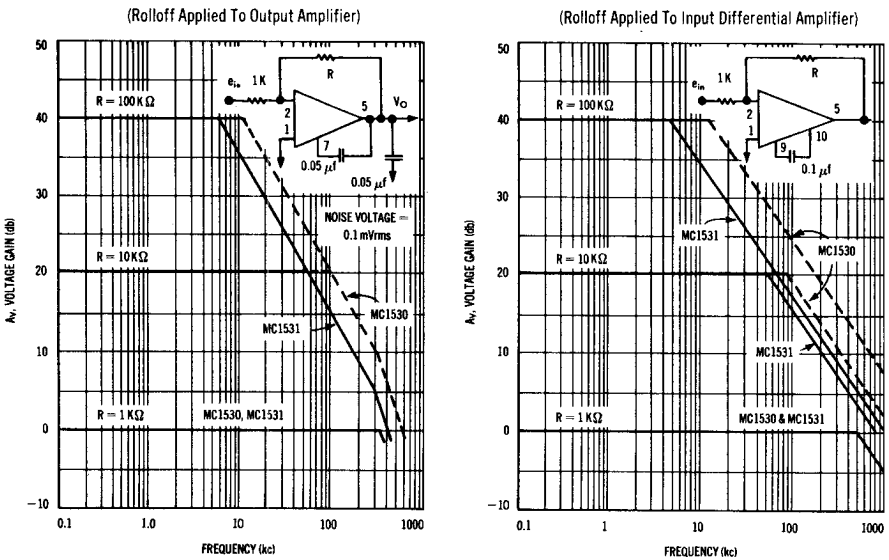
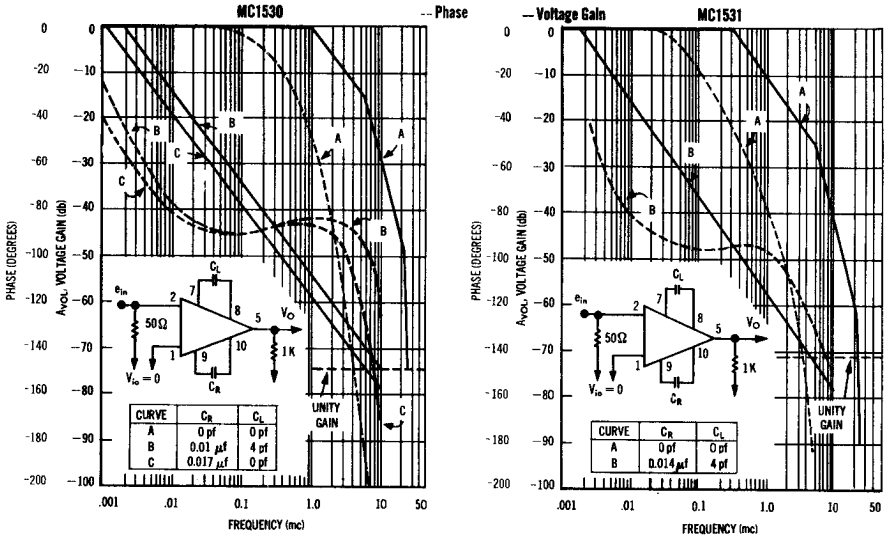


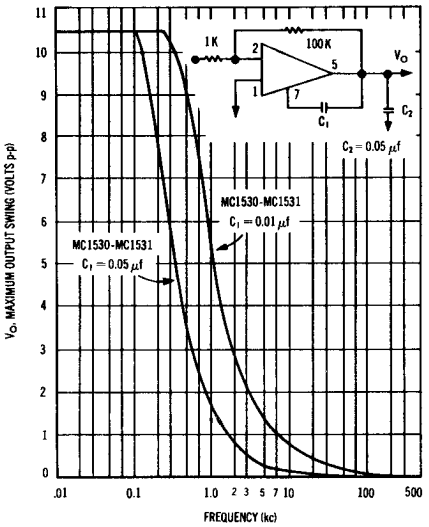
FIGURE 6 — OPEN LOOP VOLTAGE GAIN AND PHASE ANGLE versus FREQUENCY



MC1530, MC1531 (continued)

FIGURE 7 — MAXIMUM OUTPUT VOLTAGE SWING versus FREQUENCY

(Rolloff Applied To Output Amplifier)



(Rolloff Applied To Input Differential Amplifier)

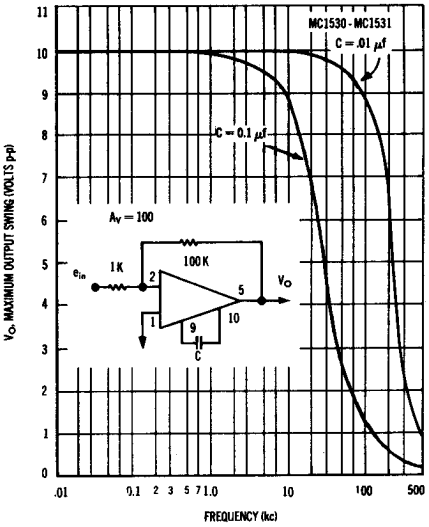


FIGURE 8 — OPEN LOOP VOLTAGE GAIN versus FREQUENCY

(Rolloff Applied To Input Differential Amplifier)

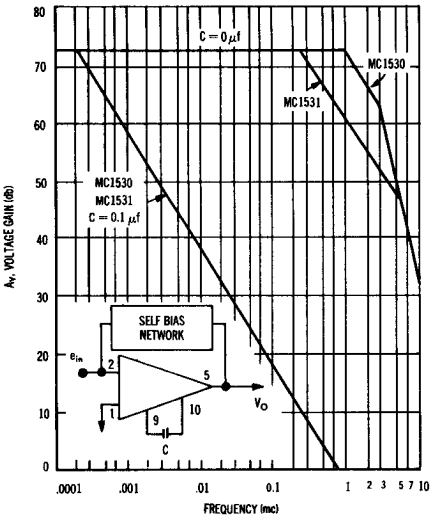
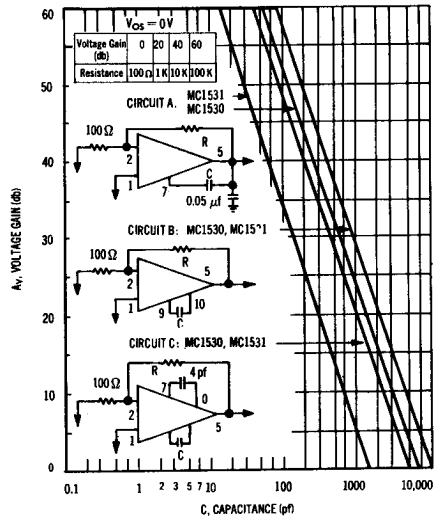


FIGURE 9 — VOLTAGE GAIN versus MINIMUM ROLLOFF CAPACITANCE



MC1530, MC1531 (continued)

TEMPERATURE CHARACTERISTICS

FIGURE 10 – RMS NOISE VOLTAGE

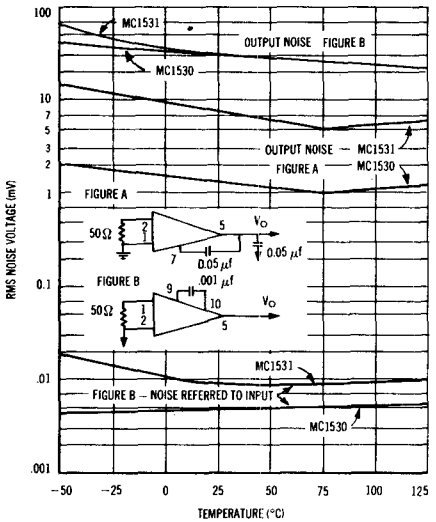


FIGURE 11 – SAFE OPERATING AREA
(No Heat Sink)

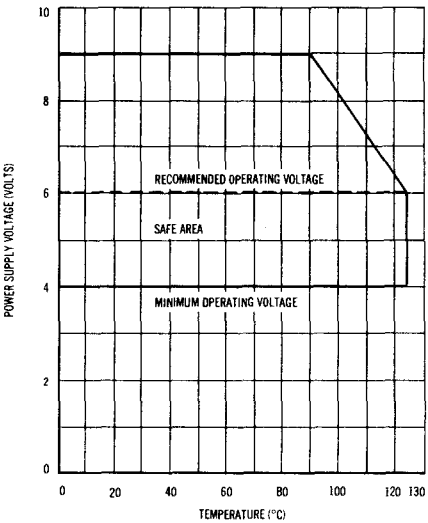


FIGURE 12 – SLEW RATE versus ROLLOFF CAPACITANCE

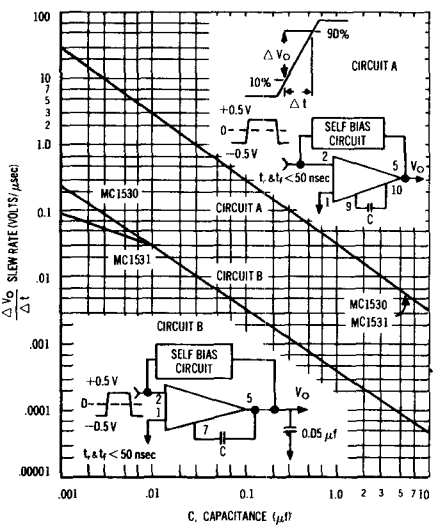
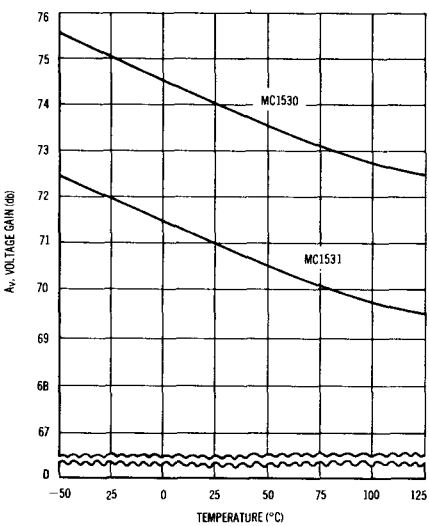


FIGURE 13 – OPEN LOOP VOLTAGE GAIN



MC1530, MC1531 (continued)

TEMPERATURE CHARACTERISTICS

FIGURE 14 – OFFSET VOLTAGE NORMALIZED

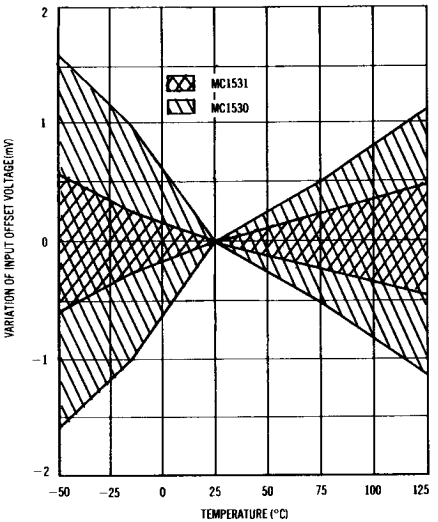


FIGURE 15 – INPUT IMPEDANCE

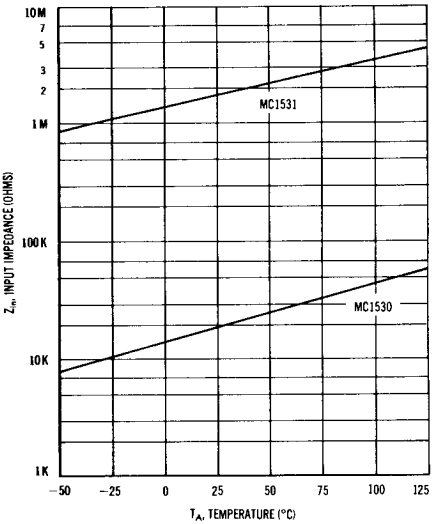


FIGURE 16 – INPUT BIAS CURRENT

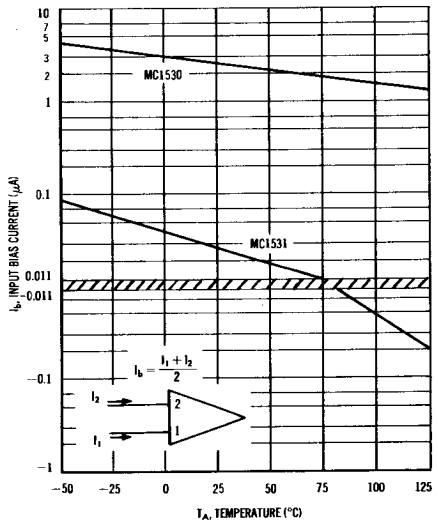
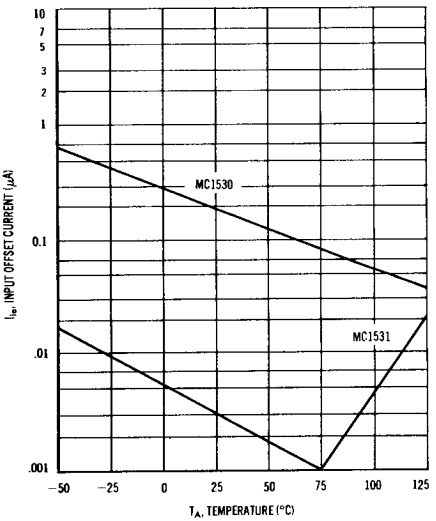


FIGURE 17 – INPUT OFFSET CURRENT



HARDWARE

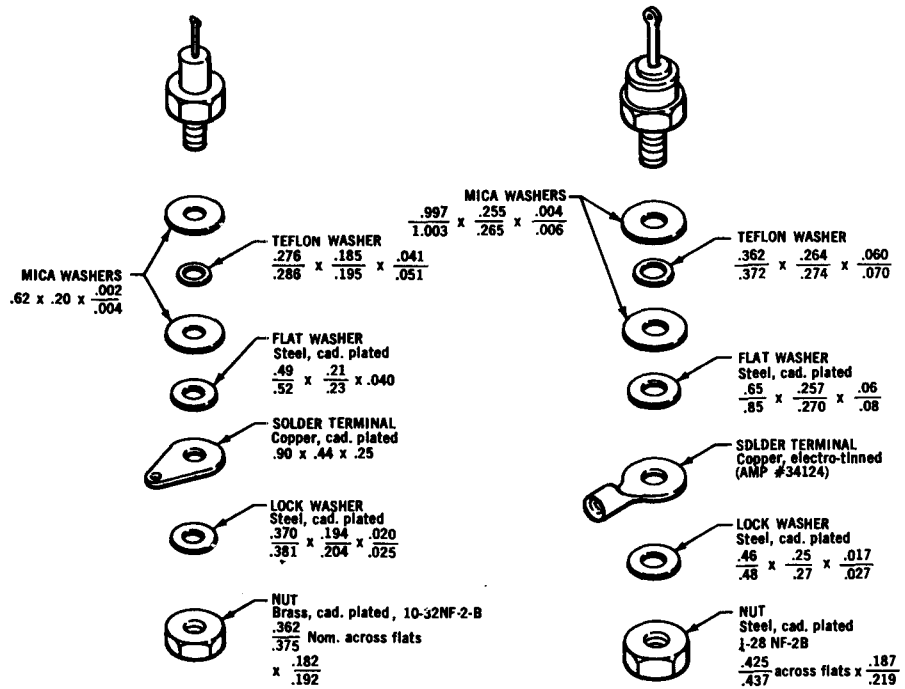
THE FOLLOWING SEMICONDUCTOR HARDWARE IS INCLUDED IN THIS SECTION.

MH745 MH746	Rectifier - zener diode mounting hardware
MK10 MK15 MK20 MK25	Power transistor mounting hardware
MS10 MS15	Power transistor heat-sinks
XC63 XC72	Integrated circuit interconnecting patchboards

MOUNTING HARDWARE
FOR
7/16" RECTIFIER AND 10 WATT ZENER DIODE
11/16" RECTIFIER AND 50 WATT ZENER DIODE STUD PACKAGES

MH745

MH746



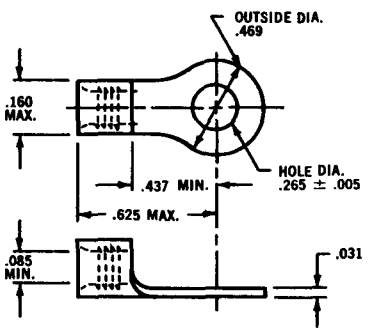
7/16 STUD
(MH 745)

11/16 STUD
(MH 746)

Mounting hardware is supplied with the units. For additional hardware, order by kit number:

MH745 — 7/16" STUD MOUNTING HARDWARE

MH746 — 11/16" STUD MOUNTING HARDWARE



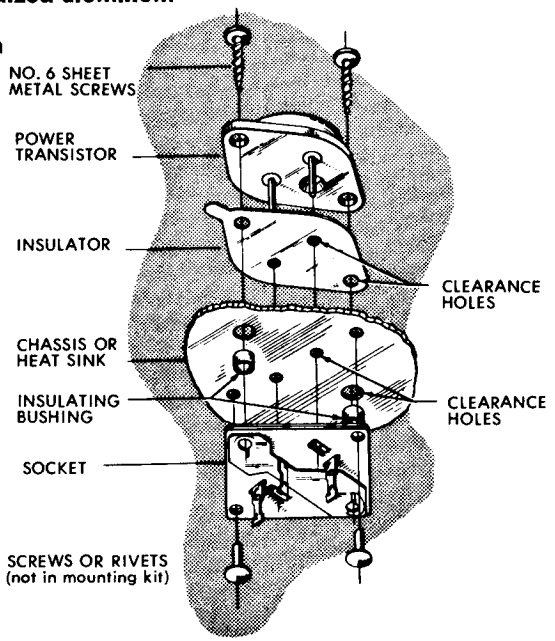
POWER TRANSISTOR MOUNTING KITS

MK-10 — teflon

MK-15 — mica

MK-20 — anodized aluminum

MK-25 — mica



Typical thermal characteristics for teflon, mica, and anodized aluminum insulators used in mounting kits are given in the table below. (Figures may vary with mounting torque applied. Do not over stress.)

KIT TYPE	INSULATING WASHER	TYPICAL THERMAL RESISTANCE (°C/Watt)	
		Dry	With DC4*
—	No Insulator	.20	.10
MK-10	Teflon	1.45	.80
MK-15	Mica	.80	.40
MK-20	Anodized Aluminum	.40	.35
MK-25	Mica		

*DC4 is Dow Corning No. 4 Silicone Lubricant.

Mounting kits, types MK-10, MK-15, MK-20, and MK-25 provide the necessary hardware for correctly mounting all TO-3 and TO-66 industry standard power transistor types to a chassis. With these kits, power transistors can be electrically insulated from the heat sink chassis, while maintaining complete heat transfer characteristics.

Included in these highly useful kits are a transistor mounting socket, front and back mounting templates for hole drilling guides, two #6 mounting screws, two insulating bushings, an insulating washer and complete mounting instructions.

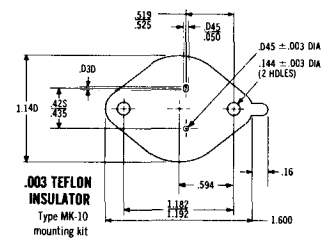
MK-10, MK-15, MK-20, MK-25 (continued)

The teflon-coated glass cloth insulating washer, included in kit MK-10, will find use in installations requiring an insulator of excellent durability. The mica insulator, in kit MK-15 and MK-25, is characterized by very high thermal conductivity. In applications where both good thermal conduction and durability are necessary, the anodized aluminum insulator supplied in kit MK-20, is recommended.

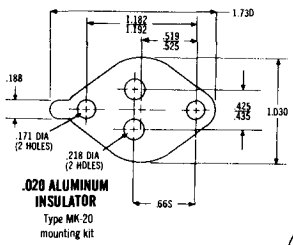
The transistor socket included in all mounting kits, is made of rugged laminated phenolic, with contacts of phosphor bronze.

Three cadmium plated solder lugs, having a 15-amp maximum current capacity, are provided for base, emitter and collector connections.

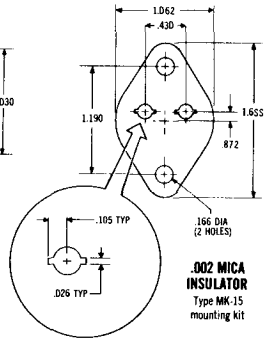
TO-3



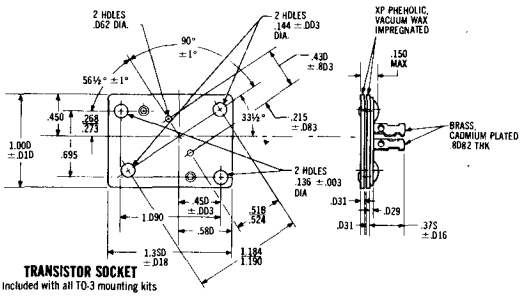
.003 TEFLON INSULATOR
Type MK-10 mounting kit



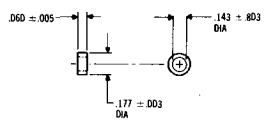
.020 ALUMINUM INSULATOR
Type MK-20 mounting kit



.002 MICA INSULATOR
Type MK-15 mounting kit

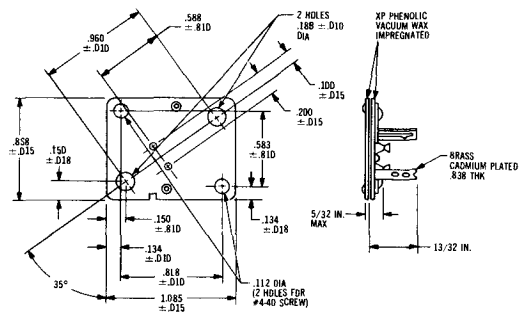


TRANSISTOR SOCKET
Included with all TO-3 mounting kits

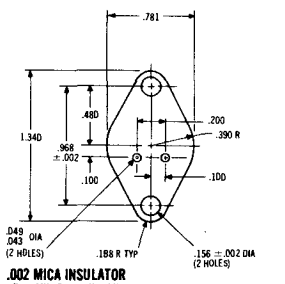


TEFLON INSULATING BUSHING
Included with all mounting kits

TO-66



TRANSISTOR SBCKET
Included with all TO-66 mounting kits



.002 MICA INSULATOR
Type MK-25 mounting kit

TEFLON INSULATING BUSHING
Included with all mounting kits
(Same as for TO-3)

MS-10 POWER TRANSISTOR HEAT SINK

Designed specifically for use with the industry standard type TO-3 (diamond) power transistor, this heat sink will reduce transistor junction temperatures and permit safe operation at higher power levels or under high ambient temperatures.

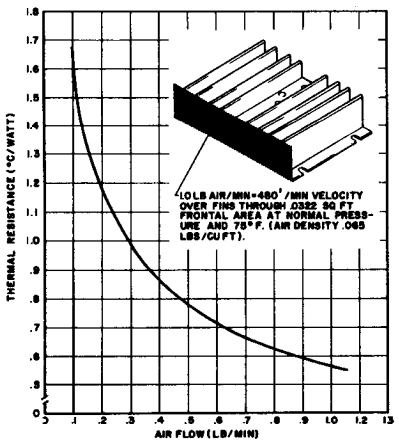
Cooling is accomplished with the MS-10 by conduction, convection and radiation. Although measuring only 4-1/2" by 3-1/16", the MS-10 makes possible thermal dissipation effectively equal to that of a flat sheet of aluminum 10" by 8" by 1/8". This greatly reduces the chassis area necessary for heat dissipation at higher power levels.

The transistor with use of silicon grease should be mounted directly to the MS-10 heat sink with the insulating washers placed at each of the (4) mounting points located on the heat sink flange. This is accomplished by placing (1) shoulder washer on the bottom and (1) flat washer on top of each mounting point of the heat sink. A mica washer is supplied to isolate the transistor from the heat sink if desired.

The MS-10 has a hole pattern arrangement which will accommodate the mounting of one TO-3 power transistor and/or two 10/32" stud mounting diodes. Provided with each MS-10 package is an MK-15 power transistor mounting kit which contains a power transistor socket, mounting screws, complete mounting instructions and a mica insulating washer for use in mounting transistors to the heat sink.

This heat sink is easy to install and does not interfere with the operation of the transistor. For optimum efficiency, the MS-10 should be mounted with the fins vertical.

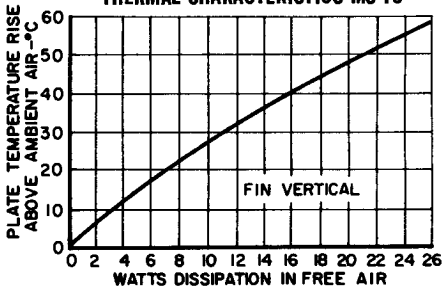
PERFORMANCE UNDER FORCED AIR FLOW OF MS-10 NATURAL CONVECTION TRANSISTOR HEAT SINK



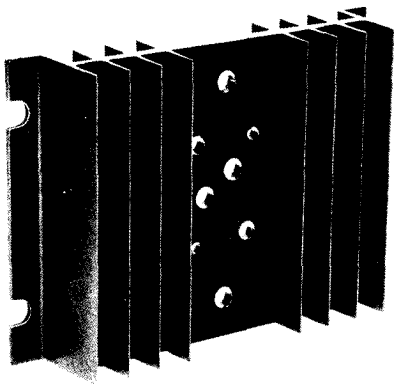
SPECIFICATIONS

Material	Aluminum Alloy
Finish	Black
Total Surface Area	65 Sq. In. (approx.)
Thermal Resistance	3°C/watt

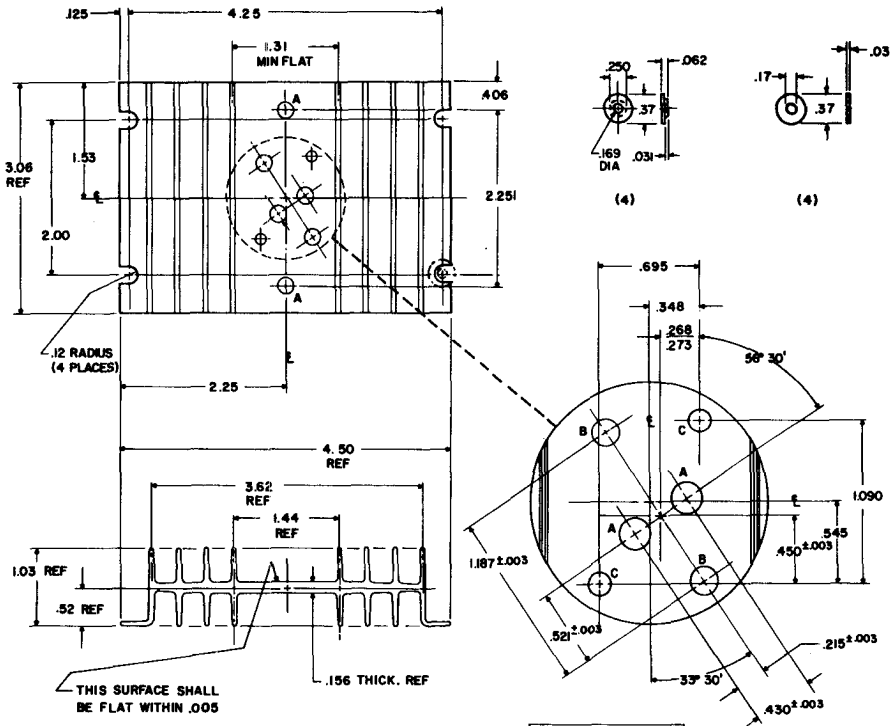
THERMAL CHARACTERISTICS MS-10



MS-10 (continued)



Providing cooling by conduction, convection and radiation, the MS-10 Heat Sink, measuring only 4-1/2" by 3-1/16", has thermal dissipation equal to that of a flat sheet of aluminum 10" x 8" x 1/8".



NATURAL CONVECTION COOLER
IS ALUMINUM. FINISH IS BLACK.

HOLE LIST	
HOLE	SIZE
A	.218 DIA
B	.188 DIA
C	.140 DIA

MS-15 POWER TRANSISTOR HEAT SINK

Designed specifically for use with the industry standard type TO-36 ("doorknob") power transistor, this heat sink will reduce transistor junction temperatures and permit safe operation at higher power levels or under high ambient temperatures.

Cooling is accomplished with the MS-15 by conduction, convection and radiation. Although measuring only 4-1/2" by 3-1/16", the MS-15 makes possible thermal dissipation effectively equal to that of a flat sheet of aluminum 10" by 8" by 1/8". This greatly reduces the chassis area necessary for heat dissipation at higher power levels.

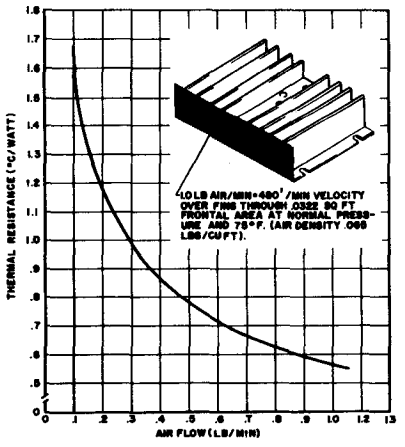
The MS-15 has a hole pattern arrangement which will accommodate the mounting of one TO-36 power transistor. Provided with each MS-15 package is assorted mounting hardware such as: insulating bushing, mica washer, nut, flat washer, solder terminal and insulating washers used in mounting the heat sink to the chassis.

The transistor with use of silicon grease should be mounted directly to the MS-15 heat sink with the insulating washers placed at each of the (4) mounting points located on the heat sink flange. This is accomplished by placing (1) shoulder washer on the bottom and (1) flat washer on top of each mounting point of the heat sink. A mica washer is supplied to isolate the transistor from the heat sink if desired.

NOTE: When mounting the transistor to the heat sink a torque of 20 in. lbs. max should be applied to the stud.

This heat sink is easy to install and does not interfere with the operation of the transistor. For optimum efficiency, the MS-15 should be mounted with the fins vertical.

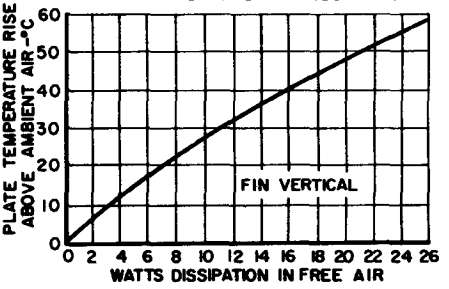
PERFORMANCE UNDER FORCED AIR FLOW OF MS-15 NATURAL CONVECTION TRANSISTOR HEAT SINK



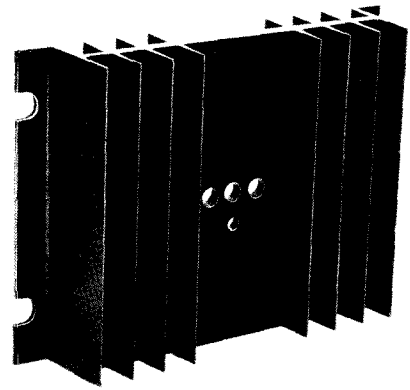
SPECIFICATIONS

Material	Aluminum Alloy
Finish	Black
Total Surface Area	65 Sq. In. (approx.)
Thermal Resistance	3°C/watt

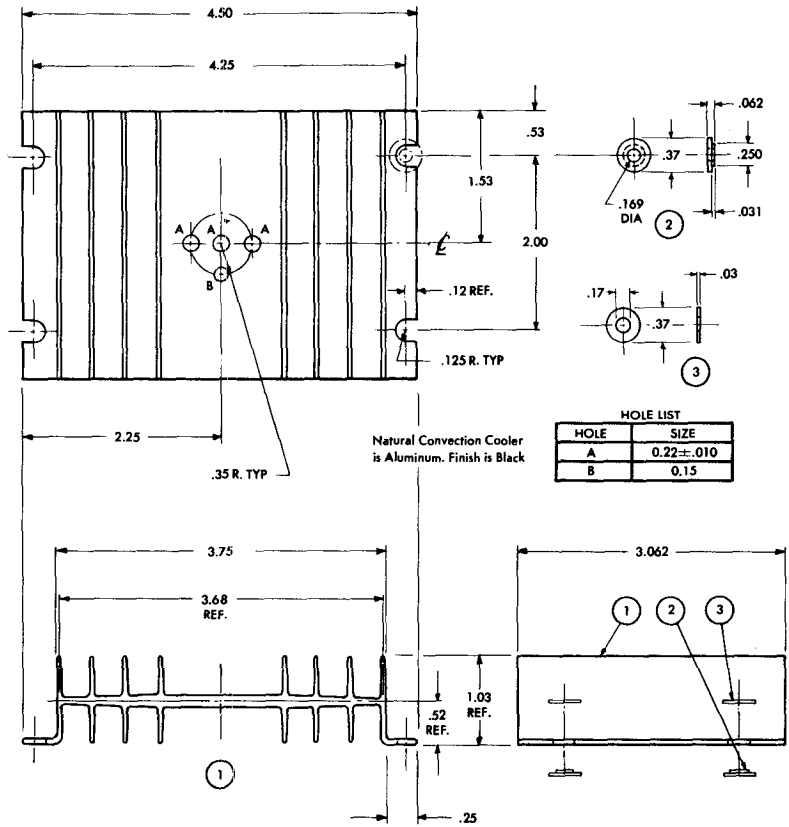
THERMAL CHARACTERISTICS MS-15



MS-15 (continued)



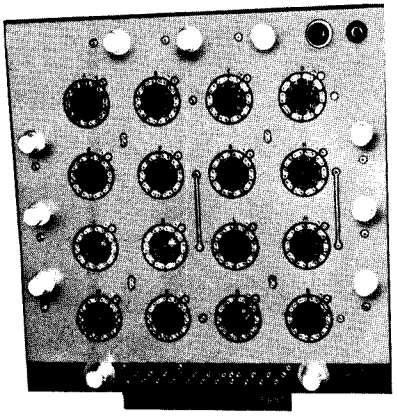
Providing cooling by conduction, convection and radiation, the MS-15 Heat Sink, measuring only 4-1/2" by 3-1/16", has thermal dissipation equal to that of a flat sheet of aluminum 10" x 8" x 1/8".



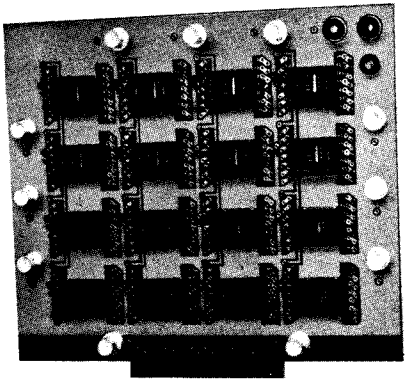
xc63
xc72

INTEGRATED CIRCUIT INTERCONNECTION PATCHBOARDS

Integrated Circuit Interconnection Patchboards, designed to allow rapid interconnection and evaluation of individual integrated circuits or complete logic designs. Little or no soldering is required as a result of the extensive use of sockets and connectors.



XC63



XC72

PATCHBOARD SPECIFICATIONS

Specification	XC63 (TO-5 Package)	XC72 (Flat Package)
Number of Sockets	16	16
Type of Socket	10-pin	14-pin
Number of Pin Jacks per Socket Pin	2	2
Input/Output	22-pin PC edge connector or 11 BNC coaxial connectors	22-pin PC edge connector or 11 BNC coaxial connectors
Power Connection	2 banana plugs plus 1 or 3 edge connector pins	3 banana plugs or 3 edge connector pins
Power Distribution	3 voltages next to each socket	3 voltages next to each socket
Temperature Range	-65°C to +150°C	-65°C to +150°C
Printed Circuit	1/16" glass epoxy with 2 oz gold plated runs	1/16" glass epoxy with 2 oz gold plated runs
Frequency Range	DC to 50 mc	DC to 50 mc
Edge Connector*	22-pins	22-pins

*Fits into Amphenol 143-022-01 connector, which is not included with patchboard.

XC63, XC72 (continued)

HOW TO USE INTERCONNECTION PATCHBOARDS

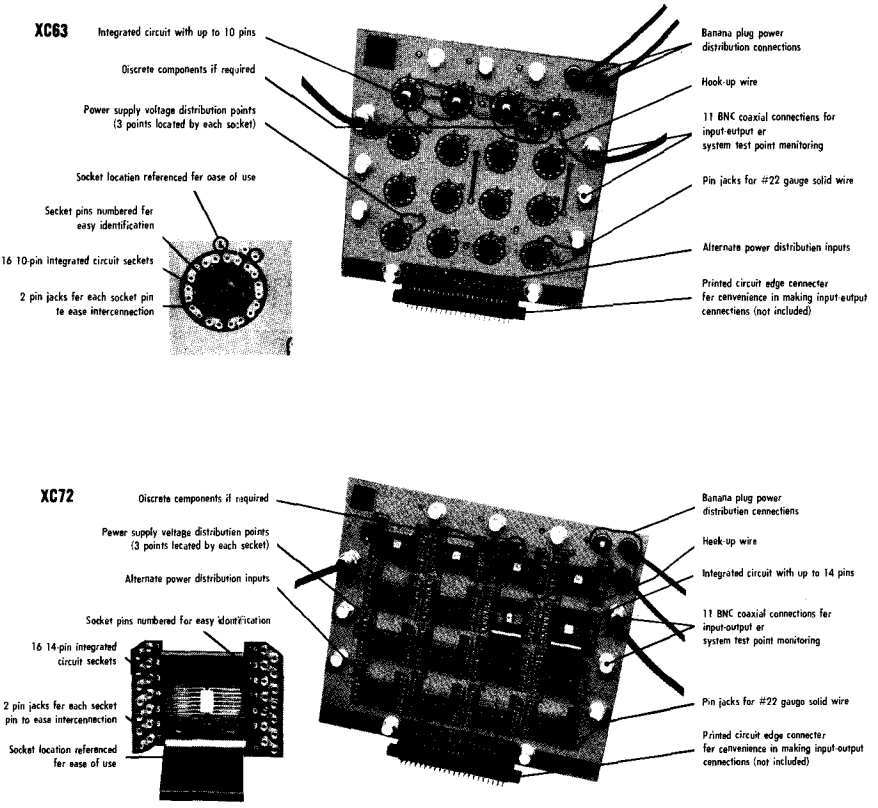
The Integrated Circuit Interconnection Patchboards are, in effect, "universal chassis" designed to simplify testing of individual devices and breadboarding of complete integrated circuit subsystems. Patchboard XC63 is designed for TO-5 integrated circuit packages with up to 10 leads, and Patchboard XC72 is designed for flat packs with up to 14 leads.

The boards contain 16 sockets for direct plug-in of integrated circuit packages. Associated with each socket are a number of spring-loaded pin jacks which are connected, through printed wiring, to the device pins. There are two pin jacks connected to each socket pin for greater interconnection flexibility. Interconnections between circuits are made simply by inserting 22 gauge (0.025 inch) solid hook-up wire into the appropriate pin jacks, which are designed for high retention capability even after numerous insertions.

A series of eleven BNC coaxial connectors, located around the periphery of the board provide convenient access points for applying input signals and sampling the outputs. Additional communication to and from the board can be made through 22 pin jacks, located on one edge of the board, which are wired to accommodate an edge-mounted, printed circuit strip connector (n supplied).

Three voltage-distribution planes are provided on each board. Two of these, in the form of a copper lamination on each side of the board, are accessible to power supply inputs through banana jacks mounted on the board. Two pin jacks near each socket location are in contact with the copper (one with each plane) and provide a ready means for applying the power supply voltages to the various jacks. A third voltage may be distributed from the edge-mounted strip connector pin jacks which have printed wiring runs to a number of additional pin jacks mounted at convenient locations throughout the board.

Each of the 16 integrated circuit sockets is lettered to aid in correlating logic block diagrams with the patchboard. The pins of each socket are numbered as a further aid. The use of these boards permits the same integrated circuits to be used repeatedly for the evaluation of many commonly used logic configurations with a minimum of effort. More complex designs may be studied by interconnecting several breadboards. Thus, all designs may be evaluated and finalized before the integrated circuits are permanently interconnected in the system.



LATE ADDITIONS

This "Late Additions" section was designed specifically to include the latest devices manufactured prior to the publishing of this book.

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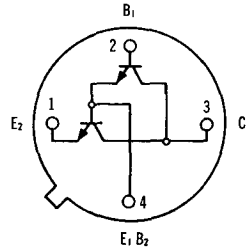
2N998
2N999

$V_{CB} = 60 - 100$ V
$I_C = 500$ mA



CASE 20
(TO-72)

Darlington amplifiers containing two NPN silicon annular transistors are designed for applications requiring very high gain, low noise, and high input impedance.



MAXIMUM RATINGS

Characteristic	Symbol	2N998	2N999	Unit
Collector-Emitter Voltage	V_{CE}	60	60	Vdc
Collector-Base Voltage	V_{CB}	100	60	Vdc
Emitter-Base Voltage	V_{EB}	15		Vdc
Collector Current	I_C	500		mAdc
Total Device Dissipation @ $T_A = 25^oC$ Derate above 25^oC	P_D	0.5 2.86		Watt $mW/^oC$
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	1.8 10.3		Watts $mW/^oC$
Operating Junction Temperature	T_J	200		^oC
Storage Temperature Range	T_{stg}	-65 to +300		^oC

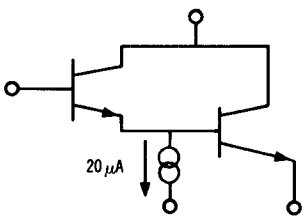
2N998, 2N999 (continued)

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Sustaining Voltage* (I_C = 30 mAdc, I_B = 0)		$BV_{CEO(sus)}$*	60	—	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	2N998 2N999	BV_{CBO}	100 60	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	15	—	Vdc
Collector Cutoff Current (V_{CB} = 90 Vdc, I_E = 0)	2N998	I_{CBO}	—	0.01	μAdc
(V_{CB} = 90 Vdc, I_E = 0, T_A = 150°C)	2N998		—	15	
(V_{CB} = 60 Vdc, I_E = 0)	2N999		—	0.01	
(V_{CB} = 60 Vdc, I_E = 0, T_A = 150°C)	2N999		—	10	
Emitter Cutoff Current (V_{BE} = 10 Vdc, I_C = 0)		I_{EBO}	—	0.01	μAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 1 mAdc, V_{CE} = 5 Vdc)	2N998	h_{FE}*	800	—	—
(I_C = 10 mAdc, V_{CE} = 5 Vdc)	2N998		1,600	8,000	
(I_C = 100 mAdc, V_{CE} = 5 Vdc)	2N998		2,000	—	
(I_C = 0.1 mAdc, V_{CE} = 10 Vdc)	2N999		1,000	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc)	2N999		4,000	—	
(I_C = 100 mAdc, V_{CE} = 10 Vdc)	2N999		7,000	70,000	
(I_C = 100 mAdc, V_{CE} = 10 Vdc, T_A = -55°C)	2N999		1,000	—	
(I_C = 10 mAdc, V_{CE} = 5 Vdc, measured across each transistor within the device)	2N998		25	—	
(I_C = 10 mAdc, V_{CE} = 10 Vdc, measured across each transistor within the device)	2N999		25	—	
DYNAMIC CHARACTERISTICS					
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 140 kHz)	2N998 2N999	C_{ob}	— —	30 20	pF
Input Capacitance (V_{BE} = 0.5 Vdc, I_C = 0, f = 140 kHz)	2N998 2N999	C_{ib}	— —	50 10	pF
Small-Signal Current Gain (I_C = 1 mAdc, V_{CE} = 5 Vdc, f = 1 kHz)	2N998	h_{fe}	1,800	—	—
Noise Figure** (I_C = 0.1 mAdc, V_{CE} = 10 Vdc, R_S = 5 kilohms, f = 1 kHz, Bandwidth = 200 Hz)	2N998	NF**	—	8	dB

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 1%
**Measured with constant current supply of 20 μAdc connected to the emitter of the input transistor. (See Figure 1)

FIGURE 1 — NOISE FIGURE TEST CIRCUIT



2N2646
2N2647

$V_{BB} = 35$ V
$I_E = 50$ mA RMS



Silicon annular unijunction transistors for oscillators, timing circuits, pulse generators, bistable circuits, sensing circuits and SCR triggering.

MAXIMUM RATINGS (At 25°C)

Characteristic	Rating	Unit
RMS Power Dissipation*	300	mW
RMS Emitter Current	50	mA
Peak Emitter Current	2	Amps
Emitter Reverse Voltage	30	Volts
Interbase Voltage	35	Volts
Operating Junction Temp. Range	-65 to 125	°C
Storage Temperature Range	-65 to 150	°C

*Derate 3 mW/°C ambient temperature increase

ELECTRICAL CHARACTERISTICS (at $T_A = 25°C$)

Device	2N2646			2N2647			
Parameter	Minimum	Typical	Maximum	Minimum	Typical	Maximum	Units
η	0.56	-	0.75	0.68	-	0.82	
R_{BBO}	4.7	7	9.1	4.7	7	9.1	kΩ
αR_{BBO}*	0.1	-	0.9	0.1	-	0.9	%/°C
$V_{E(sat)}$ **	-	3.5	-	-	3.5	-	Volts
$I_{B2(mod)}$	-	15	-	-	15	-	mA
I_{EO}	-	0.005	12	-	0.005	0.2	μA
I_P**	-	1	5	-	1	2	μA
I_V	4	6	-	8	10	18	mA
V_{oB1}	3	5.5	-	6	8	-	Volts

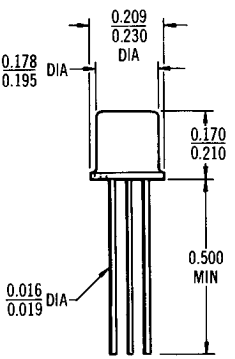
2N2646, 2N2647 (continued)

Definitions and Conditions

Symbol	
η(Eta)	Intrinsic Standoff Ratio (V_{BB}=10V, $\eta = \frac{V_P - V_{FEB1}}{V_{BB}}$, V_{FEB1}= Junction Diode Drop (App. 0.5 V)
R_{BBO}	Interbase Resistance (V_{BB}=3V, I_E=0)
α_{RBBO}	Interbase Resistance Temperature Coefficient (V_{BB}=3V; I_E=0; T_A = -55°C to +125°C)
$V_{E(sat)}$	Emitter Saturation Voltage (V_{BB}=10V, I_E=50mA)
$I_{B2(mod)}$	Modulated Interbase Current (V_{BB}=10V, I_E=50mA)
I_{EO}	Emitter Reverse Current (V_{B2E}= 30 V, I_{B1}= 0)
I_P	Peak Point Emitter Current (V_{BB}=25V)
I_v	Valley Point Current (V_{BB}=20V, R_{B2}= 100Ω)
V_{oB1}	Base 1 Peak Pulse Voltage (See Fig. 3)

*Suggested nominal temperature compensating resistor (R_{B2}) for unijunction only over ambient temperature range of -55°C to +125°C in circuit similar to Figure 3 is approximately 330 ohms for the 2N2646 and 560 ohms for the 2N2647.

**When testing for Emitter Saturation Voltage [$V_{E(sat)}$] and Valley Point Current (I_V) a duty cycle of 10% or more may cause internal heating due to interbase modulation resulting in erroneous readings.



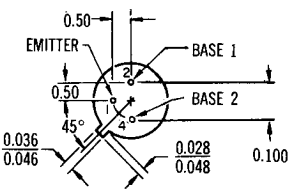


FIGURE 1
SYMBOL AND NOMENCLATURE

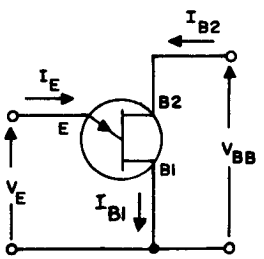


FIGURE 2
EMITTER CHARACTERISTICS

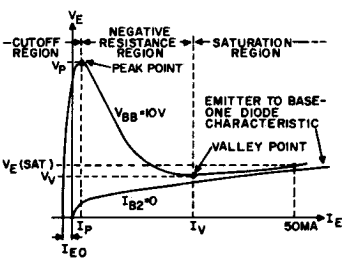
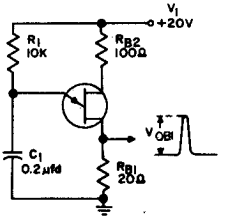
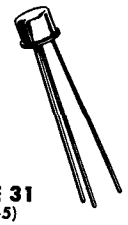


FIGURE 3
V_{oB1} TEST CIRCUIT



2N3053 (SILICON)

$V_{CEO} = 40$ V
$I_C = 700$ mA
$P_D = 5$ W



CASE 31
(TO-5)

NPN silicon annular transistor designed for medium-current switching and amplifier applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	40	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	5	Vdc
Collector Current-Continuous	I_C	700	mAdc
Total Device Dissipation @ $T_C = 25^oC$ Derate above 25^oC	P_D	5 28.6	Watts $mW/^oC$
Operating Junction Temperature Range	T_J	200	^oC
Storage Temperature Range	T_{stg}	-65 to +200	^oC

ELECTRICAL CHARACTERISTICS ($T_A = 25^oC$ unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Collector-Emitter Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BV_{CEO}	40	—	Vdc
Collector-Emitter Breakdown Voltage ($I_C = 100$ mAdc, $R_{BE} = 10$ ohms)	BV_{CER}	50	—	Vdc
Collector-Base Breakdown Voltage ($I_C = 100\ \mu$Adc, $I_E = 0$)	BV_{CBO}	60	—	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100\ \mu$Adc, $I_C = 0$)	BV_{EBO}	5	—	Vdc
Collector Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 1.5$ Vdc)	I_{CEX}	—	0.25	μAdc
Base Cutoff Current ($V_{CE} = 60$ Vdc, $V_{EB(off)} = 1.5$ Vdc)	I_{BL}	—	0.25	μAdc
ON CHARACTERISTICS				
DC Current Gain ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc) ($I_C = 150$ mAdc, $V_{CE} = 10$ Vdc)*	h_{FE}	25 50	— 250	—
Collector-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{CE(sat)}$	—	1.4	Vdc
Base-Emitter Saturation Voltage ($I_C = 150$ mAdc, $I_B = 15$ mAdc)	$V_{BE(sat)}$	—	1.7	Vdc
Base-Emitter On Voltage ($I_C = 150$ mAdc, $V_{CE} = 2.5$ Vdc)	$V_{BE(on)}$	—	1.7	Vdc
DYNAMIC CHARACTERISTICS				
Current-Gain—Bandwidth Product ($I_C = 50$ mAdc, $V_{CE} = 10$ Vdc, $f = 20$ MHz)	f_T	100	—	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 140$ kHz)	C_{ob}	—	15	pF
Input Capacitance ($V_{BE} = 0.5$ Vdc, $I_C = 0$, $f = 140$ kHz)	C_{ib}	—	80	pF

*Pulse Test: Pulse Width = 300 μs, Duty Cycle = 2%

2N3823 (SILICON)



V_{DS} = 30 V
I_D = 10 mA
P_D = 300 mW



CASE 20
(TO-72)

Silicon N-channel junction field-effect transistor designed for VHF amplifier and mixer applications. Drain and source may be interchanged.

Characteristic	Symbol	Rating	Unit
Drain-Source Voltage	V_{DS}	30	Vdc
Drain-Gate Voltage	V_{DG}	30	Vdc
Gate-Source Voltage	V_{GS}	-30	Vdc
Gate Current	I_D	10	mAdc
Power Dissipation Derate above 25°C	P_D	300 2	mW mW/°C
Operating Junction Temperature	T_J	175	°C
Storage Temperature Range	T_{stg}	-65 to +200	°C

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

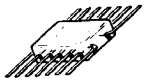
Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Gate-Source Breakdown Voltage (I_G = -1 μAdc, V_{DS} = 0)	$V_{(BR)GSS}$	-30	-	Vdc
Gate Reverse Current (V_{GS} = -20 Vdc, V_{DS} = 0) (V_{GS} = -20 Vdc, V_{DS} = 0, T_A = 150°C)	I_{GSS}	- -	-0.50 -500	nAdc
Gate-Source Cutoff Voltage (I_D = 0.50 nAdc, V_{DS} = 15 Vdc)	$V_{GS(off)}$	-	-8	Vdc
Gate-Source Voltage (I_D = 0.4 mAdc, V_{DS} = 15 Vdc)	V_{GS}	-1.0	-7.5	Vdc
ON CHARACTERISTICS				
Zero-Gate-Voltage Drain Current* (V_{DS} = 15 Vdc, V_{GS} = 0)	I_{DSS}*	4	20	mAdc
DYNAMIC CHARACTERISTICS				
Forward Transfer Admittance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$\lvert y_{fs} \rvert$ *	3500 3200	6500 -	μmhos
Input Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$Re(y_{is})$	-	800	μmhos
Output Conductance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 kHz)* (V_{DS} = 15 Vdc, V_{GS} = 0, f = 200 MHz)	$\lvert y_{os} \rvert$ * $Re(y_{os})$	- -	35 200	μmhos
Input Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{iss}	-	6	pF
Reverse Transfer Capacitance (V_{DS} = 15 Vdc, V_{GS} = 0, f = 1 MHz)	C_{rss}	-	2	pF
Common-Source Spot Noise Figure (V_{DS} = 15 Vdc, V_{GS} = 0, R_S = 1000 ohms, f = 100 MHz)	NF	-	2.5	dB

*Pulse Test: Pulse Width = 100 ms, Duty Cycle ≤ 10%

MC313F

MECL

Quad 2-Input NOR Gate



CASE 83

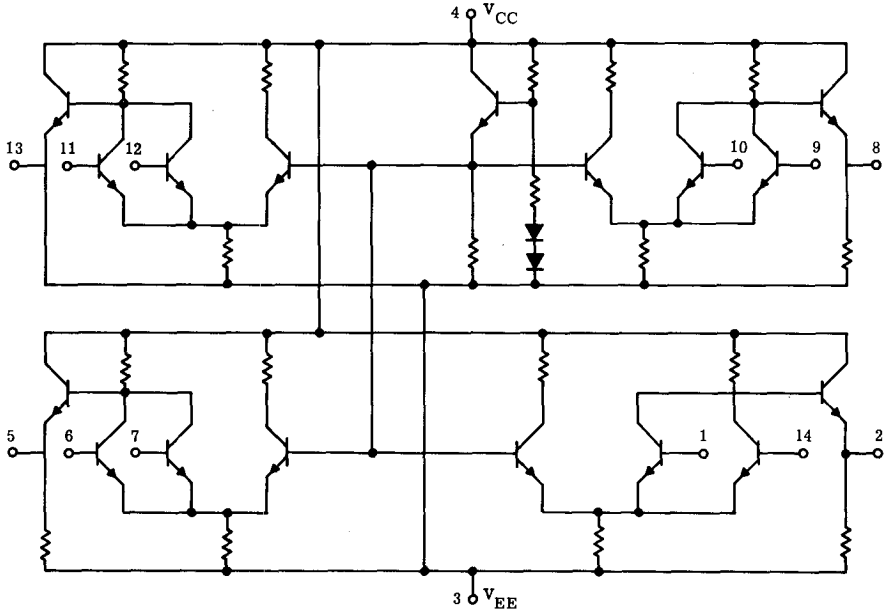
The MC313F is a monolithic Integrated Circuit Emitter Coupled Logic (MECL) Quad 2-Input Gate element. This gate element provides the positive logic "NOR" function. A bias driver is "built-in" to the circuit, eliminating the necessity for any external biasing.

The MC313F is available in the TO-86 1/4" x 1/4" 14 lead flat pack in the full military temperature range of -55° to +125°C.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Logic Input Voltage (Pins 1, 6, 7, 9, 10, 11, 12 & 14)	—	5	Volts
Power Supply Voltage	—	10	Volts
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

FIGURE 1 — CIRCUIT SCHEMATIC



MC313F (continued)

ELECTRICAL CHARACTERISTICS (@ 25°C)

V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0 Vdc All unused inputs are returned to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 2)				
Logical "1" Output Voltage (V_{in} = -1.35 Vdc each input)	V_1	0.690	0.795	Vdc
Logical "0" Output Voltage (V_{in} = -0.795 Vdc each input)	V_4	1.465	1.750	Vdc
Saturation Breakpoint Voltage ($dv(NOR)/dV_{in}$ = 0)	V_3	—	0.55	Vdc
Output Voltage Change (no load to full load) No load = 0 ma Full load = -2.5 ma	ΔV_1	—	0.055	Vdc
Total Unit Power Supply Current Drain	I_E	23	30	mAdc
Input Current (V_1 = -0.690 Vdc each input)	I_{in}	—	100	μAdc
Fan Out	n	—	25	—
Switching Characteristics (Figure 3)				
Fan Out = 1	t_{d1}	—	11.0	ns
Fan Out = 1	t_{d2}	—	13.5	ns
Fan Out = 1	t_r	—	12.0	ns
Fan Out = 1	t_f	—	14.0	ns

ELECTRICAL CHARACTERISTICS (@ −55°C)

DC Characteristics (Figure 2) (V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Logical "1" Output Voltage (V_{in} = -1.45 Vdc each input)	V_1	0.825	0.945	Vdc
Logical "0" Output Voltage (V_{in} = -0.945 Vdc each input)	V_4	1.560	1.850	Vdc
Saturation Breakpoint Voltage ($dv(NOR)/dV_{in}$ = 0)	V_3	—	0.40	Vdc
Output Voltage Change (no load to full load) No load = 0 mA, Full load = 2.5 mA	ΔV_1	—	0.055	Vdc

ELECTRICAL CHARACTERISTICS (@ 125°C)

DC Characteristics (Figure 2) (V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Logical "1" Output Voltage (V_{in} = -1.30 Vdc each input)	V_1	0.525	0.655	Vdc
Logical "0" Output Voltage (V_{in} = -0.655 Vdc each input)	V_4	1.340	1.675	Vdc
Saturation Breakpoint Voltage ($dv(NOR)/dV_{in}$ = 0)	V_3	—	0.68	Vdc
Output Voltage Change (no load to full load) No load = 0 mA - Full load = -2.5 mA	ΔV_1	—	0.060	Vdc

MC313F (continued)

FIGURE 2 — TRANSFER CHARACTERISTICS and METHOD OF TEST

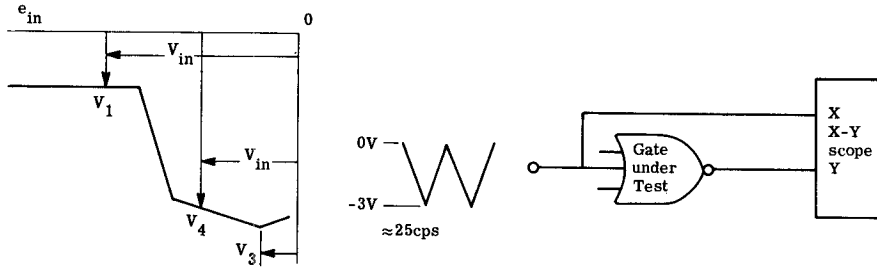
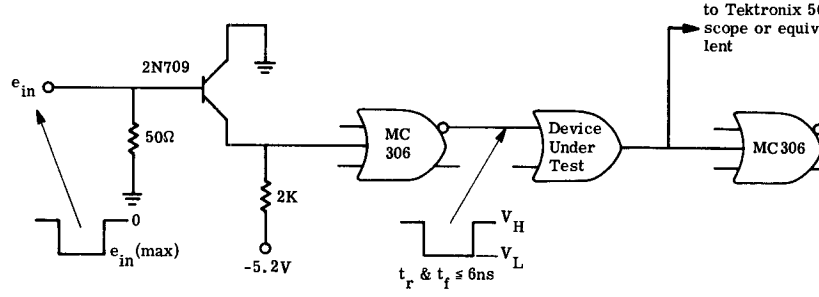
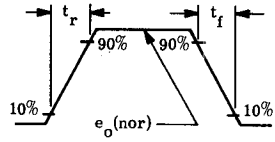


FIGURE 3 — SWITCHING TEST CIRCUIT and WAVEFORMS

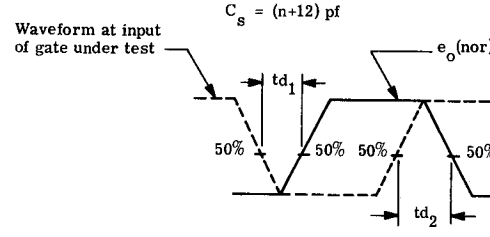


e_{in}(max) Temp.
-.800V +25°C

n = number of fan outs



C_s = (n+12) pf

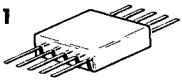


MC314

AC Coupled MECL J-K Flip-Flop



SUFFIX "G" DEVICES
CASE 71



SUFFIX "F" DEVICES
CASE 72

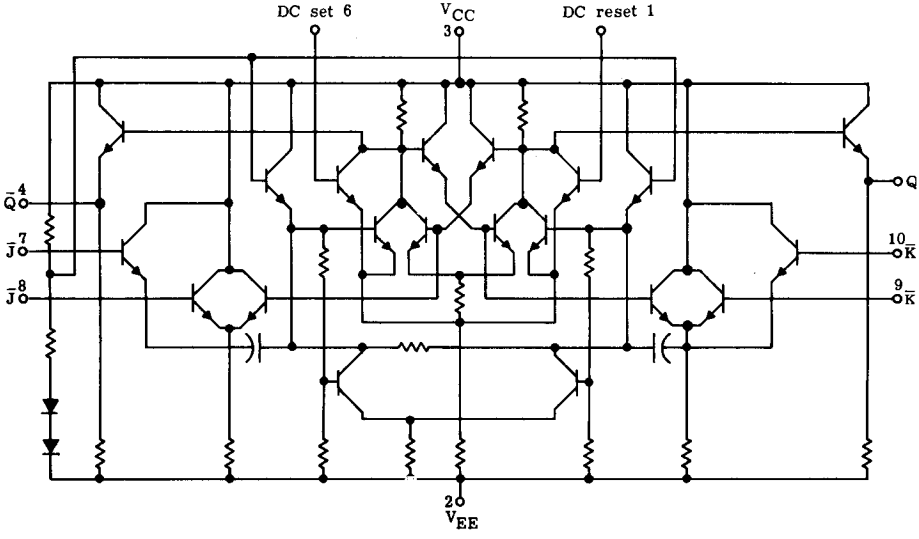
The MC314 is a J-K Flip Flop in the MECL series of monolithic Integrated Circuits designed for use in high speed digital computer systems. It is designed to operate reliably across the full military temperature range of -55° to +125°C at clock frequencies of 30 Mhz. The MC314 contains logic performing inputs (J and K) as well as DC set and reset inputs.

It is electrically interchangeable with the MC308 when clock frequencies higher than the MC308's capabilities are required.

MAXIMUM RATINGS (@ 25°C)

Characteristic	Symbol	Max	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

CIRCUIT SCHEMATIC



MC314 (continued)

ELECTRICAL CHARACTERISTICS (@ 25°C)

(V_{EE} = -5.2 Vdc ± 1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 1)				
"Q" logical "1" Output Voltage	V_1	0.690	0.795	Vdc
"Q" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.65	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.690	0.795	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.65	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx$	∞			
Latch Voltage	V_L	1.09	1.21	Vdc
Total Unit Current Drain	—	—	28.5	mAdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.055	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.055	Vdc
Switching Characteristics (See Figure 2)				
Propagation Delay Time (Both Outputs)	t_{dr} t_{df}	— —	16.0 16.0	ns ns
Rise Time (Both Outputs)	t_r	—	16.0	ns
Fall Time (Both Outputs)	t_f	—	16.0	ns
Clock Noise Insensitivity (Unit must not toggle, See Fig. 3)	C_{V1}	300	—	mV
Clock Amplitude (Unit must toggle, See Figure 4)	C_{V2}	550	—	mV
Maximum Effective Clock Rise Time	t_{rC}	—	50	ns
Toggle Frequency	f_T	30	—	MHz

MC314 (continued)

ELECTRICAL CHARACTERISTICS (@-55°C)

V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 1)				
"Q" logical "1" Output Voltage	V_1	0.825	0.945	Vdc
"Q" logical "0" Output Voltage	V_2	1.595	1.850	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.50	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.825	0.945	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.595	1.850	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.50	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$				
Latch Voltage	V_L	1.16	1.34	Vdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.055	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.055	Vdc

ELECTRICAL CHARACTERISTICS (@ 125°C)

DC Characteristics (Figure 1) (V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

"Q" logical "1" Output Voltage	V_1	0.525	0.655	Vdc
"Q" logical "0" Output Voltage	V_2	1.340	1.675	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.75	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.525	0.655	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.345	1.675	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.75	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$				
Latch Voltage	V_L	0.93	1.07	Vdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.060	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.060	Vdc

MC314 (continued)

FIGURE 1 — TRANSFER CHARACTERISTICS

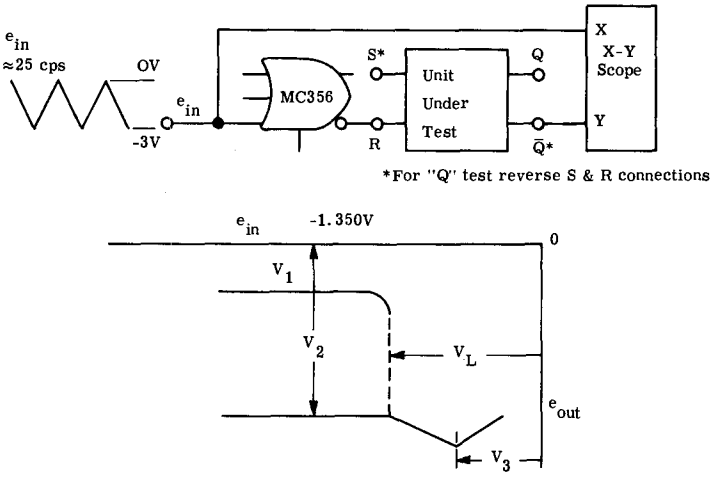
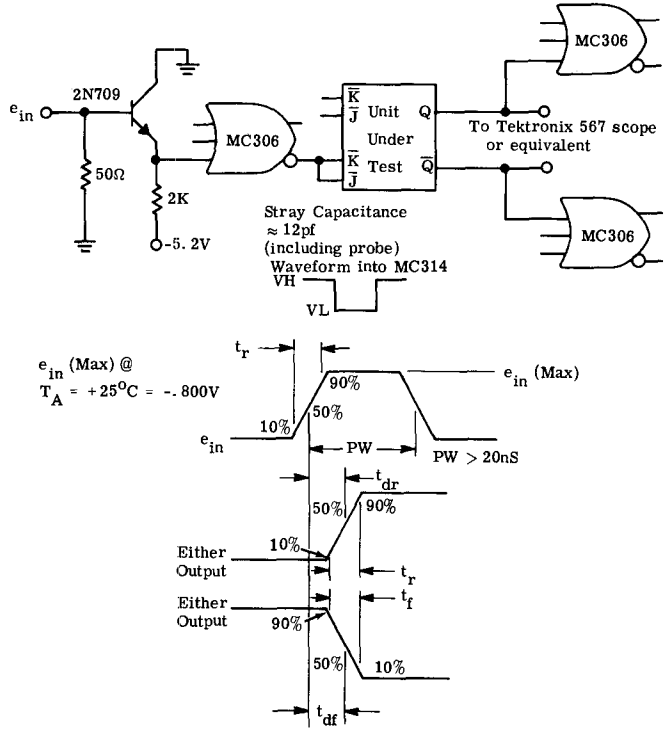


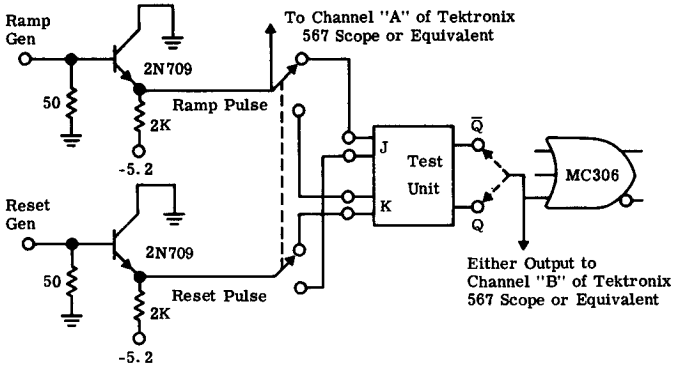
FIGURE 2 — SWITCHING TEST CIRCUIT and WAVEFORMS



MC314 (continued)

FIGURE 3 — NOISE INSENSITIVITY

(Unit must not toggle)



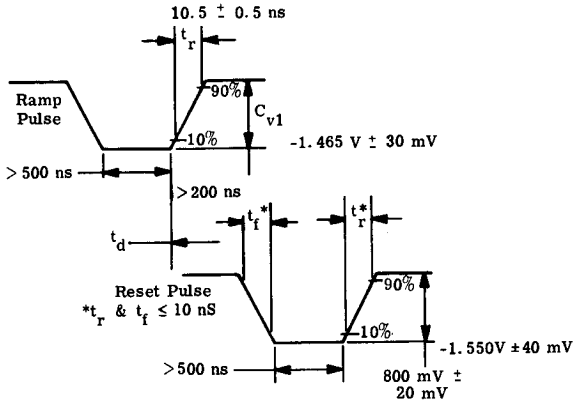
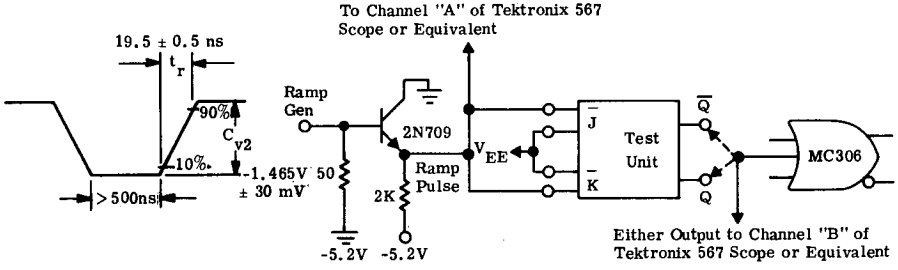


FIGURE 4 — CLOCK AMPLITUDE

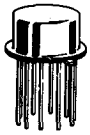
(Unit must toggle)



MC315

MECL

Line and Capacity Driver



SUFFIX "G" DEVICES

CASE 71



SUFFIX "F" DEVICES

CASE 72

The MC315 was designed to drive lines from 50 to 200 ohms. The circuit can also be used as a clock driver and is the same as the MC306 gate except for the output stage. The logic is a 3 input OR, NOR circuit with both outputs available simultaneously.

The circuit is capable of driving up to 25 gate loads while terminated with 50 Ω, and can drive 1000 pF with a typical propagation delay of 20 ns.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Operating Temperature Range	T_A	-55 to +125	°C
Storage Temperature	T_{stg}	-65 to +150	°C

ELECTRICAL CHARACTERISTICS (at 25°C)

V_{CC} = 0, V_{EE} = -5.2 Vdc ±1%, V_{BB} = -1.15 Vdc ±1%. All unused inputs connected to V_{EE}.

Test	Conditions	Symbol	Min	Max	Unit
"NOR" Logical "1" Output Voltage	V_{in} = -1.35 Vdc each input R_5 = 50 Ω	V_1	-0.670	-0.795	Vdc
"OR" Logical "0" Output Voltage	V_{in} = -1.35 Vdc each input R_4 = 50 Ω	V_2	-1.450	-1.750	Vdc
"NOR" Logical "0" Output Voltage	V_{in} = -0.795 Vdc each input R_5 = 50 Ω	V_4	-1.450	-1.750	Vdc
"OR" Logical "1" Output Voltage	V_{in} = -0.795 Vdc each input R_4 = 50 Ω	V_5	-0.670	-0.795	Vdc
Max Input Current	V_{in} = -0.690 Vdc each input V_1 = -1.15 Vdc	$I_{6, 7, 8}$	—	100	μAdc
Total Unit Current Drain	With 50 ohm load to ground, from Pins 4 & 5	I_E	—	65	mAdc

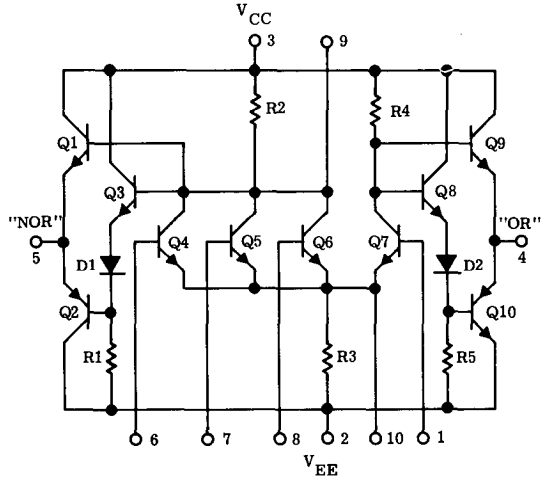
MC315 (continued)

ELECTRICAL CHARACTERISTICS

Switching Characteristics: V_{CC} = 0, V_{EE} = -5.2 Vdc ±1%, V_{BB} = -1.15 Vdc ±1%
V_H = -0.75 Vdc, V_L = -1.55 Vdc, Fan In = 1

Test	Conditions	Symbol	Typ	Max	Unit
Propagation Delay					
"NOR" Output	R_T = 50 Ω C_T = 500 pf (see Fig. 3)	t_{d1}	14	30	ns
"OR" Output		t_{d1}	16	35	ns
"NOR" Output		t_{d1}	17	35	ns
"OR" Output		t_{d1}	14	30	ns
Rise Time					
"NOR" Output		t_r	20	37	ns
"OR" Output		t_r	16	35	ns
Fall Time					
"NOR" Output		t_f	20	37	ns
"OR" Output		t_f	19	37	ns

FIGURE 1 — CIRCUIT SCHEMATIC, MECL LINE DRIVER



MC315 (continued)

FIGURE 2 — TRANSFER CHARACTERISTICS and METHOD OF TEST

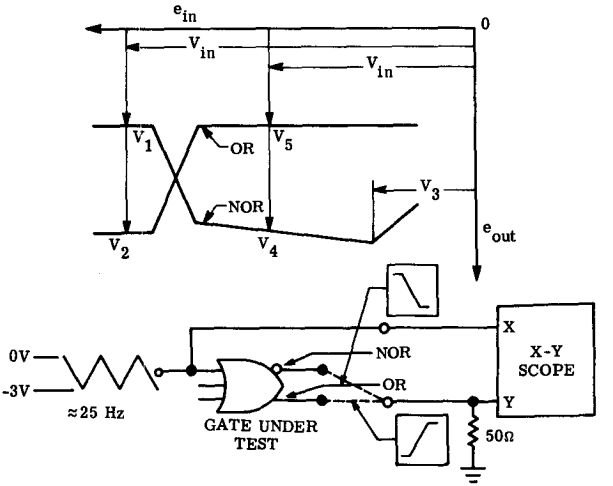
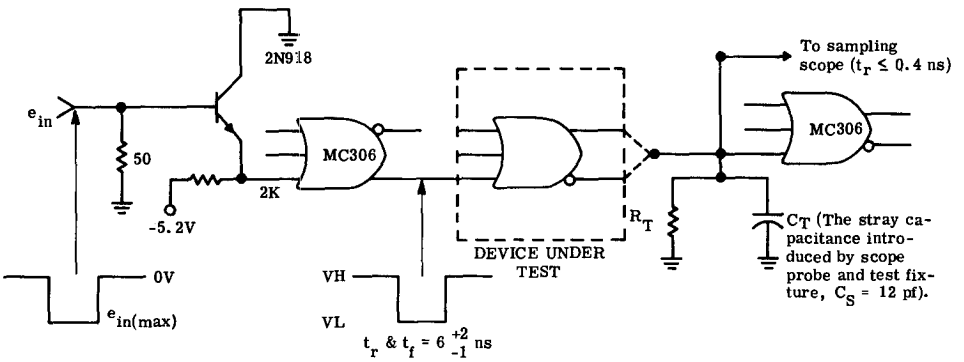
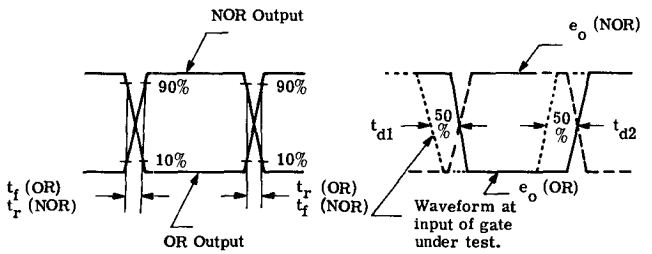


FIGURE 3 — SWITCHING TIME TEST CIRCUIT and WAVEFORMS (NDR & OR)





MC315 (continued)

TYPICAL SWITCHING CHARACTERISTICS

FIGURE 4 — "OR" OUTPUT

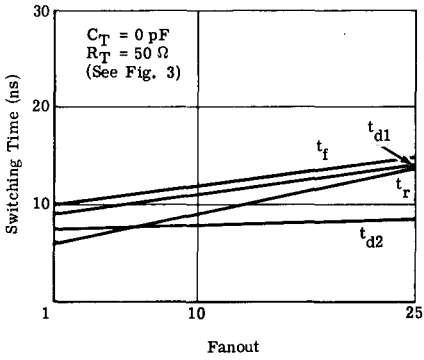
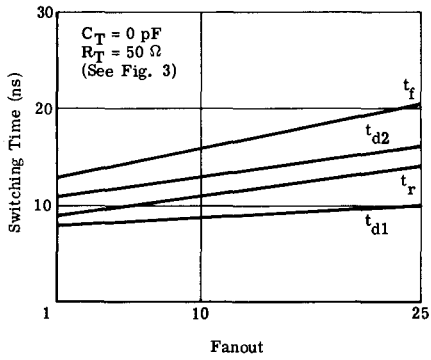


FIGURE 5 — "NOR" OUTPUT



Typical Switching Characteristics with Fanout Loading, $R_T = 50$, $C_T = 0$ pF (See Fig. 3)

FIGURE 6 — "OR" OUTPUT

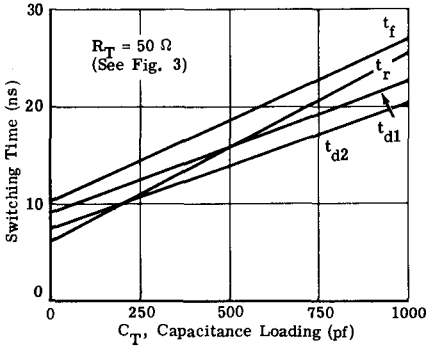
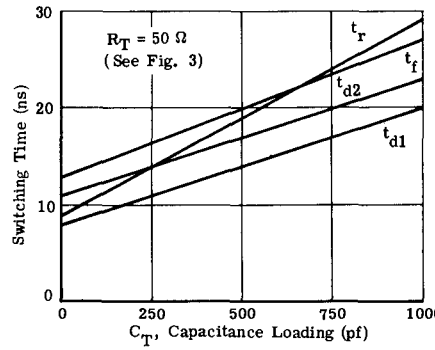


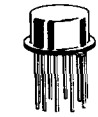
FIGURE 7 — "NOR" OUTPUT



Typical Switching Characteristics with R_T = 50 Ω loading (See Fig. 3)

MC358A

AC Coupled MECL J-K Flip-Flop



SUFFIX "G" DEVICES
CASE 71



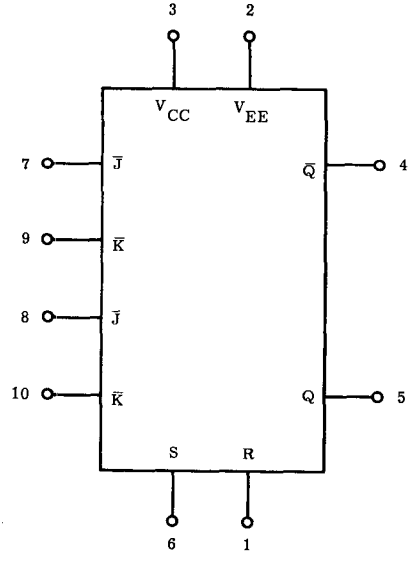
SUFFIX "F" DEVICES
CASE 72
TO-91

The MC358A is a J-K Flip-Flop in the MECL series of monolithic Integrated Circuits designed for use in high speed digital computer systems. It is designed to operate reliably across the limited temperature range of 0 to +75° C. The MC358A contains logic performing inputs (J and K) as well as DC set and reset inputs.

It is electrically interchangeable with the MC358.

MAXIMUM RATINGS (@ 25°C)

Characteristic	Symbol	Max	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C



MC358A (continued)

ELECTRICAL CHARACTERISTICS (@ 25°C)

(V_{EE} = -5.2 Vdc ± 1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 2)				
"Q" logical "1" Output Voltage	V_1	0.670	0.795	Vdc
"Q" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.65	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.670	0.795	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage "Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$	V_3	—	0.65	Vdc
Latch Voltage	V_L	1.09	1.21	Vdc
Total Unit Current Drain	—	—	16	mAdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.065	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.065	Vdc
Switching Characteristics (See Figure 1)				
Propagation Delay Time (Both Outputs)	t_{dr} t_{df}	— —	15.0 16.0	ns ns
Rise Time (Both Outputs)	t_r	—	16.0	ns
Fall Time (Both Outputs)	t_f	—	16.0	ns
Clock Noise Insensitivity (Unit must not toggle, See Fig. 3)	C_{V1}	250	—	mV
Clock Amplitude (Unit must toggle, See Figure 4)	C_{V2}	590	—	mV

MC358A (continued)

ELECTRICAL CHARACTERISTICS (@ 0°C)

V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 2)				
"Q" logical "1" Output Voltage	V_1	0.715	0.850	Vdc
"Q" logical "0" Output Voltage	V_2	1.510	1.800	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.61	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.715	0.850	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.510	1.800	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.61	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$				
Latch Voltage	V_L	1.11	1.25	Vdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.065	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.065	Vdc

ELECTRICAL CHARACTERISTICS (@ 75°C)

(V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

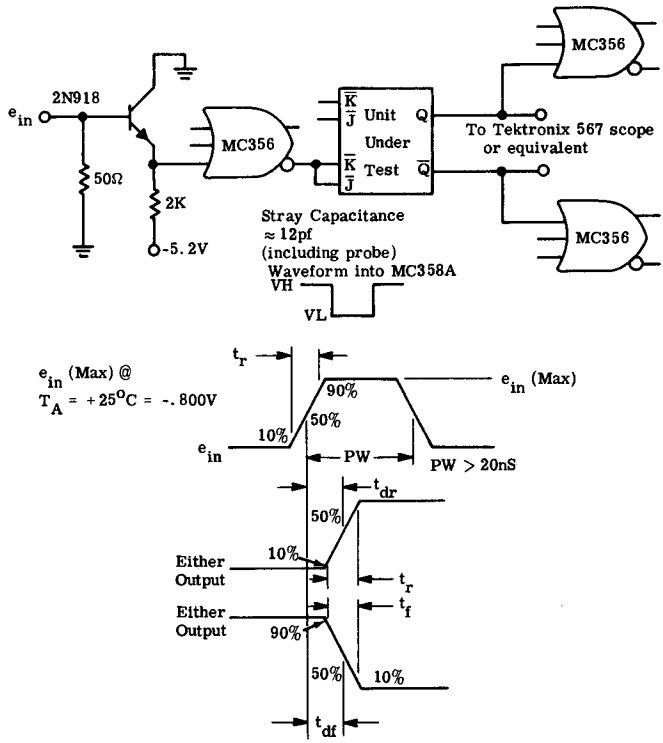
Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 2)				
"Q" logical "1" Output Voltage	V_1	0.580	0.725	Vdc
"Q" logical "0" Output Voltage	V_2	1.395	1.730	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.73	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.580	0.725	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.395	1.730	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.73	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$				
Latch Voltage	V_L	1.02	1.14	Vdc

MC358A (continued)

ELECTRICAL CHARACTERISTICS (@ 75°C) (continued)

Characteristic	Symbol	Min	Max	Unit
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = 02.5 mA)	ΔV_1	—	0.075	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.075	Vdc

FIGURE 1 — SWITCHING TEST CIRCUIT & WAVEFORMS



MC358A (continued)

FIGURE 2 — TRANSFER CHARACTERISTICS

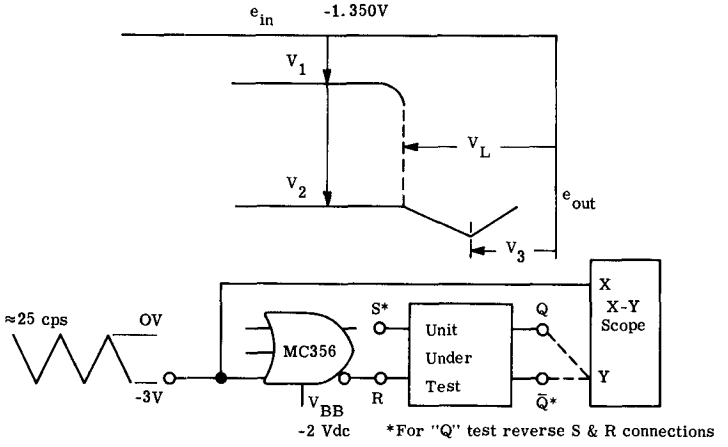
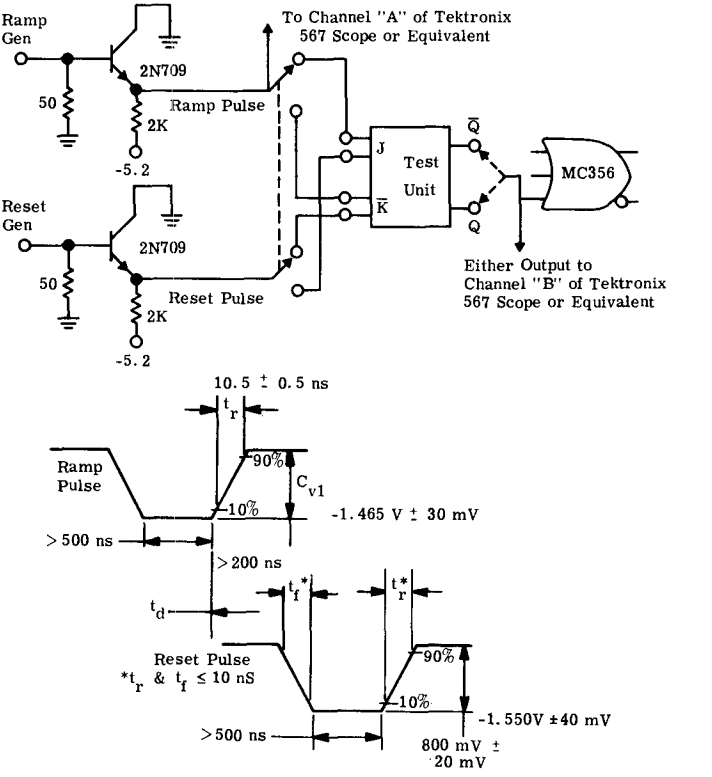


FIGURE 3 — NOISE INSENSITIVITY

(Unit must not toggle)



MC358A (continued)

FIGURE 4 — CLOCK AMPLITUDE

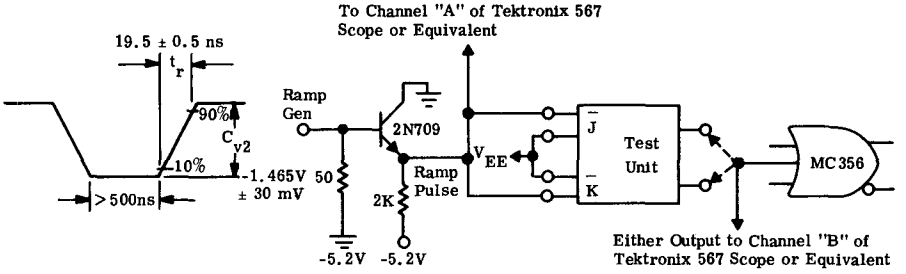
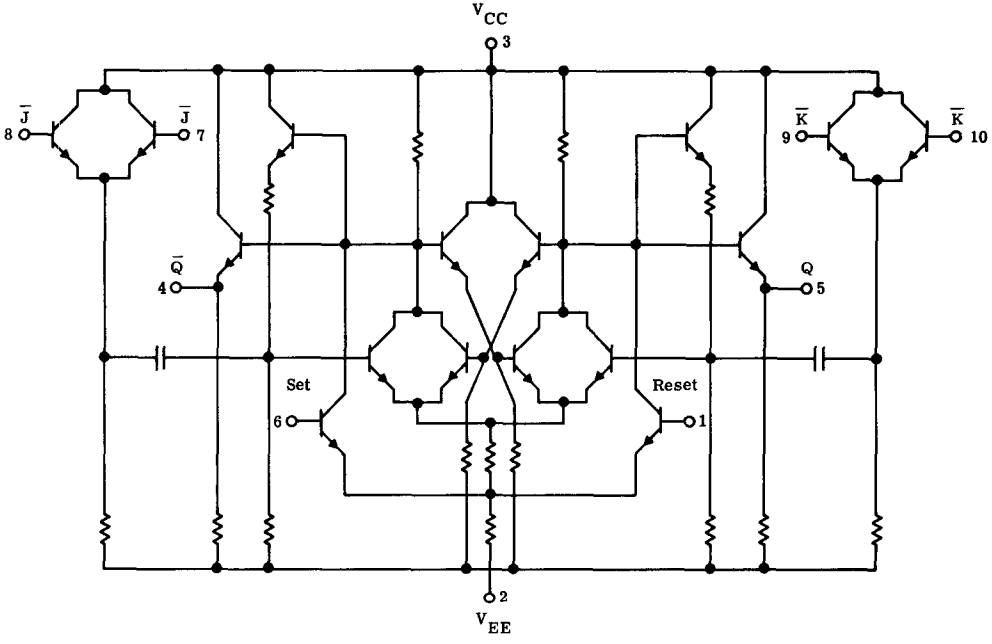


FIGURE 5 — CIRCUIT SCHEMATIC



MC364

AC Coupled MECL J-K Flip-Flop



CASE 71
SUFFIX "G" DEVICES



CASE 72
SUFFIX "F" DEVICES

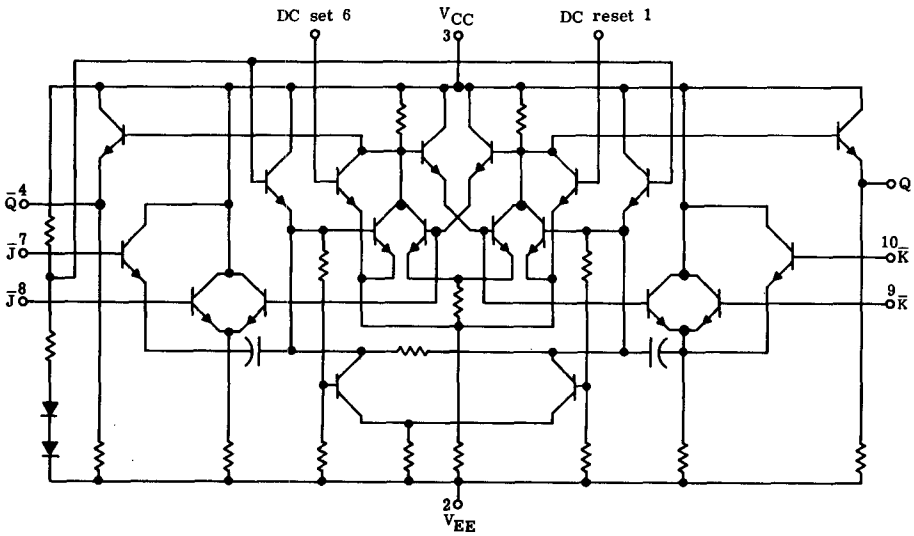
The MC364 is a J-K Flip Flop in the MECL series of monolithic Integrated Circuits designed for use in high speed digital computer systems. It is designed to operate reliably across the limited temperature range of 0 to +75°C at clock frequencies of 30 MHz. The MC364 contains logic performing inputs (J and K) as well as DC set and reset inputs.

It is electrically interchangeable with MC358A when clock frequencies higher than the MC358A's capabilities are required.

MAXIMUM RATINGS (@ 25°C)

Characteristic	Symbol	Max	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature Range	T_{stg}	-65 to +150	°C

CIRCUIT SCHEMATIC



MC364 (continued)

ELECTRICAL CHARACTERISTICS (@ 25°C)

(V_{EE} = -5.2 Vdc ± 1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 1)				
"Q" logical "1" Output Voltage	V_1	0.670	0.795	Vdc
"Q" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.65	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.670	0.795	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.465	1.750	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage "Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx \infty$	V_3	—	0.65	Vdc
Latch Voltage	V_L	1.09	1.21	Vdc
Total Unit Current Drain	—	—	28.5	mAdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.065	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.065	Vdc
Switching Characteristics (See Figure 2)				
Propagation Delay Time (Both Outputs)	t_{dr} t_{df}	— —	18.0 18.0	ns ns
Rise Time (Both Outputs)	t_r	—	19.0	ns
Fall Time (Both Outputs)	t_f	—	19.0	ns
Clock Noise Insensitivity (Unit must not toggle, See Fig. 3)	C_{V1}	250	—	mV
Clock Amplitude (Unit must toggle, See Fig. 4)	C_{V2}	590	—	mV
Maximum Effective Clock Rise Time	t_{rC}	—	50	ns
Toggle Frequency	f_T	30	—	MHz

MC364 (continued)

ELECTRICAL CHARACTERISTICS (@ 0°C)

(V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

Characteristic	Symbol	Min	Max	Unit
DC Characteristics (Figure 1)				
"Q" logical "1" Output Voltage	V_1	0.715	0.850	Vdc
"Q" logical "0" Output Voltage	V_2	1.510	1.800	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.61	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.715	0.850	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.510	1.800	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.61	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx$	∞			
Latch Voltage	V_L	1.11	1.25	Vdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.065	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.065	Vdc

ELECTRICAL CHARACTERISTICS (@ 75°C)

DC Characteristics (Figure 1) (V_{EE} = -5.2 Vdc ±1%, V_{CC} = 0) All unused inputs connected to V_{EE}

"Q" logical "1" Output Voltage	V_1	0.580	0.725	Vdc
"Q" logical "0" Output Voltage	V_2	1.395	1.730	Vdc
"Q" Saturation Breakpoint Voltage	V_3	—	0.73	Vdc
"$\overline{Q}$" logical "1" Output Voltage	V_1	0.580	0.725	Vdc
"$\overline{Q}$" logical "0" Output Voltage	V_2	1.395	1.730	Vdc
"$\overline{Q}$" Saturation Breakpoint Voltage	V_3	—	0.73	Vdc
"Q" and "$\overline{Q}$" $dV_1/dV_{in} \approx$	∞			
Latch Voltage	V_L	1.02	1.14	Vdc
Loading Characteristics				
"Q" Output Voltage Change Between No Load (I_5 = 0) & Full Load Conditions (I_5 = -2.5 mA)	ΔV_1	—	0.075	Vdc
"$\overline{Q}$" Output Voltage Change Between No Load (I_4 = 0) & Full Load Conditions (I_4 = -2.5 mA)	ΔV_1	—	0.075	Vdc

MC364 (continued)

FIGURE 1 — TRANSFER CHARACTERISTICS

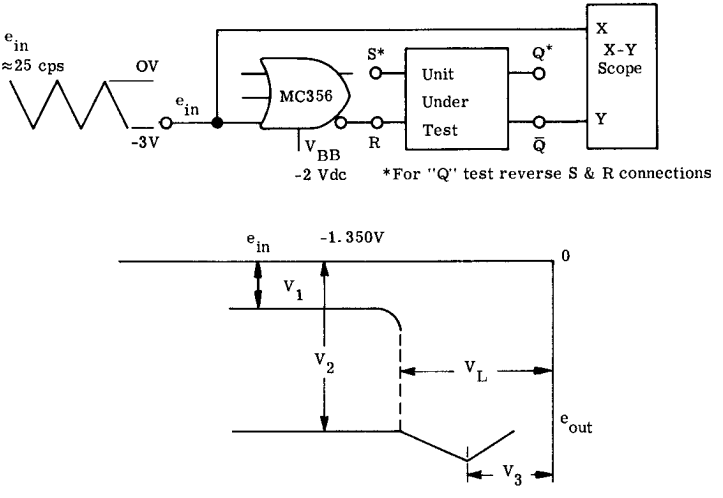
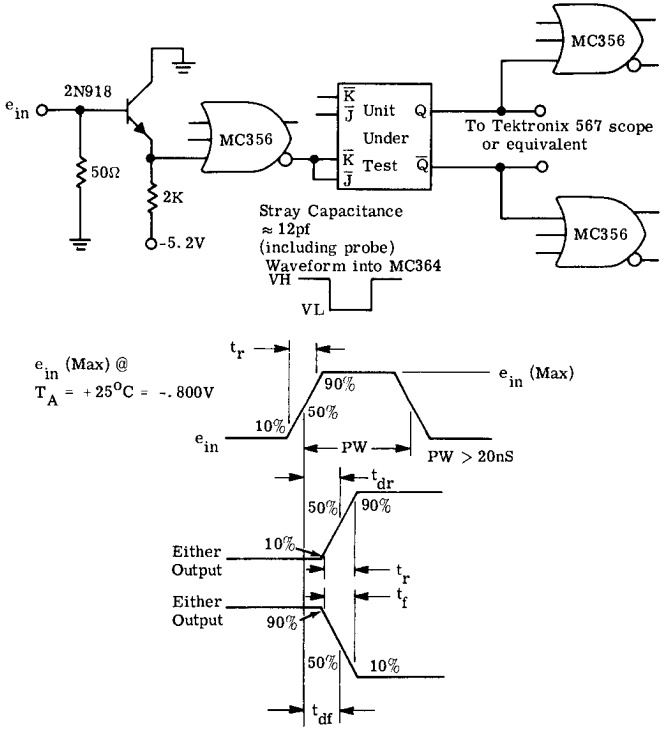


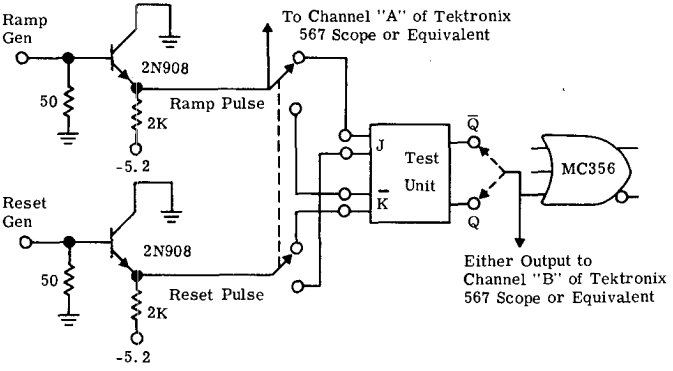
FIGURE 2 — SWITCHING TEST CIRCUIT and WAVEFORMS



MC364 (continued)

FIGURE 3 — NOISE INSENSITIVITY

(Unit must not toggle)



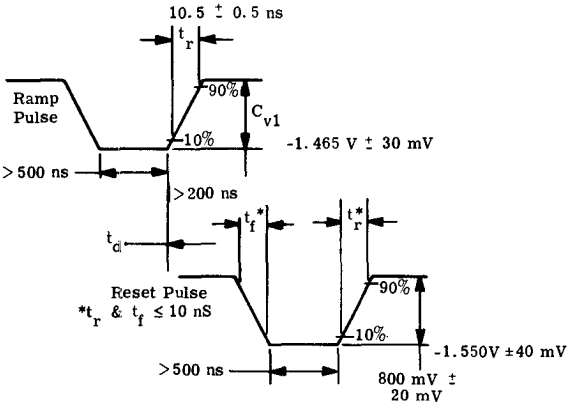
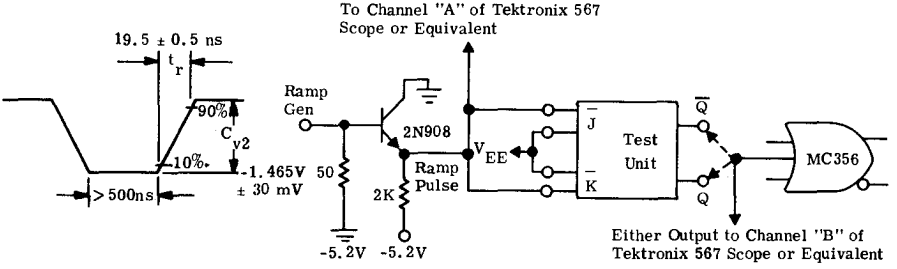


FIGURE 4 — CLOCK AMPLITUDE

(Unit must toggle)



MC365 MECL

Line and Capacity Driver



CASE 71
SUFFIX "G" DEVICES



CASE 72
SUFFIX "F" DEVICES

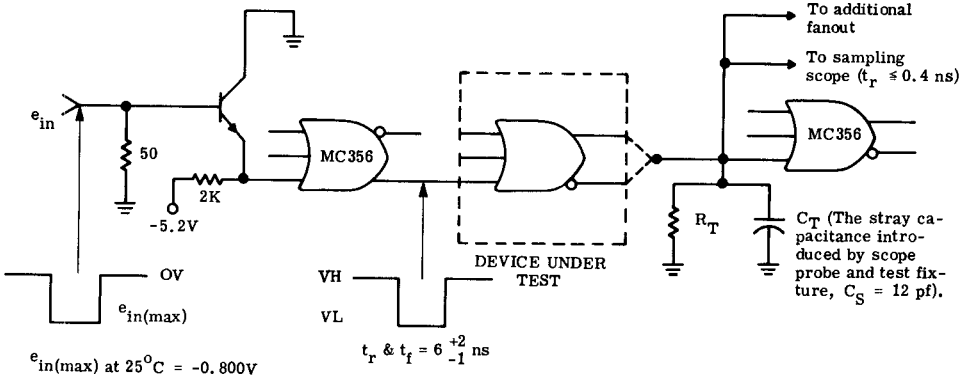
The MC365 was designed to drive lines from 50 to 200 ohms. The circuit can also be used as a clock driver and is the same as the MC356 gate except for the output stage. The logic is a 3 input OR, NOR circuit with both outputs available simultaneously.

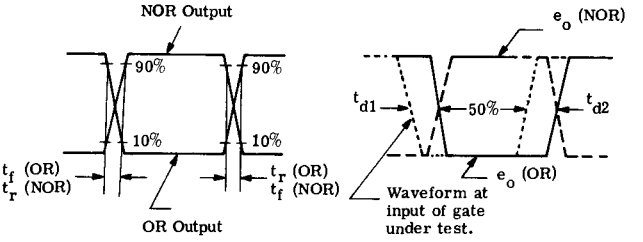
The circuit is capable of driving up to 25 gate loads while terminated with 50 Ω and can drive 1000 pF with a typical propagation delay of 20 ns.

MAXIMUM RATINGS

Characteristic	Symbol	Max	Unit
Logic Input Voltage	—	5	Vdc
Power Supply Voltage	—	10	Vdc
Output Source Current	I_o	10	mAdc
Operating Temperature Range	T_A	0 to +75	°C
Storage Temperature	T_{stg}	-55 to +150	°C

FIGURE 1 — SWITCHING TIME TEST CIRCUIT and WAVEFORMS (NOR & OR)





MC365 (continued)

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$)

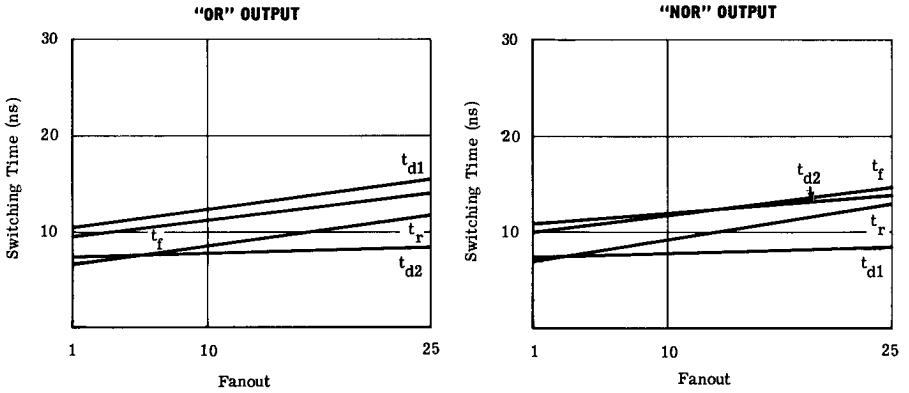
$V_{CC} = 0$, $V_{EE} = -5.2$ Vdc ±1%, $V_{BB} = -1.15$ Vdc ±1%, All unused inputs connected to V_{EE}.

Test	Conditions	Symbol	Min	Max	Unit
"NOR" Logical "1" Output Voltage	V_{in} = -1.35 Vdc each input	V_1	-0.650	-0.795	Vdc
"OR" Logical "0" Output Voltage	V_{in} = -1.35 Vdc each input	V_2	-1.455	-1.750	Vdc
"NOR" Logical "0" Output Voltage	V_{in} = -0.795 Vdc each input	V_4	-1.455	-1.750	Vdc
"OR" Logical "1" Output Voltage	V_{in} = -0.795 Vdc each input	V_5	-0.650	-0.795	Vdc
Max Input Current	V_{in} = -0.690 Vdc each input V_1 = -1.15 Vdc	$I_{6, 7, 8}$	—	100	μAdc
Total Unit Current Drain	With 50 ohm load to ground, from Pins 4 & 5	I_E	—	65	mAdc

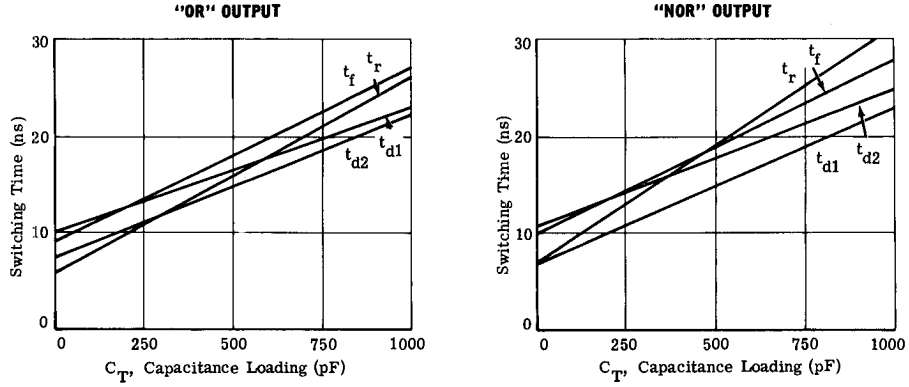
Switching Characteristics: $V_{CC} = 0$, $V_{EE} = -5.2$ Vdc, $V_{BB} = -1.15$ Vdc (all ±1%), $V_H = -0.75$ Vdc, $V_L = -1.55$ Vdc, Fan In = 1

Test	Conditions	Symbol	Typ	Max	Unit
Propagation Delay					
"NOR" Output	$R_T = 50\ \Omega$ $C_T = 1000$ pF (See Fig. 1)	t_{d1}	15	30	ns
"OR" Output		t_{d1}	17	35	ns
"NOR" Output		t_{d2}	18	35	ns
"OR" Output		t_{d2}	15	30	ns
Rise Time					
"NOR" Output		t_r	19	37	ns
"OR" Output		t_r	16	35	ns
Fall Time					
"NOR" Output		t_f	19	37	ns
"OR" Output		t_f	19	37	ns

MC365 (continued)

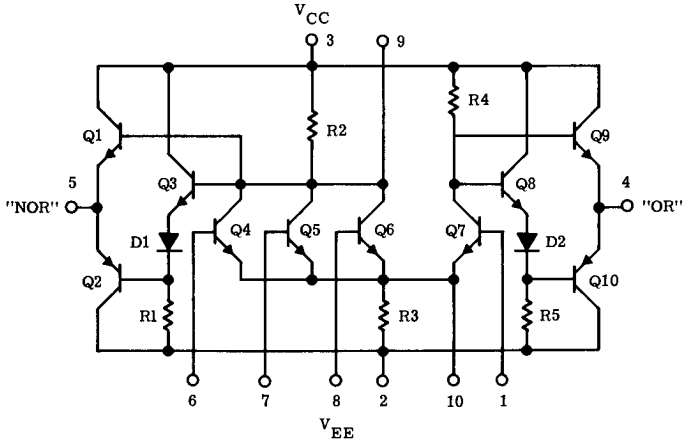


Typical Switching Characteristics with Fanout loading, $R_T = 50\Omega$, $C_T = 0$ pF



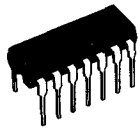
Typical Switching Characteristics with $R_T = 50\Omega$ loading

CIRCUIT SCHEMATIC, MECL LINE DRIVER



MC700P SERIES

MRTL PLASTIC INTEGRATED CIRCUITS



Milliwatt MRTL (low power) & MRTL (medium power) devices designed for use in commercial-industrial applications. Circuit loading guaranteed over a temperature range of +15°C to +55°C, one-piece, injection-molded plastic with dual in-line pin arrangement for automatic insertion.

MILLIWATT MRTL — *Low Power*

LOGIC GATES	
Quad 2-input Gate	MC717P
Dual 3-input Gate	MC718P
Dual 4-input Gate	MC719P
Triple 3-input Gate	MC793P
DUAL BUFFER	MC798P

MRTL — *Medium Power*

LOGIC GATES	
Dual 3-input Gate	MC715P
Quad 2-input Gate	MC724P
Dual 4-input Gate	MC725P
Hex Inverter	MC789P
Triple 3-input Gate	MC792P
DUAL BUFFER	MC799P
DUAL BUFFER (Non-Inverting)	MC788P
J-K FLIP-FLOP	MC723P
DUAL J-K FLIP-FLOP	MC790P

GENERAL RULES

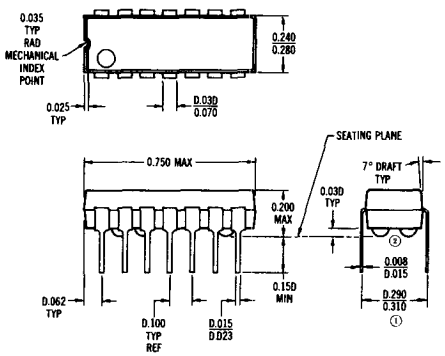
The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.

All unused inputs should be returned to ground.

V_{CC} is applied to Pin 11 with Pin 4 grounded.

Loading diagrams are intended for use when mixing Milliwatt MRTL and MRTL in system applications.

OUTLINE DIMENSIONS



① This dimension is measured at the seating plane.

② 4 insulating stand-offs are provided.

DEFINITIONS

I_{A3}, I_{A4}, I_{A10}, I_{A13}, I_{A16}	Minimum available output current for outputs with a loading factor of 3, 4, 10, 13, and 16 respectively
I_{AB}	Minimum available output current from a buffer
I_{in}	Maximum input current, with V_{in} applied and a fan-in greater than one
V_{BOT}	Maximum input voltage
V_{CC}	Supply voltage
V_{CE}	Maximum saturation voltage, V_{BOT} applied to input
V_{in}	Minimum high-level voltage
V_{off}	Maximum input voltage that will not turn the transistor on
V_{on}	Minimum turn-on voltage
V_{out}	Maximum output voltage, V_{on} applied to input
V_R	Value of external resistor connected from buffer output to V_{CC} to obtain indicated output voltage readings

MC700P SERIES (continued)

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Symbol	Rating	Unit
Logic Input Voltage		±4	Vdc
Power Supply Voltage (Pulsed ≤ 1 second)		+12	Vdc
Power Dissipation	P_D	250	mW
Operating Temperature Range	T_A	+15 to +55	°C
Storage Temperature Range	T_{stg}	-55 to +125	°C

TEST CONDITIONS AND LIMITS

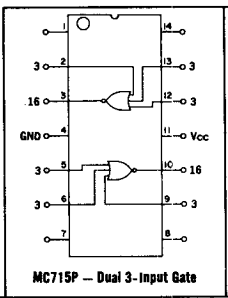
	Milliwatt MRTL			MRTL			Unit
	+15°C	+25°C	+55°C	+15°C	+25°C	+55°C	
TEST CONDITIONS							
V_{BOT}	1.8	1.8	1.8	1.8	1.8	1.8	Vdc
V_{CC}	3.6	3.6	3.6	3.6	3.6	3.6	Vdc
V_{in}	0.865	0.850	0.800	0.865	0.850	0.800	Vdc
V_{off}	0.475	0.460	0.430	0.475	0.460	0.430	Vdc
V_{on}	0.865	0.850	0.800	0.865	0.850	0.800	Vdc
V_R*	4600	4800	5000	640	640	640	Ohms

*mW MRTL - Highest node resistance value
MRTL - Nominal resistance value

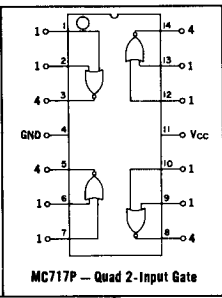
TEST LIMITS

I_{A3}	420	420	420	—	—	—	μAdc min
I_{A4}	570	570	570	—	—	—	μAdc min
I_{A10}	—	—	—	1.65	1.65	1.56	mAdc min
I_{A13}	—	—	—	2.15	2.15	2.03	mAdc min
I_{A16}	—	—	—	2.65	2.65	2.5	mAdc min
I_{AB}	5.0	5.0	5.0	13.5	13.75	12.5	mAdc min
I_{in}	150	150	150	500	500	470	μAdc max
V_{out}	0.400	0.300	0.320	0.400	0.300	0.320	Vdc max
V_{CE}	0.220	0.230	0.320	0.300	0.290	0.320	Vdc max

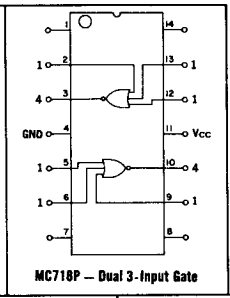
LOADING DIAGRAMS (Valid from +15°C to +55°C with V_{CC} = 3.6 V ±10% — TOP VIEWS)



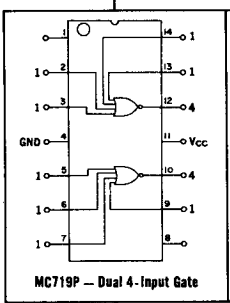
MC715P — Dual 3-Input Gate



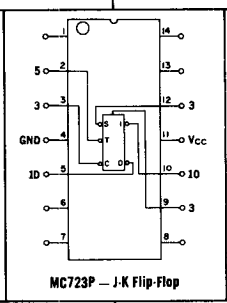
MC717P — Quad 2-Input Gate



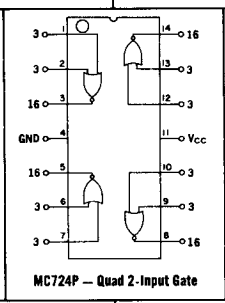
MC718P — Dual 3-Input Gate



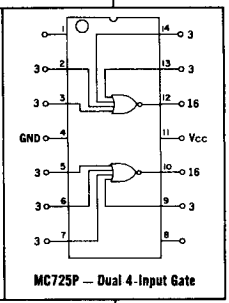
MC719P — Dual 4-Input Gate



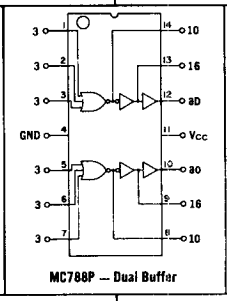
MC723P — J-K Flip-Flop



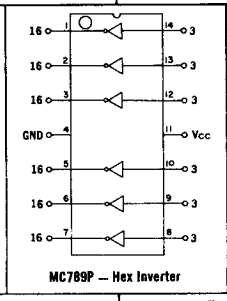
MC724P — Quad 2-Input Gate



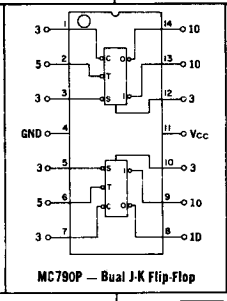
MC725P — Dual 4-Input Gate



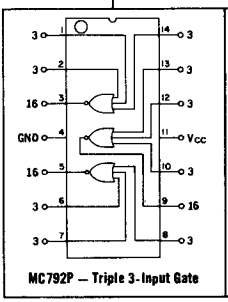
MC788P — Dual Buffer



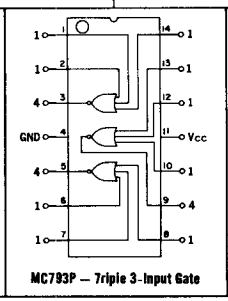
MC789P — Hex Inverter



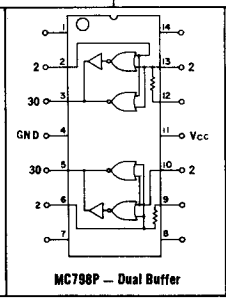
MC790P — Dual J-K Flip-Flop



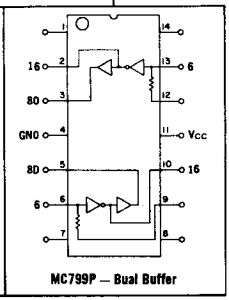
MC792P — Triple 3-Input Gate



MC793P — Triple 3-Input Gate



MC798P — Dual Buffer

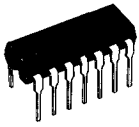


MC799P — Dual Buffer

Numbers at end of terminals indicate loading.

MC830P SERIES

MDTL PLASTIC INTEGRATED CIRCUITS



MC830P series MDTL integrated circuits designed for use in a commercial-industrial applications with circuit loading guaranteed over a temperature range of 0° to +75°C. Circuits are contained in a one-piece, pressure-molded plastic package with dual in-line pin arrangement for automatic insertion.

GENERAL RULES

- The number of load circuits that may be driven from an output is determined by the input loading factor. The summation of input loading should not exceed the drive capability of the output.
- The outputs of the Dual 4-input gate may be tied together to perform the wired-collector OR function. For each added gate subtract 1 unit fan-out. For six added gates only 5 unit loads need be subtracted.
- The outputs of the Dual Buffer may not be tied together.
- The outputs of the Dual Power Gate may be tied together to perform the wired-collector OR function.
- An external load resistor should be utilized with the Dual Power Gate. At $V_{CC} = 5.0 \pm 0.5$ V, subtract the following output loads:

R	
2 kΩ	— 2 loads
1 kΩ	— 4 loads
510 Ω	— 8 loads

- For increased current capability, the inputs and outputs of ½ MC832P and ½ MC844P can be paralleled (up to and including 4 common outputs). The combined output will equal 100 loads while each combined input will equal 4 loads.

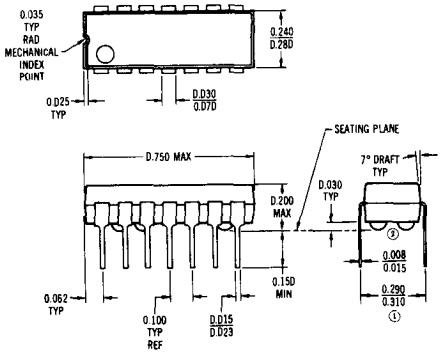
LOGIC FUNCTIONS

GATES	
Dual 4-Input Gate	MC830P
Dual 4-Input Power Gate	MC844P
Quad 2-Input Gate	MC846P
Triple 3-Input Gate	MC862P
GATE EXPANDER	MC833P
DUAL BUFFER	MC832P
CLOCKED FLIP-FLOPS	MC831P MC845P MC848P

DEFINITIONS

I_{CEX}	Collector-to-emitter leakage of the output transistor
$\frac{2}{3} I_F$	Forward current of input diodes which are ⅔ of unit load
I_F	Forward current of input diodes for unit input load
$2 I_F$	Forward current of input diodes which are twice the unit load
i_{FCP}	Forward current of clock input diodes
I_{FD}	Forward current of dual expander diodes
i_{FS}	Forward current of set and clear input diodes
I_{max}	Maximum rated power supply current with V_{max} applied
I_{OH}	Output high current
I_{OL}	Output low current
I_{PDH}	Power supply drain with the inputs high
i_R	Reverse current of input diodes with V_R applied
i_{RCP}	Reverse current of clock input diodes
I_{SC}	Short circuit obtained from device output when one or more inputs are low
V_{CC}	Power supply voltage
V_{CEX}	Output transistor collector-to-emitter voltage
V_{CPTH}	Clock threshold voltage
V_F	Forward voltage of input diodes
V_{FD}	Forward voltage of dual expander diodes
V_{IH}	Voltage for high input voltage state
V_{IL}	Voltage for low input voltage state
V_{ILS}	Voltage for low set and clear input voltage state
V_{max}	Maximum rated power supply voltage (V_{CC})
V_{OH}	Output high voltage with I_{OH} flowing out of pin
V_{OL}	Output low voltage with I_{OL} flowing into pin
V_{PD}	Power supply voltage for power dissipation test
V_R	Reverse voltage for input diode leakage test
V_X	Low voltage utilized in testing expander inputs

OUTLINE DIMENSIONS



① This dimension is measured at the seating plane.
② 4 insulating stand-offs are provided.

MC830P SERIES (continued)

MAXIMUM RATINGS ($T_A = 25°C$)

Characteristic	Rating	Unit
Supply Voltage Continuous Pulsed, < 1 second	 +8 +12	Vdc
Output Current into Outputs MC832P, MC844P - Continuous Pulsed, < 30 ms All other types	 150 300 30	mAdc
Input Forward Current	-10	mAdc
Input Reverse Current MC832P, MC844P All other types	 5.0 1.0	mAdc
Operating Temperature Range	0 to +75	°C
Storage Temperature Range	-55 to +125	°C

ELECTRICAL CHARACTERISTICS

Characteristic	Applicable to:	0°C	+25°C	+75°C	Unit
V_{OL} @ I_{OL} & V_{IH}	Gates, Flip-Flops, Buffer	0.45	0.45	0.50	Vdc max
V_{OH} @ I_{OH} & V_{IL}	Gates**, Flip-Flops, Buffer	2.60	2.60	2.50	Vdc min
LV_{CE} @ I_{CE}	MC844P	-	6.0	-	Vdc min
V_{FD} @ I_{FD}	MC833P	0.75* 0.90‡	0.68* 0.82‡	0.60* 0.75‡	Vdc min Vdc max
I_{SC}	MC830P, MC846P, MC862P MC832P	-1.30 -15	-1.30 -16	-1.25 -14	mAdc max mAdc min
I_R @ V_R	All Types	5.0	5.0	10	μAdc max
2 I_R @ V_R	MC833P	-	10	-	μAdc max
I_{RCP} @ V_R	Flip-Flops	30	30	40	μAdc max
I_{CEX} @ V_{CEX}	Gates, Buffer	-	100	-	μAdc max
I_F @ V_F	Gates, Buffer	-1.40	-1.40	-1.33	mAdc max
2/3 I_F @ V_F	Flip-Flops	-0.95	-0.95	-0.90	mAdc max
I_{FCP} @ V_{IL}	Flip-Flops	-2.80	-2.80	-2.67	mAdc max
I_{FS} @ V_F	MC831P MC845P, MC848P	-1.05 -2.80	-1.05 -2.80	-1.00 -2.67	mAdc max

* Ground pins 2, 3, 5, and 6 OR 9, 10, 12, and 13 simultaneously.
‡ Ground pins 2, 3, 5, and 6 OR 9, 10, 12, and 13 sequentially.

(continued)

MC830P SERIES (continued)

ELECTRICAL CHARACTERISTICS (continued)

Characteristic	Applicable to:	0°C	+25°C	+75°C	Unit
I_{PDH} @ V_{PD}	MC830P	-	8.0	-	mAdc max
	MC831P	-	14.0	-	
	MC832P	-	30.0	-	
	MC844P	-	22.5	-	
	MC845P	-	14.0	-	
	MC846P	-	16.0	-	
	MC848P	-	17.0	-	
	MC862P	-	12.0	-	
I_{max} @ V_{max}	MC830P, MC832P, MC844P	-	8.0	-	mAdc max
	MC831P, MC845P	-	18.0	-	
	MC846P	-	16.0	-	
	MC848P	-	22.5	-	
	MC862P	-	12.0	-	

TEST CONDITIONS

I_{OL}	MC830P, MC846P, MC862P	12.0	12.0	11.4	mAdc
	MC831P	10.5	10.5	10.2	
	MC832P	36.0	36.0	34.0	
	MC844P	40.0	40.0	36.0	
	MC845P	16.8	16.8	16.0	
	MC848P	15.4	15.4	14.6	
I_{OH}	MC832P	-2.0	-2.5	-3.0	mAdc
	Gates**, Flip-Flops	-120	-120	-120	μAdc
I_{CE}		-	5.0	-	mAdc
I_{FD}		2.0	2.0	2.0	mAdc
V_{IL}		1.2	1.1	0.95	Vdc
V_{ILS}		1.2	1.1	0.95	Vdc
V_{IH}		2.0	1.9	1.8	Vdc
V_X		-	1.8	-	Vdc
V_F		0.45	0.45	0.50	Vdc
V_R		4.0	4.0	4.0	Vdc
V_{CEX}		-	5.0	-	Vdc
V_{CC}		5.0	5.0	5.0	Vdc
V_{PD}		-	5.0	-	Vdc
V_{max}		-	8.0	-	Vdc
V_{CPTH}		1.0	0.95	0.85	Vdc

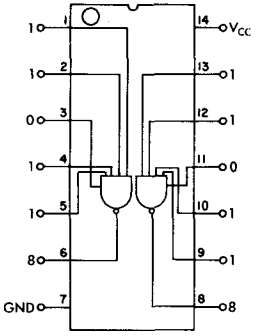
**Excludes Dual 4-Input Power Gate, MC844P

MC830P SERIES (continued)

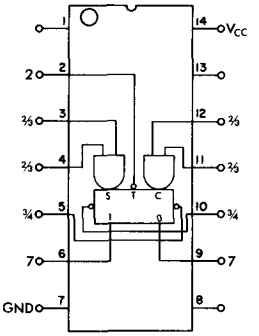
LOADING DIAGRAMS

Valid from 0°C to +75°C
with $V_{CC} = 5.0\ V \pm 10\%$
TOP VIEWS

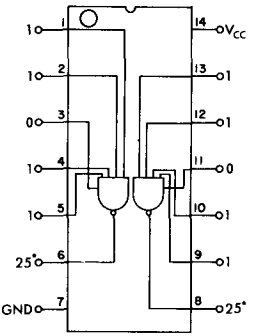
Numbers at end of terminals indicate loading.



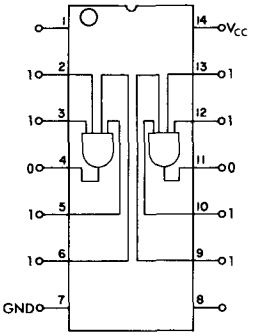
MC830P — Dual 4-Input Gate



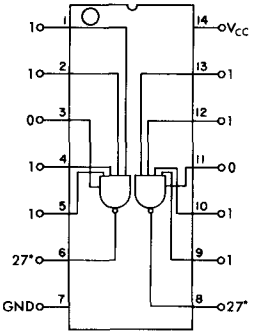
MC831P — Clocked Flip-Flop



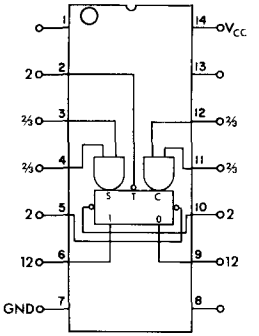
MC832P — Dual Buffer



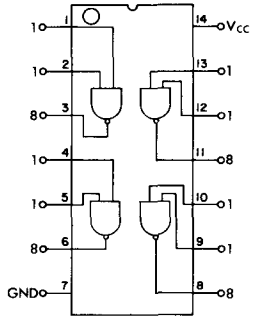
MC833P — Gate Expander



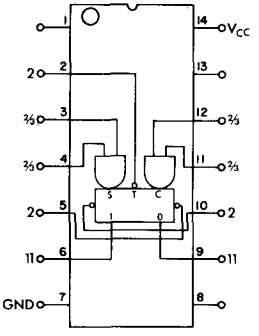
MC844P — Dual 4-Input Power Gate



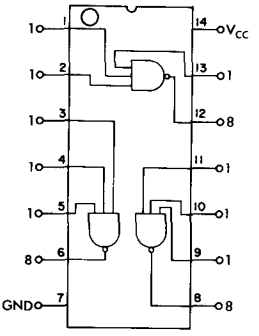
MC845P — Clocked Flip-Flop



MC846P — Quad 2-Input Gate



MC848P — Clocked Flip-Flop



MC862P — Triple 3-Input Gate

*See General Rules

MC1525
MC1526

LINEAR CIRCUIT SERIES

A_{dd} = 65-140
V_{IO} = 5-7 mV
CMR = 80 dB
BW = 0.5-1.4 MHz



CASE 71

Integrated circuit NPN differential amplifiers designed for applications requiring extremely high gain.

MAXIMUM RATINGS (T_A = 25°C unless otherwise noted)

Characteristic	Symbol	Rating	Unit
Power Supply Voltage	V_{CC}	+14	Vdc
Power Supply Voltage	V_{EE}	-14	Vdc
Differential Input Signal	V_{in}	±5	Vdc
Operating Temperature Range	T_J	-55 to +125	°C
Storage Temperature Range	T_{stg}	-65 to +175	°C
Total Power Dissipation Derate above 25°C	P_D	300 2	mW mW/°C

FIGURE 1 — MC1525

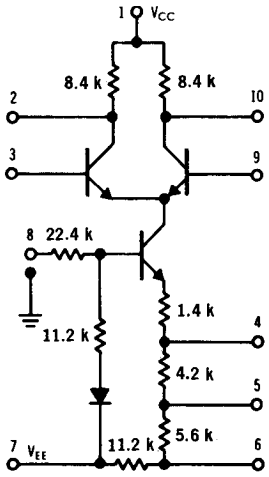
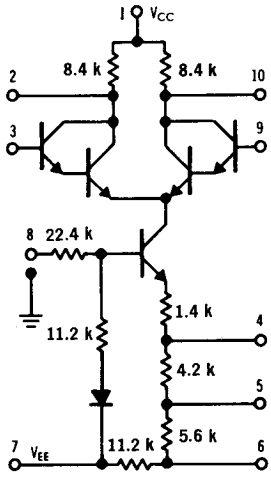


FIGURE 2 — MC1526



MC1525, MC1526 (continued)

ELECTRICAL CHARACTERISTICS

(Vcc = +12 Vdc, V_{EE} = −12 Vdc, at T_A = 25°C unless otherwise noted)

Characteristic	Fig No	Symbol	Min	Typical	Max	Unit
Differential Voltage Gain MC1525 MC1526	3, 13	A_{dd}	 120 50	 140 65	 80 75	—
Single Ended Voltage Gain MC1525 MC1526	4	A_v	 — —	 75 45	 — —	—
Output Voltage, Common Mode Both Types	5, 14	$V_{O(CM)}$	6.0	7.0	8.0	Vdc
Maximum Output Swing Both Types	6	V_o	7.0	—	—	$V_{(p-p)}$
AC Unbalance Both Types	6	U	—	—	300	$mV_{(p-p)}$
Input Offset Voltage MC1525 MC1526	7, 15	V_{io}	 — —	 — —	 5 7	mVdc
Input Offset Current MC1525 MC1526	8, 16	I_{io}	 — —	 — —	 4 2	μAdc
Input Current MC1525 MC1526	8, 18	I_{in}	 — —	 — —	 20 3.5	μAdc
Common Mode Rejection Both Types	9, 17	CM_{Rej}	80	—	—	dB
Bandwidth MC1525 MC1526	10	BW	 1400 500	 — —	 — —	kHz
Differential Input Impedance MC1525 MC1526	11	Z_{in}	 2.0 60	 — —	 — —	kΩ
Single Ended Output Impedance Both Types	12	Z_{out}	—	—	11	kΩ

MC1525, MC1526 (continued)

DC Common Mode Input Voltage Set at: $V_{CM(min)} = 5.5$ Vdc for MC1526 and
$V_{CM(min)} = 6.2$ Vdc for MC1525.

FIGURE 3 — DIFFERENTIAL VOLTAGE GAIN

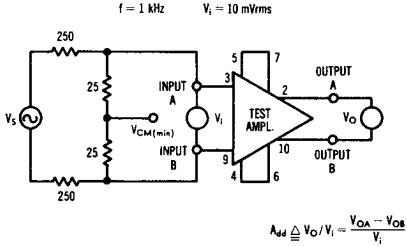


FIGURE 4 — SINGLE-ENDED VOLTAGE GAIN

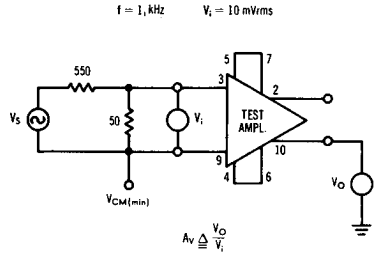


FIGURE 5 — OUTPUT VOLTAGE — COMMON MODE

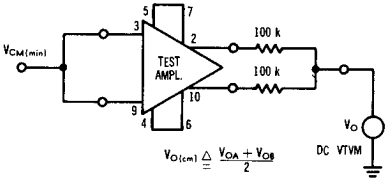


FIGURE 6 — MAXIMUM OUTPUT SWING

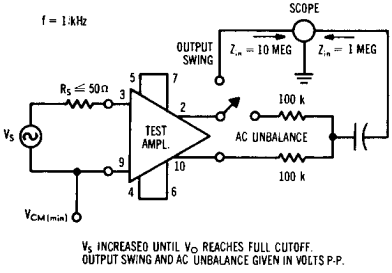


FIGURE 7 — INPUT OFFSET VOLTAGE

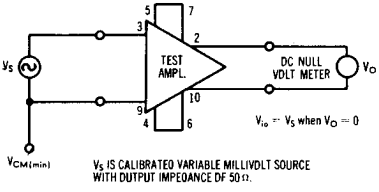
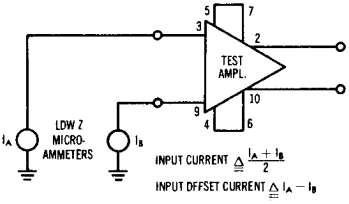


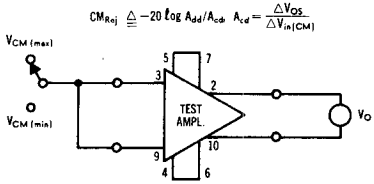
FIGURE 8 — INPUT OFFSET CURRENT and INPUT CURRENT



MC1525, MC1526 (continued)

DC Common Mode Input Voltage Set at: $V_{CM(min)} = 5.5$ Vdc for MC1526 and $V_{CM(min)} = 6.2$ Vdc for MC1525.

FIGURE 9 — COMMON MODE REJECTION



$\triangle V_{OS}$ RECORDED FOR A CHANGE IN THE COMMON MODE INPUT BIAS FROM MAXIMUM TO MINIMUM VALUES.

FIGURE 10 — BANDWIDTH

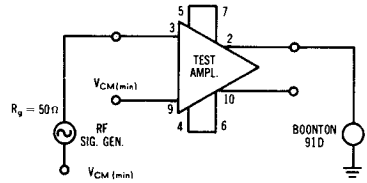
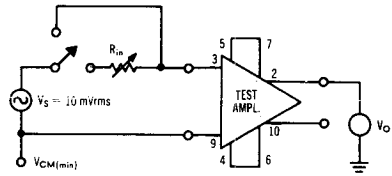


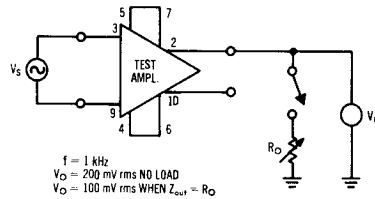
FIGURE 11 — DIFFERENTIAL INPUT IMPEDANCE



WHEN R_{in} SWITCHED INTO CIRCUIT THE OUTPUT CHANGE SHALL BE 6 dB.

THEN $Z_{in} = R_{in}$

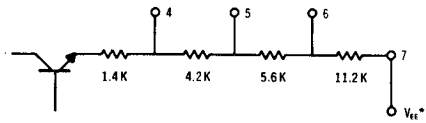
FIGURE 12 — SINGLE-ENDED OUTPUT IMPEDANCE



f = 1 kHz
V_O = 200 mV rms NO LOAD
V_O = 100 mV rms WHEN $Z_{out} = R_O$

BIASING ARRANGEMENT

In the emitter of the current source transistor of each of the differential amplifiers, there are four resistors of different values which may be connected in seven ways. The resultant effective resistance in conjunction with a given V_{EE} makes provision for different current levels. For convenience, the seven methods together with their effective resistances are tabulated below.



*Pin 7 is connected to the substrate and must be connected to the V_{EE} supply for proper circuit operation.

METHOD	1	2	3	4	5	6	7
PIN CONNECTIONS	4-7	4-6, 5-7	4-5, 6-7	4-6	4-5	5-6	4,5,6 OPEN
EFFECTIVE RESISTANCE	1.4 k	3.37 k	7.0 k	12.6 k	18.2 k	21.8 k	22.4 k

MC1525, MC1526 (continued)

EFFECT OF TEMPERATURE ON CHARACTERISTICS

FIGURE 13 — DIFFERENTIAL MODE GAIN

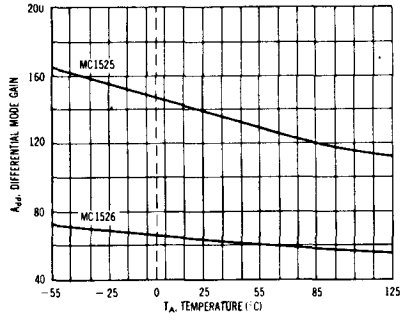


FIGURE 14 — OUTPUT VOLTAGE — COMMON MODE

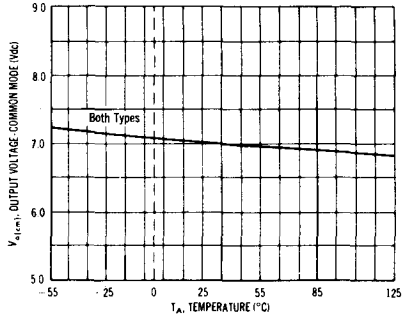


FIGURE 15 — INPUT OFFSET VOLTAGE

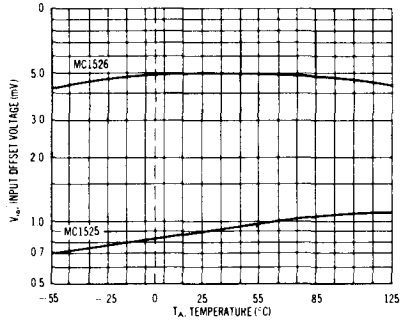


FIGURE 16 — INPUT OFFSET CURRENT

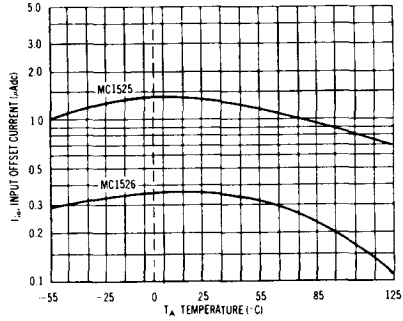


FIGURE 17 — COMMON MODE REJECTION

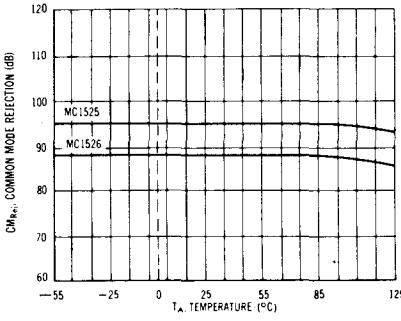
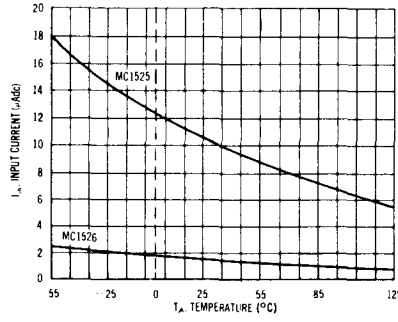
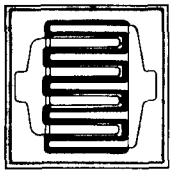


FIGURE 18 — INPUT CURRENT



MPS3702 (SILICON)
MPS3703



V_{CEO} to 30 V
I_C = 200 mAdc
P_D = 310 mW

PNP silicon annular plastic encapsulated transistors designed for low-power, large-signal audio applications.



CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	MPS3702	MPS3703	Unit
Collector-Emitter Voltage	V_{CEO}	25	30	Vdc
Collector-Base Voltage	V_{CB}	40	50	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current - Continuous	I_C	200		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.8I		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

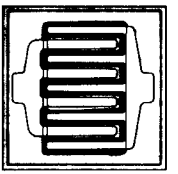
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_B = 0)	MPS3702 MPS3703	BV_{CEO}*	25 30	- -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3702 MPS3703	BV_{CBO}	40 50	- -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 5 Vdc)	MPS3702 MPS3703	h_{FE}*	60 30	300 150	-
Collector-Emitter Saturation Voltage* (I_C = 50 mAdc, I_B = 5 mAdc)		$V_{CE(sat)}$*	-	0.25	Vdc
Base-Emitter On Voltage* (I_C = 50 mAdc, V_{CE} = 5 Vdc)		$V_{BE(on)}$*	0.6	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain-Bandwidth Product (I_C = 50 mAdc, V_{CE} = 5 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, f = 1 MHz)		C_{ob}	-	12	pF

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3704 (SILICON)
MPS3705
MPS3706



V_{CEO} to 30 V
I_C = 600 mAdc
P_D = 310 mW

NPN silicon annular plastic encapsulated transistors designed for low-power, large-signal audio applications.



CASE 29
(TO-92)

MAXIMUM RATINGS

Characteristic	Symbol	MPS3704 MPS3705	MPS3706	Unit
Collector-Emitter Voltage	V_{CEO}	30	20	Vdc
Collector-Base Voltage	V_{CB}	50	40	Vdc
Emitter-Base Voltage	V_{EB}	5		Vdc
Collector Current - Continuous	I_C	600		mAdc
Total Device Dissipation @ T_A = 25°C Derate above 25°C	P_D	310 2.81		mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135		°C

THERMAL CHARACTERISTICS

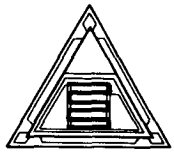
Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

ELECTRICAL CHARACTERISTICS (T_A = 25°C unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* (I_C = 10 mAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	BV_{CEO}*	 30 30 20	 - - -	Vdc
Collector-Base Breakdown Voltage (I_C = 100 μAdc, I_E = 0)	MPS3704 MPS3705 MPS3706	BV_{CBO}	 50 50 40	 - - -	Vdc
Emitter-Base Breakdown Voltage (I_E = 100 μAdc, I_C = 0)		BV_{EBO}	5	-	Vdc
Collector Cutoff Current (V_{CB} = 20 Vdc, I_E = 0)		I_{CBO}	-	100	nAdc
Emitter Cutoff Current (V_{BE} = 3 Vdc, I_C = 0)		I_{EBO}	-	100	nAdc
ON CHARACTERISTICS					
DC Current Gain* (I_C = 50 mAdc, V_{CE} = 2 Vdc)	MPS3704 MPS3705 MPS3706	h_{FE}*	100 50 30	300 150 600	-
Collector-Emitter Saturation Voltage* (I_C = 100 mAdc, I_B = 5 mAdc)	MPS3704 MPS3705 MPS3706	$V_{CE(sat)}$*	- - -	0.6 0.8 1.0	Vdc
Base-Emitter On Voltage* (I_C = 100 mAdc, V_{CE} = 2 Vdc)		$V_{BE(on)}$*	0.5	1.0	Vdc
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product (I_C = 50 mAdc, V_{CE} = 2 Vdc, f = 20 MHz)		f_T	100	-	MHz
Output Capacitance (V_{CB} = 10 Vdc, I_E = 0, f = 1 MHz)		C_{ob}	-	12	pF

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MPS3826 (SILICON)
MPS3827



$V_{CEO} = 45$ V
$I_C = 30$ mAdc
$P_D = 310$ mW



CASE 29
(TO-92)

NPN silicon annular plastic encapsulated transistors designed for general purpose, low-level audio applications.

MAXIMUM RATINGS

Characteristic	Symbol	Rating	Unit
Collector-Emitter Voltage	V_{CEO}	45	Vdc
Collector-Base Voltage	V_{CB}	60	Vdc
Emitter-Base Voltage	V_{EB}	4	Vdc
Collector Current - Continuous	I_C	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	310 2.81	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-55 to +135	°C

THERMAL CHARACTERISTICS

Characteristic	Symbol	Max	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	0.357	°C/mW

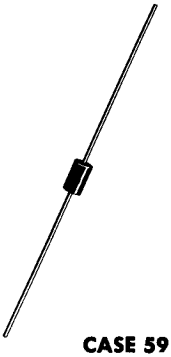
ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted)

Characteristic		Symbol	Min	Max	Unit
OFF CHARACTERISTICS					
Collector-Emitter Breakdown Voltage* ($I_C = 10$ mAdc, $I_B = 0$)		BV_{CEO}*	45	-	Vdc
Collector-Base Breakdown Voltage ($I_C = 100$ μAdc, $I_E = 0$)		BV_{CBO}	60	-	Vdc
Emitter-Base Breakdown Voltage ($I_E = 100$ μAdc, $I_C = 0$)		BV_{EBO}	4	-	Vdc
Collector Cutoff Current ($V_{CB} = 30$ Vdc, $I_E = 0$) ($V_{CB} = 30$ Vdc, $I_E = 0$, $T_A = 85°C$)		I_{CBO}	- -	0.1 5	μAdc
ON CHARACTERISTICS					
DC Current Gain* ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc)	MPS3826 MPS3827	h_{FE}*	40 100	160 400	-
DYNAMIC CHARACTERISTICS					
Current-Gain—Bandwidth Product ($I_C = 10$ mAdc, $V_{CE} = 10$ Vdc, $f = 100$ MHz)		f_T	200	800	MHz
Output Capacitance ($V_{CB} = 10$ Vdc, $I_E = 0$, $f = 1$ MHz)		C_{ob}	-	3.5	pF
Collector-Base Time Constant ($V_{CB} = 10$ Vdc, $I_E = 10$ mAdc, $f = 31.9$ MHz)		$r_b'C_c$	-	100	ps

*Pulse Test: Pulse Width = 300 μs; Duty Cycle = 2%

MR2360

REF. VOLTAGE = 0.67 ± 5% V
I_F = 10 mA



CASE 59

Forward Reference Diode - a high-conductance silicon diode designed as a stable forward reference source for biasing transistor amplifiers and similar applications.

MAXIMUM RATINGS

Rating	Symbol	MR2360	Unit
DC Power Dissipation @ T_A = 75°C Derate above 75°C	P_D	1000 10	mW mW/°C
Operating and Storage Junction Temperature Range	T_J, T_{stg}	-65 to +175	°C

ELECTRICAL CHARACTERISTICS (At 25°C unless otherwise noted)

Characteristic	Symbol	Min	Max	Unit
Forward Reference Voltage (I_F = 10 mAdc) (I_F = 100 mAdc)	V_F	 0.64 0.73	 0.70 0.80	Volts
Reverse Current (V_R = 5.0 Vdc)	I_R	—	10.0	μA

THERMAL CHARACTERISTICS

Thermal Resistance, Junction to Ambient: θ_{JA} = 100°C/W MAX.

MECHANICAL CHARACTERISTICS

CASE: Void free, flameproof silicone polymer case.

FINISH: All external surfaces corrosion-resistant and leads readily solderable.

POLARITY: Indicated by polarity band. (Cathode end.)

MOUNTING POSITIONS: Any.

FIGURE 1 — FORWARD VOLTAGE CHARACTERISTICS

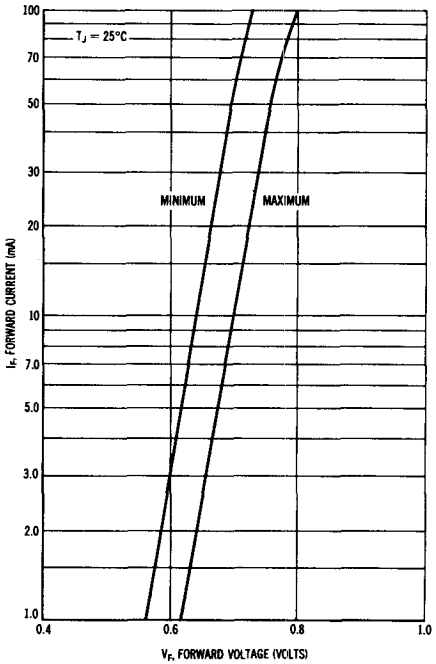


FIGURE 2 — TEMPERATURE COEFFICIENT

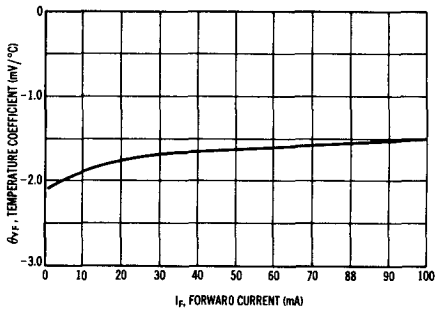
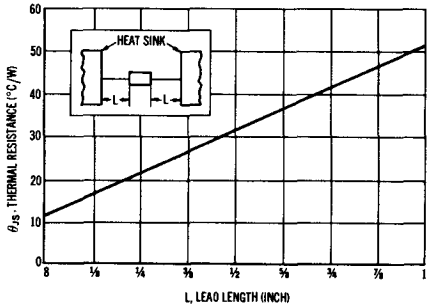


FIGURE 3 — TYPICAL THERMAL RESISTANCE



APPLICATION NOTES

HOW TO GET MORE VALUE OUT OF A TRANSISTOR DATA SHEET

Engineers involved in the design of transistor circuits can gain many benefits from the proper use of transistor data sheets that have well specified characteristics. The extreme requirements of today's designs can only lead to confusion if the engineer does not have the proper limits within which to design. This report is intended to explain the relationship between published characteristics and design requirements.

A modern, well-prepared, informative data sheet should provide the design engineer with all the necessary information for selecting a transistor capable of performing a particular job. To accomplish this, the data sheet is normally divided into six general sections. A description of the device is given first, followed by sections on absolute ratings, and electrical and thermal characteristics. Mechanical data and applications information are also included.

The description of the device usually gives the broad general application which permits the designer to classify transistors according to his specific requirements. Thus, a typical power transistor description might indicate whether the unit was designed for audio work or switching applications. In addition, the power and/or current rating is specified, the polarity (whether PNP or NPN) is given, and the type of material is called out. At a glance, therefore, the engineer can determine if a particular transistor or group of transistors, is generally suitable for a particular purpose.

From here on, however, the selection of a specific transistor for a particular object becomes more involved. The unit must be considered from its various electrical ratings and characteristics to make sure that it fits the application from every conceivable standpoint. And, the engineer is generally faced with the problem of selecting the least expensive transistor which will perform adequately in his proposed circuit. This requires a comprehensive study and evaluation of the information usually given in the finer print. Only a thorough understanding of this information will permit him to do his job satisfactorily.

DISTINCTION BETWEEN RATINGS AND CHARACTERISTICS

A rating is defined as a limiting value assigned by the manufacturer which, if exceeded, may result in permanent damage to the device. On the other hand, a characteristics is a measurable property of the device under specific operating conditions for which the transistor will provide reliable performance.

ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings are those ratings beyond which degradation of a transistor may be expected. These ratings are established by each manufacturer based on the internal physical construction, semiconductor material and manufacturing processes. Because these are "ratings," most data sheets will not indicate test conditions under which these "ratings" are specified. Therefore, "ratings" are the extreme capabilities of a transistor and are not to be used as design conditions.

For example, under absolute maximum ratings the parameter BV_{CEO} indicates that the B when placed before a characteristic symbol usually means breakdown. Therefore, BV_{CBO}, BV_{CEO}, BV_{CES}, BV_{CEX}, and BV_{EBO}, are

the breakdown ratings of the device. It is a very well known fact in the semiconductor industry that when transistor ratings are exceeded an avalanche or breakdown condition may take place. This avalanche or breakdown condition in almost every instance will destroy a transistor. Breakdown is dependent upon temperature and a certain voltage and current condition, the combination of which can trigger an avalanching effect leading to instant destruction.

As a practical example, the graph in Figure 1 illustrates the typical output characteristics of a 2N1530 power transistor. The absolute maximum voltage BV_{CEO} is 45 volts. The absolute maximum current is 5 amps.

With an absolute maximum power rating of 90 W as shown on the data sheet for this particular transistor, it is now possible for the design engineer to calculate and plot a maximum voltage current relationship which can't be exceeded without endangering the life of the transistor.

It is obvious from the graph that the absolute maximum voltage and the absolute maximum current cannot be applied at the same time. While it is conceivable that an occasional excursion beyond this absolute maximum power for a short period of time will do no harm to the transistor, this practice is not recommended where reliability is concerned.

Thermal characteristics, also listed under the absolute maximum ratings, are expressed in degrees C per watt and define the dissipation capability of the transistor regarding the junction temperature in relation to case temperature.

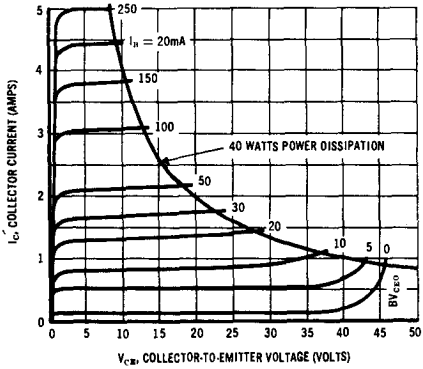


Figure 1 – Typical Output Characteristics, Motorola 2N1530

ELECTRICAL CHARACTERISTICS

It is in this portion of the data sheet that the design engineer can find the limits on those electrical parameters which are most important to his particular circuit design. Whereas the absolute maximum specifications provide the limits beyond which reliable operation cannot be obtained, the electrical characteristics give the design centers around which practical circuits can evolve. When discussing any specific characteristics, the test conditions must be specified in order that a common understanding is held by both the user and the manufacturer of the transistor. Almost every parameter listed on a data sheet is subject to variation among manufacturers because of difficult test conditions. We shall now refer to the data sheet on the power transistor series from 2N1539 thru 2N1548 and discuss each parameter in order. (See Figure 2)

COLLECTOR-BASE LEAKAGE CURRENTS

I_{CBO} is a very common term loosely used by designer and manufacturer and initially used to signify the quality of a transistor. Actually, there exist three very definite I_{CBO}'s which are important to the designer. The first is the reading taken at some low collector-base voltage, in this case 2 volts, with a maximum value of I_C indicated at this voltage.

This for all practical purposes represents the thermal component of the collector current, which cannot be reduced by further decrease of V_{CB}. This is true for a given temperature and is subject to change with temperature. As the ambient temperature increases, the leakage current increases.

ELECTRICAL CHARACTERISTICS, GENERAL (At 25°C Mounting Base Temperature)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Collector-Base Cutoff Current	I_{CBO}				
V_{CB} = -25V 2N1539, 2N1544		-	-	2.0	mA
V_{CB} = -40V 2N1540, 2N1545		-	-	2.0	mA
V_{CB} = -55V 2N1541, 2N1546		-	-	2.0	mA
V_{CB} = -65V 2N1542, 2N1547		-	-	2.0	mA
V_{CB} = -80V 2N1543, 2N1548		-	-	2.0	mA
Collector-Base Cutoff Current	I_{CBO}				
V_{CB} = -2V (all types)		-	-	200	μA
Collector-Base Cutoff Current	I_{CBO}				
at T_B = +90°C		-	-	20	mA
at V_{CB} = 1/2 BV_{CES} rating					
Emitter-Base Cutoff Current	I_{EBO}				
V_{EB} = 12V (all types)		-	-	0.5	mA
Collector-Emitter Breakdown Voltage	BV_{CES}				
I_C = 500mA, V_{EB} = 0					
2N1539, 2N1544		30	-	-	volts
2N1540, 2N1545		45	-	-	volts
2N1541, 2N1546		60	-	-	volts
2N1542, 2N1547		75	-	-	volts
2N1543, 2N1548		90	-	-	volts
Collector-Emitter Leakage Current	I_{CEX}				
V_{BE} = 1.0V					
V_{CE} = 40 2N1539, 2N1544		-	-	20	mA
V_{CE} = 60 2N1540, 2N1545		-	-	20	mA
V_{CE} = 80 2N1541, 2N1546		-	-	20	mA
V_{CE} = 100 2N1542, 2N1547		-	-	20	mA
V_{CE} = 120 2N1543, 2N1548		-	-	20	mA
Collector-Emitter Breakdown Voltage	BV_{CEO}				
I_C = 500mA, I_B = 0					
2N1539, 2N1544		20	-	-	volts
2N1540, 2N1545		30	-	-	volts
2N1541, 2N1546		40	-	-	volts
2N1542, 2N1547		50	-	-	volts
2N1543, 2N1548		60	-	-	volts
Collector-Base Breakdown Voltage	BV_{CBO}				
I_C = 20mA					
2N1539, 2N1544		40	-	-	volts
2N1540, 2N1545		60	-	-	volts
2N1541, 2N1546		80	-	-	volts
2N1542, 2N1547		100	-	-	volts
2N1543, 2N1548		120	-	-	volts

Figure 2 — Electrical Characteristics as given on a typical data sheet

ELECTRICAL CHARACTERISTICS, COMMON EMITTER (At 25°C)

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Current Gain	h_{FE}				
V_{CE} = -2V, I_C = 3A					
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		50	-	100	-
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		75	-	150	-
Base-Emitter Drive Voltage	V_{BE}				
I_C = 3A, I_B = 300mA					
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	-	0.7	volts
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	-	0.5	volts
Collector Saturation Voltage	$V_{CE(SAT)}$				
I_C = 3A, I_B = 300mA					
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	0.2	0.6	volts
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	0.1	0.3	volts
Frequency Cutoff	f_{ae}				
V_{CE} = -2V, I_C = 3A					
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	4	-	kc
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	4	-	kc
Switching Characteristics					
I_C = 3A					
Delay + Rise Time	$t_d + t_r$				
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	5	-	μsec
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	5	-	μsec
Storage Time	t_s				
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	3	-	μsec
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	3	-	μsec
Fall Time	t_f				
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		-	5	-	μsec
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		-	8	-	μsec
Transconductance	g_{FE}				
V_{CE} = -2V, I_C = 3A					
2N1539, 2N1540, 2N1541, 2N1542, 2N1543		3.0	6.0	-	mhos
2N1544, 2N1545, 2N1546, 2N1547, 2N1548		5.0	7.5	-	mhos

Figure 2 (continued) — Electrical Characteristics as given on a typical data sheet

With this value, the designer can easily predict what the leakage will be at some higher temperature. Using the emperical rule that the thermal component of current will double for every 10°C, the design engineer can pinpoint the temperature component of the leakage current.

COLLECTOR-BASE VOLTAGE CHARACTERISTICS

The other I_{CBO} which is important in high-temperature usage is that current due to the portion of the collector-base voltage characteristics which adds another maximum I_{CBO} to the temperature complement of the total leakage. The data sheet indicates that V_{CB} at 25 volts on the 2N1539 power transistor gives a maximum leakage of 2 milliamps. This voltage component is not temperature sensitive. Therefore, the design engineer, wishing to determine his leakage value at some higher temperature (e.g. T_J75°C), can safely assume that the maximum increase in the thermal component of leakage current (I_C) will be 32 times 200 microamps. Adding to this the 2 milliamp voltage component he could arrive

at a value of 8.5 milliamps maximum leakage at 75°C with 25 volts across the transistor. All future references to temperature in this report will refer to the transistor case temperature and not the ambient temperature.

HIGH-TEMPERATURE COLLECTOR-BASE LEAKAGE CURRENTS

Since there are many voltages and many applications to be considered, it is difficult for any manufacturer to specify leakage under all voltages at all temperatures. Our company has led the way in specifying a guaranteed maximum leakage at 90°C at a voltage which is within reliable usage of any given transistor. In this case, it is one-half the BV_{CES} rating. The selection of the one-half BV_{CES} voltage rating for the high-temperature test is an arbitrary one, by at a point where the device will be in a reliable operating area.

EMITTER-BASE CUTOFF CURRENT (I_{EBO})

One of the least used parameters on a data sheet is I_{EBO}. It is well to know the I_{EBO} limit of any given junction within a transistor; therefore this limit is shown at a region where most design will be taking place. In most Motorola power transistors the emitter-base diode breakdown voltage rating is far greater than the 12 volts shown on the data sheet. This is indicated by the BV_{EBO} listed under the absolute maximum ratings.

COLLECTOR-EMITTER LEAKAGE CURRENT (I_{CEX})

The X in this symbol means that there is some known back-bias voltage applied to the base-emitter diode. And, for each transistor this back-bias voltage must be specified as a test condition for any given I_{CEX} or BV_{CEX} rating. This rating is very useful in the design of converters. In this switching application, while one transistor is conducting the other transistor has been back-biased on the off condition thus waiting for transformer action to turn it back on. This rating is given as I_{CEX} rather than BV_{CEX}.

It is much easier for a transistor to stand off a given voltage and guarantee that the current will not be above a certain maximum value than to apply a test current and see if the voltage will be above a certain minimum value. This test could be related to a second breakdown type of relationship. On many diodes, applying a given test current could show a voltage rating of many volts above the listed rating.

Let us assume a condition where we apply 20 milliamps to the collector from a constant current source with a one volt base-emitter back bias. In some extreme cases, the collector-emitter voltage could go to 150 or 200 volts giving an extreme power dissipation problem, putting the device into the very dangerous second breakdown region; thus, the reason for specifying I_{CEX} rather than BV_{CEX}. The reverse is true of the breakdown voltage collector to emitter (BV_{CES}), with the base and emitter short circuits.

COLLECTOR-EMITTER BREAKDOWN (BV_{CES})

The most important rating that the engineer can consider when selecting the transistor for his circuit is BV_{CES}. (See Figure 3)

Most all power transistor applications require source voltages, collector-to-emitter. This forces V_{CE} ratings to be equal to or larger than the source voltage. Inductive loads will make this requirement higher. For the design engineer, a useful rating would be BV_{CER} which falls between BV_{CES} and BV_{CEO}

in applications utilizing alloy transistors. The test current of 500 milliamps for power transistors was selected to insure an adequate range of operation under this condition. On many of these test conditions, high dissipation can be experienced with the combination of test voltage and test current. Therefore, many of these tests are specified as sweep tests or pulse tests where the duty cycle is low enough that the maximum junction temperature is not exceeded. These tests should be performed with the transistor mounted on an adequate heat sink.

COLLECTOR-EMITTER BREAKDOWN VOLTAGE WITH THE BASE OPEN (BV_{CEO})

This test is related to I_{CBO} and the gain characteristic h_{FE}. With the base open, a condition can be reached where h_{FE} will multiply the I_{CBO} at a given voltage and start an avalanche condition as the junction temperature rises due to self-heating. This can quickly reach breakdown conditions if not carefully tested by the sweep method.

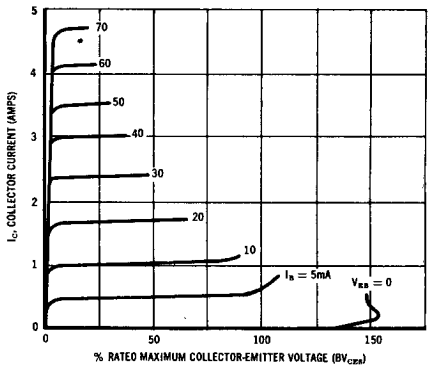


Figure 3 — Collector Characteristics, Common Emitter

Although BV_{CEO} is the most difficult of all tests to meet, especially at high voltages, it is a condition which is occasionally met in actual operation, such as in series regulated power supplies and power amplifiers. In switching circuits this condition can be met instantaneously when the transistor is switched from on to off, thus passing a region where the base has infinite resistance or is essentially open. We protect for this condition by showing the BV_{CEO} rating on our data sheet and making it a part of our safe area curves.

COLLECTOR-BASE BREAKDOWN VOLTAGE (BV_{CBO})

This rating will show the limitation of the collector-base junction, but is a rating which is only occasionally used in actual circuit considerations. Many engineers make the error of selecting a transistor based on this parameter putting themselves into a high priced, low availability category, when actually the true ratings could have been defined by BV_{CES}. Circuits should be carefully analyzed to determine if BV_{CBO} or some collector-to-emitter rating is the controlling factor.

CURRENT GAIN (h_{FE})

This is the most arbitrary of all test conditions listed on a data sheet. Our company in designing power transistors, has calculated the structure to center upon or yield a given gain at a given collector current depending upon market requirements. For alloy transistors, current-gain is a function of collector-current and in most cases will decrease when I_C increases. (See Figure 4)

It is best to design around data sheet limits. However, circuit requirement could dictate current gain spreads. Under these circumstances, it would be beneficial for the design engineer to work closely with the manufacturer to obtain a special device. This parameter is one that will vary to some degree with

life, and is therefore used as an end-of-life characteristic. It is with this realization that we introduced our Meg-A-Life Program where end-of-life limits are given for both h_{FE} and I_{CBO} on industrial transistors.

BASE TO EMITTER VOLTAGE (V_{BE})

This parameter is very important to those who require knowledge of the input voltage at the specified test condition, especially to people designing converters and switching circuits. See Figure 5. The test for this parameter is usually performed with the transistor in saturation.

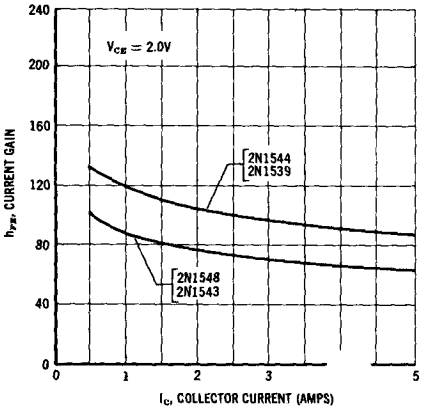


Figure 4 — Current Gain versus Collector Current

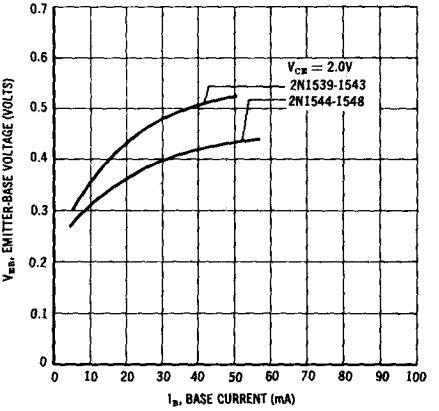


Figure 5 — Emitter-Base Voltage versus Base Current

SATURATION VOLTAGE ($V_{CE\,sat}$)

Saturation voltage, V_{CEsat} (See Figure 6) is the minimum voltage necessary to sustain normal transistor action at a particular collector-current. At collector voltages, lower than V_{CEsat}, the base-collector diode is forward biased and the current-voltage relationship changes abruptly. Thus, the saturation voltage is the minimum collector-emitter voltage required to maintain full conduction when enough base drive is supplied. Further applications of base drive will reduce V_{CEsat} with diminishing effect. Since the V_{CEsat} VS I_C curve is almost a straight line, some transistor manufacturers list the characteristic as saturation resistance (V_{CEsat}). V_{CEsat} is part of the output characteristic.

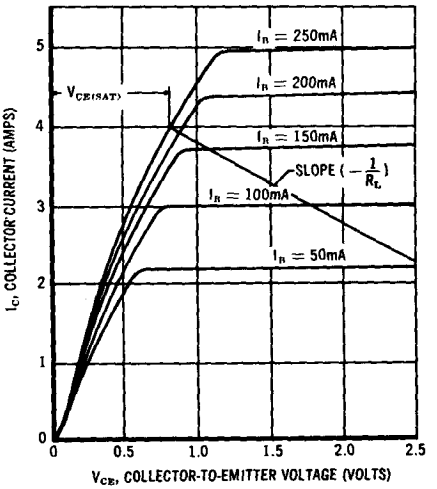


Figure 6 — Output Characteristics, Saturation Region, 2N351A

Transistor efficiency in converters is a function of switching speed and power dissipated in the fully-on condition. A very low saturation

voltage is extremely desirable and is a function of the collector-current and base-current drive. Saturation voltage will increase with an increase in collector current and will also be inversely related to the gain (h_{FE}) of the transistor.

COMMON EMITTER-CUTOFF FREQUENCY (f_{ae})

Current gain frequency cutoff (f_{ae}) for the common emitter configuration, (also called the beta cutoff frequency) is the frequency where the small-signal, forward-current gain is .707 of the current gain value to be found at a given reference frequency. The .707 point represents a 3 db. reduction in current gain. The common emitter cutoff frequency F_{ab} is usually between 5 K_C and 10 K_C for power transistors. The common base frequency cutoff F_{ab} (generally not specified for power transistors) is approximately equal to h_{fe} times f_{ae}.

SECOND BREAKDOWN VOLTAGE

Second Breakdown Voltage, a destructive condition, was first observed when the first breakdown condition ($V_{BE} = 0$) was allowed to continue until point "A" was reached as illustrated by line 4 (BV_{CES}) of Figure 7. The current was allowed to increase after the curve had entered into the first negative resistance portion and a second negative resistance occurred which switched the characteristic onto Line 7 of Figure 7. Further investigation has shown that other base-emitter conditions trigger second breakdown. If the base-shorted-to-the-emitter ($V_{BE} = 0$) condition is used as a reference point, there exists a locus of points where second breakdown is initiated for both negative and positive base-to-emitter voltage conditions, which is shown by the dashed line. Thus, high negative base drive will cause second breakdown to be generated at much greater collector current by a lower collector voltage than at the $V_{BE} = 0$ point. When the base is positive, the locus is more difficult to determine since the trigger point lies in a negative resistance region. The exact locus varies considerably from one device to the next. However, if the collector diode breakdown and the BV_{CES} are within specifications for the transistor, the locus will always be to the right of and above lines D-E and E-F shown in Figure 8.

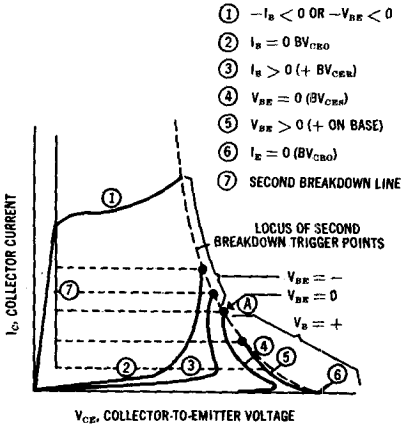


Figure 7 — Collector Current versus Collector-to-Emitter Voltage

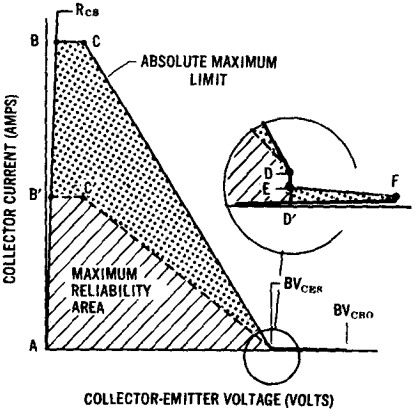


Figure 8 — Reliable V_C — I_C Areas

$I_B = 0$ line. This is because more I_{CBO} flows through the internal base resistance ($R_{BB'}$) which causes the internal base-emitter junction to see a more negative voltage on the base side. In fact, high I_{CBO} current will cause the $V_{BE} = 0$ line to lose its negative resistance portion (the tail) and approach the low temperature $I_B = 0$ case.

DETERMINATION OF PEAK POWER

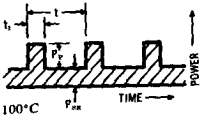
The peak allowable power is:

$$P_P = \frac{(T_J - T_A - \theta_{JA} P_{AS})}{\theta_{JC}\left(\frac{t}{C_P}\right) + \theta_{CA}\,(t_1/t)}$$

C_P is a coefficient of power as obtained from the chart. T_J is junction temperature in °C; T_A is ambient temperature in °C; θ_{JC} is junction to case thermal resistance in °C/W; θ_{CA} is case to ambient thermal resistance in °C/W; θ_{JA} is the sum of $\theta_{JC} + \theta_{CA}$; t_1 is pulse width; t is the pulse period; (t_1/t) is the duty cycle; P_{AS} is a constant power dissipation and P_P is the additional allowable pulse power dissipation above the amount of P_{AS}.

The above equation is usable when a heat sink is used which has thermal capacity very much larger than the transistors thermal capacity.

The chart is normalized with respect to the thermal time constant, which is on the order of 50 milliseconds for these power transistors.



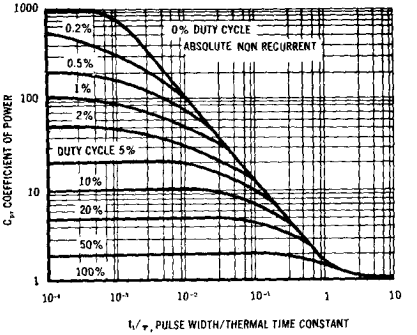
EXAMPLE
Given:
$P_{AS} = 10W$ $T_A = 40°C$
Pulse width $(t_1) = 1$ msec
Duty Cycle = 20%
$\theta_{CA} = 3°C/W$
$\theta_{JC} = 0.8°C/W$ $T_{J\,max} = 100°C$

Solution: Enter the graph at $t_1/\tau = 1$ msec/50msec, and Duty Cycle 20%. Find $C_P = 5$. Solve equation

$$P_P = \frac{100 - 40 - (3 + 0.8)\,10}{\frac{0.8}{5} + 3 \times .2}$$

$P_P = 29$ watts in addition to the steady 10 watts resulting in 39 watts peak.

PEAK POWER DERATING CURVE



Caution In all cases the peak pulse power should stay within the Safe Operating Area.

Figure 9 — Peak Power Derating

—— Application Notes ——

A well specified transistor data sheet will contain all of the above information. Some designs do not require specifications other than voltage, power dissipation and gain. The extreme requirements of present day industrial equipment as well as military specifications in most cases taxes the ingenuity of the design engineer and the time available for him to design the best equipment. TIME WHICH CAN BE SAVED DUE TO PROPER SPECIFICATION IS JUST AS IMPORTANT AS TIME SAVED DUE TO PROPER DESIGN. Because the semi-

UNDERSTANDING TRANSISTOR RESPONSE PARAMETERS

THE RANGE OF FREQUENCIES over which a transistor performs a useful circuit function is limited by inherent parameters. Manufacturers' data sheets usually specify only one or two of these parameters, while the user may need others. Therefore, a clear understanding of these parameters and the relationships between them is of value evaluating transistor performance.

Typical of such parameters is h_{fb} (alpha, the common base a-c short-circuit forward current gain). As frequency is increased, h_{fb} remains approximately equal to h_{fbo} (the value of h_{fb} at 1 kc). After the upper frequency limit is reached, h_{fb} begins to decrease rapidly.

The frequency at which a significant decrease in h_{fb} occurs provides a basis for comparison of the expected high frequency performance of different transistors. The common base current gain cutoff frequency, $f_{\alpha b}$, is defined as that frequency at which h_{fb} is 3 db below h_{fbo}. Expressed in magnitude, h_{fb} at $f_{\alpha b}$, is 70.7 per cent of h_{fbo}. Power gains, current gains, and voltage gains for a few common decibel values are found in Table 1. A curve of h_{fb} versus frequency for a transistor with an $f_{\alpha b}$ of 1 mc is shown in Fig. 1.

This curve has the following significant characteristics: (1) at frequencies below $f_{\alpha b}$, h_{fb} is nearly constant and approximately equal to h_{fbo}; (2) h_{fb} begins to decrease significantly in the region of $f_{\alpha b}$; (3) above $f_{\alpha b}$, the rate of decrease in h_{fb} with increasing frequency approaches 6 db per octave in the limit.

The curve of common base current gain versus frequency for any transistor has these characteristics, and the same general appearance as the curve of Fig. 1.

The common emitter parameter which corresponds to $f_{\alpha b}$ is $f_{\alpha e}$, the common emitter current gain cutoff frequency. By definition, $f_{\alpha e}$ is the frequency at which h_{fe} (beta, the common emitter of a-c short-circuit current gain), has decreased 3 db below h_{feo} (the value of h_{fe} at 1 kc). A typical curve of h_{fe} versus frequency for a transistor with an $f_{\alpha e}$ of 100 kc is shown in Fig. 2.

Table 1: Conversion table for power, voltage, and current ratios into decibels.

db	Power Ratio	Voltage or Current Ratio	db	Power Ratio	Voltage or Current Ratio
0	1.00	1.00	10	10.0	3.2
0.5	1.12	1.06	15	31.6	5.6
1.0	1.26	1.12	20	100	10
1.5	1.41	1.19	25	316	18
2.0	1.58	1.26	30	1,000	32
3.0	2.00	1.41	40	10,000	100
4.0	2.51	1.58	50	10^5	316
5.0	3.16	1.78	60	10^6	1,000
6.0	3.98	2.00			
7.0	5.01	2.24			
8.0	6.31	2.51			
9.0	7.94	2.82			

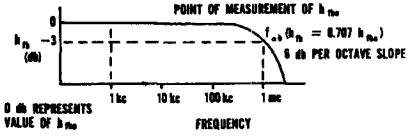


Fig. 1. Graph *represents a curve of a common base current gain plotted against frequency variations.*

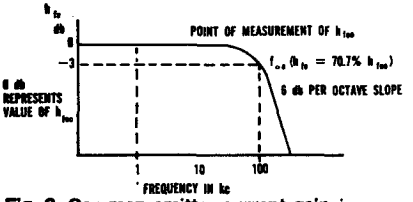


Fig. 2. Common emitter current gain *is plotted against frequency in the curve shown.*

This curve also has the significant characteristics listed for Fig. 1. These characteristics allow such a curve to be constructed for a particular transistor by knowing only h_{feo} and $f_{\alpha e}$. From the curve, h_{fe} at any frequency could be determined. Furthermore, if $f_{\alpha e}$, is not known, a curve could also be constructed if h_{feo} and h_{fe} at any frequency above $f_{\alpha e}$ were known. Thus to determine h_{fe} at any frequency, it is necessary to know only h_{feo} and either $f_{\alpha e}$ or h_{fe} at some frequency f, where f is greater than $f_{\alpha e}$.

Sometimes, h_{feo} is needed and only h_{fbo} is given, or vice versa. The quantities h_{fbo} and h_{feo} are related by the following:

$$h_{feo} = \frac{h_{fbo}}{1 - h_{fbo}} \tag{1}$$

$$h_{fbo} = \frac{h_{feo}}{h_{feo} + 1} \tag{2}$$

Equations 1 and 2 are plotted in Fig. 3. To further facilitate computations, the low frequency current gain scales of Fig. 7-10 contain both an h_{fbo} and an h_{feo} scale, and may be entered with a knowledge of either quantity.

RELATIONSHIP BETWEEN $f_{\alpha e}$ AND $f_{\alpha b}$

Suppose two transistors are considered for a particular application where performance at high frequencies is of interest. The data sheets are compared and it is discovered that one specifies $f_{\alpha b}$ and the other $f_{\alpha e}$. What preliminary comparisons can be made from this without making any laboratory measurements?

Phillips[1] gives a discussion of the relationships between $f_{\alpha e}$ and $f_{\alpha b}$ with the following result:

$$f_{\alpha e} = K_{\theta}\,(1-h_{fbo})\,f_{\alpha b}$$

where K_{θ} is a function of excess phase value between 0.5 and 1.0. Table 2 gives approximate values of K_{θ} for a number of transistor types.

The value of 0.82 applies to all alloy junction transistors. For high-

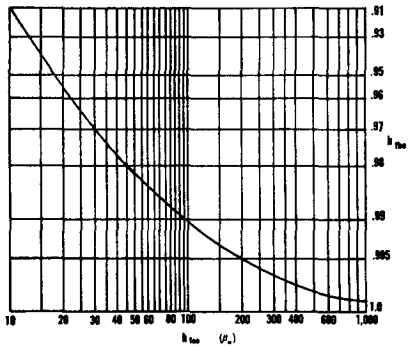


Fig. 3. The relationship *between h_{fe} and h_{fb} is given by the graph shown.*

frequency transistors, selection of K_θ is based on original design of the device regardless of how it may be specified later. For example, the 2N741 is a germanium mesa amplifier which is manufactured on a switching transistor production line; therefore, the germanium mesa switch K_θ is used for the 2N741.

The nomograms provide solutions for values of K_θ of 0.9, 0.8, and 0.6. These three values of K_θ give reasonable results for most transistor types, and if more specific information for K_θ is available, the results obtained from the nomograms are corrected accordingly.

Table 2: Approximate values of K_θ

Transistor Type	K_θ
Alloy Transistor (GPA, Alloy Power)	0.82
Germanium Mesa Switch	0.90 – 1.0
Germanium Epitaxial Mesa Amplifier	0.80
Germanium Non-Epitaxial Mesa Amplifier	0.70
Silicon Annular and Planar	0.80 – 1.0
MADT	0.60

The quantity $f_{\alpha e}$ is normally a much lower frequency than $f_{\alpha b}$ for the same transistor. For example, consider the 2N1141 germanium mesa amplifier. The data sheets give typical values $f_{\alpha b} = 1,000$ mc and $h_{fbo} = 0.98$. K_θ from Table 2 is 0.80. Substituting in Eq. 3 yields $f_{\alpha e} = 0.80\ (1 - 0.98)\ 1,000 = 16$ mc.

This result is in approximate agreement with the h_{fe} versus frequency curve of the manufacturer's 2N1141 data sheet.

GLOSSARY OF SYMBOLS

Symbol	Definition
h_{fb}	Common base a-c forward current gain (alpha)
h_{fbo}	Value of h_{fb} at 1 kc.
h_{fe}	Common emitter a-c forward current gain. (beta)
h_{feo}	Value of h_{fe} at 1 kc.
f_{α_b}	Common base current gain cutoff frequency. Frequency at which h_{fb} has decreased to a value 3 db below h_{fbo}. ($h_{fb} = 0.707\ h_{fbo}$)
$f_{\alpha e}$	Common emitter current gain cutoff frequency. Frequency at which h_{fe} has decreased to a value of 3 db below h_{feo} ($h_{fe} = 0.707\ h_{feo}$)
f_T	Gain bandwidth product. Frequency at which $h_{fe} = 1$ (0 db).
G_e	Common emitter power gain
f_{max}	Maximum frequency of oscillation. Frequency at which $G_e = 1$ (0 db).
K_θ	Excess phase shifter factor. Factor which is a function of excess phase shift of current in the base of a transistor.

For the practical application of Eq. 3, refer to Fig. 7 and 9. When any two of the quantities $f_{\alpha e}$, $f_{\alpha b}$, h_{fbo}, or h_{feo} are known, use the nomograms to find the third quantity.

A common high-frequency parameter is f_T, the gain bandwidth product and is defined as that frequency at which $h_{fe} = 1$ (0 db).

The value f_T is sometimes specified indirectly on high-frequency transistor data sheets. This is done by specifying h_{fe} at some frequency above $f_{\alpha e}$, thus, f_T is then obtained by multiplying the magnitude of h_{fe} by the frequency of measurement. This relationship arises from the 6 db per octave characteristic of the h_{fe} versus frequency curve above $f_{\alpha e}$. Since 6 db represents a current gain magnitude of 2, h_{fe} is halved each time frequency is doubled, and vice versa. Therefore, the product of h_{fe} and frequency on the sloping portion of the curve yields f_T.

For example, consider the 2N2217 silicon planar transistor. The data sheet gives a typical h_{fe} of 4. 0 at 100 mc. Multiplication of h_{fe} times the frequency of measurement yields $f_T = 4.0 \times 100 - 400$ mc. This is in agreement with the data sheet which specifies a typical f_T of 400 mc.

The parameter f_T is also equal to the product of h_{feo} and $f_{\alpha e}$, expressed by

$$f_T = h_{feo} \times f_{\alpha e} \tag{4}$$

with h_{feo} known, Eq. 4 provides a simple means of finding $f_{\alpha e}$ when f_T is known or vice versa. (See Fig. 5.)

Philips also develops the following relationship between $f_{\alpha b}$ and f_T:

$$f_T = K_\theta \, h_{fbo} \, f_{\alpha b} \tag{5}$$

where K_θ is the same quantity as in Eq. 3. Notice that since K_θ lies between 0.5 and 1.0, the f_T of a transistor is approximately equal to or slightly less than its $f_{\alpha b}$. (See Fig. 8 and 10.)

RULES FOR DETERMINING h_{fe}

The following rules summarize how to determine h_{fe} at some frequency f:

Rule 1. When $f < f_{\alpha e}$, $h_{fe} \approx h_{feo}$

Rule 2. When $f \approx f_{\alpha e}$, $h_{fe} \approx 0.7\, h_{feo}$

Rule 3. When $f > f_{\alpha e}$, consider h_{fe} to be decreasing at 6 db per octave at frequency f and use Fig. 4 to find h_{fe}.

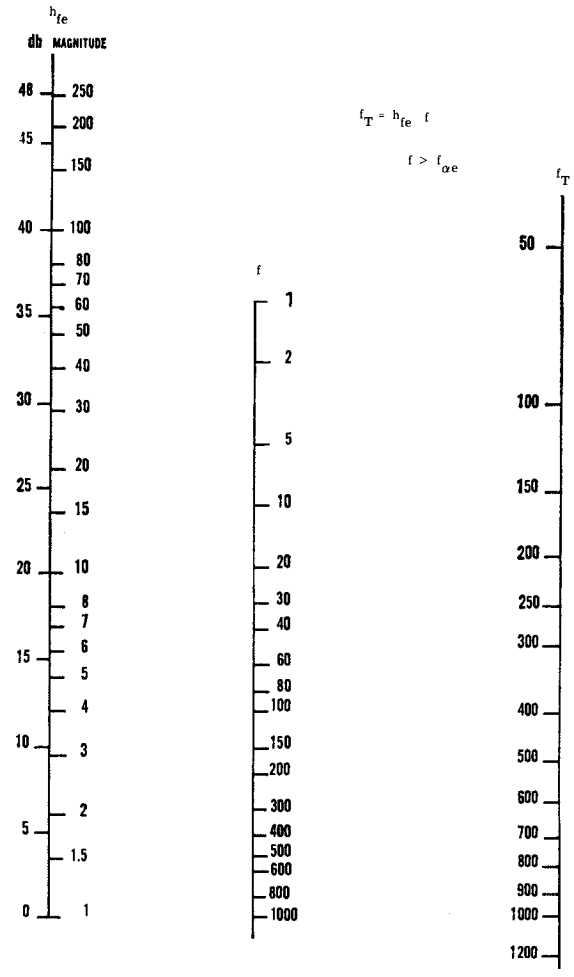


Fig. 4. This nomogram is useful *in finding* h_{fe} *when a frequency* $f > f_{\alpha e}$.

Rule 4. (A) If h_{fbo} not h_{feo} is known, use Fig. 3 find h_{feo}.

(B) If f_T is not known use Fig. 5 to find f_T if h_{feo} and $f_{\alpha e}$ are known or Fig. 8 to find f_T if $f_{\alpha b}$ is known (Fig. 10 for MADT types).

(C) If $f_{\alpha e}$ is not known, use Fig. 5 to find $f_{\alpha e}$ if f_T is known (Fig. 7 to find $f_{\alpha e}$ if $f_{\alpha b}$ is known (Fig. 9 for MADT types).

Though common emitter current gain is equal to 1 at f_T, there may still be considerable power gain at f_T due to different input and output impedance levels.

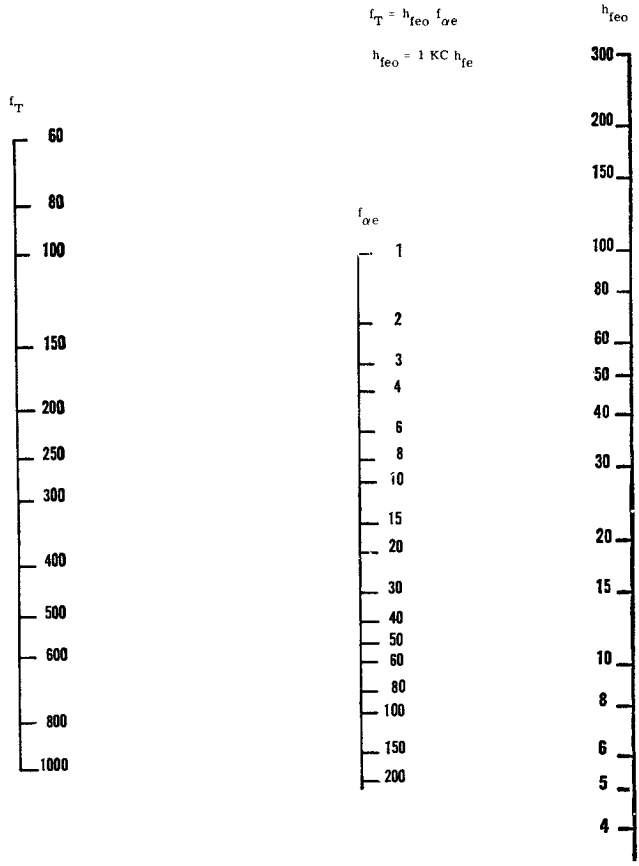


Fig. 5. The quantity f_T *is found from this nomogram once $f_{\alpha e}$ and h_{feo} are known.*

Thus, f_T is not necessarily the highest useful frequency of operation of a transistor, and an additional parameter, the maximum frequency of oscillation (f_{max}), is sometimes encountered. The term f_{max} is the frequency at which common emitter power gain is equal to 1, and is related to f_T by

$$f_{max} \approx \sqrt{\frac{f_T}{8 \pi r_B' Cc}} \tag{6}$$

where r_B' is the base resistance and Cc is the collector capacitance.

A plot of common emitter power gain versus frequency also has the characteristics shown in Fig. 1. This leads to another gain bandwidth product

$$f_{max} \approx f \sqrt{\text{Power Gain}} \quad (7)$$

where f is the frequency of measurement and power gain is expressed in magnitude not in decibels. Hence, f_{max} may be found by measuring power gain at some frequency on the 6 db per octave portion of the power gain versus frequency curve, and multiplying the square root of the power gain with the frequency of measurement (see Fig. 6). The symbol for common emitter power gain is G_e.

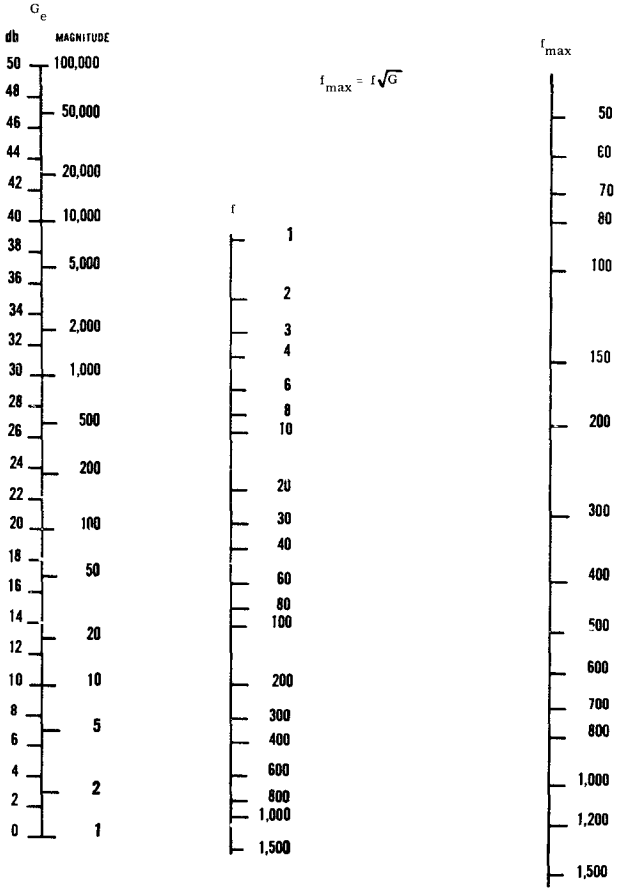
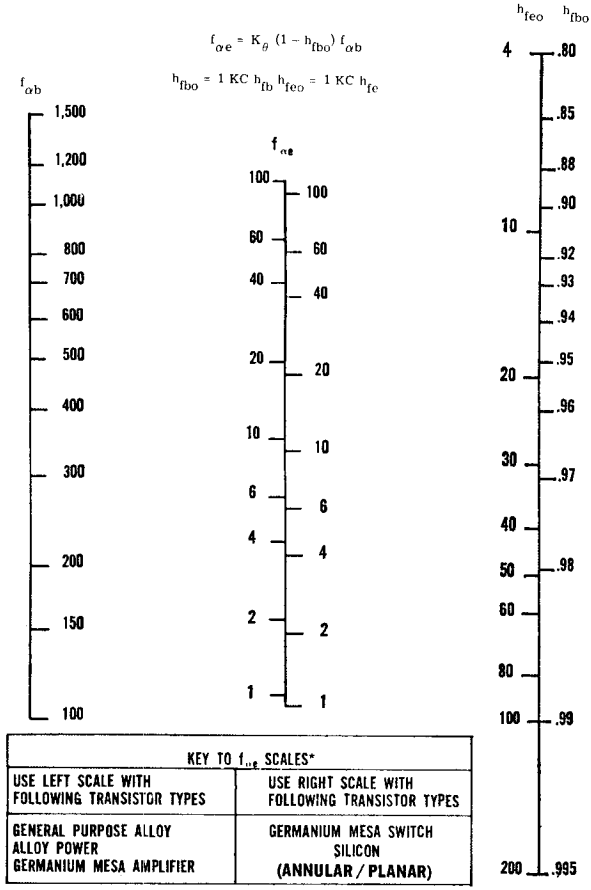


Fig. 6. Maximum frequency *is found from this nomogram knowing the frequency and power gain.*

The parameters are voltage and current dependent, and operating point must be considered in all cases. For example, the high-frequency h_{fe} measurement at one collector voltage and current must not be used to calculate f_T directly at another voltage and/or current without considering the added effects of the different operating point. Most of the mesa data sheets have curves showing typical variations of f_T with collector voltage and current.

The parameter $f_{\alpha e}$ for present mesa transistors usually lies in the region between 10 and 50 mc. The term h_{fe}, measured at any frequency above this region is assumed on the 6 db per octave portion of h_{fe} versus frequency curve and is used to calculate f_T directly.

Mesa transistor power gain measured at any frequency above 50 mc is assumed on the 6 db per octave portion of the power gain versus frequency curve and is used to calculate f_{max} directly.



KEY TO $f_{\alpha\theta}$ SCALES*	
USE LEFT SCALE WITH FOLLOWING TRANSISTOR TYPES	USE RIGHT SCALE WITH FOLLOWING TRANSISTOR TYPES
GENERAL PURPOSE ALLOY ALLOY POWER GERMANIUM MESA AMPLIFIER	GERMANIUM MESA SWITCH SILICON (ANNULAR / PLANAR)
LEFT SCALE, $K_\theta = 0.8$	RIGHT SCALE, $K_\theta = 0.9$

*FOR MADT TYPES, SEE FIG. 9

Fig. 7. Once $f_{\alpha b}$ *is known this nomogram is used to find* $f_{\alpha e}$.

INSTRUCTIONS FOR CURVES AND NOMOGRAMS

The nomograms assume no shift in operating point. Known parameters used to find an unknown must be measured at the same collector voltage and collector current as the desired unknown.

Frequency scales on the nomograms are calibrated in numbers only without units. Furthermore, all nomograms contain two frequency scales. Decimal points may be shifted on the frequency scales of any nomogram as long as they are shifted the same amount on both scales (i.e., both frequency scales of a nomogram must be multiplied by 10 to the same power). This enables the same nomogram to be used for both high and low-frequency transistors.

The nomograms assume that both power gain and current gain decrease with increasing frequency at a rate of 6 db per octave at high frequencies.

All power gain and current gain scales (except h_{fbo} and h_{feo}) are calibrated in both actual magnitudes and decibel values for convenience.

EXAMPLE 1

To find h_{feo} when h_{fbo} is known or vice versa, enter Fig. 3 with the known value and read the unknown directly. Given: $h_{fbo} = 0.96$. Find: h_{feo}, Answer = 24.

EXAMPLE 2

Figure 4 is a nomogram of f_T and h_{fe} at some frequency f, where $f > f_{\alpha e}$. Given: h_{fe} at 100 mc is 6 db. Find: h_{fe} at 75 mc. Answer: 4, or 12 db.

EXAMPLE 3

There are no special instructions for the nomogram of Fig. 5, merely use it to find the unknown parameter when any two are known. Given: $h_{feo} = 40$ and $f_T = 400$ mc. Find: $f_{\alpha e}$. Answer: 10 mc.

EXAMPLE 4

Figure 6 is a nomogram of f_{max} and common emitter power gain measured at some frequency f where power gain is known to be decreasing at 6 db per octave. Given: power gain at 400 mc is 6 db. Find: f_{max}. Answer: 800 mc. Given: $f_{max} = 1000$ mc. Find: power gain at 250 mc. Answer: 12 db.

EXAMPLE 5

Fig. 7 is a nomogram of $f_{\alpha b}$, $f_{\alpha e}$, and either h_{fbo} or h_{feo}. To account for variations in this relationship with different transistor types, there are two $f_{\alpha e}$ scales, with a guide to which one to use. Given: for a GPA transistor, $f_{\alpha b}$ = 1 mc and $h_{fbo} = 0.90$. Find: $f_{\alpha e}$. Answer: 80 kc. For MADT types, see Fig. 9.

EXAMPLE 6

Figure 8 is a nomogram of f_T, $f_{\alpha b}$, and either h_{fbo} or h_{foe}. To account for variations in this relationship with different transistor types, there are two f_T

scales, with a guide to which one to use. Given: for a germanium mesa switching transistor, f_T = 400 mc and h_{fbo} = 0.90. Find: $f_{\alpha b}$. Answer: 494 mc. For MADT types, see Fig. 10.

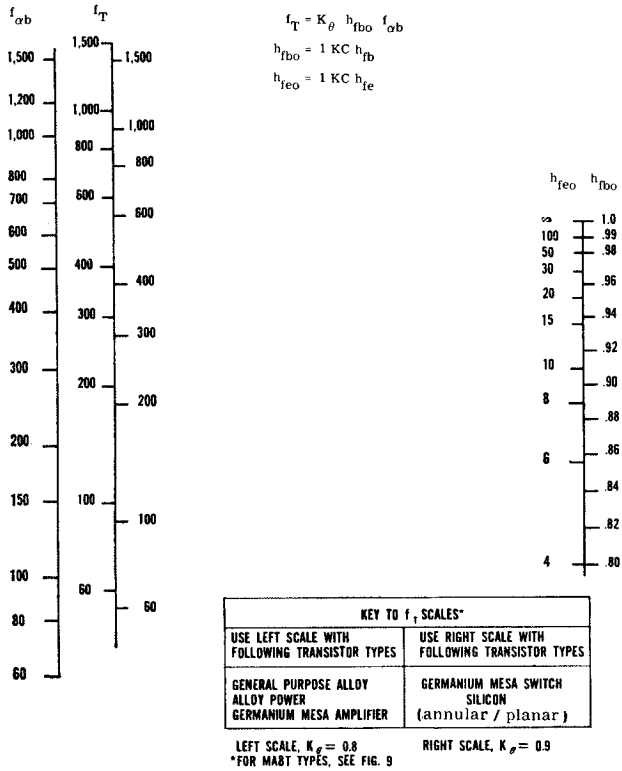


Fig. 8. This nomogram represents f_T, f_b, and either h_{fbo} or h_{feo}.

EXAMPLE 7

Figure 9 is a nomogram which is identical to Fig. 7 except that it is for use with MADT transistors (see instructions for Fig. 7).

EXAMPLE 8

Figure 10 is a nomogram which is identical to Fig. 8 except that it is for use with MADT transistors (see instructions for Fig. 8).

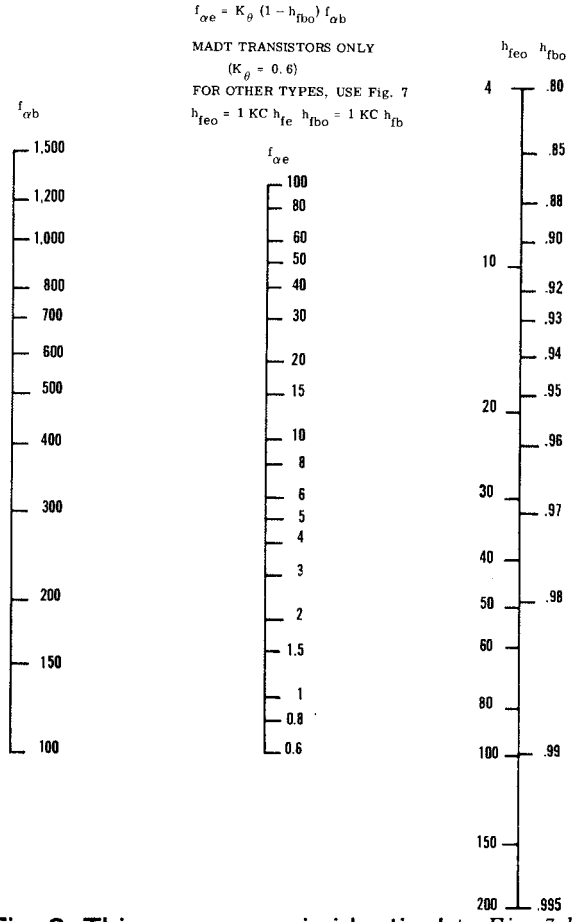


Fig. 9. This nomogram is identical *to Fig. 7 but is used for MADT transistors.*

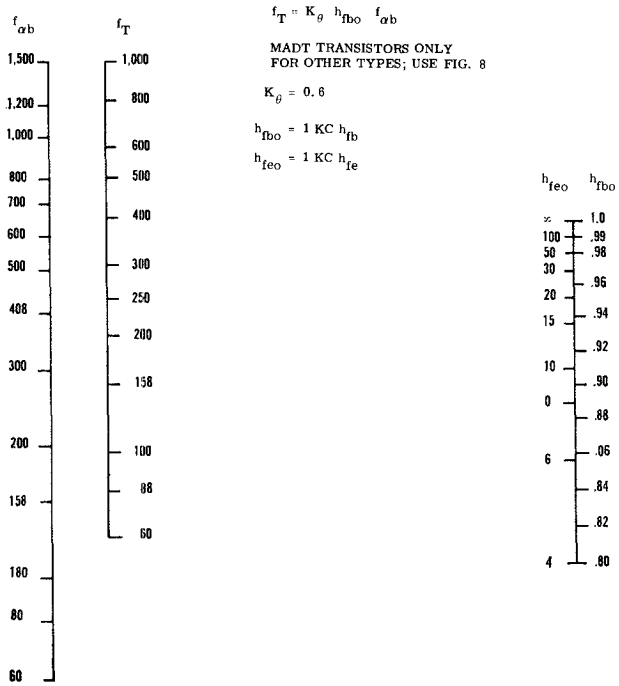


Fig. 10. Identical *to Fig. 8, this nomogram is used only for MADT transistors.*

REFERENCE

1. A. B. Phillips, "Transistor Engineering," McGraw-Hill Book Company, Inc., New York, N. Y., Chapter 14.

WHATS AND WHYS ABOUT Y-PARAMETERS

Misconceptions concerning the use of transistor data-sheet parameters often confuse circuit designers. This article is designed to remove some of the haze. It tells why different transistor parameters appear on data sheets for different applications. It shows why one often chooses y parameters for high-frequency design and illustrates the minimum number of steps necessary to solve a practical design problem. Clarifying examples appear throughout.

WHY USE PARAMETERS?

Engineers know that if they bias a device such as a transistor to a stable d-c operating point and make certain a-c input and output measurements, they then can accurately predict its a-c behavior in many different circuits in which they might use it. The d-c operating point must remain the same in these circuits as it was when a-c input and output data were taken. It the operating point shifts, the transistor characteristics will change also.

For example, if a transistor manufacturer wanted to get design data to put on a transistor data sheet, he might choose a d-c operating point where the transistor was used in a common-emitter configuration with a 2-ma collector current and a 5v drop across the collector-emitter contacts. (He would know from the size of the transistor, past experience and the way the device was made that this would be a satisfactory operating point.)

The d-c circuit might look like Fig. 1. This bias circuit holds the d-c conditions steady while a-c measurements are made.

Circuit theory states that if one has a device, say an amplifier, with two input and two output terminals, he can predict its circuit behavior if he has enough data to write two equations relating a-c input and output characteristics[1]. These two equations take the form:

$$A_1 = B_{11}C_1 + B_{12}C_2 \quad (1)$$

$$A_2 = B_{21}C_1 + B_{22}C_2 \quad (2)$$

These equations represent a device under test when it is driven from a signal "generator" C_1 and terminated with an output "generator" C_2 (C_2 is normally a passive load that "generates" nothing but absorbs power from the device). The "signals" resulting from these "generators" are represented by A_1 at the input and A_2 at the output. See Fig. 2.

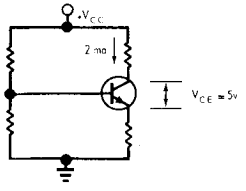


FIGURE 1 — TYPICAL DC BIAS CIRCUIT

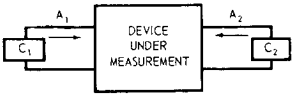


FIGURE 2 — GENERAL-CASE REPRESENTATION OF AC "GENERATORS" (C) AND "SIGNALS" (A)

WHAT DEFINES PARAMETERS?

The "B" coefficients of the "generator" terms C_1 and C_2 in Eqs. 1 and 2 are constant device characteristics called parameters, which do not vary so long as conditions such as operating point, temperature and measurement frequency do not change. The units in which these coefficients are measured are determined by the type of units that one picks for his "generators" and "signals". For example, if he chooses C_1 and C_2 to be voltage "generators" and A_1 and A_2 to be "signal" currents, then all four "B" coefficients have the units of i/e or mhos.

To show this, look at Eq. 1. It would be easy to solve Eq. 1 for B_{11} if the right-hand term were equal to zero. So to find B_{11}, set the term $B_{12}C_2$ equal to zero! To make $B_{12}C_2$ zero, one shorts C_2, the output "generator" in Fig. 2. This forces the voltage across C_2 to equal zero, since no voltage can appear across a short. Now Eq. 1 becomes:

$$A_1 = B_{11}C_1 + 0 \tag{3}$$

Solving for B_{11}:

$$B_{11} = \frac{A_1}{C_1} \Bigg| \begin{array}{l} \text{When} \\ C_2 = 0 \end{array} \tag{4}$$

A_1 is a current and C_1 is a voltage

so

$$B_{11} = \frac{i_1}{e_1} \Bigg| \begin{array}{l} \text{When} \\ C_2 = 0 \end{array} \tag{5}$$

B_{11} in Eq. 5 has the unit's mhos since it is a current divided by a voltage. This is an admittance and we arbitrarily can call it y_{11} if we choose. This defines y_{11} as the ratio of input current i_1 to input voltage e_1 only when the output voltage is zero. By alternately making C_1 and C_2 zero by shorting input and output voltages, it is very easy to solve Eqs. 1 and 2 for the other "B" parameters. They all are equal to a current divided by a voltage, which makes them admittances. Our general-case input and output box has changed in this special case to the one shown in Fig. 3. This is only because the input and output "generators" were chosen to be voltages and the input and output "signals" were chosen to be currents.

From Fig. 3, Eqs. 1 and 2 now become:

$$i_1 = y_{11}e_1 + y_{12}e_2 \tag{6}$$

$$i_2 = y_{21}e_1 + y_{22}e_2 \tag{7}$$

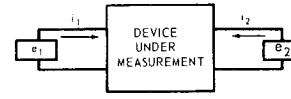


FIGURE 3 — SPECIAL CASE WHERE "GENERATORS" ARE VOLTAGES AND "SIGNALS" ARE CURRENTS

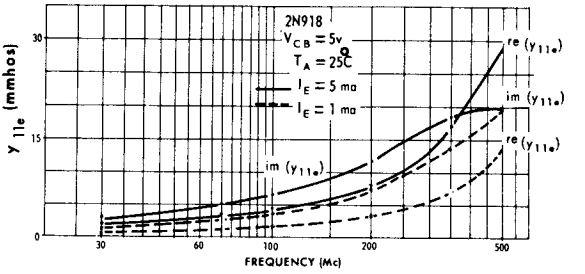


FIGURE 4 — y_{11e} AS A FUNCTION OF FREQUENCY

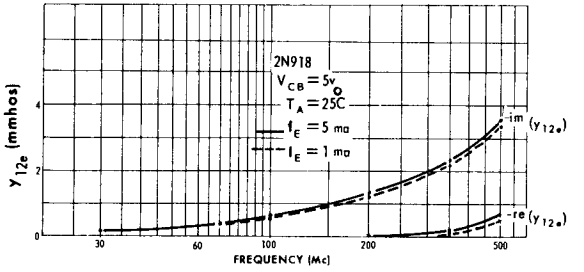


FIGURE 5 — y_{12e} AS A FUNCTION OF FREQUENCY

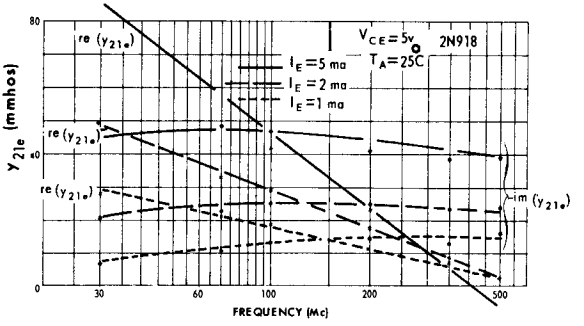


FIGURE 6 — y_{21e} AS A FUNCTION OF FREQUENCY

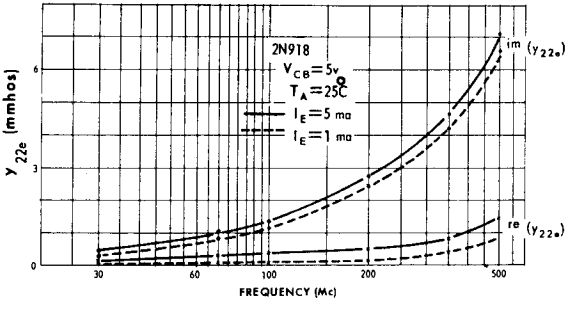


FIGURE 7 — y_{22e} AS A FUNCTION OF FREQUENCY

In the same manner that Eq. 5 became:

$$y_{11} = \frac{i_1}{e_1}\Bigg|_{e_2 = 0} \quad \text{When} \tag{8}$$

Eqs. 6 and 7 become:

$$y_{12} = \frac{i_1}{e_2}\Bigg|_{e_1 = 0} \quad \text{When} \tag{9}$$

$$y_{21} = \frac{i_2}{e_1}\Bigg|_{e_2 = 0} \quad \text{When} \tag{10}$$

$$y_{22} = \frac{i_2}{e_2}\Bigg|_{e_1 = 0} \quad \text{When} \tag{11}$$

Eqs. 8 through 11 define the y parameters. They tell what a-c measurements to make and what ratios to take to get defining y coefficients on any device. For y_{11}, the input admittance, measure the input current and input voltage with the output shorted so that e_2 is zero. Then take the proper ratio. By similarly measuring input and output voltages and currents and taking required ratios, one can get a complete set of y parameters.[2]

WHY USE y PARAMETERS?

Why pick "generators" and "signals" that require alternately shorting the input and output in order to make measurements? The answer is that it is often simpler to get a-c short-circuits at high frequencies than it is to get open circuits. (One method of getting a-c shorts that does not disturb the d-c circuit is to use bypass capacitors first across the output and then across the input terminals. Another method uses coaxial lines, since their length can be short in the VHF-UHF range.) So one reason why y parameters are used in characterizing devices at high frequencies is that this set of measurements to get all four "generator" coefficients is easier to make. And design equations for high-frequency parallel-resonant circuits often come out in simple form for admittances when they might not for other parameters such as impedances.

OTHER PARAMETERS

By picking other units for "generators" and "signals" one could get equations that were still of the same general form as Eqs. 1 and 2. But the "B" coefficients would have had other units. They would have served equally well in predicting circuit behavior, but it might have been harder to make measurements to determine different "B" coefficients in the high-frequency range. Also, after one gets a complete set of parameters, such as admittance parameters, he can mathematically manipulate these into any other set that he might

prefer to work with in actual circuit design. For example, if he gets a complete set of y parameters because they are easier to measure, he can transform these into a complete set of hybrid (h) parameters if it is easier to predict circuit performance by using them. Hybrid parameters often are used for audio-circuit design because it is easy to measure them on transistors at low frequencies.

Semiconductor manufacturers often use exotic measuring equipment to give high-frequency phase as well as magnitude information about their devices. The General Radio Model 1607A Bridge is a coaxial instrument from which one reads both real and imaginary admittance components from about 30 to 1500 Mc. It uses coaxial lines to get a-c opens or shorts and can measure hybrid as well as admittance parameters. The Boonton Radio Corp. Model 250A RX Meter gives real and imaginary components for 1/y values from 500 kc to 250 Mc. Capacitors provide a-c shorts for this instrument. Data sheets normally show average or typical data taken from a production spread of transistor parameters. Many transistor types do not have this information on the data sheet, but manufacturers usually will supply this information to their customers free of charge, if asked.

GENERAL CALCULATIONS

How does one use y data in circuit design?

Perhaps the most effective method first was proposed by J. G. Linvill[3], and well explained further by other authors[4, 6]. All of these authors outline a powerful method using y parameters to graphically represent interrelations among stage gain, circuit terminations and circuit stability. The graphical outlines are beyond the scope of this paper, but one of their results shows that if the device is unconditionally stable, the maximum unneutralized power gain is given by

$$A_{PFM} = K_G \frac{P_{oo}}{P_{io}} \tag{12}$$

where

$$\frac{P_{oo}}{P_{io}} = \frac{|y_{21}|^2}{4\mathrm{re}(y_{11})\mathrm{re}(y_{22}) - 2\mathrm{re}(y_{12}y_{21})} \tag{13}$$

$|y_{21}|$ is the magnitude of y_{21}

re designates the real parts of the respective y parameters or y-parameter products.

P_{oo}/P_{io} is a valuable tool for the circuit designer.

A calculation of the criticalness factor C will determine stablility. If C is less than 1, the device is inherently stable and cannot oscillate without external feedback paths (unconditional stability).

$$C = 2 \frac{P_{oo}}{P_{io}} \frac{|y_{12}|}{|y_{21}|} \tag{14}$$

Once C is found, K_G in equation (12) is

$$K_G = (2)\frac{1 - \sqrt{1 - C^2}}{C^2} \tag{15}$$

The maximum unneutralized gain obtainable per stage now is found by Eq. 12 if C is less than 1.

If C is greater than 1, K_G has no meaning and the maximum calculated stage gain can approach infinity. The circuit effect describing this condition is one of instability or oscillation. That is, if C is greater than 1, the device can oscillate under certain stage terminations even though no external feedback paths exist.

For the frequency ranges where the device is inherently unstable, the designer must carefully choose his load or output termination. One rule of thumb is to heavily mismatch the output admittance y_{22}. The output load admittance is made much larger than y_{22}. This is to heavily load the stage, and it means that the load impedance is less than the output impedance. The calculated quantity P_{oo}/P_{io} is usually still within a few db of the gain to expect from a stable stage if one uses collector loads in the 100 to 1000-ohm range for most of today's VHF transistors. (If measured gain is much higher, one suspects regeneration.) P_{oo}/P_{io} forms a figure of merit useful even when C is greater than 1 so long as unstable terminations are avoided.

STABILITY AND GAIN CALCULATION — PRACTICAL DESIGN EXAMPLE

Suppose one wanted to design a tuned RF amplifier at 51 Mc, the low end of the amateur 6-meter band, using a 2N918 silicon VHF transistor. Figs. 4 through 7 show 2N918 y parameters plotted versus frequency for 5v V_{CE} and 1 ma I_C at 51 Mc:

$$y_{11} = 1.0 + j2.0 \text{ mmhos} \tag{16}$$
$$y_{12} = 0 - j0.2 \text{ mmhos} \tag{17}$$
$$y_{21} = 25 - j10 \text{ mmhos} \tag{18}$$
$$y_{22} = 0.02 + j0.6 \text{ mmhos} \tag{19}$$

Eqs. 16 through 19 show the real and imaginary admittance components arranged in rectangular form. Polar forms would simplify calculating P_{oo}/P_{io} from Eq. 13. Look at Fig. 8 to get the polar form of y_{11}, for example.

The magnitude of y_{11} is equal to the length of the hypotenuse of a right triangle whose sides are the real and imaginary components. θ_1 is the angle whose tangent is equal to 2/1 in this example (from Eq. 16). This says:

Solving Eq. 20:

$$\text{Arc tan } \theta_1 = 2 \tag{20}$$
$$\theta_1 = 63.4° \tag{21}$$

Since the length of the hypotenuse of this right triangle is equal to the length of the side adjacent to θ_1 divided by the cosine of θ_1

$$| y_{11} | = \frac{1}{\text{Cos } \theta_1} = \frac{1}{\text{Cos } 63.4°} = 2.25 \qquad (22)$$

The final vector is

$$y_{11} = 2.25 \angle 63.4° \qquad (23)$$

The polar form of y_{12} is easy. It has zero real component, so θ_2 is -90.0° (see Fig 9)

$$y_{12} = 0.2 \angle -90.0° \qquad (24)$$

From Fig. 10:

$$\theta_3 = \text{Arc tan } \frac{-10}{25} = -21.8° \qquad (25)$$

$$y_{21} = \frac{25}{\text{Cos } \theta_3} \angle \theta_3 = \frac{25}{\text{Cos } -21.8°} \angle -21.8° \qquad (26)$$

$$\text{so that } y_{21} = 26.9 \angle -21.8° \qquad (27)$$

Now we can calculate $\frac{P_{oo}}{P_{io}}$:

$$\frac{P_{oo}}{P_{io}} = \frac{|y_{21}|^2}{4\text{re}(y_{11})\text{re}(y_{22}) - 2\text{re}(y_{12}y_{21})} \qquad (13)$$

$$\frac{P_{oo}}{P_{io}} = \frac{(26.9)^2}{4(1)(0.02) - 2\text{re}[(0.2 \angle -90.0°)(26.9 \angle -21.8°)]}$$

$$= \frac{725}{0.08 - 2\text{re}(5.38 \angle -111.8°)} \qquad (28)$$

(To multiply two vectors, multiply their magnitudes and add their angles.)

To get the real part of $5.38 \angle -111.8°$ for use in the denominator of Eq. 28, look at Fig. 11.

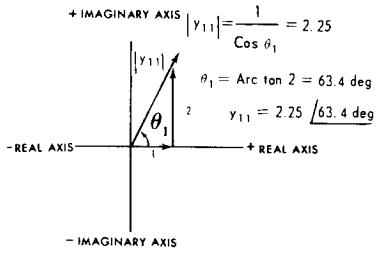


FIGURE 8 — CALCULATION OF MAGNITUDE AND ANGLE OF y_{11}

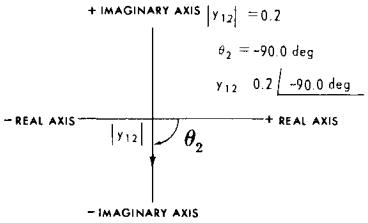


FIGURE 9 — CALCULATION OF MAGNITUDE AND ANGLE OF y_{12}

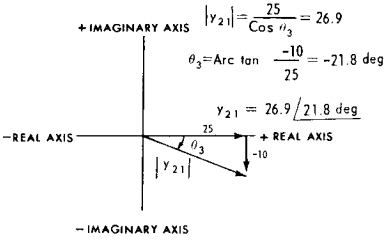


FIGURE 10 — CALCULATION OF MAGNITUDE AND ANGLE OF y_{21}

$$re(y_{12}y_{21}) = 5.38 \sin 21.8° = -2.00 \tag{29}$$

so

$$\frac{P_{oo}}{P_{io}} = \frac{725}{0.08 - 2(-2.00)} = 178 \tag{30}$$

To determine stability

$$C = 2\frac{P_{oo}}{P_{io}}\frac{|y_{12}|}{|y_{21}|} \tag{14}$$

$$C = 2\,(178)\,\frac{0.2}{26.9} = 2.64 \tag{31}$$

Since C is larger than 1, the 2N918 will be inherently unstable in our 51-Mc circuit and calculations for K_G in Eqs. 12 and 15 will not hold. If C had been less than 1, we could have found A_{PFM}, the maximum possible forward power gain for the amplifier, by using Eqs. 12 and 15.

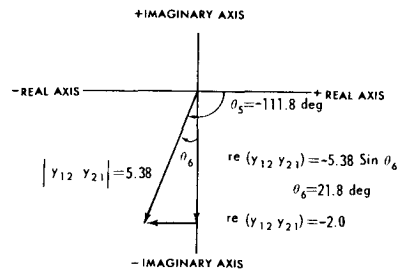


FIGURE 11 — CALCULATION OF REAL COMPONENT OF $(y_{12}\,y_{21})$

OUTPUT-CIRCUIT DESIGN

Experience has shown that if one heavily mismatches the transistor output, the stage likely will be stable. Many transistors require collector loads in the range between 100 and 1000 ohms: 500 ohms is a good starting point. The designer likely will use a tuned circuit to get rid of any imaginary components.

Most 51-Mc coils with ferrite tunable slugs have values of unloaded Q_u in the 50-100 range. To keep coil losses small, the loaded Q_L should be much less than unloaded Q_u. Q_L equal to 5 is a reasonable value.

This determines the collector-circuit bandwidth (neglecting the input circuit, which will reduce overall stage bandwidth if it also is tuned).

$$BW_{coll} = \frac{f_o}{Q_L} = \frac{51\text{ Mc}}{5} \approx 10\text{ Mc} \tag{32}$$

This will make the amplifier usable over the low end of the 6-meter band.

To insure Q_L = 5, examine the circuit shown in Fig. 12. The total parallel resistance across the tuned circuit is the transistor output resistance in parallel with the load. Assume the load is 500 ohms and smaller than the output resistance. Calculate the value of parallel capacitance to get an approximate Q_L of 5:

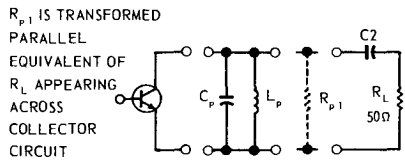


FIGURE 12 — EQUIVALENT AC OUTPUT CIRCUIT

$$C_p = \frac{Q_L}{2\pi f_o R_p} = \frac{5}{2(3.14)51(10)^6(500)} = 31\text{ pf} \tag{33}$$

where f_o = resonant frequency in cps

R_p = parallel resistance in ohms

Total parallel capacitance should be 31 pf. Transistor capacitance is about 2 pf, C_2 (Eq. 35) is about 20 pf and stray wiring capacitance is about 2 pf. These all contribute to total capacitance, so add a variable capacitor across the circuit that will vary from about 5-20 pf to insure that it can tune to resonance.

What value of inductance will resonate with 31 pf at 51 Mc?

$$L_p = \frac{1}{4\pi^2 f_o^2 C_p}$$

$$= \frac{1}{4(9.86)(2600)10^{12}31(10)^{-12}} = 0.31\ \mu h \qquad (34)$$

Suppose now we want to match the collector load into 50 ohms, C_2 in Fig. 12 should be:

$$C_2 = \frac{1}{2\pi f_0}\sqrt{\frac{1}{R_L(R_{p1} - R_L)}}$$

$$= \frac{1}{2\pi(51)10^6}\sqrt{\frac{1}{50(500-50)}} = 21\ \text{pf} \qquad (35)$$

Use 20 pf since this is a standard size. This value of C_2 insures that the 50-ohm load is transformed into the 500-ohm equivalent load desired across the collector circuit for stability.

INPUT-CIRCUIT DESIGN

Add a tuned circuit to the input for selectivity and matching. Fig. 13 shows a matching circuit to transform 50 ohms into 500 ohms to match

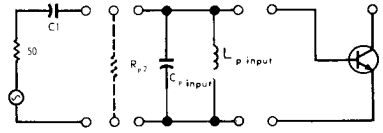


FIGURE 13 — EQUIVALENT AC INPUT CIRCUIT

$$\frac{1}{2}\left(\frac{1}{re(y_{11})}\right)$$

Since the transistor is terminated in 500 ohms instead of a short-circuit its input resistance drops below

$$\frac{1}{re(y_{11})}$$

Set the resistive component across the input circuit due to the transformed generator impedance to 500 ohms. C1 is 20 pf, the same as C_2, since the desired impedance transformation is the same. These 500 ohms are in parallel now with approximately

$$\frac{1}{2}\left(\frac{1}{re(y_{11})}\right)$$

across the input coil. The total parallel resistance across the coil then is

$$R_{P2} = \frac{(500)(500)}{500 + 500} = 250 \text{ ohms} \tag{36}$$

Use R_{P2} to calculate Q_L for the input similar to the calculations for the collector circuit. Let $Q_L = 10$ for higher input selectivity.

$$C_p \text{ input} = \frac{Q_L \text{ input}}{2\pi f_0 R_{P2}}$$
$$= \frac{10}{(6.28)(51)(10)^6(250)} = 125 \text{ pf} \tag{37}$$

Make the input variable capacitor tune 75-200 pf.

$$L_p \text{ input} = \frac{1}{4\pi^2 f_0^2 C_p \text{ input}}$$
$$= \frac{1}{(4)(9.86)(51)^2(10)^{12}(125)(10)^{-12}}$$
$$= 0.07\ \mu h \tag{38}$$

If the generator impedance should have been transformed into something other than 500 ohms, the designer could have calculated C_1 from:

$$C_1 = \frac{1}{2\pi f_0}\sqrt{\frac{1}{R_{gen}(R_p \text{ transformed} - R_{gen})}} \tag{39}$$

DC CIRCUIT DESIGN

D-c bias design remains. See Fig. 14. Say a 6v battery is specified. With 5v across the collector-emitter, 1v is available to drop across an emitter resistor. For 1 ma I_E, the emitter resistor must be:

$$R_4 = \frac{V_E}{I_E} = \frac{1v}{1 \times 10^{-3} \text{ amp}} = 1k \tag{40}$$

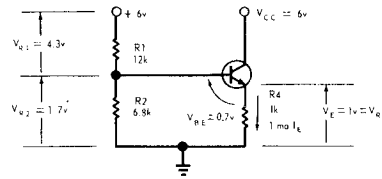


FIGURE 14 — DC BIAS RESISTORS

The base voltage V_{R2} will be the emitter voltage V_{R4} plus V_{BE}. Since V_{BE} is about 0.7v for a silicon transistor,

this sum is about 1.7v. The base divider network R_1 and R_2 must give 1.7v on the transistor base. Also, the current in R_2 should be about 1/4 I_E (or larger) for d-c temperature stability.

$$\text{Let } I_{R2} = I_E/4 = 0.25 \text{ ma.}$$

$$V_{R2} = 1.7\text{v}$$

$$R_2 = \frac{V_{R2}}{I_{R2}} = \frac{1.7}{0.25 \times 10^{-3}} = 6.8\text{k} \tag{41}$$

If h_{FE} (d-c beta) is high, the current through R_1 will nearly equal the current through R_2. If h_{FE} is low, say 10, then

$$I_B \approx \frac{I_E}{h_{FE}} = \frac{1 \text{ ma}}{10} = 0.1 \text{ ma} \tag{42}$$

The current through R_1,

$$I_{R1} = I_{R2} + I_B = 0.25 + 0.10 = 0.35 \text{ ma} \tag{43}$$

The voltage drop across R_1 is

$$V_{R1} = V_{cc} - V_{R2} = 6.0\text{v} - 1.7\text{v} = 4.3\text{v} \tag{44}$$

$$R_1 = \frac{V_{R1}}{I_{R1}} = \frac{4.3}{0.35 \times 10^{-3}} = 12\text{k} \tag{45}$$

Bypass capacitors can be 0.001-μf ceramic discs if their leads are less than 1/4 inch. If their leads are longer, the capacitors could be operating above the point of series resonance with their own lead inductance. They then would look inductive at this high frequency instead of capacitive. Fig. 15 lists resonant frequencies for some typical capacitor values with 1/4-inch leads. Each capacitor value should be used below its resonant frequency to avoid parasitic resonances.

CAPACITANCE (μf)	MAXIMUM BYPASS FREQUENCY (RESONANCE)
0.1	5 Mc
0.01	16 Mc
0.004	25 Mc
0.001	50 Mc
200 pf	110 Mc
100 pf	160 Mc

FIGURE 15 — APPROXIMATE RESONANT FREQUENCY OF CAPACITORS WITH TWO ¼-INCH LEADS

FINAL CALCULATIONS

This completes the RF amplifier design. Fig. 16 shows the complete circuit. Fig. 17 shows measured data on this circuit. Average power gain on five transistors is 22.7 db. This compares with the calculated figure of merit.

$$\frac{P_{oo}}{P_{io}}\text{ (db)} = 10 \log_{10} \frac{P_{oo}}{P_{io}}$$

$$= 10 \log_{10}(178) = 22.5 \text{ db} \tag{46}$$

Normally P_{oo}/P_{io} will be within a few db of realizable stage gain for stable load terminations. If measured gain is considerably higher than P_{oo}/P_{io}, one should check the stage for regeneration. In the case of regeneration, a smaller R_{p1} may be required. This is obtained by increasing C_2 in Fig. 12.

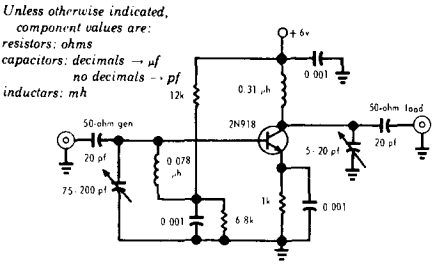


FIGURE 16 — COMPLETE 51 Mc AMPLIFIER

Calculated bandwidth for the two cascaded single-tuned circuits (input and output) is

$$\text{Overall BW} \approx \frac{f_o}{Q_L}(0.75) = \frac{51}{10}(0.75) = 3.8 \text{ Mc} \qquad (47)$$

Calculated bandwidth and gain vary slightly from measured values. This could be because individual transistor admittances vary from unit to unit. Also, the transistors measured in the circuit shown in Fig. 16 were not the identical units on which the original y-parameter data were taken for Figs. 4 through 7. Since the measured gain was slightly higher than calculated gain and since the measured bandwidth was slightly less than calculated for most of the transistors, the amplifier is likely operating slightly regenerative. No oscillations occurred, but if the amplifier were to be operated over a temperature range where parameter changes could occur, increased collector loading on the order of 250 ohms (instead of the 500 ohms used) would increase circuit stability. This would only slightly decrease the gain (3 db or less).

	TRANSISTOR NO.	TRANSDUCER POWER GAIN (db)	BW Mc
2N918	1	23.9	2.6
$f = 51$ Mc	2	20.7	3.6
$V_{CE} = 5v$	3	22.9	3.1
$I_E = 1ma$	4	23.6	3.1
	5	22.6	3.5
	Average	22.7 db	3.2 Mc

FIGURE 17 — MEASURED VALUES FOR 51 Mc AMPLIFIER

More exact circuit predictions are possible by using some of the graphical methods referenced earlier. But they are considerably more involved than the methods shown. If the output mismatch is enough to make the device stable and retain gain nearly equal to P_{oo}/P_{io}, both methods generally yield similar results.

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DETERMINING MAXIMUM RELIABLE LOAD LINES FOR POWER TRANSISTORS

Operation of power transistors within their power-temperature ratings alone is not a sufficient safeguard to guarantee circuit reliability. An additional consideration of the allowable collector-emitter voltage vs. collector current must be taken into account, otherwise a distinctive condition termed "secondary breakdown" can occur.

To avoid this secondary breakdown condition, it is necessary to maintain the load line within safe voltage and current limits.

As described later, secondary breakdown is a function of time in addition to voltage or current and, since transistors can be operated at an infinite number of time intervals and operating points, reliable load line operation is specified by safe operating areas including time as a parameter.

SECONDARY BREAKDOWN

For a fixed bias on the base-emitter junction, as collector voltage is increased on a power transistor the collector current increases slowly to a certain point at which the increase becomes rapid and an avalanche condition exists. The collector voltage at which avalanche occurs is determined by the voltage condition across the emitter-base junction. In other words, the transistor bias condition determines the point of avalanche. Avalanche in itself is nondestructive if power dissipation is limited, but a destructive breakdown can occur if the collector current is allowed to increase to a high value. This is called "second breakdown"[1, 2, 3].

Second breakdown is associated with the collector-base junction, and is controlled by the mitter-base junction. The electrical interplay of the junctions is such that second breakdown is triggered at lower voltages as collector current is increased. The locus of secondary breakdown trigger points is shown in Figure 1 for a 1/2 wave 60 cps pulse.

The exact action of second breakdown is not known but seems to be associated with a sudden concentration of energy into a small area, the energy being a function of collector voltage, collector current, and time. This concentrated energy dissipates power in a very small volume which causes the temperature to exceed the melting point of the semiconductor material. The two junctions can then flow together causing a collector-to-emitter short.

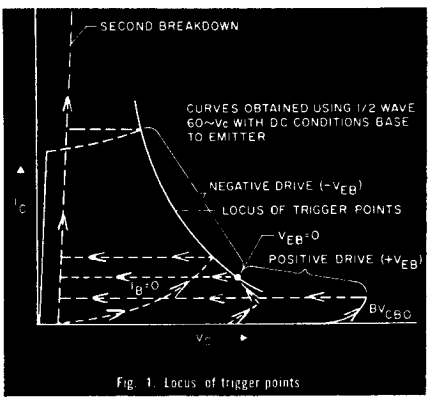


Fig. 1. Locus of trigger points

PULSE TEST

To establish safe operating areas, through destructive testing, for various pulse widths, the test circuit shown in Fig. 2 was developed. In this circuit, a reverse bias sufficient to keep the transistor cut off until the pulse is applied, is always present between base and emitter. The 10-ohm resistor in the bias circuit is necessary to permit a negative voltage to build up and turn on the transistor when the pulse is applied.

The pulse test signal is obtained from a pulse generator and a transistor amplifier. The amplifier transistor must be a high-speed germanium device such as a 2N2832. The pulse amplitude is controlled by setting the output of the pulse generator high enough to saturate the amplifier transistor. The signal into the transistor under test is controlled by varying the collector supply voltage.

The output waveform is monitored on an XY oscilloscope across a sensing resistor which is made from Cantol type A-1 flat ribbon. A 0.1-ohm sensing resistor is used for collector currents below five amperes and a 0.01-ohm sensing resistor is used at higher collector currents.

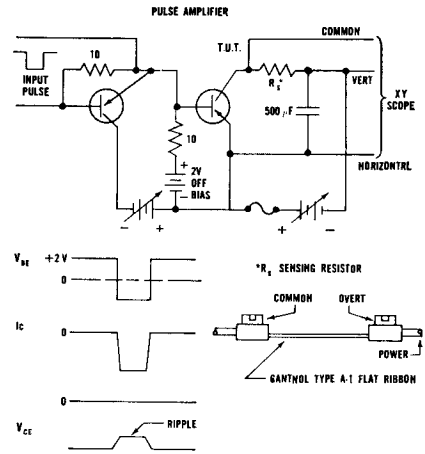


Fig. 2 Circuit used to establish safe operating areas.

To keep the voltage drop in the interconnecting wiring to a negligible value, number 10 wire is used for circuit connections and number 4 stranded cable is employed for connecting to the batteries used as the voltage source.

The 500 μf capacitor bypasses voltage transients resulting from the rapid change of current through the inductance of the connecting leads. The fuse or circuit breaker is necessary to prevent burning out the sensing resistor or other components when the transistor shorts.

The source voltage is set at a fixed level in steps of 12 volts each. Collector current is increased by increasing the base drive until second breakdown occurs. A short occurs, since no current limiting is used.

PLOT OF BREAKDOWNS

The voltage and current failure point is observed on the XY scope and recorded on a graph similar to Fig. 3. To establish a usable safe area curve, at least 5 to 10 transistors are tested and destroyed at each pulse width and voltage. To construct the safe area curve on the graph, a line is drawn connecting the worst-case points of each voltage group.

Notice that, regardless of the pulse width, as current is increased the device will withstand less voltage.

Using an average of the failure points from Fig. 3, the typical graph of energy in watt-seconds required for second breakdown is plotted in Fig. 4. The shape of these curves is logical since as current increases the effective emitter area

decreases and as voltage increases the effective base width decreases. Thus, as current and voltage increase there is a continuous shrinking of the active volume containing the energy.

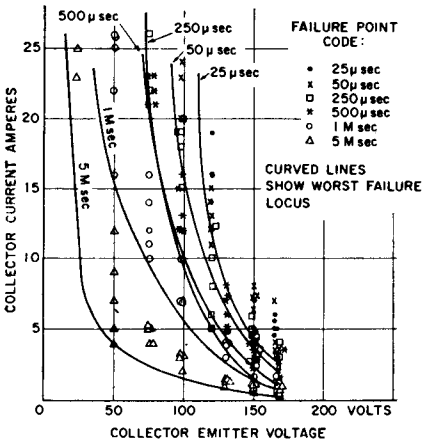


Fig. 3. Graph shows typical failure points for 2N2528 transistor.

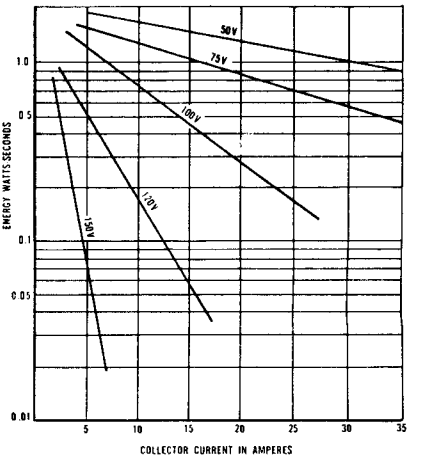


Fig. 4. Typical energy required to cause transistor failure is plotted against current with a constant voltage applied.

It is difficult to relate the results theoretically, due to all the variables which affect current crowding, although the effect of base width changing with voltage is a well-known expression. Also, since base width decreases with voltage, the effective base resistance increases due to the transverse area shrinking, which intensifies the current crowding.

DC TESTS

The test circuit used to determine failures under dc and long-time pulse conditions is shown in Fig. 5. A common-base circuit is used for this test to prevent thermal runaway.

Also, since power levels approaching 200 watts may be encountered during tests, a water-cooled heat sink is necessary. The heat sink consists of a 4" X 4" X 1/8" copper sheet with a "U" shaped copper tubing soldered to it around the transistor mounting area. Ice water is circulated through the tubing to remove heat from the copper plate.

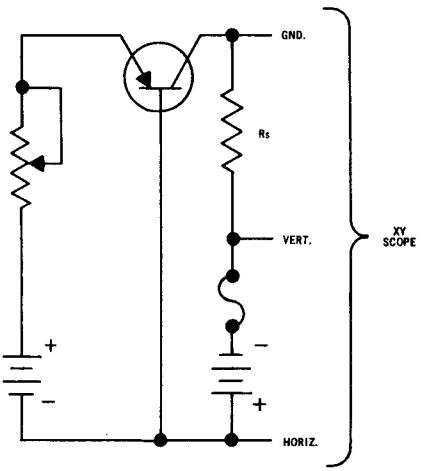


Fig. 5. Circuit used to establish dc safe operating areas.

The dc failure points were determined in a similar manner as previously described for the pulse tests.

POWER-TEMPERATURE DERATING vs SAFE AREA

This application note shows safe area curves for many Power Transistors and includes de-ratings due to temperature effects. In addition to the Safe Areas, a power dissipation curve is plotted for each device. This power curve represents the allowable average power which could be dissipated at a given case temperature (usually 25°C) without exceeding the particular maximum junction temperature. At higher case temperatures the allowable average power will be less depending on thermal resistance and the power area would be represented by a curve drawn to the left and below the one shown. In general, the allowable power at 25°C (case) is beyond the allowable dc and longtime pulse safe areas and the device is breakdown-voltage limited. However, at higher case temperatures the device may be power-dissipation limited.

In any event, both average power-temperature de-rating and safe areas must be obeyed. In addition, the switching of power causes time-dependent temperature increases which are of concern but are separate from the safe area considerations.

This temperature dependency is associated with the thermal time constant of the transistor.

The proper control of temperature rise and peak power will insure that the maximum junction temperature is not exceeded. In addition, the proper control of pulse load line to stay within the applicable Safe Area curve will insure that a collector to emitter short will not be caused.

EXTENSION TO COLLECTOR-BASE BREAKDOWN

Some devices have a collector-base breakdown rating greater than the collector-emitter breakdown. Operation is allowable in the region between $V_{CE(max)}$ and $V_{CB(max)}$; however, it is recommended that the current be kept as low as possible by back biasing of the base-emitter junction.

APPLICATION CHECKS

The safe areas were double checked in the following applications to see if the pulse safe area curves were meaningful: (1) audio, (2) solenoid driver, (3) power inverter, and for dc safe area, (4) low frequency audio and dc regulators.

(1) Audio

The audio application was used to test low-frequency effects which should correlate with the 5 millisecond safe areas. Devices were put into the class A circuit shown in Fig. 6, with an ac resistive load, the dc being bypassed by a shunt inductance. The input was deliberately overdriven and then the load resistor removed to obtain a reactive load line.

It was hoped that an elliptical load line could be obtained with an excursion controlled by drive voltage and with time of the excursion controlled by frequency. While this did occur, the excursion was very low at high frequencies and thus the fast pulse areas could not be probed. At frequencies between 50-200 cps, a large excursion was possible and failures were caused by exceeding the 5 msec safe area curve.

(2) Solenoid Driver

The solenoid driver consisted of controlling the load line with a suppression diode across the inductance or a zener diode across the transistor. The diode across the inductance clamps the load line excursion at the dc source voltage as indicated in Fig. 7. The zener diode method resulted in a rectangular load line as indicated in Fig. 8 and clamping occurs at the zener voltage.

A word of caution is necessary concerning this application. The fast switching can cause induced voltage in long lead lengths to the power supply. Thus, it is necessary to connect the suppression diode as close to the collector as possible and use a clamping capacitor from the emitter to the connecting point of the diode and inductance. When using the zener diode it should be soldered as close to the emitter and collector pin as possible. No failures occurred when the load line was contained within the 25-μsec safe area curve.

(3) Power Inverters

One of the most critical operations of power transistors is in inverter circuits similar to that shown in Fig. 9. A typical inverter circuit was used to test several types of power transistors. The load line was observed while holding the peak current constant and increasing the voltage until failures occurred. Then the current was increased at a constant supply voltage until failures were encountered. Cases of failure occurred after the load line was well beyond the 25-μsec safe area.

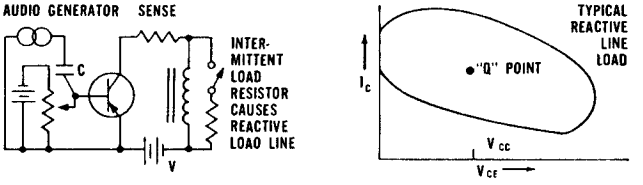


Fig. 6. Transistor arrangement for a class A audio circuit.

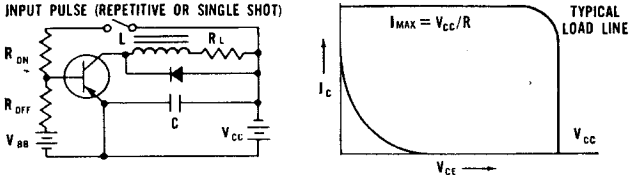


Fig. 7 Circuit for a transistor solenoid driver with diode suppression.

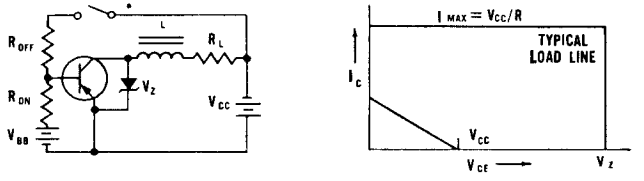
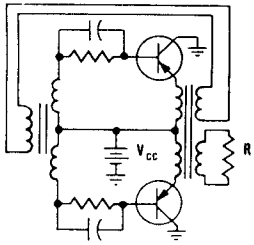


Fig. 8. Circuit for transistorized solenoid driver with zener diode.



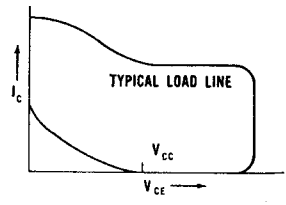


Fig. 9. Circuit arrangement for inverter.

(4) DC and Low Frequency Audio

In dc applications such as voltage regulators and in low frequency (below 100 cycle) audio circuits, the dc safe-area curve in conjunction with the power-temperature derating curve establishes reliable operating limits. Depending upon the device type and case temperature, the load line may be limited by either the power dissipation rating or the dc safe-area rating. In some instances, the dc safe limit and the power dissipation limit can cross. In this case, the load line limit would be established at low currents and high voltage by the dc safe limit and by the power dissipation limit at high current and low voltage.

The above discussion also applies to low duty cycle surge conditions such as encountered in incandescent lamp flashers where low initial resistance of the lamp permits a high-current surge for 50 to 100 milliseconds. This can trigger secondary breakdown even though succeeding current pulses are very low after the lamp resistance increases.

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RF SMALL SIGNAL DESIGN USING ADMITTANCE PARAMETERS

INTRODUCTION

Design of the solid-state small-signal RF amplifier using two port parameters is a systematic, mathematical procedure, with an exact solution (free from approximation) available for the complete design problem. The only sources of error in the final design are parameter variations resulting from transistor parameter distributions and strays in the physical circuit. Parameter distributions result from limits in measurement and random variations among identically designed transistors.

The purpose of this paper is to provide, in a single working reference, the important relationships necessary for the complete solution of the RF small signal design problem using admittance parameters.

The paper is based on work by Linvill, Stern, and others. Those who may wish to consider the derivations of some of the expressions should refer to the original work presented in the references.

The report assumes that the reader is familiar with the two port parameter method of describing a linear active network. Several references are available on this subject. [1,2]

It has also been assumed that a suitable transistor for the task at hand has been selected, and that admittance parameters are available for the frequency and bias point which will be used. Device selection will not be covered as a separate topic in this report; rather, a thorough understanding of the material in the report should provide the designer with the tools he needs to select transistors for a particular small signal application.

The equations given in the text of the report are applicable to the common emitter, common base, or common collector configuration, if the applicable set of parameters (common emitter, common base, or common collector parameters) is used.

While directed primarily toward circuit design with conventional junction transistors, two port network theory has the advantage of being applicable to any linear active network. The same design approach and equations may therefore be used with field effect transistors or any other devices which may be described as a linear active two port network with measurable parameters.

Finally, various parameter interrelationships and other data are given in the Appendix.

GENERAL DESIGN CONSIDERATIONS

Design of the RF small signal tuned amplifier is usually based on a requirement for a specified power gain at a given frequency. Other design goals include bandwidth, stability, and input-output isolation. After a basic circuit type is selected, the applicable design equations can be solved.

Circuits may be categorized according to feedback (neutralization, unilateralization, or no feedback), and matching at transistor terminals (circuit admittances either matched or mismatched to transistor input and output admittances). Each of these circuit categories will be discussed, including the applicable design equations and the considerations leading to the selection of a particular configuration.

STABILITY

A major factor in the overall design is the potential stability of the transistor. This may be determined by computing the Linvill stability factor[2] C using the following expression:

$$C = \frac{|y_{12}\ y_{21}|}{2g_{11}\ g_{22} - \text{Re}\ (y_{12}y_{21})} \tag{1}$$

When C is less than 1, the transistor is unconditionally stable. When C is greater than 1, the transistor is potentially unstable.

The C factor is a test for stability under a hypothetical worst case condition; that is, with both input and output transistor terminals open circuited. With no external feedback, an unconditionally stable transistor will not oscillate with any combination of source and load. If a transistor is potentially unstable, certain source and load combinations will produce oscillations.

Although the C factor may be used to determine the potential stability of a transistor, the conditions of open circuited source and load which are assumed in the C factor test are not applicable to a practical amplifier. Consequently it is also desirable to compute the relative stability of actual amplifier circuits, and Stern[3] has defined a stability factor k for this purpose. The k factor is similar to the C factor except that it also takes into account finite source and load admittances connected to the transistor. The expression for k is: †

$$k = \frac{2\ (g_{11} + G_s)\ (g_{22} + G_L)}{|y_{12}y_{21}| + \text{Re}\ (y_{12}y_{21})} \tag{2}$$

If k is greater than one, the circuit will be stable. If k is less than one, the circuit will be unstable.

Note that the C factor simply predicts potential stability of a transistor with an open circuited source and load, while the k factor provides a precise stability computation for a specific circuit.

Stability considerations will be discussed further in the descriptions of each basic circuit type to follow.

GENERAL DESIGN EQUATIONS

There are a number of design equations which are applicable to most types of amplifiers. These equations will be discussed first. Descriptions of specific amplifier types will then follow, and each will contain additional design equations applicable to that particular amplifier.

† Re $(Y_{12}Y_{21})$ = Real part of $(Y_{12}Y_{21})$

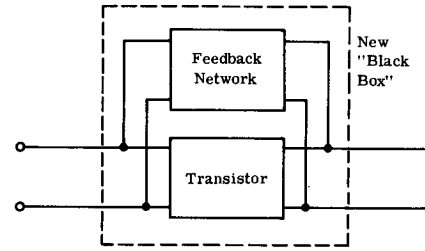
POWER GAIN

The general expression for power gain is:

$$G = \frac{|y_{21}|^2 \ \mathrm{Re}\,(Y_L)}{|Y_L + y_{22}|^2 \ \mathrm{Re}\,(y_{11} - \frac{y_{12}y_{21}}{y_{22} + Y_L})} \qquad (3)$$

Equation 3 applies to circuits with no external feedback. It can also be used with circuits which have external feedback if the composite y parameters of both transistor and feedback network are substituted for the transistor y parameters in the equation. The composite y parameters are determined by considering the transistor and the feedback network to be two "black boxes" in parallel:

For example, the above combination of transistor and feedback network may be characterized as a single "black box" by the following equations: †



$$y_{11c} = y_{11t} + y_{11f}$$

$$y_{12c} = y_{12t} + y_{12f}$$

$$y_{21c} = y_{21t} + y_{21f} \qquad (4)$$

$$y_{22c} = y_{22t} + y_{22f}$$

Where:

y_{11c}, y_{12c}, y_{21c}, y_{22c} are the composite y parameters of the parallel combination of transistor and feedback network.

y_{11t}, y_{12t}, y_{21t}, y_{22t} are the y parameters of the transistor.

y_{11f}, y_{12f}, y_{21f}, y_{22f} are the y parameters of the feedback network.

Note that, since this approach treats the transistor and feedback network combination as a single "black box" with y11c, y12c, y21c, and y22c as its y parameters, the composite y parameters may therefore be substituted in any of the design equations applicable to a linear, active, two port analysis.

The neutralized and unilateralized amplifiers are special cases of this general concept, and equations associated with those special cases will be given later.

Equation 3 provides a solution for power gain of the linear active network (transistor) only. Input and output networks are considered to be part of the

†Refer to Seshu and Balabanian, "Linear Network Analysis," John Wiley and Sons, 1959, P321

source and load, respectively. Two important points should therefore be kept in mind:

(1) Power gain computed from equation 3 will not take into account network losses. Input network loss reduces power delivered to the transistor. Power lost in the output network is computed as useful power output, since the load admittance Y_L is the combination of the output network and its load.

(2) Power gain is independent of source admittance. An input mismatch results in less input power being delivered to the transistor. Accordingly, note that equation 3 does not contain the term Y_S.

The power gain of a transistor together with its associated input and output networks may be computed by measuring the input and output network losses, and subtracting them from the power gain computed with equation 3.

In some cases it may be desirable to include the effects of input matching in power gain computations. A convenient term is transducer gain G_T, defined as output power delivered to a load by the transistor, divided by the maximum input power available from the source.

The equation for transducer gain is:

$$G_T = \frac{4 \text{ Re } (Y_s) \text{ Re } (Y_L) \left|y_{21}\right|^2}{\left|(y_{11} + Y_s)(y_{22} + Y_L) - y_{12}y_{21}\right|^2} \qquad (5)$$

In this equation, Y_L is the composite transistor load admittance-composed of both output network and its load, and Y_S is the composite transistor source admittance-composed of both input network and its source. Therefore, transducer gain includes the effects of the degree of admittance match at the transistor input terminals but does not take into account input and output network losses.

As in equation 3, the composite y parameters of a transistor feedback network combination may be substituted for the transistor y parameters when such a combination is used.

The Maximum Available Gain MAG is an often used transistor figure-of-merit. The MAG is the theoretical power gain of a transistor with its reverse transfer admittance y_{12} set equal to zero, and its source and load admittances conjugately matched to y_{11} and y_{22}, respectively.

If $y_{12} = 0$, the transistor exhibits an input admittance equal to y_{11} and an output admittance equal to y_{22}.† The equation for MAG is, therefore, obtained by solving the general power gain expression, equation 3, with the conditions

$$y_{12} = 0$$

$$y_L = y_{22}^*$$

$$\text{and } y_s = y_{11}^*$$

† Obtained by solving the equations for transistor Y_{IN} and Y_{OUT} with y_{12} equal to zero. These equations are given later in the report.

which yields:

$$MAG = \frac{|y_{21}|^2}{4\ Re\ (y_{11})\ Re\ (y_{22})} \tag{6}$$

MAG is a figure of merit only, since it is physically impossible to reduce y_{12} to zero without changing the other parameters of the transistor. An external feedback network may be used to achieve a composite y_{12} of zero, but then the other composite parameters will also be modified according to the relationships given in the discussion of the composite transistor - feedback network "black box."

TRANSISTOR INPUT AND OUTPUT ADMITTANCES

The expression for the input admittance of a transistor is:

$$Y_{IN} = y_{11} - \frac{y_{12}\ y_{21}}{y_{22} + Y_L} \tag{7}$$

The expression for the output admittance of a transistor is:

$$Y_{OUT} = y_{22} - \frac{y_{12}\ y_{21}}{y_{11} + Y_s} \tag{8}$$

When the feedback parameter y_{12} is not zero, Y_{IN} is dependent on load admittance and Y_{OUT} is dependent on source admittance.

AMPLIFIER STABILITY

One of the major considerations in RF amplifier design is stability. The stability of a final design can be assured by including stability computations and considering stability in all design decisions relating to feedback and transistor source and load admittances.

The potential stability of the transistor should first be computed using equation 1.

The various alternatives concerning input-output matching and neutralization-unilateralization will now be discussed for both the unconditionally stable transistor and the potentially unstable transistor.

THE UNCONDITIONALLY STABLE TRANSISTOR

When the Linvill stability factor of the transistor as determined by equation 1 is less than one, the transistor is unconditionally stable. Oscillations will not occur using any combination of source and load admittances without external feedback. Stability is therefore eliminated as a factor in the remainder of the design, and complete freedom is possible with regard to matching and neutralization to optimize the amplifier for other performance requirements.

AMPLIFIERS WITHOUT FEEDBACK

The amplifier with no feedback is a logical choice for the unconditionally stable transistor in many applications since it may offer the advantages of fewer components and a simple tuning procedure.

Source and load admittances may be selected for maximum gain and/or any number of other requirements. Power gain and transducer gain may be computed using equations 3 and 5, respectively; input and output admittances may be computed using equations 7 and 8, respectively.

The amplifier stability factor may be computed using equation 2. While amplifier stability was assured from the beginning by the use of an unconditionally stable transistor, the designer may still wish to perform this computation to provide some insight into danger of instability under adverse environmental conditions, source and load variations, etc.

G_{max}

G_{max}, the highest transducer gain possible without external feedback, forms a special case of the no feedback amplifier.

The source and load admittances required to achieve G_{max} may be computed from the following:

$$G_S = \frac{1}{2\ \mathrm{Re}\,(y_{22})} \left\{ \left[2\ \mathrm{Re}\,(y_{11})\,\mathrm{Re}\,(y_{22}) - \mathrm{Re}\,(y_{12}y_{21}) \right]^2 - \left| y_{12}y_{21} \right|^2 \right\}^{\frac{1}{2}} \tag{9}$$

$$B_S = -\ \mathrm{Im}(y_{11}) + \frac{\mathrm{Im}(y_{21}y_{12})}{2\ \mathrm{Re}(y_{22})} \tag{10}$$

$$G_L = \frac{1}{2\ \mathrm{Re}(y_{11})} \left\{ \left[2\ \mathrm{Re}\,(y_{11})\,\mathrm{Re}\,(y_{22}) - \mathrm{Re}\,(y_{12}y_{21}) \right]^2 - \left| y_{12}y_{21} \right|^2 \right\}^{\frac{1}{2}} \tag{11}$$

$$B_L = -\ \mathrm{Im}(y_{22}) + \frac{\mathrm{Im}(y_{21}y_{12})}{2\ \mathrm{Re}(y_{11})} \tag{12}$$

Therefore, if the maximum possible power gain without feedback is desired for an amplifier, equations 9, 10, 11, and 12 are used to compute Y_S and Y_L.

The magnitude of G_{max} may be computed from the following expression:

$$G_{max} = \frac{\left| y_{21} \right|^2}{2\ \mathrm{Re}(y_{11})\,\mathrm{Re}(y_{22}) - \mathrm{Re}(y_{12}y_{21}) + \left\{ \left[2\,\mathrm{Re}(y_{11})\,\mathrm{Re}(y_{22}) - \mathrm{Re}(y_{12}y_{21}) \right]^2 - \left| y_{12}y_{21} \right|^2 \right\}^{\frac{1}{2}}} \tag{13}$$

Equations 9, 10, 11, and 12 can be obtained by differentiating equation 5 with respect to G_S, B_S, G_L, and B_L, and setting the four derivatives equal to zero. The G_S, B_S, G_L, and B_L thus computed can then be substituted in equation 5 to obtain the expression for G_{max}, equation 13.

THE LINVILL METHOD

The amplifier without feedback design problem may also be solved graphically using a technique developed by J.G. Linvill.† Linvill's technique is very useful for a certain class of problems. Since it is so fully discussed in many good references we will not go into it further here. An advantage of the Linvill technique is that it provides a reasonably rapid graphic solution relating gain, bandwidth, and stability. A disadvantage is its scope of usefulness, since the standard Linvill solution applies only to an amplifier with no external feedback and with Y_S conjugately matched to the transistor input admittance, Y_{IN}.

THE UNILATERIZED AMPLIFIER

Unilateralization consists of employing an external feedback network to achieve a composite y_{12} of zero.

While unilateralization is perhaps most often used to achieve stability with a potentially unstable transistor, other circuit considerations may also warrant the use of unilateralization with the unconditionally stable transistor. For example, the input-output isolation afforded by unilateralization may be desirable in a particular design.

Design equations for the unilateralized case are obtained by first computing the composite y parameters of the transistor-feedback network combination and then substituting the composite parameters in the general equations.

Referring to the discussion on composite y parameters and setting up the basic condition that y_{12c} must equal zero, the other composite y parameters can be computed. Assuming that a passive feedback network is being used, then

$$y_{11f} = y_{22f} = -y_{12f} = -y_{21f}$$

$$\text{and since } y_{12c} = 0,\ y_{12t} + y_{12f} = 0$$

$$\text{then } y_{12t} = -y_{12f},$$

$$\text{and } y_{12t} = -y_{12f} = y_{11f} = y_{22f} = -y_{21f}$$

Substituting the above results in equation 4 yields the following:

$$y_{11c} = y_{11t} + y_{12t}$$

$$y_{22c} = y_{22t} + y_{12t}$$

$$y_{12c} = y_{12t} - y_{12t} = 0$$

$$y_{21c} = y_{21t} - y_{12t}$$

Substituting these composite y parameters in equations 7, 8, 3, 16, and 5 respectively, yields equations 14, 15, 16, 17 and 18 for the unilateralized case:

Unilateralized input admittance

$$Y_{IN} = y_{11} + y_{12} \tag{14}$$

†Application Note AN166 Motorola Semiconductor Products, Inc. Dept T1C, 5005 E. McDowell Rd., Phoenix, Arizona. See also reference 6 in the bibliography.

Unilateralized output admittance

$$Y_{OUT} = y_{22} + y_{12} \tag{15}$$

Unilateralized power gain, general expression:

$$G_{PU} = \frac{\left|y_{21} - y_{12}\right|^2 \, Re\,(Y_L)}{\left|Y_L + y_{22} + y_{12}\right|^2 \, Re(y_{11})} \tag{16}$$

Unilateralized power gain with Y_L conjugately matched to Y_{OUT}:

$$G_U = \frac{\left|y_{21} - y_{12}\right|^2}{4\,Re(y_{11} + y_{12})\,(y_{22} + y_{12})} \tag{17}$$

Unilateralized transducer gain:

$$G_{TU} = \frac{4\,Re(Y_s)\,Re(Y_L)\,\left|y_{21} - y_{12}\right|^2}{\left|(y_{11} + y_{12} + Y_s)\,(y_{22} + y_{12} + Y_L)\right|^2} \tag{18}$$

Note that equations 14, 15, 16, 17, and 18, are given entirely in terms of the transistor y parameters, not those of the feedback network or the composite.

Another benefit of unilateralization is input-output isolation. As can be seen in equations 14 and 15, Y_{IN} is completely independent of Y_L, and Y_{OUT} is similarly independent of Y_S. In a practical sense, this means that in a single or multi-stage amplifier using unilateralized stages, tuning of any one network will not affect tuning in other parts of the circuit. Thus, the troublesome task of having to re-peak an entire amplifier following a change in tuning at a single point can be eliminated.

NEUTRALIZATION

Neutralization consists of employing a feedback network to reduce y_{12} to some value other than zero. Neutralization is generally used for the same purposes as unilateralization, but provides something less than the ideal cancellation of the transistor feedback parameter which unilateralization achieves. A typical example of neutralization might be a feedback network which provides a composite b_{12} of zero while having only a negligible effect on the transistor g_{12}.

The equations for a particular neutralized case would be developed in the same manner as those for the unilateralized case. Since there are an infinite number of possibilities, no specific equations will be given here.

This completes the discussion of design with the unconditionally stable transistor. The potentially unstable transistor will now be considered.

THE POTENTIALLY UNSTABLE TRANSISTOR

When the Linvill stability factor of the transistor as determined by equation 1 is greater than one, the transistor is potentially unstable. Certain combinations of source and load admittances will cause oscillations if no feedback is

used. In designing with the potentially unstable transistor, steps must be taken to ensure that the amplifier will be stable.

Stability is usually achieved by one or both of two methods:

(1) Using a feedback network which reduces the composite y_{12} to a value which ensures stability.

(2) Choosing a source and load admittance combination which provides stability.

A discussion of these basic methods is given below.

USING FEEDBACK TO ACHIEVE STABILITY

Either unilateralization or neutralization may be used to achieve stability. If unilateralization is used, the transistor-feedback network combination will be unconditionally stable. This may be verified by computing the Linvill stability factor of the combination. Since $y_{12c} = 0$, the numerator in equation 1 would be zero.

With stability thus assured, the remainder of the design may then be done to satisfy other requirements placed on the amplifier. After unilateralization has converted the potentially unstable transistor to an unconditionally stable combination, all other aspects of the design are identical to the unilateralized case with the unconditionally stable transistor. Power gains and input and output admittances may be computed using equations 14 through 18.

If neutralization is used to achieve stability, the Linvill stability factor can be used to compute the potential stability of any transistor-neutralization-network combination. Since in this case $y_{12c} \neq 0$, C will have a value other than zero.

After unconditional stability of the transistor-neutralization network combination has been achieved, the design may then be completed by treating the combination as an unconditionally stable transistor, and proceeding with the case of the unconditionally stable transistor in an amplifier without feedback. Power gains, input and output admittances, and the circuit stability factor may be computed by using the composite parameters of the combination in equations 2, 3, 5, 7, and 8.

STABILITY WITHOUT FEEDBACK

A stable design with the potentially unstable transistor is possible without external feedback by proper choice of source and load admittances. This can be seen by inspection of equation 2; G_S and/or G_L can be made large enough to yield a stable circuit regardless of the degree of potential instability of the transistor.

This suggests a relatively simple way to achieve a stable design with a potentially unstable transistor. A circuit stability factor k is selected, and equation 2 is used to arrive at values of G_S and G_L which will provide the desired k. In achieving a particular circuit stability factor, the designer may choose any of the following combinations of matching or mismatching of G_S and G_L to the transistor input and output conductances, respectively:

(1) G_S matched and G_L mismatched

(2) G_L matched and G_S mismatched

(2) Both G_S and G_L mismatched

Often a decision on which combination to use will be dictated by other performance requirements or practical considerations.

Once G_S and G_L have been chosen, the remainder of the design may be completed using the relationships which apply to the amplifier without feedback. Power gain and input and output admittances may be computed using equations 3, 5, 7, and 8.

Although the above procedure may be adequate in many cases, a more systematic method of source and load admittance determination is desirable for designs which demand maximum power gain per degree of circuit stability. Stern has analyzed this problem and developed equations for computing the conductance and susceptance of both Y_S and Y_L for maximum power gain for a particular circuit stability factor.[3, 5] These equations are given here:

$$G_S = \sqrt{\frac{k\left[\left|y_{12}y_{21}\right| + \mathrm{Re}(y_{12}y_{21})\right]}{2}} \cdot \sqrt{\frac{g_{11}}{g_{22}}} - g_{11} \tag{19}$$

$$G_L = \sqrt{\frac{k\left[\left|y_{12}y_{21}\right| + \mathrm{Re}(y_{12}y_{21})\right]}{2}} \cdot \sqrt{\frac{g_{22}}{g_{11}}} - g_{22} \tag{20}$$

$$B_S = \frac{(G_S + g_{11})\ Z_o}{\sqrt{k\left[\left|y_{12}y_{21}\right| + \mathrm{Re}(y_{12}y_{21})\right]}} - b_{11} \tag{21}$$

$$B_L = \frac{(G_L + g_{22})\ Z_o}{\sqrt{k\left[\left|y_{12}y_{21}\right| + \mathrm{Re}(y_{12}y_{21})\right]}} - b_{22} \tag{22}$$

Where,

$$Z = \frac{(B_S + b_{11})(G_L + g_{22}) + (B_L + b_{22})\, k(L + M)/2\,(G_L + g_{22})}{\sqrt{k\ (L + M)}} \tag{23}$$

$$L = \left|y_{12}y_{21}\right| \tag{24}$$

$$M = \mathrm{Re}(y_{12}y_{21}) \tag{25}$$

Defining D as the denominator in equation 5 yields:

$$D = \frac{Z^4}{4} + \frac{\left[k(L + M) + 2M\right] Z^2}{2} - 2NZ\sqrt{k(L + M)} + A^2 + N^2 \tag{26}$$

where,

$$A = \frac{k(L + M)}{2} - M, \tag{27}$$

$$N = \mathrm{Im}(y_{12}y_{21}), \tag{28}$$

and,

Z_O = that real value of Z which results in the smallest minimum of D, found by setting,

$$\frac{dD}{dZ} = Z^3 + \left[k(L + M) + 2M\right] Z - 2N\sqrt{k(L + M)}. \tag{29}$$

equal to zero.

Computation of Y_S and Y_L using equations 19 through 29 is a bit tedious to be done very frequently, and this may have discouraged wide usage of the complete Stern solution. However, examination of Stern's work suggests some interesting shortcuts:

(A) COMPUTATION OF G_S AND G_L ONLY, USING EQUATIONS 19 AND 20. If a value equal to $-b_{22}$ is then chosen for B_L, the resulting Y_L will be very close to the true Y_L for maximum gain. The transistor Y_{IN} can then be computed from Y_L using equation 7, and B_S can be set equal to $-I_M(Y_{IN})$.

Computation of B_S and B_L comprise by far the more complex portion of the Stern solution. This alternate method therefore permits the designer to closely approximate the exact Stern solution for Y_S and Y_L while avoiding that portion of the computations which are the most complex and time consuming. Further, the circuit can be designed with tuning adjustments for varying B_S and B_L, thereby creating the possibility of experimentally achieving the true B_S and B_L for maximum gain as accurately as if all the Stern equations had been solved.

(B) MISMATCHING G_S TO g_{11} AND G_L TO g_{22} BY AN EQUAL RATIO YIELDS A TRUE STERN SOLUTION FOR G_S AND G_L. This can be derived from equations 19 and 20, which lead to the following result:

$$\frac{G_L}{g_{22}} = \frac{G_S}{g_{11}} \tag{30}$$

If a mismatch ratio, R, is defined as follows,

$$R = \frac{G_L}{g_{22}} = \frac{G_S}{g_{11}} \tag{31}$$

then R may be computed for any particular circuit stability factor using the equation:

$$(1 + R)^2 = k\left[\frac{|y_{21}y_{12}| + \mathrm{Re}(y_{12}y_{21})}{2\, g_{11}\, g_{22}}\right] \tag{32}$$

Equation 32 was derived from equation 2. Having thus determined R, G_S and G_L can be quickly found using equation 31.

B_S and B_L can then be determined in the manner described above in alternate method (A).

This alternate method may be advantageous if source and load admittances and power gains for several different values of k are desired. Once the R for a particular k has been determined, the R for any other k may be quickly found from the equation

$$\frac{(1 + R_1)^2}{(1 + R_2)^2} = \frac{k_1}{k_2} \tag{33}$$

where R_1 and R_2 are values of R corresponding to k_1 and k_2, respectively.

(C) COMPUTER DESIGN. The complete Stern design problem may be programmed into a computer. Power gain, circuit stability factor, Y_S and Y_L can be obtained from the computer for any value of k. MAG, GU, and the Linvill stability factor of the transistor may also be included in the program.

After employing either the complete Stern solution or an alternate method to obtain Y_S and Y_L for the potentially unstable transistor in an amplifier without feedback, power gains and input and output admittances may be obtained using equations 3, 5, 7, and 8.

SENSITIVITY

In all but the unilateralized amplifier, Y_{IN} is a function of load admittance. Thus Y_{IN} changes with output circuit tuning, and this can be troublesome. Consequently, it is sometimes desirable to compute the extent of variation of Y_{IN} with changes in Y_L. A term, sensitivity δ, has been defined to provide a measure of this characteristic, and is equal to per cent change in Y_{IN} divided by per cent change in Y_L. The equation for sensitivity is:

$$\delta = \left|\frac{Y_L}{y_{22} + Y_L}\right| \cdot \left|\frac{g_{11}}{y_{11}}\right| \cdot \frac{K}{\left|\frac{y_{22} + Y_L}{g_{22}} + \frac{g_{11}}{y_{11}}\, K\, e^{j\theta}\right|} \tag{34}$$

where,

$$K = \frac{y_{21}\, y_{12}}{g_{11}\, g_{22}}$$

$$\theta = \arg\,(-y_{12}y_{21})\ *$$

$$K\, e^{j\theta} = K\,(\cos\theta + j\,\sin\theta)$$

A more complete discussion of sensitivity is given in reference 7.

SUMMARY

The small signal amplifier performance of a transistor is completely described by two port admittance parameters. Based on these parameters, equations for computing the stability, gain, and optimum source and load admittances for the unilateralized, neutralized, and no-feedback amplifier cases have been discussed.

The unconditionally stable transistor will not oscillate with any combination of source and load admittances, and circuits using a stable transistor may be optimized for other performance requirements without fear of oscillations.

The potentially unstable transistor requires that steps be taken to guarantee a stable design. Stability is usually achieved by unilateralization, neutralization, or selection of source and load admittances which result in a stable amplifier.

Unilateralization and neutralization reduce the composite reverse transfer admittance. They may be used to achieve stability, input-output isolation, or both.

Maximum power gain per degree of circuit stability without feedback may be achieved using Stern's equations.

The degree of input-output isolation is described by the term sensitivity, which makes it possible to compute changes in input admittance for any change in load admittance.

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GLOSSARY

C	=	Linvill's stability factor	Y_s	=	Complex source admittance
k	=	Stern's stability factor	G_T	=	Transducer gain
G_s	=	Real part of the source admittance	MAG	=	Maximum available gain
G_L	=	Real part of the load admittance	*	=	Conjugate
B_s	=	Imaginary part of the source admittance	Y_{IN}	=	Input admittance
B_L	=	Imaginary part of the load admittance	Y_{OUT}	=	Output admittance
g_{11}	=	Real part of y_{11}	G_{max}	=	Maximum gain without feedback
g_{22}	=	Real part of y_{22}	G_U	=	Unilateralized gain
G	=	Generalized power gain	G_{TU}	=	Unilateralized transducer gain
Y_L	=	Complex load admittance	δ	=	Sensitivity

APPENDIX I

A. Conversions among parameter types for y, z, h, and g parameters.

h to y

$$y_{11} = \frac{1}{h_{11}} \qquad y_{12} = \frac{-h_{12}}{h_{11}} \qquad y_{21} = \frac{h_{21}}{h_{11}} \qquad y_{22} = \frac{\Delta h}{h_{11}}$$

where $\Delta h = h_{11} h_{22} - h_{12} h_{21}$

y to h

$$h_{11} = \frac{1}{y_{11}} \qquad h_{12} = \frac{-y_{12}}{y_{11}} \qquad h_{21} = \frac{y_{21}}{y_{11}} \qquad h_{22} = \frac{\Delta y}{y_{11}}$$

where $\Delta y = y_{11} y_{22} - y_{12} y_{21}$

h to z

$$z_{11} = \frac{\Delta h}{h_{22}} \qquad z_{12} = \frac{h_{12}}{h_{22}} \qquad z_{21} = \frac{-h_{21}}{h_{22}} \qquad z_{22} = \frac{1}{h_{22}}$$

z to h

$$h_{11} = \frac{\Delta z}{z_{22}} \qquad h_{12} = \frac{z_{12}}{z_{22}} \qquad h_{21} = \frac{-z_{21}}{z_{22}} \qquad h_{22} = \frac{1}{z_{22}}$$

where $\Delta z = z_{11} z_{22} - z_{12} z_{21}$

h to g

$$g_{11} = \frac{h_{22}}{\Delta h} \qquad g_{12} = \frac{-h_{12}}{\Delta h} \qquad g_{21} = \frac{-h_{21}}{\Delta h} \qquad g_{22} = \frac{h_{11}}{\Delta h}$$

where $\Delta h = h_{11} h_{22} - h_{12} h_{21}$

g to h

$$h_{11} = \frac{g_{22}}{\Delta g} \qquad h_{12} = \frac{-g_{12}}{\Delta g} \qquad h_{21} = \frac{-g_{21}}{\Delta g} \qquad h_{22} = \frac{g_{11}}{\Delta g}$$

where $\Delta g = g_{11} g_{22} - g_{12} g_{21}$

z to y

$$y_{11} = \frac{z_{22}}{\Delta z} \qquad y_{12} = \frac{-z_{12}}{\Delta z} \qquad y_{21} = \frac{-z_{21}}{\Delta z} \qquad y_{22} = \frac{z_{11}}{\Delta z}$$

where $\Delta z = z_{11} z_{22} - z_{12} z_{21}$

y to z

$$z_{11} = \frac{y_{22}}{\Delta y} \qquad z_{12} = \frac{-y_{12}}{\Delta y} \qquad z_{21} = \frac{-y_{21}}{\Delta y} \qquad z_{22} = \frac{y_{11}}{\Delta y}$$

where $\Delta y = y_{11} y_{22} - y_{12} y_{21}$

z to g

$$g_{11} = \frac{1}{z_{11}} \qquad g_{12} = \frac{-z_{12}}{z_{11}} \qquad g_{21} = \frac{z_{21}}{z_{11}} \qquad g_{22} = \frac{\Delta z}{z_{11}}$$

where $\Delta z = z_{11} z_{22} - z_{12} z_{21}$

g to z

$$z_{11} = \frac{1}{g_{11}} \qquad z_{12} = \frac{-g_{12}}{g_{11}} \qquad z_{21} = \frac{g_{21}}{g_{11}} \qquad z_{22} = \frac{\Delta g}{g_{11}}$$

where $\Delta g = g_{11} g_{22} - g_{12} g_{21}$

g to y

$$y_{11} = \frac{\Delta g}{g_{22}} \qquad y_{12} = \frac{g_{12}}{g_{22}} \qquad y_{21} = \frac{-g_{21}}{g_{22}} \qquad y_{22} = \frac{1}{g_{22}}$$

where $\Delta g = g_{11} g_{22} - g_{12} g_{21}$

y to g

$$g_{11} = \frac{\Delta y}{y_{22}} \qquad g_{12} = \frac{y_{12}}{y_{22}} \qquad g_{21} = \frac{-y_{21}}{y_{22}} \qquad g_{22} = \frac{1}{y_{22}}$$

where $\Delta y = y_{11} y_{22} - y_{12} y_{21}$

B. Conversions among common emitter, common base, and common collector parameters of the same type for y, and h parameters.

Common emitter y parameters in terms of common base and common collector y parameters.

$$y_{11e} = y_{11b} + y_{12b} + y_{21b} + y_{22b} = y_{11c}$$

$$y_{12e} = -(y_{12b} + y_{22b}) = -(y_{11c} + y_{12c})$$

$$y_{21e} = -(y_{21b} + y_{22b}) = -(y_{11c} + y_{21c})$$

$$y_{22e} = y_{22b} = y_{11c} + y_{12c} + y_{21c} + y_{22c}$$

Common base y parameters in terms of common emitter and common collector y parameters.

$$y_{11b} = y_{11e} + y_{12e} + y_{21e} + y_{22e} = y_{22c}$$

$$y_{12b} = -(y_{12e} + y_{22e}) = -(y_{21c} + y_{22c})$$

$$y_{21b} = -(y_{21e} + y_{22e}) = -(y_{12c} + y_{22c})$$

$$y_{22b} = y_{22e} = y_{11c} + y_{12c} + y_{21c} + y_{22c}$$

Common collector y parameters in terms of common emitter and common base y parameters.

$$y_{11c} = y_{11e} = y_{11b} + y_{12b} + y_{21b} + y_{22b}$$

$$y_{12c} = -(y_{11e} + y_{12e}) = -(y_{11b} + y_{22b})$$

$$y_{21c} = -(y_{11e} + y_{22e}) = -(y_{11b} + y_{12b})$$

$$y_{22c} = y_{11e} + y_{12e} + y_{21e} + y_{22e} = y_{11b}$$

Common emitter h parameters in terms of common base and common collector h parameters.

$$h_{11e} = \frac{h_{11b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{h_{11b}}{1 + h_{21b}} = h_{11c}$$

$$h_{12e} = \frac{h_{11b}\,h_{22b} - h_{12b}(1+h_{21b})}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{h_{11b}\,h_{22b}}{1 + h_{21b}} - h_{12b} = 1-h_{12c}$$

$$h_{21e} = \frac{-h_{21b}(1-h_{12b}) - h_{22b}\,h_{11b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{-h_{21b}}{1 + h_{21b}} = -(1 + h_{21c})$$

$$h_{22e} = \frac{h_{22b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{h_{22b}}{1 + h_{21b}} = h_{22c}$$

Common base h parameters in terms of common emitter and common collector h parameters.

$$h_{11b} = \frac{h_{11e}}{(1 + h_{21e})(1-h_{12e}) + h_{11e}\,h_{22e}} \approx \frac{h_{11e}}{1 + h_{21e}}$$

$$= \frac{h_{11c}}{h_{11c}\,h_{22c} - h_{21c}\,h_{12c}} \approx \frac{-h_{11c}}{h_{21c}}$$

$$h_{12b} = \frac{h_{11e}\,h_{22e} - h_{12e}(1 + h_{21e})}{(1 + h_{21e})(1-h_{12e}) + h_{11e}\,h_{22e}} \approx \frac{h_{11e}\,h_{22e}}{1 + h_{21e}} - h_{12e}$$

$$= \frac{h_{21c}(1-h_{12c}) + h_{11c}\,h_{22c}}{h_{11c}\,h_{22c} - h_{21c}\,h_{12c}} \approx (h_{12c} - 1) - \frac{h_{11c}\,h_{22c}}{h_{21c}}$$

$$h_{21b} = \frac{-h_{21e}(1-h_{12e}) - h_{11e}\,h_{22e}}{(1 + h_{21e})(1-h_{12e}) + h_{11e}\,h_{22e}} \approx \frac{-h_{21e}}{1 + h_{21e}}$$

$$= \frac{h_{12c}(1 + h_{21c}) - h_{11c}\,h_{22c}}{h_{11c}\,h_{22c} - h_{21c}\,h_{12c}} \approx \frac{-(1 + h_{21c})}{h_{21c}}$$

$$h_{22b} = \frac{h_{22e}}{(1 + h_{21e})(1-h_{12e}) + h_{11e}\,h_{22e}} \approx \frac{h_{22e}}{1 + h_{21e}}$$

$$= \frac{h_{22c}}{h_{11c}\,h_{22c} - h_{21c}\,h_{12c}} \approx \frac{h_{22c}}{h_{21c}}$$

Common collector h parameters in terms of common base and common emitter h parameters.

$$h_{11c} = \frac{h_{11b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{h_{11b}}{1 + h_{21b}} = h_{11e}$$

$$h_{12c} = \frac{1 + h_{21b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx 1 = 1-h_{12e}$$

$$h_{21c} = \frac{h_{12b} - 1}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{-1}{1 + h_{21b}} = -(1 + h_{21e})$$

$$h_{22c} = \frac{h_{22b}}{(1 + h_{21b})(1-h_{12b}) + h_{22b}\,h_{11b}} \approx \frac{h_{22b}}{1 + h_{21b}} = h_{22e}$$

Expressions for voltage gain, current gain, input impedance, and output impedance in terms of y, z, h, and g parameters.

Voltage Gain

$$A_v = \frac{z_{21}\,Z_L}{\Delta z + z_{11}\,Z_L} = \frac{-y_{21}}{y_{22} + Y_L} = \frac{-h_{21}\,Z_L}{h_{11} + \Delta h Z_L} = \frac{g_{21}\,Z_L}{g_{22} + Z_L}$$

Current Gain

$$A_i = \frac{-z_{21}}{z_{22} + Z_L} = \frac{-y_{21}\,Y_L}{\Delta y + y_{11}\,Y_L} = \frac{h_{21}\,Y_L}{h_{22} + Y_L} = \frac{-g_{21}}{\Delta g + g_{11}\,Z_L}$$

Input Impedance

$$Z_{IN} = \frac{\Delta z + z_{11}\,Z_L}{z_{22} + Z_L} = \frac{y_{22} + Y_L}{\Delta y + y_{11}\,Y_L} = \frac{\Delta h + h_{11}\,Y_L}{h_{22} + Y_L}$$

$$= \frac{g_{22} + Z_L}{\Delta g + g_{11}\,Z_L}$$

Output Impedance

$$Z_{OUT} = \frac{\Delta z + z_{22} Z_s}{z_{11} + Z_s} = \frac{y_{11} + Y_s}{\Delta y + y_{22} Y_s} = \frac{h_{11} + Z_s}{\Delta h + h_{22} Z_s}$$

$$= \frac{\Delta g + g_{22} Y_s}{g_{11} + Y_s}$$

USING LINVILL TECHNIQUES FOR R.F. AMPLIFIERS

INTRODUCTION

Transistors are nonunilateral devices and may exhibit potential instability in some frequency range. Since oscillations will occur for some terminations at potentially unstable frequencies, several methods have been developed to select terminations which assure stable operation. In particular, the Linvill (1) technique relates device stability, gain, bandwidth, and sensitivity graphically (2). In addition to the advantages of the graphical approach, once the engineer becomes familiar with the Linvill technique, an amplifier may be rapidly designed.

To illustrate the technique, a Linvill chart for a device at an unconditionally stable frequency is drawn and an amplifier designed using this chart. At a lower frequency the device is potentially unstable and a chart is drawn to illustrate this case.

As the development of the Linvill concept is treated in the references, only procedures are given in this paper. This approach requires many formulae and remarks be accepted without proof. Nevertheless, the material presented is sufficiently complete to be used without benefit of the underlying theory.

SOME DEFINITIONS

If a device is "potentially unstable" oscillations will result for certain combinations of loads and sources. If a device is "unconditionally stable" no combination of source and load will produce oscillations without the aid of external feedback.

SYMBOLS

B_L	= Load susceptance = $Im(Y_L)$	Y_L	= Complex load admittance
b_{ij}	= $Im(y_{ij})$	Y_S	= Complex source admittance
g	= Ratio of an arbitrary gain to G_{oo}	y_{22}^*	= Conjugate of y_{22}
g_{ij}	= $Re(y_{ij})$	h_{ij}	= Hybrid parameter = $h_{ijr} + jh_{iji}$
G_{oo}	= Power gain for $Y_L = y_{22}^*$	h_{ijr}	= $Re(h_{ij})$
G_L	= Load conductance = $Re(Y_L)$	h_{iji}	= $Im(h_{ij})$
G_T	= Transducer gain = power dlvd to load/power available from the source	ω	= $2\pi f$
y_{ij}	= Admittance parameter = $g_{ij} + jb_{ij}$	*	= Conjugate

1) Transistors and Active Circuits, J. G. Linvill and J. F. Gibbons, McGraw-Hill Book Co., Inc., New York (1961).

2) "High-Frequency Amplifier Design Using Admittance Parameters: Parts 1 & 2," G.D. Johnson, P. Norris, and F. Opp, Electro-Technology, November, December, 1963.

Linvill defined a stability factor, the C-factor, which, when represented graphically, separates the potentially oscillatory loads from stable loads. Furthermore, if the device is unconditionally stable, the C-factor may be used to determine the maximum unneutralized gain, G_{max}.

Power gain is defined as the ratio of power delivered to the load to the power delivered to the input of the device. Linvill defined a power ratio, G_{OO}, as the power gain when a device is terminated in the conjugate of the output parameter, i.e., y_{22}, h_{22}, etc. This power ratio is also used to determine G_{max}.

LINVILL CHART PREPARATION

A Linvill chart is a modified Smith chart. The Smith chart is rotated 180° and relabeled. For admittance parameters, label the 1.0 conductance circle $G_2 = 2g_{22}$. Label the 1.0 and -1.0 susceptance circles $B_2 = 1.0\ g_{22}$ and $-1.0\ g_{22}$ respectively as in Fig. 1. Also add 1.0 to each conductance circle. Having thus modified a Smith chart, the Linvill chart is prepared as follows:

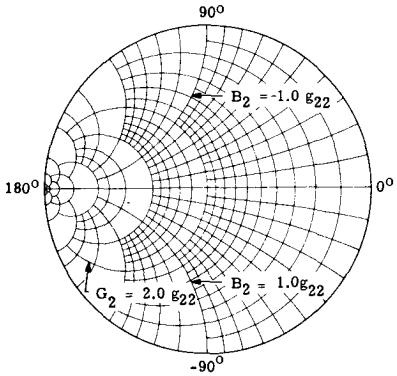


FIGURE 1 — MODIFIED SMITH CHART. (ADAPTED FROM REF. 1)

(1) Obtain admittance parameters at the desired frequency. For instance, typical common emitter y-parameters for the 2N3279 series at 200 Mc (I_C = -2 mA, V_{CE} = -6 V) are:

y_{11} = 17.0 + j11.7 mmhos

y_{12} = 0 -j0.92 mmhos

y_{21} = 22.8 -j44.8 mmhos

y_{22} = 0.29 +j1.91 mmhos

(2) Compute the gradient-line angle, θ, and plot the gradient-line at angle θ measured from 0° and through the center of the chart as in Fig. 2.

$\theta \triangleq \text{Arg}\ (-y_{21}y_{12})^*$

$y_{21}y_{12} = 46.3\ \angle -153.0°$

$-y_{21}y_{12} = -46.3\ \angle -153°$

$= 46.3\ \angle 27°$

$(-y_{21}y_{12})^* = 46.3\ \angle -27°$

$\theta = -27°$

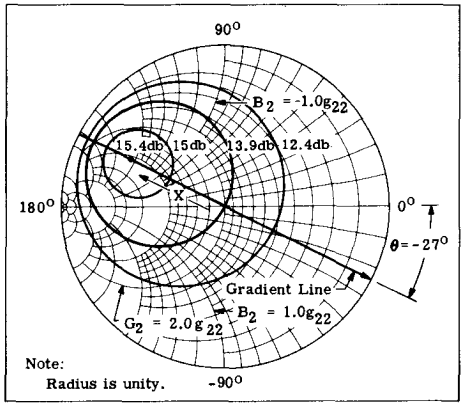


FIGURE 2 — 200 Mc LINVILL CHART

3) Compute the C-factor.

$$C = \frac{|y_{21}y_{12}|}{2g_{11}g_{22} - Re(y_{12}y_{21})}$$

$$= 0.903$$

Since $C < 1$ the device is unconditionally stable. When $C > 1$ the procedure of the second example applies.

4) Compute G_{oo}.

$$G_{oo} = \frac{C}{2}\left|\frac{y_{21}}{y_{12}}\right|$$

$$= 24.6 \text{ or } 13.9 \text{ db}$$

5) Compute G_{max}.

$$G_{max} = K G_{oo}$$

$$K = 2\left[\frac{1 - \sqrt{1-C^2}}{C^2}\right]^*$$

$$= 1.39$$

$$G_{max} = 15.4 \text{ db}$$

* Applies only if $C < 1$.

An infinite number of terminations will yield the same gain with the exception of G_{max}. On the Linvill chart, circles represent all possible loads which will give one gain. These circles have centers at

$$x = \frac{Cg}{2}$$

where x is measured along the gradient-line as shown in Fig. 2. The radii of these circles are found from

$$r = \left[1 - g + \left(\frac{Cg}{2}\right)^2\right]^{1/2}$$

where g is the ratio of any gain to G_{oo}. The maximum g is K for $C = 1$. Notice the radius of the chart is unity.

6) Compute the gain circle data.

g	g (db)	Center Cg/2	$r=\left[1 - g + (Cg/2)^2\right]^{1/2}$
1.39	+1.4	0.63	0
1.28	+1.1	0.58	0.23
1	0	0.45	0.45
0.707	-1.5	0.32	0.64

7) Plot these circles as the 15.4 db, 15 db, 13.9 db, 12.4 db corresponding to g's of 1.39, 1.28, 1.0, 0.707, respectively.

This completes the Linvill chart. The chart as prepared for use at our company is shown in Fig. 3. The use of the chart is explained in the design example.

AMPLIFIER DESIGN EXAMPLE

1) Assume it is desired to achieve maximum gain. The maximum gain is G_{max} = 15.4 db. Locate this point and read the coordinates in terms of $G_2 + jB_2$:

$$G_2 + jB_2 = 3.2\, g_{22} - j2.1\, g_{22}$$

2) The load is found from:

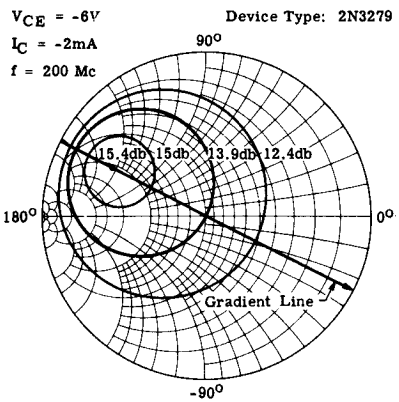
$$G_2 + jB_2 = Y_L + Y_{22}$$

$$G_L = G_2 - g_{22} = 2.2\, g_{22}$$

$$= 0.64 \text{ mmhos}$$

$$B_L = B_2 - b_{22} = -2.1\, g_{22} - 1.91$$

$$= -2.5 \text{ mmhos}$$

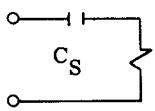


y_{11} = 17.0 + j11.7
y_{12} = 0 - j0.92
y_{21} = 22.8 - j44.6
y_{22} = 0.29 + j1.91

θ = -27°
G_{oo} = 13.9db
C = 0.903

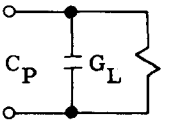
FIGURE 3

3) Assume the load the amplifier must be matched to is 50Ω. Let a transforming network be used as illustrated:



R_L = 50 Ω

which is equivalent to:



Using the relationships:

$$Q = \left(\frac{1}{G_L R_L} - 1\right)^{1/2}$$

$$X_S = Q R_L$$

and

$$C_P = C_S \frac{1}{\left(1 + \frac{1}{Q^2}\right)}$$

yields

$$C_S \cong C_P \cong 3 \text{ pf}$$

4) Bandwidth information is obtained from the chart using:

$$C_T = \frac{\Delta B}{2\Delta\omega}$$

Where C_T is the total parallel capacitance at the collector including the C_{out} of the device. ΔB is the total change in susceptance read from the chart. $\Delta\omega$ is the 3 db bandwidth. To find ΔB locate the $G_2 = 3.2\ g_{22}$ conductance circle. Follow this line in both directions from G_{max} to the gain circle 3 db below G_{max} (use the 12.4 db circle).

$$\Delta B = 8 g_{22} + 3.8\ g_{22} = 11.8\ g_{22}$$

For a 20 Mc bandwidth

$$\Delta\omega = (2\pi)\ (20 \times 10^6)$$

and

$$C_T = 13.6 \text{ pf}$$

5) C_T includes the output capacitance of the device. C_{out} is found from

$$Y_{out} = y_{22} - \frac{y_{12}\, y_{21}}{y_{11} + Y_S}$$

where

$Y_S = Y_{in}^*$ for maximum gain.

$$Y_{in} = y_{11} - \frac{y_{21} y_{12}}{y_{22} + Y_L}$$

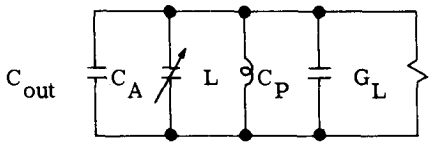
$$= 38.4 + j47.8$$

$$Y_S = 38.4 - j47.8$$

using this value of Y_S yields

$$C_{out} = 2.3 \text{ pf}$$

To find the additional capacitance required refer to the figure.



$$C_T = C_{out} + C_A + C_P$$

$$C_A = C_T - C_P - C_{out}$$

$$= 13.6 - 3 - 2.3 = 8.3 \text{ pf}$$

Supply this capacitance with a variable capacitor.

6) The proper value of B_L must now be obtained. Use

$$B_L = \omega C_L - \frac{1}{\omega L} = -2.5 \text{ mmhos (Step 2)}$$

where

$$C_L = C_P + C_A$$

Solving for L:

$$L = 0.045\ \mu h$$

7) Assume a 50 Ω source resistance and match this to Y_{in}* to complete the design.

An amplifier was constructed using the above values and is shown in Fig. 4. The performance was considered excellent: The device transducer gain was calculated within 0.5 db of G_{max} when circuit loss was added to circuit gain. Measured bandwidth also agreed favorably with the predicted value.

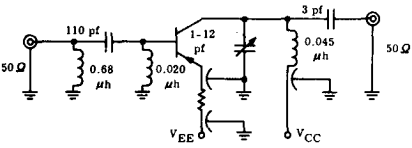


FIGURE 4 — 200 Mc AMPLIFIER

LINVILL CHART FOR POTENTIALLY UNSTABLE DEVICES

The same device may be used to illustrate this case at 100 Mc. The procedure is the same with two exceptions. As C > 1 for this case G_{max} has no meaning: as the device may oscillate, output power can be obtained for no input power. In other words, the gain is infinite.

For this case compute:

$$x = \frac{1}{C}$$

Draw a line perpendicular to the gradient line at 1/C (Fig. 5). Loads for x > 1/C result in potential unstability (shaded area).

To examine the situation in more detail, locate the point $G_2 + jB_2 = 2\,g_{22} + j0$ and recall that

$$B_2 = B_L + b_{22} = \omega C_T - \frac{1}{\omega L} + b_{22}$$

If C_T is reduced B_2 will be decreased. Moving along the $G_2 = 2g_{22}$ conductance circle, the gain will increase until the shaded area on the chart is reached. Thus, the circuit cannot be tuned. To be tunable the device must be loaded to about 20 g_{22}. Examining this conductance circle, decreasing C_T will result first in an increase, then a maximum, and finally a decrease in gain.

To design an amplifier, choose a conductance circle tangent to the gain circle required by the amplifier specification. This establishes G_2. B_2 is

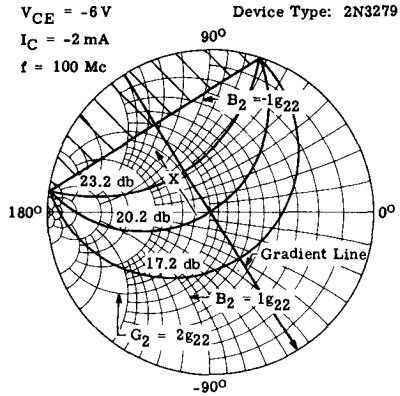


FIGURE 5

found at the point of tangency of the appropriate gain and G_2 circles. Proceed with the design as before.

The chart normalized in g_{22} is often difficult to use for the unstable case. However, as C, G_{oo}, g, and the gain circle constants are invariant, only the gradient-line angle must be recalculated and the chart redrawn to obtain a much more convenient display of the data. Defining:

$$\varphi = \text{Arg } (-h_{21}h_{12})^*$$

The h-parameters may easily be found:

$$h_{21} = \frac{y_{21}}{y_{11}} = 4.34 \angle -79^\circ \text{ mmhos}$$

and

$$h_{12} = \frac{-y_{12}}{y_{11}} = 0.037 \angle 43^\circ \text{ mmhos}$$

Then

$$\varphi = -144^\circ$$

The new chart is shown in Fig. 6. Y_L is then found using h_{22}.

SUMMARY

Two Linvill charts have been prepared for a device at unconditionally stable and potentially unstable frequencies. A design procedure has been presented for the stable case and the method discussed for the unstable case.

The reader is referred to Reference 2 for a brief development of the Linvill technique and to the references cited in that paper for a thorough treatment of stability.

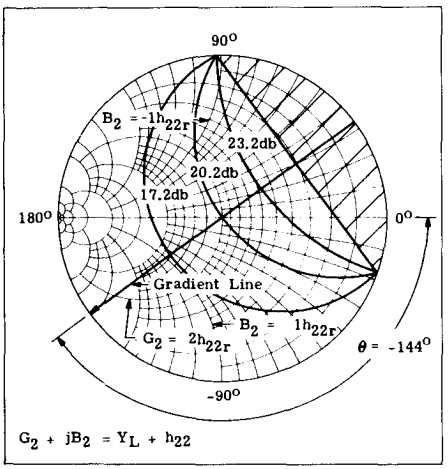


FIGURE 6 — 100 Mc LINVILL CHART FOR H-PARAMETERS

SIGNIFICANCE OF Q_T IN SWITCHING CIRCUITS

The charge factor (Q) in a transistorized pulse system is a figure of merit in much the same manner that gain-bandwidth product (f_t) is a figure of merit for an amplifier. Consider briefly a pulse transmission system where the voltage of a line must be changed by V volts. Since a finite capacity C is associated with the line, a charge Q = CV must be moved in order to effect this change. To move this charge in a given time t, a certain current I is required; viz. Q = It. Thus with a given current, low Q is synonymous with fast switching.

The concept of total control charge, Q_T, is not only a figure of merit but is a useful tool in the design of transistor circuits particularly where capacitors are used for triggering or R-C networks are used to improve response time.

The concept is most easily understood by examining the familiar linear circuit of Figure 1. It is well known that if the time constant of the speed up network, $\tau_1 = R_1C_1$, equals the time constant, $\tau_2 = R_2C_2$, the waveform at point C will be a perfect reproduction of that at B, but reduced in amplitude according to the ratio of R_1 and R_2. During the time that a constant level is applied at point A, charge Q_1 developed on C_1 will also equal the charge Q_2 developed on C_2.

The impedance of this network, of course, decreases with frequency so that the signal at B may show rise time deterioration compared to the signal from the source at point A. However, there is no distortion of the signal in passing from B to C.

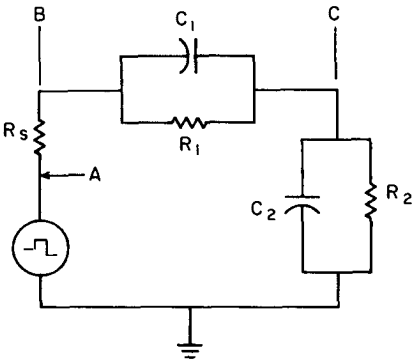


FIGURE 1
Linear Circuit Compensation

Several authors have shown that all frequency effects of a transistor can be represented by an R-C network from internal base to emitter. Base spreading resistance r'_b can be lumped with R_s. If a transistor were substituted for the network R_2C_2, by adjusting τ_1 for a square wave output, the transistor input impedance could be deduced. If the transistor were driven into saturation, a square wave output would occur during turn-on regardless of the value of τ_1, but information can be gained by observing the waveform during turn-off. Since a transistor in saturation is grossly non-linear, approximating its behavior by a linear network is not satisfactory. But the use of a speedup network to find the charge required to turn off a transistor has proven to be valuable.

When a transistor is held in a conductive state by a base current I_B, a charge Q_S is developed or "stored" in the transistor. If I_B were suddenly removed, the transistor would continue to conduct until Q_S is removed from the active regions through an external path or through internal recombination. Since the internal recombination time is long compared to the ultimate capability of a transistor, for fast switching the designer needs to know the value of the internal charge. Q_S may be written as –

$$Q_S = Q_I + Q_V + Q_X$$

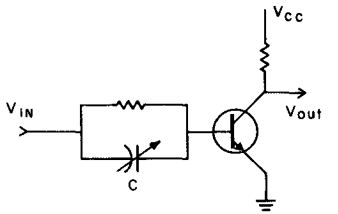
Q_I is the charge required to develop the required collector current. This charge is primarily a function of alpha cutoff frequency. Q_V is the charge required to change the collector-emitter voltage. It is primarily caused by collector-base feedback capacity. Q_X is excess charge resulting from overdrive, i. e., operation in saturation. The carriers which result compromise Q_X and are stored in the base and collector regions.

The charge required to turn a transistor "on" to the edge of saturation is $Q_I + Q_V$ but to turn it off, the full charge Q_S must be removed. Referring to the circuit of Figure 1, if the charge on the speedup capacitor Q_T equals the charge on the transistor Q_S, then when point B is grounded turn-off would be immediate if transistor r'_b were zero. In practice, point A is a more convenient place to ground and R_S and r'_b limits circuit speed.

A test circuit which measures Q_T is shown in Figure 2. C is adjusted to the minimum value which will produce a waveform similar to the one indicated by the solid trace in Figure 3. This will be where the "bumps" just disappear. It has not been established under this condition of turn-off that the charge Q_T on C actually equals the charge Q_S in the device, but Q_T certainly represents the charge necessary to control the turn-off of the transistor from a circuit designer's point of view. The charge is given by –

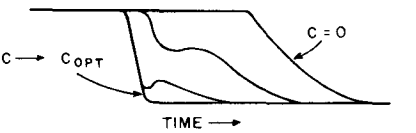
$$Q_T = C\,(V_{in} - V_{BE})$$

Using this relation, the designer may optimize C for any input voltage if Q_T at the desired operating point is known.



Q_T TEST CIRCUIT

FIGURE 2



TURN-OFF WAVEFORM
(PNP TRANSISTOR)

FIGURE 3

When making measurements with this circuit it is important that the input pulse be long enough to allow carrier equilibrium to be reached. One μsec is long enough for VHF transistors. For greatest accuracy pulse instrumentation should have capability to at least 15 ns rise time and utmost care must be given to the selection and mounting of the R-C network and transistor socket. A low source impedance also makes the effects of capacitor adjustment easier to discern.

Charge measurements of representative silicon logic transistors are shown in Figure 4. It is evident that the low figures for the 2N834 permit faster switching in any given circuit since low charge means less current is required to switch the transistor in any given time. The curves also permit optimum values of speedup capacitors to be selected.

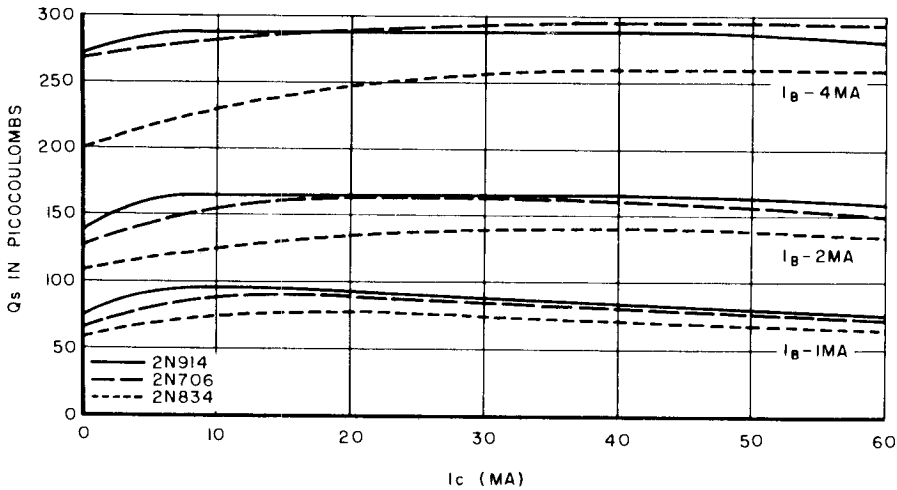


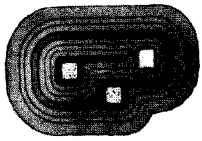
FIGURE 4
COMPARATIVE Q_T

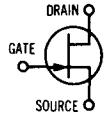
Using too large a speedup capacitor will cause a slight reduction in response time but a heavy penalty will be paid in circuit recovery time which will limit pulse repetition frequency.

FIELD-EFFECT TRANSISTORS IN THEORY AND PRACTICE

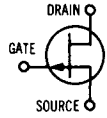
BASIC THEORY

There are, today, two types of field-effect transistors, known as the Junction Field-Effect Transistor (JFET) and the Insulated Gate Field-Effect Transistor (IGFET), sometimes called the "metal-oxide-semiconductor" (MOS) transistor. The principles on which these devices operate (current controlled by an electric field) are very similar – the primary difference being in the methods by which the control element is made. This difference, however, results in a considerable difference in device characteristics and necessitates variances in circuit design. These will be discussed later in the article.





N-Channel JFET



P-Channel JFET

JUNCTION FIELD-EFFECT TRANSISTOR (JFET)

In its simplest form the junction field-effect transistor starts with nothing more than a bar of doped silicon that behaves as a resistor (Figure 1a). By convention, the terminal into which current is injected is called the source terminal, since, as far as the FET is concerned, current orginates from this terminal. The other terminal is called the drain terminal. Current flow between source and drain is related to the drain-source voltage by the resistance of the intervening material. In Figure 1b, p-type regions have been diffused into the n-type substrate of Figure 1a leaving an n-type channel between the source and drain. (A complementary p-type channel is made by reversing all of the material types.) These p-type regions will be used to control the current flow between the source and the drain and are thus called gate regions.

As with any p-n junction, a depletion region surrounds the p-n junctions when the junctions are reverse biased (Figure 1c). As the reverse voltage is increased, the depletion regions spread into the channel until they meet, creating an almost infinite resistance between the source and the drain.

Consider now the case of zero gate voltage, but with an external voltage applied between source and drain (Figure 1d). Drain current flow in the channel sets up a reverse bias, along the surface of the gate, parallel to the channel. As the drain-source voltage increases, the depletion regions again spread into the channel because of the voltage drop in the channel which reverse biases the junctions. As V_{DS} is increased, the depletion regions grow until they meet, whereby any further increase in voltage is counterbalanced by an increase in the depletion region toward the drain. There is an effective increase in channel resistance that prevents any further increase in drain current. The drain-source voltage that causes this current limiting condition is called the "pinch-off" voltage (V_p). Further increases in drain-source voltage produce only a slight increase in drain current.

The drain-current (I_D) vs. drain-source voltage (V_{DS}) with zero gate-source voltage (VGS) is shown in Figure 2a. In the low-current region, the drain-current is linearly related to V_{DS}. As I_D increases, the "channel" begins to deplete and the slope of the I_D curve decreases. At ($V_{DS} = V_p$), I_D "saturates" and stays relatively constant until drain to gate avalanche is reached. If a

reverse voltage is applied to the gates, channel pinch-off occurs at a lower I_D level (Figure 2b) because the depletion region spread caused by the reverse-biased gates adds to that produced by V_{DS}, thus reducing the maximum current for any value of V_{DS}.

A PRACTICAL STRUCTURE

Due to the difficulty of diffusing impurities into both sides of a semiconductor wafer, a single ended geometry is normally used. Diffusion for this geometry (Figure 3) is from one side only. The substrate is of p-type material onto which an n-type channel is epitaxially ground. A p-type gate is then diffused into the n-type epitaxial channel. This completes the structure.

The substrate, which functions as gate 2 of Figure 1, is of relatively low resistivity material to maximize gain. For the same purpose, gate 1 is of very low restivity material, allowing the depletion region to spread mostly into the n-type channel.

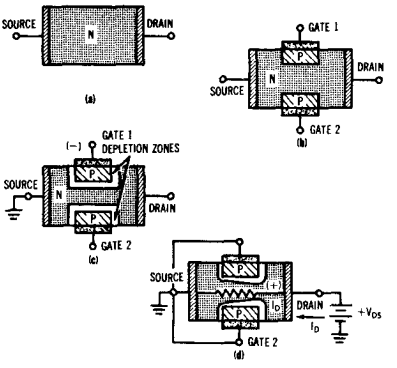
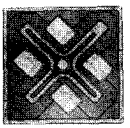
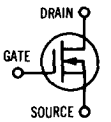
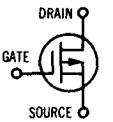


Figure 1 — Development of junction field-effect transistors





N-Channel IGFET



P-Channel IGFET

INSULATED GATE FIELD-EFFECT TRANSISTORS (IGFET)

The insulated-gate field-effect transistor (IGFET) operates with a slightly different control mechanism than the JFET. Figure 4 shows the development. The substrate may be high resistivity p-type material, as for the MM2102. This time two separate low resistivity n-type regions (source and drain) are diffused into the substrate as shown in Figure 4b. Next, the surface of the structure is covered with an insulating oxide layer (Figure 4c). Holes are cut into the oxide layer allowing metallic contact

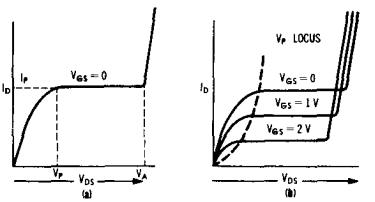


Figure 2 — Drain current characteristics

to the source and drain. Then, the gate metal area is overlayed on the oxide, covering the entire channel region and, simultaneously, metal contacts to the drain and source are made as shown in Figure 4d. The contact to the metal area covering the channel is the gate terminal. Note that there is no physical penetration of the metal through the oxide into the substrate. Since the drain and source are isolated by the substrate, any drain-to-source current in the absence of gate voltage is extremely low because the structure is analogous to two diodes connected back to back.

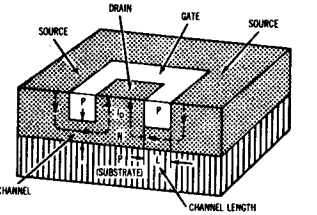


Figure 3 — Single-ended geometry junction FET

The metal area of the gate in conjunction with the insulating oxide layer and the semiconductor channel form a capacitor. The metal area is the top plate; the substrate material is the bottom plate.

For the structure of Figure 4, consider a positive gate potential (see Figure 5). Positive charges at the metal side of the metal-oxide capacitor induce a corresponding negative charge at the semiconductor side. As the positive charge at the gate is increased, the negative charge "induced" in the semiconductor increases until the region beneath the oxide becomes an n-type semiconductor region, and current can flow between drain and source through the "induced" channel. In other words, drain current flow is "enhanced" by the gate potential. Thus drain current flow can be modulated by the gate voltage; i.e., the channel resistance is directly related to the gate voltage. The n-channel structure may be changed to a p-channel device by reversing conductivity of the semiconductor regions.

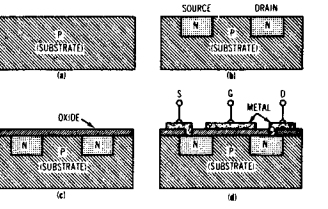


Figure 4 — Development of n-channel insulated-gate field-effect transistor, enhancement mode type.

An equivalent circuit for the IGFET is shown in Figure 6. Here, $C_{g(ch)}$ is the distributed gate-to-channel capacitance representing the oxide capacitance. C_{gs} is the gate-source

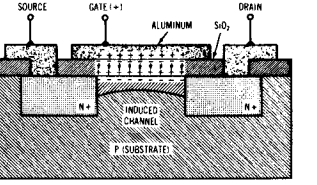


Figure 5 — Channel enhancement. Application of positive gate voltage causes redistribution of minority carriers in the substrate and results in the formation of a conductive channel between source and drain.

capacitance of the metal gate area overlapping the source, while C_{gd} is the gate-drain capacitance of the metal gate area overlapping the drain. $C_{d(sub)}$ and $C_{s(sub)}$ are junction capacitances from drain to substrate and source to substrate. Y_{fs} is the transadmittance between drain current and gate-source voltage. The modulated channel resistance is r_{ds}. R_D and R_S are the bulk resistances of the drain and source.

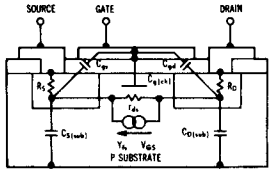


Figure 6 — Equivalent circuit of enhancement mode IGFET.

The input resistance of the IGFET is exceptionally high because the gate behaves as a capacitor with very low leakage ($r_{in} \approx 10^{14}\Omega$). The output impedance is a function of r_{ds} (which is related to the gate voltage) and the drain and source bulk resistances (R_D and R_S).

To turn the IGFET "on," the gate-channel capacitance $C_{g(ch)}$, the miller capacitance (C_{gd}) and the drain-substrate capacitance ($C_{d(sub)}$) must be charged. The resistance of the substrate determines the peak charging current of $C_{d(sub)}$.

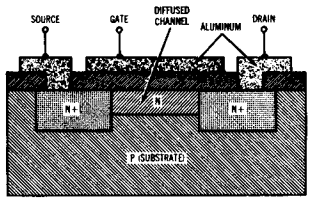


Figure 7 — Depletion mode IGFET structure. This type of device may be designed to operate in both the enhancement and depletion modes.

The FET just described is called an enhancement type IGFET. A depletion type IGFET can be made in the following manner: Starting with the basic structure of Figure 4, a moderate resistivity n-channel is diffused between the source and drain so that drain current can flow when the gate potential is at zero volts (Figure 7). In this manner, the IGFET can be made to exhibit depletion characteristics. For positive gate voltages, the structure enhances in the same manner as the device of Figure 4. With negative gate voltage, the enhancement process is reversed and the channel begins to deplete of carriers as seen in Figure 8. As with the JFET, drain-current flow depletes the channel area nearest the drain first.

The structure of Figure 7, therefore, is both a depletion and an enhancement mode device.

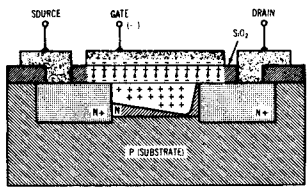


Figure 8 — Channel depletion phenomenon. Application of negative gate voltage causes redistribution of minority carriers in diffused channel and reduces effective channel thickness. This results in increased channel resistance.

MODES OF OPERATION

There are two basic modes of operation of FET's – depletion and enhancement. Depletion mode, as previously mentioned, refer to the decrease of carriers in the channel due to variation in gate voltage. Enhancement mode refers to the increase of carriers in the channel due to gate voltage. A third type of FET has also been described that can operate in both the depletion and the enhancement modes.

The basic differences between these modes can most easily be understood by examining the transfer characteristics of Figure 9. The depletion mode device has considerable drain-current flow for zero gate voltage. Drain current is reduced by applying a reverse voltage to the gate terminal. The depletion type

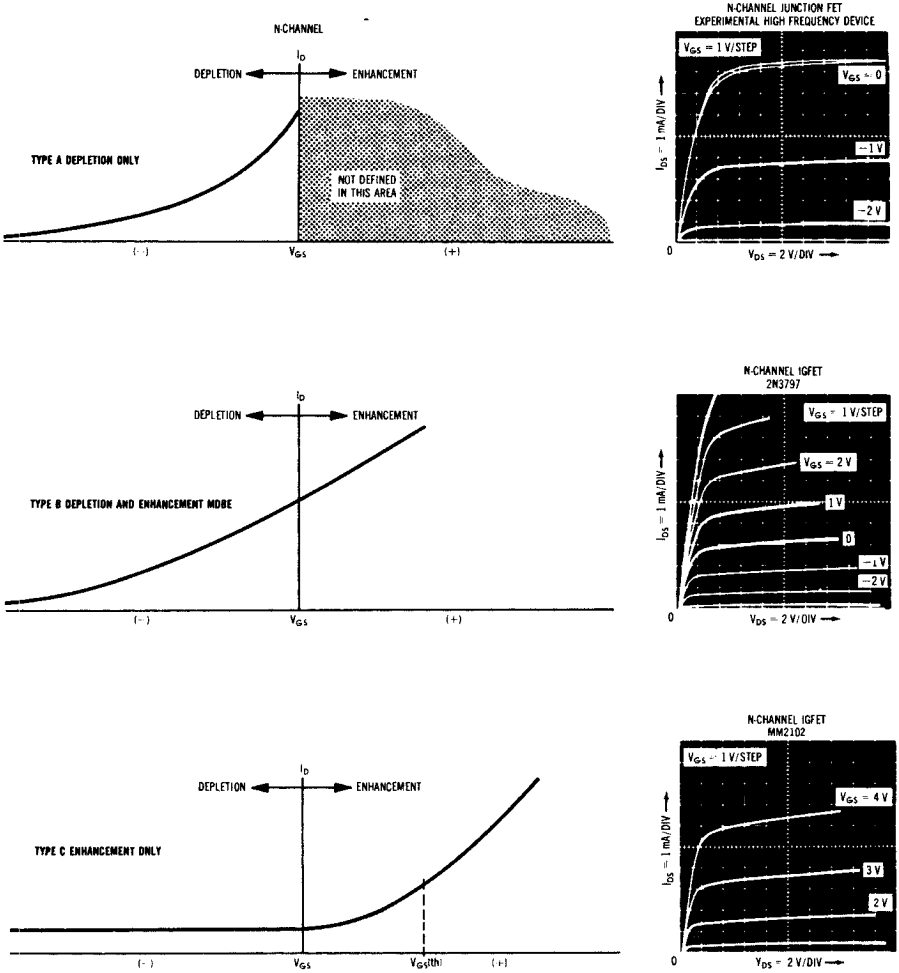


Figure 9 — Transfer characteristics and associated scope traces for types A, B and C FETs

FET is classified by the industry as a "TYPE A" FET. The "Type A" FET is not characterized with forward gate voltage.

The depletion/enhancement mode type device also has considerable drain current with zero gate voltage. This type device is classified as a "Type B" device. The "Type B" FET is defined in the forward region and may have usable forward characteristics for quite large gate voltages. Notice that for the junction FET, drain current may be enhanced by forward gate voltage ONLY until the gate-source p-n junction becomes forward biased.

The third type of FET is the strictly enhancement-mode type. This is referred to as a "Type C" FET. The "Type C" FET has extremely low drain current flow for zero gate-source voltage. Drain current conduction occurs for a V_{GS} greater than some threshold value. For gate voltages greater than the threshold, the transfer characteristics are similar to the "Type B" FET.

ELECTRICAL CHARACTERISTICS

Because the basic mode of operation for field-effect devices differs greatly from that of conventional junction transistors, the terminology and specifications are necessarily different. An understanding of pertinent FET terminology and an interpretation of the characteristics are necessary to evaluate their comparative merits from data-sheet specifications.

Because availability of production type field-effect transistors is still relatively recent, the industry has only recently standardized on a set of specifications and appropriate symbols called out on data sheets. Accordingly, a variety of symbols denoting a specific characteristic may be found. In the following discussion some of this conflicting terminology will be correlated.

STATIC CHARACTERISTICS

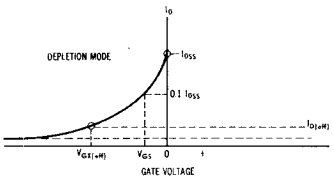
Static characteristics define the operation of an active device under the influence of applied d-c operating conditions. Of primary interest are those specifications that indicate the effect of a control signal on the output current. The V_{GS}-I_D transfer characteristics curves are illustrated in Figure 9 for the three types of FETs. Figure 10 lists the data sheet specifications normally employed to describe these curves, as well as the test circuits that yield the indicated specifications.

Of additional interest is the special case of tetrode-connected devices in which the two gates are separately accessible for the application of a control signal. At the present time, only junction devices are available in the tetrode connection. The pertinent specifications are those which define drain-current cutoff when one of the gates is connected to the source and the bias voltage is applied to the second gate. These are usually specified as $V_{G1S(off)}$, Gate 1 – source cutoff voltage (with gate 2 connected to source), and $V_{G2S(off)}$, Gate 2 – source cutoff voltage (with gate 1 connected to source). The gate voltage required for drain current cutoff with one of the gates connected to the source is always higher than that for the triode-connected case where both gates are tied together.

Reach-through voltage is another specification uniquely applicable to tetrode-connected devices. This defines the amount of difference voltage that may be applied to the two gates before the depletion region of one spreads into the junction of the other – causing an increase in gate current to some small specified value. Obviously, reach-through is an undesirable condition since it causes a decrease in input resistance as a result of an increased gate current, and large amounts of reach-through current can destroy the FET.

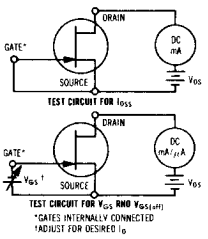
GATE LEAKAGE CURRENT

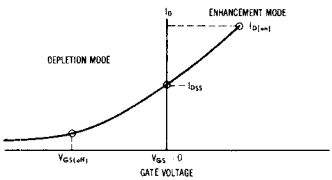
Of interest to circuit designers is the input resistance of an active component. For FETs, this characteristic is specified in the form of I_{GSS} – the reverse-bias gate-to-source current with the drain shorted to the source (Figure 11). As might be expected, because the leakage current across a reverse-biased p-n junction (in the case of a JFET) and across a capacitor (in the case of an IGFET) is very small, the input resistance is extremely high. At a temperature of 25°C, the JFET input resistance is on the order of hundreds of megohms while that of an IGFET is even greater. For junction devices, however, input resistance may decrease by several orders of magnitude as temperature is raised to 150°C. Such devices, therefore, have gate-leakage current specified at two temperatures. Insulated-gate FETs are not drastically affected by temperature, and their input resistance remains extremely high even at elevated temperatures.



FOR TYPE A FETs (USUALLY JFETs)

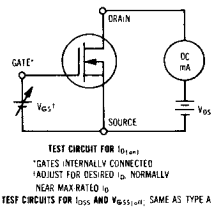
CHARACTERISTIC	DESCRIPTION
I_{DSS} @ V_{GS} = 0, $V_P < V_{DS} < V_A$	Zero-gate-voltage drain current. Represents maximum drain current.
$V_{GS(off)}$ @ I_D = 0.001 I_{DSS}, $V_P < V_{DS} < V_A$	Gate voltage necessary to reduce I_D to some specified negligible value at the recommended V_{DS}, i.e. cutoff.
V_{GS} @ I_D = 0.1 I_{DSS}, $V_P < V_{DS} < V_A$	Gate voltage for a specified value of I_D between I_{DSS} and I_{DS} at cutoff – normally 0.1 I_{DSS}.

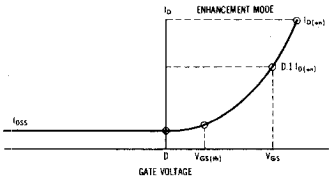




FOR TYPE B FETs (USUALLY IGFETs)

CHARACTERISTIC	DESCRIPTION
$I_{D(on)}$ @ V_{GS} > 0, $V_P < V_{DS} < V_A$	An arbitrary current value (usually near max rated current) that locates a point in the enhancement operating mode.
I_{DSS} @ V_{GS} = 0, $V_P < V_{DS} < V_A$	Zero-gate-voltage drain current.
$V_{GS(off)}$ @ I_D = 0.001 I_{DSS}	Voltage necessary to reduce I_D to some specified negligible value at the recommended V_{DS}, i.e. cutoff.





FOR TYPE C FETs (IGFETs)

CHARACTERISTIC	DESCRIPTION
$I_{D(on)}$ @ V_{GS} > 0, $V_P < V_{DS} < V_A$	An arbitrary current value (usually near max rated current) that locates a point in the enhancement operating mode.
V_{GS} @ 0.1 $I_{D(on)}$	Gate-source voltage for a specified drain current of 0.1 $I_{D(on)}$.
$V_{GS(th)}$ @ I_D = 0.001 $I_{D(on)}$ or less	Gate cutoff or turn-on voltage.
I_{DSS} @ V_{GS} = 0, $V_P < V_{DS} < V_A$	Leakage drain current.

$I_{D(on)}$ TEST CIRCUIT
SAME AS FOR TYPE B

V_{GS} TEST CIRCUIT
SAME AS FOR $I_{D(on)}$

$V_{GS(th)}$ TEST CIRCUIT
SAME AS $V_{GS(on)}$ IN TYPE A, EXCEPT REVERSE V_{GS} BATTERY POLARITY

I_{DS} TEST CIRCUIT
SAME AS FOR TYPE A

Figure 10 — Static characteristics for the three FET types are defined by the above curves, tables, and test circuits.

Gate leakage current, on some data sheets may be specified as I_{GDO} (leakage between gate and drain with the source open), or as I_{GSO} (leakage between gate and source with the drain open). These usually result in lower values of leakage current and do not represent worst-case conditions. The I_{GSS} specification, therefore, is usually preferred by the user.

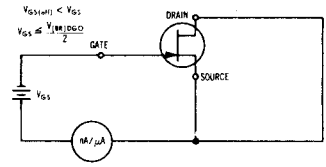


Figure 11 — Test circuit for leakage current

VOLTAGE BREAKDOWN

There is a variety of specifications indicating the maximum voltage that may be applied to various elements of a FET. Among those in common use are the following:

$V_{(BR)GSS}$ = Gate-to-source breakdown voltage

$V_{(BR)DGO}$ = Drain-to-gate breakdown voltage

$V_{(BR)DSX}$ = Drain-to-source breakdown voltage normally used only for IGFETS

In addition, there may be ratings and specifications indicating the maximum voltages that may be applied between the individual gates and the drain and source (for tetrode-connected devices), between drain and gate, and so on. Obviously, not all of these specifications are found on every data sheet since some of them provide the same information in somewhat different form. By understanding the various breakdown mechanisms, however, the reader should be able to interpret the intent of each specification and rating. For example:

In junction FETs, the maximum voltage that may be applied between any two terminals is the lowest voltage that will lead to breakdown of the gate junction. In the case of $V_{(BR)GSS}$ (Figure 12a), an increasingly higher reverse voltage is applied between the common gates and the source. Junction breakdown can be determined by an increase in gate current (beyond I_{GSS}) which indicates the beginning of avalanche.

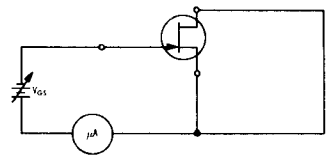


Figure 12a — $V_{(BR)GSS}$ test circuit

Some reflection will reveal that for junction FETs, the $V_{(BR)DGO}$ specification really provides the same information as $V_{(BR)GSS}$. In this case, the gates are connected together and an increasing voltage is applied between drain and gates. When this applied voltage becomes high enough, the drain-gate junction will go into avalanche, indicated either by a significant increase in drain current or by an increase in gate current (beyond I_{DGO}). For both specifications, breakdown should normally occur at

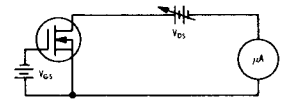


Figure 12b — $V_{(BR)DSS}$ and $V_{(BR)DSX}$ test circuit (usually used for IGFETs only). For $V_{(BR)DSS}$ — $V_{GS} = 0$; For $V_{(BR)DSX}$ — $V_{GS} > V_{GS(off)}$.

the same voltage value. Breakdown voltage is synonymous with avalanche voltage (V_A).

From Figure 2 it is seen that avalanche occurs at a lower value of V_{DS} when the gate is reverse biased than for the zero-bias condition. This is cuased by the fact that the reverse-bias gate voltage adds to the drain voltage, thereby increasing the effective voltage across the junction. The maximum amount of drain-source voltage that may be applied is, therefore, $V_{DS(max)} = V_{(BR)DGO} - V_{GS}$, which indicates avalanche with reverse bias gate voltage applied.

For insulated gate FETs, the breakdown mechanism is somewhat different. Consider, for example, the enhancement mode structure of Figure 5. Here, the gate is completely insulated from the drain, source, and channel by an oxide layer. The breakdown voltage between the gate and any of the other elements, therefore, is dependent on the thickness and purity of this insulating layer, and represents the voltage that will physically puncture the oxide layer. Consequently, the voltages must be specified separately.

The drain-to-source breakdown is a different matter. For type C devices, with the gate connected to the source (the cutoff condition) and the substrate floating, there is no effective channel between drain and source and the applied drain-source voltage appears across two back-to-back-connected, reverse-biased diodes, represented by the source-to-substrate and substrate-to-drain junctions. Drain current remains at a very low (picoampere) level as drain voltage is increased until drain voltage reaches a value that causes reverse (reach-through or punch-through) breakdown of the diodes. This particular condition, represented by $V_{(BR)DSS}$, is indicated by an increase in I_D above the I_{DSS} level, as shown in Figure 12b.

For Type B devices, the $V_{(BR)DSS}$ symbol is sometimes replaced by $V_{(BR)DSX}$. Note that the principal difference between the two symbols is the replacement of the last subscript s with the subscript x. Whereas the s normally indicates that the gate is shorted to the source, the x indicates that the gate is biased to cutoff or beyond. To achieve cutoff in Type B devices, a depleting bias voltage must be applied to the gate, Figure 12b.

An important static characteristic for switching FETs is the "on" drain-source voltage $V_{(DS(on)}$. This characteristic for the IGFETs resembles the $V_{CE(sat)} - I_B$ characteristics of junction transistors, and the curve for these characteristics can be used as a design guide to determine the minimum gate voltage necessary to achieve a specified output logic level.

DYNAMIC CHARACTERISTICS

Unlike the static characteristics, the dynamic characteristics of field-effect transistors apply equally to Types A, B, and C. The conditions and presentation of the dynamic characteristics, however, depend largely upon the intended application. For example, the following table indicates the dynamic characteristics needed to adequately describe a FET for various applications.

Let's consider these parameters one at a time: y_{fs} The forward transadmittance (transconductance) is the key dynamic characteristic for all field-effect transistors. It serves as a basic design parameter in audio and RF, and is a widely accepted device figure of merit.

Audio	RF-IF	Switching	Chopper
y_{fs} (1 kc)	y_{fs} (1 kc)	y_{fs} (1 kc)	y_{fs} (1 kc)
C_{iss}	C_{iss}	C_{iss}	C_{iss}
C_{rss}	C_{rss}	C_{rss}	C_{rss}
y_{os} (1 kc)	y_{fs} (HF)	$Cd_{(sub)}$	$Cd_{(sub)}$
y_{fs} (HF)	$Re(y_{is})$ (HF)	$r_{ds(on)}$	$r_{ds(on)}$
NF	$Re(y_{os})$ (HF)	t_{d1}, t_{d2}	
	NF	t_r, t_f	

Because field-effect transistors have many characteristics similar to those of vacuum tubes, and because many engineers still are more comfortable with tube parameters, the symbol g_m is often used in preference to y_{fs}. To further confuse things, the "g" school also uses a variety of subscripts. In addition to g_m, some data sheets show g_{fs}, while others go even farther out with g_{21}.

Regardless of the symbol used, y_{fs} defines the relation between an input signal voltage and an output signal current, i.e.,

$$y_{fs} = \Delta I_D / \Delta V_{GS} \Big|_{V_{DS} = K}$$

It has the units of mhos – current divided by voltage. Figure 13 is a typical y_{fs} test circuit for a tetrode-connected junction FET.

As a characteristic of all field-effect devices, y_{fs} is specified at 1 kc with a V_{DS} the same as that for which $I_{D(on)}$ is characterized. Since y_{fs} has both real and imaginary components, the 1 kc characteristic is an absolute magnitude and indicated as $|y_{fs}|$.

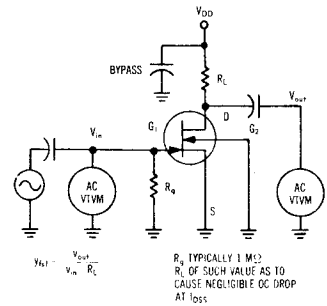


Figure 13 — Typical y_{fs} test circuit

It is interesting to note that y_{fs} varies considerably with I_D due to non-linearity in the I_D-V_{GS} characteristics curve. This variation, for a typical n-channel, Type A JFET (the 3N126) is illustrated in Figure 14. Obviously, the operating point must be carefully selected to provide the desired y_{fs} and signal swing.

For tetrode connected FETs, three y_{fs} measurements are usually specified on data-sheet tables. One of these, with the two gates tied together, provides a y_{fs} value for the condition where a signal is applied to both gates simultaneously; the others provide the y_{fs} for the two gates individually. Generally, with the two gates tied together, y_{fs} is higher and more gain may be realized in a given circuit. Because of the increased capacitance, however, gain-bandwidth product is much lower.

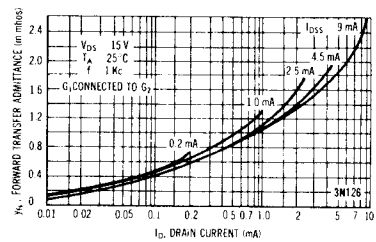


Figure 14 — Forward transfer admittance versus drain current for typical 3N126 JFETs.

For RF field-effect transistors, an additional value of y_{fs} should be specified at or near the highest frequency of operation. This value should also be measured at the same voltage conditions as those used for $I_{D(on)}$. Because of

the importance of the imaginary component at RF, the high-frequency y_{fs} specification should be a complex representation, and should be given either in the specifications table or by means of curves showing typical variations, as in Figure 15 for the 3N126 JFET.

The real portion of this high-frequency y_{fs}, Re (y_{fs}) or G_{21}, is usually considered a significant figure of merit.

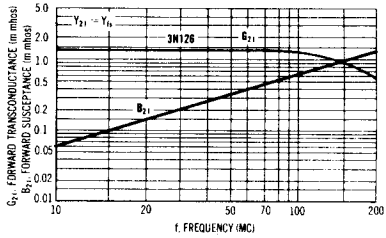


Figure 15 — Forward transfer admittance versus frequency

y_{os} Another FET parameter that offers a direct vacuum tube analogy is y_{os}, the output admittance.

$$\left(y_{os} = \triangle I_D / \triangle V_{DS} \Big|_{V_{GS} = K}\right)$$

In this case, the analogous tube parameter is r_p - i.e., $y_{os} = 1/r_p$. For Type A and B devices, y_{os} is measured with gates and source grounded (see Figure 16). For Type C units, it is measured at some specified V_{GS} which permits substantial drain-current flow.

As with y_{fs}, there is a plethora of terminology for y_{os}. In addition to the obvious parallels such as y_{22}, g_{os}, and g_{22}, it is also sometimes specified as r_d, where $r_d = 1/y_{os}$.

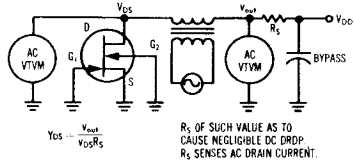


Figure 16 — y_{os} measurement circuit for type A and B FETs

Voltages and frequencies for measuring y_{os} should be exactly the same as those for measuring y_{fs}. Like y_{fs}, it is a complex number and should be specified as a magnitude at 1 kc and in complex form at high frequencies.

μ Closely related to y_{os} and y_{fs} is the amplifier factor, μ ($\mu = \Delta V_{DS} / \Delta V_{GS} \Big|_{I_p = K}$).

The amplification factor does not appear on the field-effect registration format but can be calculated by y_{fs}/y_{os}. For most small-signal applications, μ has little circuit significance. It does, however, serve as a general indication of the quality of the field-effect manufacturing process.

C_{iss} The common-source-circuit input capacitance, C_{iss}, takes the place of y_{is} in low-frequency field-effect transistors. This is because y_{is} is entirely capacitive at low frequencies. C_{iss} is conveniently measured in the circuit of

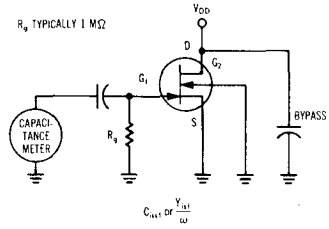
Figure 17 for the tetrode JFET. As with y_{fs}, two measurements are necessary for tetrode-connected devices.

At very high frequencies, the real component of y_{is} becomes important so that RF field-effect transistors should have y_{is} specified as a complex number at the same conditions as other high frequency parameters. For tetrode-connected RF FETs, both a gate-2-to-source and gate-1-tied-to-gate-2 readings are necessary.

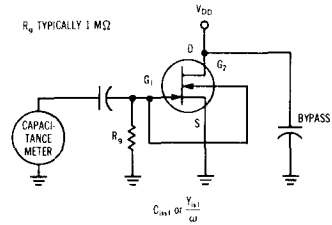
For a switching application C_{iss} is of major importance since a large voltage swing at the gate must appear across C_{iss}.

C_{rss} Reverse transfer admittance (y_{rs}) does not appear on FET data sheets. Instead C_{rss}, the reverse transfer capacitance, is specified at low frequency. Since y_{rs} for a field-effect transistor remains almost completely capacitive and relatively of constant capacitance over the entire usable FET frequency spectrum, the low-frequency capacitance is an adequate specification. C_{rss} is measured by circuits of Figure 18. For tetrode FETs, values should be specified for gate 1 and for both gates tied together.

Again, for switching applications C_{rss} is a critical characteristic. Similar to the C_{ob} of a junction transistor, C_{rss} must be charged and discharged during the switching interval. For a chopper application, C_{rss} is the feed-through capacitance for the chopper drive.



(a) with gate 2 tied to source



(b) with common gates

Figure 17 — C_{iss} measurement circuit

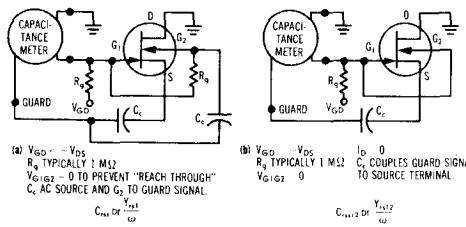


Figure 18 — Recommended C_{rss} test circuits. (a) for gate 1 individually; (b) with both gates tied together

$C_{d(sub)}$ For the insulated gate FET, the drain-substrate junction capacitance becomes an important characteristic affecting the switching behavior. $C_{d(sub)}$ appears in parallel with the load in a switching circuit and must be charged and discharged between the two logic levels during the switching interval.

(Noise Figure) Like all other active components, field-effect transistors generate a certain amount of noise. The noise figure for field-effect transistors is normally specified on the data sheet as "spot noise", referring to the noise at a particular frequency. The noise figure will vary with frequency and also with the resistance at the input of the device. Typical graphs of such variations are illustrated in Figure 19 for the 3N126. From graphs of this kind the

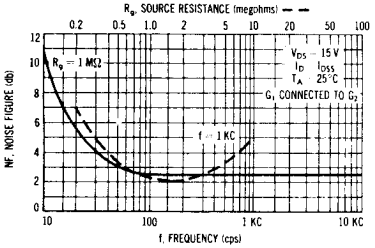


Figure 19 — Typical variations of FET noise figure with frequency and source resistance

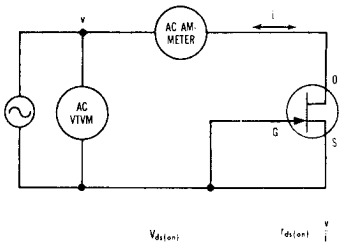


Figure 20 — Measurement circuit for JFET channel resistance

designer can anticipate the noise level inherent in his design.

$r_{ds(on)}$ Channel resistance describes the bulk resistance of the channel in series with the drain and source. From an applications standpoint, it is important primarily for switching and chopper circuits since it affects the switching speed and determines the output level. To complete the concept of multiple symbols for FET parameters, channel resistance is sometimes indicated as $r_{d(on)}$ and also as r_{DS} and r_{ds}. In either case, however, it is measured, for JFETs, by tying the gates to the source, setting all terminals equal to 0 Vdc, and applying an ac voltage from drain to source (see Figure 20). The magnitude of the ac voltage should be kept low so that there will be no pinch-off in the channel. Insulated-gate FETs may be measured with dc gate bias in the enhancement mode.

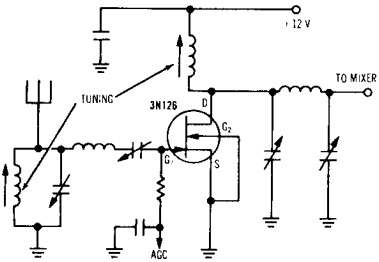


Figure 21 — RF stage of broadcast auto radio

APPLICATIONS

Field-effect transistor applications is still a young art. That this is so is clearly indicated by the lack of standardization in the industry even of such basic requirements as symbols and test points. Yet, an understanding of FET theory, coupled with circuit analysis does permit an evaluation of such devices for specific circuit applications.

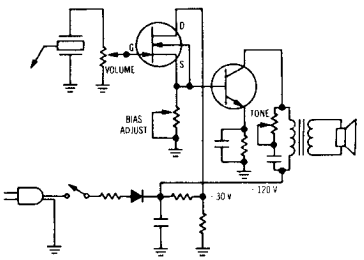


Figure 22 — Line operated phono amplifiers

DEVICE SELECTION

Obviously, different applications call for special emphasis on specific characteristics so that a simple figure of merit that compares devices for all potential uses would be hard to formulate. Nevertheless, an attempt to pinpoint the characteristics that are most significant for various applications has been made* to permit a rapid, first-order evaluation of competitive devices.

The most important single FET parameter, one that applies for any amplifier application, is y_{fs}. This parameter, or one of its many variations, is specified on all data sheets, yet some evaluation is required to come up with a reasonable comparison. For example, in the table of electrical characteristics on most JFET data sheets, y_{fs} is specified at I_{DSS} (V_{GS} = 0) where, for Type A devices, y_{fs} is maximum. This is illustrated in Figure 14, where typical variations of y_{fs} as a function of I_D are plotted. For some small-signal applications, the I_{DSS} (V_{GS} = 0) point can actually be used as a d-c operating point because small-signal excursions into the forward bias region will not actually cause the gate-source junction to become forward-biased. However, in most practical uses, some bias is necessary to allow for the anticipated signal swing; and it must be recognized the y_{fs} goes down as the bias is increased.

It is seen, also, that maximum y_{fs} increases as I_{DSS} increases so that, where maximum y_{fs} is important, a device with a high I_{DSS} specification is normally desirable.

On the other hand, where power dissipation is a factor to be considered, the figure of merit $y_{fs}/V_{GS(off)}\ I_{DSS}$ has been proposed. This term factors in not only I_{DSS}, which should be low if power dissipation is to be low, but also $V_{GS(off)}$, which indicates maximum input voltage swing. Since the signal peaks are represented by $V_{GS} = V_{GS(off)}$ and $V_{GS} = 0$, the lower $V_{GS(off)}$, the higher the figure of merit. And, for amplifier applications requiring a large signal swing, $V_{(BR)GSS}/V_{GS(off)}$ (assuming that $V_{GS(off)}$ is at or near the "pinch-off" voltage) is a satisfactory merit figure because it indicates the maximum and minimum drain voltage ratio.

For high-frequency circuits, the input capacitance (C_{iss}) and the Miller-effect capacitance (C_{rss}) becomes important, so $y_{fs}/C_{iss} + C_{rss}$ indicates a relative measure of device performance. For switching and chopper circuits, a figure of merit is not often useful. Here the magnitudes of C_{iss}, C_{rss}, $C_{d(sub)}$ and $V_{ds(on)}$ are of primary interest.

CIRCUITS

Although the number of equipments actually built with FETs so far is still relatively small, due to the relatively short time that such devices have been available at realistic price levels, the types of circuits that can utilize them are practically unlimited. In fact, many circuits designed to utilize small-signal pentode tubes can utilize FETs with only minor modifications. For example, the circuit in Figure 21 shows a typical RF stage for a broadcast-band auto radio. In this circuit, a 3N126 N-channel JFET has replaced the 12BL6

*Semiconductors: The New Figures of Merit, Donald Christiansen; EEE, October, 1965.

pentode normally employed. The specifications for the two devices, including the AGC characteristics, are similar enough to perform adequately in the circuit of Figure 21.

In an audio application, a field-effect transistor such as the 3N126 can be combined with a high voltage bipoler transistor to make a simple line driven phonograph amplifier such as that shown in Figure 22. The field-effect transistor is connected directly through a potentiometer volume control to the ceramic pickup. Collector current of the transistor, in turn, is set by the potentiometer in the source of the FET. With the proper bipolar transistor, the circuit can be driven directly from half-wave rectified line voltage, while the low voltage for the FET can be derived from a voltage divider in the power supply line.

For switching and logic circuits, complementary enhancement type field-effect transistors offer two significant advantages: Power is drawn only during switching, not in either stable state; and no coupling elements are required since the input to each FET resembles a capacitor and the coupling is inherent in the device.

One simple circuit that illustrates these advantages is the complementary inverter of Figure 23. In this circuit, +V is a logical "1" and ground is a logical "0". If the input signal is +V, the P-channel device (upper) is essentially off and conducts only I_{DSS} (picoamps for a Type C FET). The N-channel FET is forward-biased but since only I_{DSS} is available from the upper stage, V_{DS} is very low. As a result, the potential of the output is near ground – the zero reading. When the input goes to ground, the P-channel FET conducts. The N-channel device, however, is now cutoff and conducts only I_{DSS}. Since the voltage drop across the P-channel device is very low, the drain potential of the P-channel device is approximately +V. This charges capacitor C_L to +V.

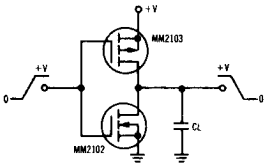


Figure 23 — Complementary inverter circuit

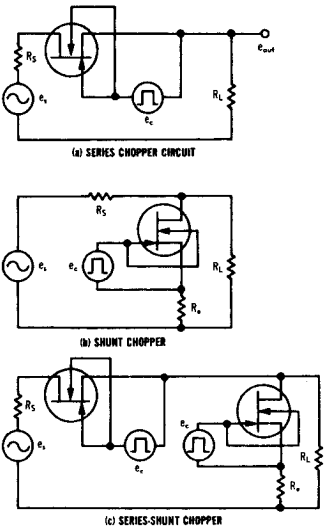


Figure 24 — FET chopper circuits

Figure 24 shows three basic chopper circuits. The advantage of the more complex series-shunt circuit (24c) is that it balances out the leakage currents of the FETs in order to reduce voltage error and is used to attain high chopping frequencies. From an applications standpoint, the FET circuit is superior to a junction transistor circuit in that there is no offset voltage with the FET turned on. On the minus side, however, the field-effect transistor chopper has a

higher series resistance $r_{ds(on)}$ than the junction transistor.

As newer and better FETs are introduced and as a larger number of designers learn to use them, the range of applications of FETs should broaden considerably. To date, there has been little activity in the logic area in spite of the advantages of FETs for some logic configurations. This situation is beginning to change rapidly and the next year should see the FET as an important addition to the tools available to the logic designer.

With its high input impedance, the field-effect transistor will play an important role in input circuitry for instrumentation and audio applications where low impedance junction transistors have been generally least successful.

HIGH-POWER VARACTOR DIODES

THEORY AND APPLICATION

Conventionally speaking, when we refer to a semiconductor diode we normally visualize a 2-terminal p-n junction operated in the forward conduction region (as a rectifier) or in the reverse avalanche region (as a zener diode). From this standpoint, the word diode applied to a varactor is actually a misnomer – for while the varactor is indeed a 2-terminal p-n junction, it operates neither as a rectifier, nor as an avalanche device. Rather, it operates principally in the region between forward conduction and reverse breakdown – the very region in which a conventional diode is considered to be cut off.

In this operating region the p-n junction can be represented by a capacitor in series with a resistor, Fig. 1. The capacitance, known as junction capacitance, is inherently associated with all p-n junctions and, while it represents an undesirable parasitic in conventional diode operation, it is the specific mechanism that permits the device to function as a varactor, or frequency multiplier. This is true because the capacitance value, as will be seen later, actually varies as a function of applied voltage and it is this factor that encourages the generation of harmonic frequencies.

The resistor is the result of bulk and contact resistance of the semiconductor material. In varactor operation this resistance is the primary parasitic affecting varactor quality. Great pains are taken in varactor design, therefore, to hold this resistance value to an absolute minimum.

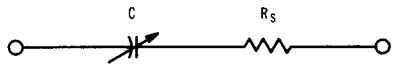


Figure 1 — Equivalent circuit of a varactor diode.

HOW THEY WORK

The cause and behavior of the junction capacitance can be determined from basic semiconductor theory, as follows:

When a junction is formed between n-type and p-type material, there is a cross-migration of charges across the junction. Electrons from the n-region cross the junction to neutralize positive carriers near the junction in the p-region, and "holes" from the p-region cross the junction to neutralize the "excess" electrons near the junction in the n-region. As a result of this migration, all free charged particles are swept out of the immediate vicinity of the junction, creating a "depletion layer" in the junction area. And, in the process, a contact potential or space charge (about 0.5V for silicon) appears across the junction, Fig. 2a.

This structure acts very much like a slightly charged capacitor, with the depletion layer representing the dielectric and the semiconductor material adjacent to the depletion layer representing the two conductive plates.

If an external voltage is connected across the p-n junction so as to reinforce the contact potential (reverse bias), the depletion layer increases, resulting in a capacitance decrease, Fig. 2b. If a forward voltage is applied, the depletion layer decreases, Fig. 2c. However, if the external forward voltage is made large enough to overcome the contact potential, forward conduction occurs and the capacitance effect is destroyed (except at very high frequencies, as discussed later).

It is obvious, therefore, that the value of the junction capacitance is a function of the externally applied voltage, so long as the junction itself remains reverse biased. This relationship is as follows:

$$C = \frac{C_0}{(1 = V/\phi)^{\gamma}} = \frac{\phi^{\gamma} C_0}{(\phi + V)^{\gamma}}$$

wnere C = capacitance at voltage V

C_0 = capacitance at zero bias

V = voltage across the diode (reverse bias)

ϕ = contact potential

γ = power law of the junction, determined by impurity gradient.

A plot of this equation, Figure 3, shows that the capacitance - voltage relationship is nonlinear. Just how this condition is useful for frequency multiplication will be seen from the following derivation.

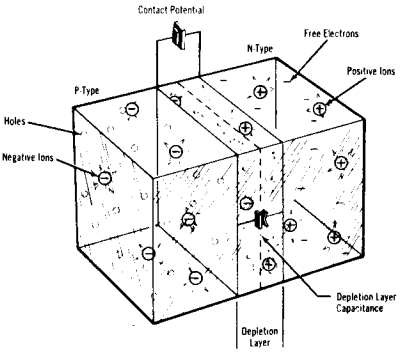


Figure 2 — (A) A representative p-n junction. The battery represents the contact potential which must be overcome before current can flow. Current carriers act as capacitor plates and the depletion layer is the dielectric.

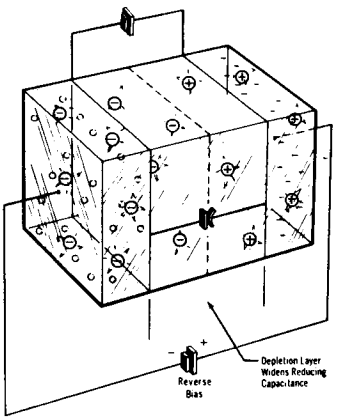


Figure 2 — (B) Reverse voltage forces carriers away from junction. This widens the depletion layer and reduces capacitance.

Assume that the voltage across a capacitor is given by the well-known relationship

$$V = \frac{Q}{C}$$

where Q = the charge on the capacitor

C = the capacitance

When a sinusodial current is applied to a capacitance

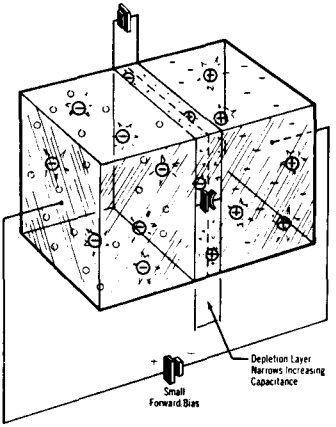


Figure 2 — (C) Forward voltage forces carriers closer to junction or across junction again changing capacitance.

$$Q = \int i\,dt$$

$$= \int I_1 \sin \omega_1 t\,dt$$

$$= A - \frac{I_1}{\omega_1} \cos \omega_1 t \qquad (3)$$

where i = instantaneous current

I_1 = maximum amplitude of the input current

$\omega_1 = 2\pi f_1$

f_1 = input frequency

A = constant of integration relating to the initial charge when time (t) = zero

Substituting Equations (1) and (3) into Equation (2) yields

$$V = \frac{A - \frac{I_1}{\omega_1} \cos \omega_1 t}{\frac{\phi^{\gamma} C_o}{(\phi + V)^{\gamma}}} \qquad (4)$$

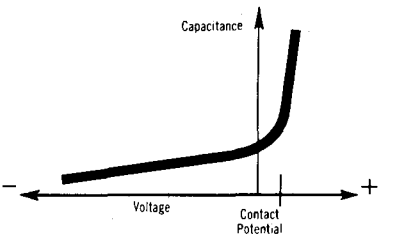


Figure 3 — Voltage-capacitance relationship for a typical varactor diode.

or, where $V >> \phi$

$$\frac{V}{V^{\gamma}} = V^{1-\gamma} = \frac{A - \frac{I_1}{\omega_1}\cos \omega_1 t}{\phi^{\gamma} C_o} \tag{5}$$

The exponent γ is a function of the impurity gradient of the p-n junction. It may vary from approximately 1/2, for step junctions, to about 1/6 for special graded junctions. If we consider the common case of a step junction, ($\gamma = 1/2$) Equation (5) resolves to

$$V = \left(\frac{A - \frac{I_1}{\omega_1}\cos \omega_1 t}{\phi^{1/2} C_o} \right)^2 = \frac{A^2 - 2A\frac{I_1}{\omega_1}\cos \omega_1 t + \left(\frac{I_1}{\omega_1}\right)^2 \cos^2 \omega_1 t}{\phi C_o^2} \tag{6}$$

Looking at each of the terms in Equation (6) we find that the voltage (V) across the varactor consists of a dc term $\left(\frac{A^2}{\phi C_o^2}\right)$, a fundamental component $\left(\frac{2A\frac{I_1}{\omega_1}\cos \omega_1 t}{\phi C_o^2}\right)$, and the term $\frac{\left(\frac{I_1}{\omega_1}\right)^2 \cos^2 \omega_1 t}{\phi C_o^2}$

The latter, through trigonometric identities, expands to

$$\left(\frac{I_1}{\omega_1}\right)^2 \frac{\left(\frac{1}{2} + \frac{1}{2}\cos 2\omega_1 t\right)}{\phi C_o^2},$$

which reduces to another dc component plus a second harmonic component.

Although quite simplified, the above derivations clearly show the generation of second harmonic voltages across the varactor diode. This second harmonic voltage can be used to produce power at that frequency simply by providing a path and a load for the second harmonic current.

In the case of a step-junction device, the second harmonic is the only harmonic frequency directly available. While it is possible, through the use of graded junctions ($\gamma < 1/2$) to obtain higher harmonics directly, the second harmonic always predominates. In fact, it is normally more efficient to obtain higher harmonics by means of the doubling and mixing action of the varactor, through the use of idler circuits (see Fig. 4), than to try to obtain a desired higher harmonic directly.

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(1) Penfield & Rafuse, "Varactor Applications", MIT Press, Copyright 1962.

VARACTOR CHARACTERISTICS

When operating as a frequency multiplier, the important varactor characteristics are: efficiency as a multiplier, power handling capability, and, in some applications, linearity of power output with changes in input power.

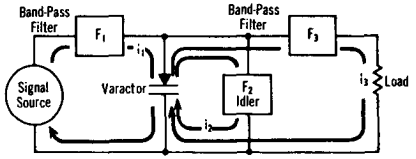


Figure 4 — Simplified multiplier circuit illustrating the use of an idler configuration to develop third and fourth harmonics.
An idler circuit is simply a tuned filter which permits the flow of a harmonic current needed to generate the desired output. If the third harmonic is desired, filter F_1 is tuned to the fundamental, idler F_2 is tuned to the 2nd harmonic, and F_3 is tuned to the 3rd harmonic. To obtain the fourth harmonic, F_4 is simply tuned to the fourth harmonic and permits the flow of the doubled 2nd harmonic current.

Efficiency

The efficiency of a varactor is a function of the cutoff frequency of the device which, in turn, is dependent on the diode quality factor (Q), defined as

$$Q = \frac{1}{2\pi f C R_S} \tag{7}$$

From this, it is seen that Q is a function of both R_S and C. The ability to obtain a high Q device is directly related to the ability to make R_S extremely low. The cutoff frequency is arbitrarily defined as that frequency at which $Q = 1$, or where $\frac{1}{2\pi f C} = R_S$. Accordingly, cutoff frequency is given as

$$f_c = \frac{1}{2\pi C R_S} \tag{8}$$

Since both R_S and C are voltage dependent, it is obvious that f_c, too, will vary with applied voltage. As reverse voltage increases, f_c will also increase. This is important in a comparative evaluation of devices since, in order to obtain a valid comparison, the f_c for the devices must be obtained at the same voltage.

Now, for varactors with step junctions, the maximum obtainable efficiency may be approximated from the expressions:(1)

For input frequencies of 0.01 f_c or less,

$$\epsilon = 1 - K\frac{f_1}{f_c} \tag{9}$$

For input frequencies of 0.2 f_c or higher,

$$\epsilon = B\frac{f_c^2}{f_1^2} \tag{10}$$

where f_c = cutoff frequency at V_B

f_1 = input frequency

K and B = constants whose values depend on the desired order of the harmonic.

For doublers, K and B of Equations 9 and 10 are equal to 20 and .0039 respectively.

For triplers and quadruplers, K is equal to 35 and 62 respectively.

From these equations it is evident that the theoretical efficiency of varactors is quite high at input frequencies of 0.01 f_c or less.

Power Handling Capability

The relationship between power handling capability (P_r) and other varactor characteristics is given by

$$P_r \propto C_o V_B^2 \tag{11}$$

where V_B = voltage breakdown of the junction

C_o = junction capacity at zero bias.

The validity of this proportionality is evident from the fact that the input power is obviously proportional to the square of the input voltage swing, which is limited at one end by V_B and on the other by the permissible amount of forward conduction. If the voltage swing in the forward direction is very much smaller than V_B, it can be neglected, and the input power is approximately proportional to V_B^2.

For large power handling capability it is desirable to make V_B as large as possible (assuming that the signal source can provide the necessary voltage swing from V_B to approximately zero). This requires that the resistivity of the material near the junction (at least on one side of the junction) be high. Yet, a high resistivity leads to a relatively high R_S which, in turn, lowers the Q of the diode and, consequently, the efficiency. Therefore, varactor diode design normally is a compromise between high power handling capability and high efficiency.

NEW VARACTOR DESIGN IMPROVES POWER HANDLING CAPABILITY

Until recently most varactors for harmonic generator applications have been designed with step junctions and their characteristics closely follow the above discussion. Some improvement in performance has been observed in varactors of the 1N4386 type whose impurity profile, Fig. 5, differs considerably from that of the customary step-junction device. These improvements include:

1) higher power handling capability at a given frequency,

2) greater linearity of power output with changes in power input.

The increase in power handling capability can be explained as follows:

To increase P_r, it is necessary to increase V_B which demands a higher resistivity material at least on one side of the junction. If one attempts to in-

crease the resistivity of a step-junction device, the value of R_S is increased significantly and efficiency is reduced accordingly. But, by employing the impurity profile shown in Fig. 5, the resistivity near the junction can be made comparatively high without changing the average resistivity. Moreover, when reverse voltage is applied, the spread of the depletion layer into the high resistivity regions actually dissipates them, leaving only the extremely low resistivity portion of the material to contribute to R_S. And, since the time that the varactor is in the reverse-voltage condition is very large compared with the time in the forward-biased condition, the average total series resistance is substantially reduced despite the increase in resistivity at the junction and a resulting increase in V_B.

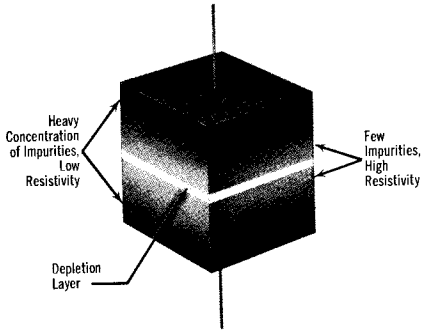


Figure 5 — Resistivity of 1N4386 is high near the junction and low near the lead contacts. When a reverse voltage is applied the depletion layer rapidly dissipates the high resistivity regions and thus, the average series resistance (R_s) is low.

By this means, it is possible to almost double the power handling capability of varactors over step-junction devices, without adversely affecting efficiency, at least as it is affected by R_S.

It might be argued that the impurity profile used in the 1N4386 type should result in lower efficiency because the capacity-voltage law (γ in Equation 1) is reduced to about a 1/5 power, thus reducing the degree of reactive nonlinearity. Indeed, this would result in a lower efficiency of harmonic generation if it were not compensated by the reduction of series resistance described above.

In addition there appears to be an added nonlinearity resulting directly from the parabolic graded impurity profile – the phenomenon of "step-recovery". Not only does step-recovery make up for the reduced junction-capacity nonlinearity, but it leads to a linear power output advantage when driven slightly into the forward bias region at the positive peak of the signal swing.

Step-recovery is a result of charge storage – a familiar phenomenon in the application of semiconductor devices. When a p-n junction is forward biased, charged carriers from one region are injected into the other to form minority carriers in that area. If permitted to wander around in the area long enough, these minority carriers will combine with majority carriers and produce a current flow. The interval between injection and recombination is related to the minority carrier "lifetime" of the material. In the interval between the time of injection and recombination, these minority carriers are effectively stored charges contributing to junction capacitance.

If the period of the applied forward voltage is less than the carrier lifetime, as is usually the case, most of the injected carriers can be brought back to the point of origin before recombination. Step-recovery comes about when the injected minority carriers are returned to the point of origin in a compact bunch. Such a movement of carriers constitutes a current waveform as shown in Fig. 6. Because of the sudden cessation of reverse current when all of the carriers are returned to their original regions, the waveform is rich in harmonics which can be utilized as an added nonlinearity to enhance multiplier action.

The impurity profile of Fig. 7 enhances step-recovery because the electric fields set up by the steep impurity gradient a short distance away from the depletion region keep the minority carriers close to the depletion layer, rather than permitting them to wander to random depths in the opposite regions. Thus, when the voltage is reversed, they return to their point of origin in a compact bunch.

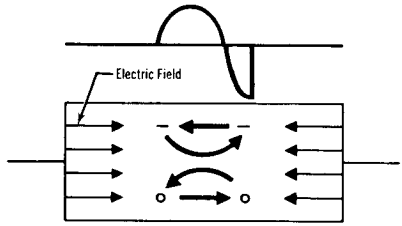


Figure 6 — When a forward voltage is applied, carriers are injected across the junction. However, before they can combine and result in a dc current flow, the applied voltage reverses and the carriers are returned to the point of origin in a bunch. This results in an abrupt cessation of reverse current and the waveform is rich in harmonics.

The step-recovery phenomenon, which is not as pronounced in step junctions because of the constant impurity level in such devices, provides an additional nonlinearity to the 1N4386 which contributes to harmonic generation.

Step-recovery results also in a device with more linear power characteristics because the percentage of harmonic current generation is not a function of signal level. It is only a function of the waveform and the abruptness of the decline of reverse current. And if self-biasing is employed, the shape of the current wave remains constant over a considerable power input range. This leads to a more constant efficiency of harmonic generation as a function of signal level than obtainable with devices dependent on junction-capacitance variations alone. This is an important feature when using varactors in amplitude modulated circuits.

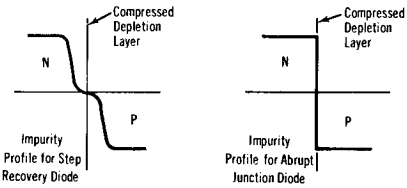


Figure 7 — Comparison of the impurity profiles for a step recovery and step junction diodes.

VARACTORS vs TRANSISTORS

In view of the fact that varactors provide no amplification, but merely convert an applied signal of one frequency to some higher frequency, one might logically ask, "Why not use transistors to directly generate the desired signal?" The answer to this is simply that there are no transistors that will provide the amount of power obtainable from varactors in the VHF and UHF regions. The best transistors today are limited to producing about 25 watts at 100 mc, and about 5 watts at 500 mc. Varactors, by contrast, can supply about three times that amount of power at those frequencies. Moreover, many VHF and UHF transmitters demand crystal control, which requires a relatively low-frequency oscillator with subsequent frequency multiplication. And, as yet, no other device operates as efficiently as a varactor for this purpose.

Even as transistors are improved, it is reasonable to assume that varactor development will keep pace, so that the latter will remain well ahead of transistors in power-frequency capabilities. As a result, it is anticipated that the varactor will become an increasingly important component in high-power, high-frequency applications.

HARMONIC GENERATOR CIRCUITS

Development of a varactor multiplier circuit is illustrated in Fig. 8. The basic premise, as shown in (a) is the conversion of a signal from a signal source to a harmonic current through the load (R_L) by means of a varactor. The necessary considerations entail 1) provisions for the necessary current paths and associated filters, 2) proper matching of source to load, and 3) development of suitable bias voltage for the varactor.

The first step in the design is the addition of suitable current paths, as shown in (b). If the output is to be the second harmonic, filter F_1 is tuned to the fundamental frequency, and F_2 is tuned to the 2nd harmonic. In designing the tuned circuits, the capacitance of the varactor must be taken into account. Since this varies over the applied signal cycle, the "average" varactor capacitance should be used. This can be approximated by the capacitance value at one-third the voltage breakdown rating of the varactor (assuming a signal voltage swing from about V_B to some small positive value) Since this average capacitance varies with signal power, some circuit detuning occurs if input power is changed appreciably. This detuning effect is less pronounced with devices of the 1N4386 structure than with step-junction devices.

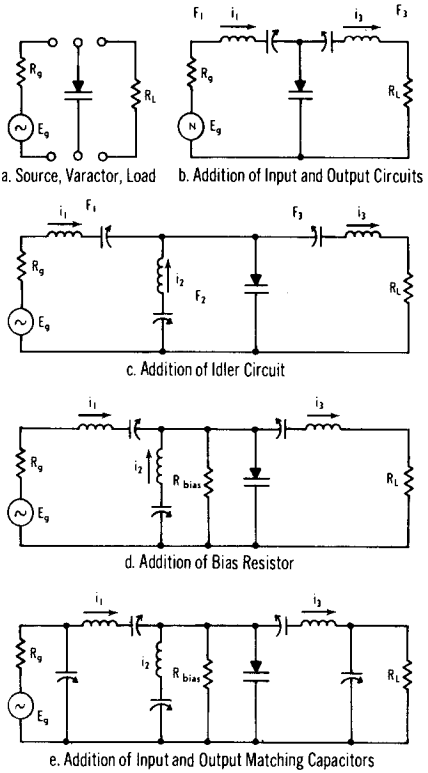


Figure 8 — Development of a harmonic generator circuit.

If the desired load current is at the third or fourth harmonic, the configuration in (c) may be used. Here, F_1 is again tuned to the fundamental and F_2 is an idler tuned to the 2nd harmonic. This permits fundamental and 2nd harmonic current flow to mix in the varactor to provide a voltage component of F_1, F_2, $F_1 + F_2$, and $2F_2$ across the varactor. (Even if F_2 were omitted, there would be components of higher order harmonics, such as F_3 and F_4 across the varactor, but, as mentioned previously, it is normally more efficient to employ a suitable addition or multiple of the fundamental and second harmonic.) Filter F_3 is then tuned to the desired third or fourth harmonic so that only the desired current will flow through the load.

Bias voltage for the varactor is obtained by shunting the varactor with a high value (around 100 KΩ) bias resistor, as in (d). Bias current is provided when the varactor is driven slightly into conduction at the peaks of the applied signal.

Proper matching between source and load can be accomplished by adding matching capacitors as shown in (e). Tapped input and output coils could accomplish the same purpose.

Obviously, the simple circuit developed in Fig. 8 can be improved upon from a performance standpoint. Higher-frequency, distributed-element circuits could be fabricated based on a circuit equivalent to Fig. 8. More complex filters, such as double-tuned circuits, may be employed for greater bandwidth and better rejection of spurious signals. In practical applications, the final circuit almost always will be more complex.

CHARACTERISTICS OF 1N4386

The 1N4386 varactor was designed to handle efficiently more than 50 watts of input power with output frequencies up to 300 mc. Typical efficiency of the device as a function of power input at 50 mc (tripler operation) is shown in Fig. 9.

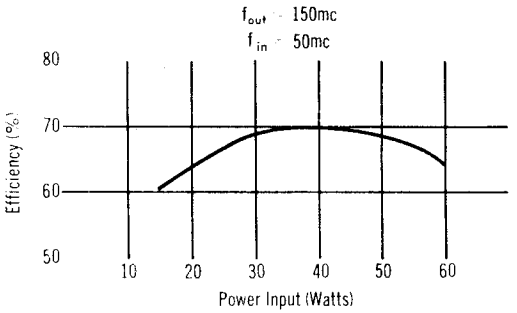


Figure 9 — Typical efficiency vs power input curve for the 1N4386 in a tripler circuit.

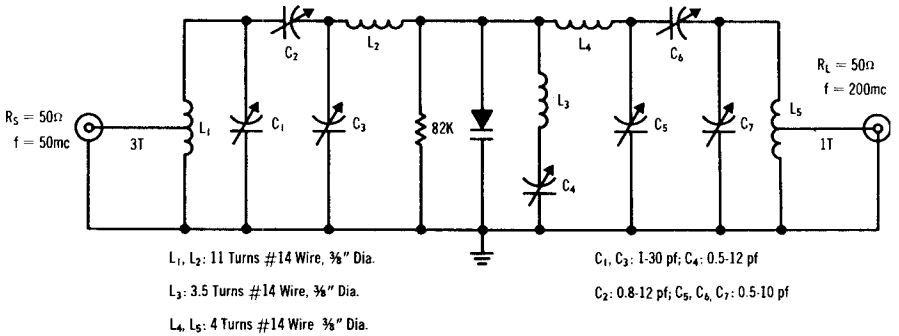


Figure 10 — 50-200 mc Varactor quadrupler

VVC TUNING DIODE THEORY AND APPLICATION

VVCs are voltage-variable capacitors, based on semiconductor junction phenomena, which can be used for electric tuning applications. This note is intended to explain how VVCs function, summarize the parameters of available VVCs, and introduce important application possibilities.

It is felt that these VVCs will become important circuit components because electric tuning offers many advantages over mechanical tuning. Electrically and electronically tuned circuits are small, reliable and extremely fast acting. However, electric tuning in the HF, UHF and VHF regions has not been extensively applied because the quality factors of the available tuning elements were poor, such as 100 at 50 mc. This situation is changed with the introduction of the VVC tuning diode series where Q's exceed 200 at 50 mc. Further with VVCs many of the important electric tuning parameters, such as temperature stability and leakage current are improved.

Generally for electric tuning it is desired to vary capacitance or inductance as a function of voltage or current. For HF through UHF frequencies the most practical electric means is to vary capacitance with voltage. The rate of change of capacity with voltage is, of course, of fundamental importance, the greatest rate being most desirable. Except for experimental hyper-abrupt semiconductor junctions the best devices approach a capacity varying inversely with the square root of applied voltage. This is discussed further in the section on VVCs work.

The most significant parameter in using tunable capacitors is Q or quality factor. For a capacitor with series resistance.

$$Q_s = \frac{1}{\omega C R_s} \tag{1}$$

where:

Q is the quality factor

ω is the frequency in radians/sec

C is the capacitance in farads

R_s is the series resistance in ohms

When the resistance is in parallel with the capacitance

$$Q_p = \omega C R_p \tag{2}$$

where:

R_p is the parallel resistance.

If both series and parallel resistances are present the following is a simple formula for Q

$$\frac{1}{Q} = \frac{1}{Q_s} + \frac{1}{Q_p} \tag{3}$$

where Q_S and Q_p are calculated by equations 1 and 2 respectively. For most circuit applications loaded circuit Q's exceeding 20 and often 100 or more are needed. Therefore, the low unloaded Q's of previously available voltage-variable capacitors limited their use.

Tuning range is another important parameter. With voltage-variable devices, this means how great a voltage swing can be achieved while maintaining acceptable capacitor characteristics. For PN junctions, the usual allowable voltage swing is from a few volts negative to the maximum reverse working voltage. Capacity swing is calculated from voltage swing by the inverse half-power relation between capacity and voltage. For large tuning ratios the maximum to minimum voltage ratio should obviously be large.

For most applications the temperature stability of all the capacitor parameters are important. VVC stability is not expected to equal the stability of the best air capacitors, but a high level of parameter stability has to be maintained either by the device itself or with some sort of compensating mechanism. An example of the deficiency of previously available devices is the relatively high leakage currents occurring at elevated temperatures.

Not to be neglected when considering devices for electric tuning is the package for the voltage-variable capacitor. Package parasites such as lead inductance or case capacity could alter the device impedance beyond use. Especially for higher frequencies previously available packages exhibited too high an inductance which degraded circuit performance.

Outlined above are the important parameters to specify for electric tuning devices. For the approximately seven years that voltage-tunable capacitors have been available, the designer has had to compromise on these parameters. Now with the VVC line these compromises are no longer necessary.

Both the previously available devices and VVCs are based on PN junction theory. The difference stems from the way the junctions are formed; allowing for the previous devices and diffusion into epitaxially grown layers for the VVCs. Before explicit performance parameters and comparisons are made, the physics of both types of devices will be briefly described.

HOW VVCs WORK

Conventionally speaking, when we refer to a semiconductor diode we normally visualize a 2-terminal p-n junction operated in the forward conduction region (as a rectifier) or in the reverse avalanche region (as a zener diode). From this standpoint, the word diode applied to a VVC is actually a misnomer– for while the VVC is indeed a 2-terminal PN junction, it operates neither as a rectifier, nor as an avalanche device. Rather, it operates principally in the region between forward conduction and reverse breakdown – the very region in which a conventional diode is considered to be cut off.

In this operating region the PN junction can be represented by a capacitor in series with a resistor,

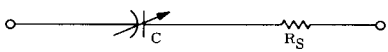


FIGURE 1

The capacitance, known as junction capacitance, is inherently associated with all PN junctions and, while it represents an undesirable parasitic in conventional diode operation, it is the specific mechanism that permits the device to function as a VVC, or

voltage-variable capacitor. This is true because the capacitance value, as will be seen later, actually varies as a function of applied voltage. This factor cannot only be used for electric tuning but also for harmonic generation and parametric application.

The resistor is the result of bulk and contact resistance of the semiconductor material. In VVC operation this resistance is the primary parasitic affecting VVC quality. Great pains are taken in VVC design, therefore, to hold this resistance value to an absolute minimum.

The cause and behavior of the junction capacitance can be determined from basic semiconductor theory, as follows:

When a junction is formed between n-type and p-type material, there is a cross-migration of charges across the junction. Electrons from the n-region cross the junction to neutralize positive carriers near the junction in the p-region, and "holes" from the p-region cross the junction to neutralize the "excess" electrons near the junction in the n-region. As a result of this migration, all free charged particles are swept out of the immediate vicinity of the junction area. And, in the process, a contact potential or space charge (about 0. 5 V for silicon) appears across the junction, Fig. 2a.

This structure acts very much like a slightly charged capacitor, with the depletion layer representing the dielectric and the semiconductor material adjacent to the depletion layer representing the two conductive plates.

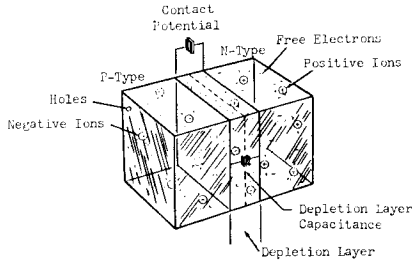


FIGURE 2 (A) — A REPRESENTATIVE P-N JUNCTION.
The battery represents the contact potential which must be overcome before current can flow. Current carriers act as a capacitor plates and the depletion layer is the dielectric.

If an external voltage is connected across the p-n junction so as to reinforce the contact potential (reverse bias), the depletion layer increases, resulting in a capacitance decrease, Fig. 2b. If a forward voltage is applied, the depletion layer decreases, Fig. 2c. However, if the external forward voltage is made large enough to overcome the contact potential, forward conduction occurs and the capacitance effect is destroyed.

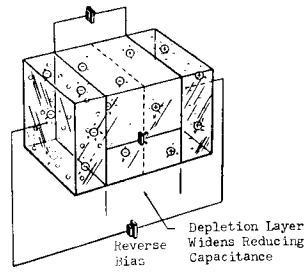


FIGURE 2 (B) — REVERSE VOLTAGE FORCES
carriers away from junction. This widens the depletion layer and reduces capacitance.

It is obvious, therefore, that the value of the junction capacitance is a function of the externally applied voltage, so long as the junction itself remains reverse biased. This relationship is:

$$C = \frac{C_o}{(1 + V/\Phi)^\gamma} + \frac{\Phi^\gamma C_o}{(\Phi + V)^\gamma} \qquad (4)$$

where:

C = capacitance at voltage V

C_o = capacitance at zero bias

V = voltage across the diode (reverse bias)

Φ = contact potential

γ = power law of the junction, determined by impurity gradient.

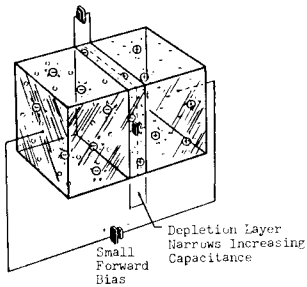


FIGURE 2 (C) – FORWARD VOLTAGE FORCES
carriers closer to junction or across junction again changing capacitance.

The exponent is a function of the impurity gradient of the PN junction. It may vary from approximately 1/2, for step junctions, to about 1/6 for specially graded junctions. For electric tuning the greatest capacity-voltage variation is desired so the step junction is generally used.

All PN junctions have to be protected from the corrosive effects of the atmosphere; therefore, packages or housings are used. Associated with the package and the internal connections to the junctions are parasitic reactances. The complete equivalent circuit of a packaged PN junction operated in the reverse voltage region for electric tuning, is shown in Fig. 3. The voltage-variable capacitance is C_j; R_S is the series resistance; R_p is the junction shunt resistance which generally can be neglected; L_S is the lead inductance and C_c is the case capacitance.

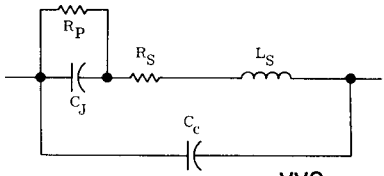


FIGURE 3 – EQUIVALENT CIRCUIT VVC

The admittance of a VVC including all parameters of Fig. 3 is:

$$y = j\omega C_c + \cfrac{1}{R_s + j\omega L_s + \cfrac{1}{\cfrac{1}{R_p} + j\omega C_j}} \tag{5}$$

where

R_p is high enough to be neglected

$$y = j\omega C_c + \frac{j\omega C_j}{1-\omega^2 L_s C_j + j\omega C_j R_s} \tag{6}$$

Inherent junction Q is defined as:

$$Q = \frac{1}{\omega C_j R_s} \tag{7}$$

If Q is high compared to $1-\omega^2 L_S C_j$ the VVC has a capacitance given by

$$Ceq = C_c + \frac{C_j}{1-\omega^2 L_s C_j} \tag{8}$$

Equation 8 shows how equivalent capacity can be modified by L_S and C_c.

Usually operation is well below the self-resonant frequency $\omega_o = 1/L_S C_j$ so that the total capacity is given by

$$C_T = C_c + C_j \tag{9}$$

and in terms of voltage

$$C_T = C_c + \frac{C_o}{\left(1 + \frac{V_R}{\Phi}\right)^{\gamma}} \tag{10}$$

where:

γ = 0.5 for step junction

Φ = 0.5 volts

The total Q is then

$$Q = \frac{1}{\omega C_t R_s} \tag{11}$$

The important device information is given by eqs. (10) and (11) with eq. (8) being significant at frequencies approaching self-resonance.

OPTIMIZING SCR TURN-OFF PARAMETERS WITH NEGATIVE BIAS

Although it is not often discussed in the literature, almost all SCR's exhibit some degree of turn-off gain.

At normal values of anode current, negative gate current will not have sufficient effect upon the internal feedback loop of the device to cause any significant change in anode current. However, it does have a marked effect at low anode current levels where it can be put to advantage to modify certain device parameters. Specifically, turn-off time may be reduced and hold current may be increased. Reduction of turn-off time and increase of hold current are useful in such circuits as inverters or in full-wave phase control circuits in which inductance is present.

Negative gate current may, of course, be produced by use of an external bias supply. It may also be produced by taking advantage of the fact that during conduction the gate is positive with respect to the cathode and providing an external conduction path such as a gate-to-cathode resistor. All of our SCR's are already constructed with a built in gate-to-cathode shunt, which produces a certain amount of negative gate current. Further change in characteristics, however, can be produced by use of an external shunt. Shunting does not produce as much of a change in characteristics as does negative bias, since the negative gate current, even with an external short circuit, is limited. When using external negative bias the current must be limited, and care must be taken to avoid driving the gate into the avalanche region.

All of our SCR lines show an improvement in turn off time of about one-third by using negative bias up to the point where no further significant improvement is obtained. The increase in hold current by use of an external shunt resistor ranges typically between 5 and 75 percent, whereas with negative bias, the range of improvement runs typically between 2-1/2 and 7 times the open gate value.

In summary, it may be said that by use of negative gate bias, the turn-off time and hold current of our SCR's may be improved significantly so that they may be used in higher frequency inverter circuits or in circuits in which higher residual current are present.

SELECTION GUIDES

GENERAL INFORMATION
- How To Use The Data Book
- Numerical Index
- Alphabetical Index
- Device Outlines

SILICON ZENER DIODES
Regulator Diodes, Reference Diodes, Precision Reference Diodes and Reference Amplifiers

SILICON RECTIFIERS

SILICON RECTIFIER ASSEMBLIES
Bridge, Full-Wave, Voltage-Doubler and High-Voltage Assemblies

THYRISTORS and TRIGGERS
SCRs, 3-Layer and 4-Layer Diodes

POWER TRANSISTORS
Silicon and Germanium General-Purpose, High-Power Transistors For Use Up to 60 MHz

GERMANIUM MILLIWATT TRANSISTORS
Alloy Transistors for Low-Frequency Switching and Amplifier Applications

SWITCHING AND GENERAL PURPOSE TRANSISTORS
Silicon and Germanium Devices for High-Speed Switching and High-Frequency Amplifier Applications

RF TRANSISTORS
Silicon and Germanium Transistors Designed for Use at VHF and UHF Frequencies in Receivers and Transmitters

FIELD EFFECT TRANSISTORS

MULTIPLE and SPECIAL DEVICES
Dual Transistors, Dual Diodes, and Field Effect Current Limiters

VARACTORS
Voltage-Variable Capacitance Diodes for High-Power Frequency Multiplication and Tuning

INTEGRATED CIRCUITS
- Digital
- Linear

HARDWARE
Heat Sinks, Mounting Hardware and Integrated Circuit Inter-Connecting Patch Boards

LATE ADDITIONS

APPLICATION NOTES