MOTOROLA
Mobile Products Division

SYNTOR X 9000 UHF

Radio System

Range 1: 406–420 MHz
Range 2: 450–470 MHz
Range 3: 470–488 MHz
Range 4: 482–500 MHz
Range 5: 494–512 MHz

THIS MANUAL HAS BEEN

DISCONTINUED

Instruction Manual

68P80102W04–O

MOTOROLA
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technical publication services
5555 North Beach Street, Fort Worth, Texas 76137

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8/15/88

Foreword

1. Scope of Manual

This manual is intended for the use of experienced technicians familiar with this general type of equipment. In it you should be able to find all the information you will need for installing and servicing the equipment it covers. It is current as of the publication date, and incorporates changes that have occurred since then in the form of instruction manual revisions (WMR's). (WMR's that cover production or engineering changes to the circuitry usually include corrected schematics and circuit board diagrams.)

2. Model and Kit Identification

Each Motorola product has an identifying model number stamped on its nameplate. In most cases, assemblies and kits that make up the product also have identifying kit numbers stamped on then. Schematics and circuit board diagrams for such kits show this same identifying number prominently in the lower left–hand or right–hand corner.

3. Service

Motorola's national service organization maintains one of the finest nation–wide installation and maintenance programs available to users of communication equipment. The administrative staff of this organization consists of national, area, and district service managers, all of whom are Motorola employees dedicated to giving our customers the best possible service. The organization has about 900 authorized Motorola Service Stations (MSS's) throughout the United States, each manned by one or more trained, FCC–licensed technicians.

Motorola selected each one of these independently owned and operated MSS's to service its customers. They offer Motorola maintenance either by the job (priced by time and material), or on a service contract at a fixed periodic fee. To buy a service contract for your Motorola equipment, contact your Motorola Service Representative or write to:

National Service Manager
Motorola Communications and Electronics, Inc.
1303 E. Algonquin Road
Schaumburg, Illinois 60196

4. Ordering Replacement Parts

When ordering replacement parts (components, kits, or chassis) or equipment information, include the complete identification number. If the component part number is not known, include in your order the number of the chassis or kit of which it is a part, and enough component description to identify the desired part.

In orders for crystal and channel elements, specify the crystal or channel element type number, crystal and carrier frequency, and the model number of the radio in which the part is used.

In orders for active filters, *Vibrasender* and *Vibrasponder* resonant reeds, specify type number and frequency, and identify the owner/operator of the communications system in which these items are to be used; also include any serial numbers stamped on the components being replaced.

Replacement Parts Ordering

MAIL ORDERS

Send written orders to the following addresses;

Replacement Parts, Test Equipment, Crystal Service Items:

Motorola, Inc.
Communications Parts Division
Attention: Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

International Orders:

Motorola, Inc.
Communications Parts Division
Attention: International Order Processing
1313 E. Algonquin Road
Schaumburg, IL 60196

Federal Government Orders:

Motorola, Inc. Communications Parts Division
Attention: Order Processing
1701 McCormick Drive
Landover, MD 20785

TELEPHONE ORDERS

Replacement Parts/Test Equipment

call: 1–800–422–4210
or Federal Government orders,
1–800–826–1913

Crystal Service Items

call: 1–800–323–1570
or Illinois residents,
1–800–445–4564

TELEX/FAX ORDERS

Replacement Parts/Test Equipment

Telex: 280127
FAX: 312–576–6285

Crystal Service Items

Telex: 433–0067
FAX: 910–277–0799

Federal Government orders

FAX: 301–925–2473 or 301–925–2474

Customer Service

Replacement Parts/Test Equipment

call: 1–800–537–7007

Crystals

call: 1–800–323–0234

Parts Identification

call: 312–576–7418

National Data Services

1711 West 17th Street, Tempe, AZ 85281

call; 602–994–6472
TWX: 910–951–1334

GENERAL SAFETY INFORMATION

The United States Department of Labor, through the provisions of the Occupational Safety and Health Act of 1970(OSHA), has established an electromagnetic energy safety standard that applies to the use of this equipment. Proper use of this radio will result in exposure below the OSHA limit. The following precautions are recommended:

DO NOT operate the transmitter of a mobile radio when someone outside the vehicle is within two feet (0.6 meter) of the antenna.

DO NOT operate the transmitter of a fixed radio (base station, microwave, and rural telephone RF equipment) or marine radio when someone is within two feet (0.6 meter) of the antenna.

DO NOT operate the transmitter of any radio unless all RF connectors are secure and any open connectors are properly terminated.

In addition,

DO NOT operate this equipment near electrical blasting caps or in an explosive atmosphere.

All equipment must be properly grounded according to Motorola installation instructions for safe operation.

All equipment should be serviced only by a qualified technician.

Refer to the appropriate section of the product service manual for additional pertinent safety information.

INSTALLATION SAFETY WARNING

Consider the occupants' safety when you choose a location for the radio. Do not mount the radio overhead or on a sidewall unless you take special precautions.

If someone were to remove the radio and fail to replace it properly, road shock could bump the radio loose, and the falling radio could in some circumstances cause serious injury to the driver or a passenger.

If you must mount the radio overhead or on a sidewall, give it the added protection of a retaining strap. Custom–made straps are available from Motrola National Parts. Order kit number HLN4698A (for *Mitrek* and *MaraTrac)* or HLN4697A (for *SYNTOR*, *SYNTOR X*, or *SYNTOR X 9000*).

WARNING

For vehicles equipped with electronic anti–skid braking systems, see "ANTI–SKID BRAKING PRECAUTIONS" Publication, Motorola Number 68P81109E34.

WARNING

To gain full access to the Common Circuits Board for servicing, the regulator heat sink screw must be removed. When operating the radio with the regulator heat sink screw removed, care should be taken to avoid the exposed hot flange.

WARNING

It is mandatory that radio installations in vehicles fueled by liquefied petroleum gas conform to the following standard.

National Fire Protection Association standard NFPA 58 applies to radio installations in vehicles fueled by liquefied petroleum (LP) gas with the LP–gas container in the trunk or other sealed–off space within the interior of the vehicles. This standard requires that:

1. Any space containing radio equipment shall be isolated by a seal from the space in which the LP–gas container and its fittings are located.
2. Remote (outside) filling connections shall be used.
3. The container space shall be vented to the outside.

FCC Requirements

The Federal Communications Commission (FCC) requires that you obtain a station license for your radio equipment before transmitting. No operating license or permit is required. The station licensee is responsible for ensuring that the transmitter power, frequency, and deviation are within limits defined by the station license.

The licensee of the station is at all times responsible for the proper operation and maintenance of the current station authorization. You must measure the power input and record the results:

- when the transmitter is first installed
- when the transmitter is changed in any way that may increase the power input
- at least once a year.

You must check the frequency and deviation of the transmitter:

- when it is first installed
- when the transmitter is changed in any way that might affect the carrier frequency or modulation characteristics.
- at least once a year.

Service

To purchase a service contract for your Motorola equipment, or to purchase additional manuals, contact:

National Service Manager
Motorola Communications Group
1301 E. Algonquin Road
Schaumburg, Illinois 60196

Safe Handling of CMOS Integrated–Circuit Devices

Many of the integrated–circuit devices used in communications equipment are of the CMOS (Complementary Metal Oxide Semiconductor) type. Because of their high open–circuit impedance, CMOS IC's are vulnerable to damage from static charges. Everyone involved in handling, shipping, and servicing them must be extremely careful not to expose them to such damage.

CMOS IC's do have internal protection, but it is effective only against overvoltages in the hundreds of volts, such as those that could occur during normal operations. Overvoltages from static discharge can be in the thousands of volts.

When a CMOS IC is installed in a system, the system's circuit elements distribute static charges and load the CMOS circuits. This decreases the vulnerability of the IC's to static discharge, but improper handling will probably cause static damage even when the IC's are so installed.

To avoid damaging CMOS IC's, take the following precautions when handling, shipping, and servicing them.

1. Before touching a circuit module, particularly after having moved around in the service area, touch both hands to a bare metal earth–grounded surface. This discharges any static charge you may have accumulated.

Note

Wear a conductive wrist strap (Motorola Part No. RSX–4015A) to minimize the buildup of static charges on your person while you are servicing CMOS equipment.

WARNING

When wearing a conductive wrist strap, be careful near sources of high voltage. By grounding you thoroughly, the wrist strap also increases the danger of lethal shock from accidental contact with such a source.

2. Whenever possible, avoid touching any electrically conductive parts of the circuit module with your hands.

3. Check the INSTALLATION and MAINTENANCE sections of the service manual and the notes on the schematic to find out whether or not you can insert or remove circuit modules with power applied to the unit, and act accordingly.

4. When servicing a circuit module, avoid carpeted areas, dry environments, and the wearing of static–generating clothing.

5. Be sure that all electrically powered test equipment is grounded. Attach the ground lead from the test equipment to the circuit module before connecting the test probe. Similarly, disconnect the test probe before removing the ground lead.

6. When you remove a circuit module from the system, lay it on a sheet of aluminum foil or other conductive surface connected to ground through 100,000 ohms of resistance.

WARNING

If the aluminum foil is connected directly to ground, you may get a shock if you touch it and another electrical circuit at the same time.

7. When soldering, be sure the soldering iron is grounded.

8. Before connecting jumpers, replacing circuit components, or touching CMOS pins (if this becomes necessary during the replacement of an integrated–circuit device), be sure to discharge any static buildup on your person (see Procedure 1, above). Because you can have a voltage difference across your body, you should use only one hand if you must touch the board wiring or any of the pins on the CMOS device.

9. When replacing a CMOS integrated–circuit device, leave the device in its metal rail container or conductive foam until you are ready to insert it into the pronged circuit module.

10. Connect any low–impedance test equipment such as a pulse generator to CMOS device inputs after you have applied power to the CMOS circuitry. Similarly, disconnect such low–impedance equipment before turning off the power.

11. Wrap CMOS modules in conductive material when transporting them from one area to another, even within the same room. Use wrapping material similar to that in which replacement modules are wrapped when they arrive from the factory. (You can also use aluminum foil.) Never use nonconductive material for packaging these modules.

Model Chart for *SYNTOR X 9000* UHF Radios

Range 1: 406–420 MHz
Range 2: 450–470 MHz
Range 3: 470–488 MHz
Range 4: 482–500 MHz
Range 5: 494–512 MHz

CODE:

● = ONE ITEM SUPPLIED

model	T74KEJ7J04AK	T74KXJ7J04AK	T74KEJ7J04AK	T74KXJ7J04AK	T64KEJ7J04AK	T64KXJ7J04AK	T64KEJ7J04AK	T64KXJ7J04AK	T64KEJ7J04AK	T64KXJ7J04AK	T34KEJ7J04AK	T34KXJ7J04AK	T34KEJ7J04AK	T34KXJ7J04AK	T34KEJ7J04AK	T34KXJ7J04AK		
description	*SYNTOR X 9000* UHF, 32 MODE, 100W RANGE 1	*SYNTOR X 9000* UHF, 32 MODE, 100W RANGE 1 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 100–50W RANGE 2	*SYNTOR X 9000* UHF, 32 MODE, 100–50W RANGE 2 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 3	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 3 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 4	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 4 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 5	*SYNTOR X 9000* UHF, 32 MODE, 78–39W RANGE 5 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 3	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 3 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 4	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 4 SECURE–CAPABLE	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 5	*SYNTOR X 9000* UHF, 32 MODE, 30–15W RANGE 5 SECURE–CAPABLE	**item**	**description**
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	UNIFIED CHASSIS (SEE SEPARATE CHART)	
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HCN1033D	CONTROL UNIT
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5104D	CONTROL UNIT CIRCUIT PANEL
	●		●		●		●		●		●		●		●		HKN4051A	POWER CABLE AND FUSE
		●		●		●		●		●		●		●		●	HKN4241A	17' POWER CABLE, NEGATIVE GROUND
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HKN4256A	17' POWER CABLE, NEGATIVE GROUND W/KEYLOAD
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4111A	INSTALLATION KIT
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4243A	BOTTOM COVER
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4262A	TUNING TOOL
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4263A	TOP COVER
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4666A	MOUNTING TRAY
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4921A	TRUNNION
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4952A	FUSE KIT FOR GREEN AND ORANGE LEADS
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4979A	NAMEPLATE
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN4983A	*SYNTOR X 9000* BASIC BUTTONS
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5027A	*SYNTOR X 9000* RADIO SOFTWARE
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5028A	*SYNTOR X 9000* EEPROM
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5064A	CONTACT REMOVAL TOOL
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5066A	CHANNEL SCAN BUTTON
		●		●		●		●		●		●		●		●	HLN5092A	*SECURENET* BUTTON
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5095A	BLANK BUTTONS
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5096A	BLANK PLUGS
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HLN5105A	HANDLE AND SHIELD
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HMN1061A	MICROPHONE
	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	HSN4018A	SPEAKER
	●	●															TAE6051A	ROOFTOP ANTENNA, RANGE 1
			●	●													TAE6052A	ROOFTOP ANTENNA, RANGE 2
						●	●	●	●	●	●	●	●	●	●	●	TAE6054A	ROOFTOP ANTENNA, RANGES 3–5

Model Chart for *SYNTOR X 9000* UHF Radios Unified Chassis Ranges 1 and 2

CODE:

● = ONE ITEM SUPPLIED

HUE2029A/HUE2031A* NON-PREAMP/PREAMP CHASSIS, 100–50W, R1	HUE2025B/HUE2027B* NON-PREAMP/PREAMP CHASSIS, 100–50W, R2	HUE2050B/HUE2051B* NON-PREAMP/PREAMP CHASSIS, 30–15W, R2			item	description
●					HLE1081A/HLE1603A*	INTERNAL CASTING, RANGE 1
	●	●			HLE1082A/HLE1087A*	INTERNAL CASTING, RANGE 2
●					HLN4759A	LOW LEVEL AMPLIFIER INTERFACE BOARD, RANGE 1, 100W
	●				HLN4466A	LOW LEVEL AMPLIFIER INTERFACE BOARD, RANGE 2, 100W
		●			HLN5119A	LOW LEVEL AMPLIFIER INTERFACE BOARD, 30W
●					HLN4354A	LOW LEVEL AMPLIFIER, RANGE 1, 100W
	●				HLE4189A	LOW LEVEL AMPLIFIER, RANGE 2, 100W
		●			HLE4395A	LOW LEVEL AMPLIFIER, 789 AND 30W
●					HLE4356A	PREDRIVER SUBSTRATE, RANGE 1, 100W
	●				HLE4179A	PREDRIVER SUBSTRATE, 100 and 78W
		●			HLE4409A	PREDRIVER SUBSTRATE, 30W
●					HLE4355A	DRIVER SUBSTRATE, RANGE 1, 100W
	●				HLE4074A	DRIVER SUBSTRATE, 100 AND 78W
		●			HLE4421A	DRIVER SUBSTRATE, 30W
●					HLE4357A	SPLITTER SUBSTRATE, RANGE 1
	●				HLE4070A	SPLITTER SUBSTRATE, RANGE 2
●					HLE4155A	COMBINER SUBSTRATE, RANGE 1
	●				HLE4065A	COMBINER SUBSTRATE, RANGE 2
●	●				HLE4345A	POWER DISTRIBUTION BOARD, 100 AND 78W
		●			HLE4405A	POWER DISTRIBUTION BOARD, 30W
●	●				HLE4445A	PA TRANSISTORS, RANGES 1 AND 2
●	●	●			HLE4447A	PA TRANSISTORS, RANGES 1 AND 2
●					HLN4770A	PA HARDWARE, RANGE 1, 100W
	●				HLN4465B	PA HARDWARE, RANGE 2, 100W
		●			HLN5016A	PA HARDWARE, RANGE 2, 30W
●					HFE4015A	HARMONIC FILTER, RANGE 1
	●				HFE4013A	HARMONIC FILTER, RANGE 2
		●			HFE4017A	HARMONIC FILTER, RANGE 2, 30W
	●				HLN4040A	CAPACITOR KIT, RANGE 2, 100W
●	●	●			HKN4130A	INTERCONNECT CABLE
●	●	●			HLE4175A	DIRECTIONAL COUPLER
●	●	●			HLN4046A	FEEDTHROUGH PLATE
●	●	●			HLN4259A	FRONT HARDWARE
●	●	●			HLN4459A	CHASSIS HARDWARE
●	●	●			HLN4460B	ANTENNA SWITCH
●					HLN4462B	RF BOARD
	●	●			HLN5215A	RF BOARD, RANGE 2
●	●	●			HLN5299B	PERSONALITY BOARD
●		●			HLN4905B	COMMON CIRCUIT BOARD, 100 AND 78W
	●				HLN5152A	COMMON CIRCUIT BOARD, 30W
●	●	●			HLN4994A	TRANSFORMER BRACKET
●	●	●			TRN8857B	BUS WIRES

* = used with W12 option

Model Chart for *SYNTOR X 9000* UHF Radios Ranges 3–5

CODE:

● = ONE ITEM SUPPLIED

HUE2041A/HUE2042A* NON-PREAMP/PREAMP CHASSIS, 78–39W, RANGE 3	HUE2052A/HUE2053A* NON-PREAMP/PREAMP CHASSIS, 30–15W, RANGE 3	HUE2043A/HUE2044A* NON-PREAMP/PREAMP CHASSIS, 78–39W, RANGE 4	HUE2054A/HUE2055A* NON-PREAMP/PREAMP CHASSIS, 30–15W, RANGE 4	HUE2045A/HUE2046A* NON-PREAMP/PREAMP CHASSIS, 78–39W, RANGE 5	HUE2056A/HUE2057A* NON-PREAMP/PREAMP CHASSIS, 30–15W, RANGE 5	item	description
●	●					HLE1083A/HLE1088A*	INTERNAL CASTING, RANGE 3
		●	●			HLE1084A/HLE1089A*	INTERNAL CASTING, RANGE 4
				●	●	HLE1085A/HLE1090A*	INTERNAL CASTING, RANGE 5
●						HLN4336A	LOW LEVEL AMPLIFIER INTERFACE BOARD, 78W
	●	●	●	●	●	HLN5119A	LOW LEVEL AMPLIFIER INTERFACE BOARD, 30W
●	●	●	●	●	●	HLE4395A	LOW LEVEL AMPLIFIER, 78 AND 30W
●		●		●		HLE4179A	PREDRIVER SUBSTRATE, 78W
	●		●		●	HLE4409A	PREDRIVER SUBSTRATE, 30W
●		●		●		HLE4074A	DRIVER SUBSTRATE, 78W
	●		●		●	HLE4421A	DRIVER SUBSTRATE, 30W
●		●		●		HLE4070A	SPLITTER SUBSTRATE, RANGE 3–5
●						HLE4065A	COMBINER SUBSTRATE, RANGE 3
		●		●		HLE4066A	COMBINER SUBSTRATE, RANGE 4 AND 5
●		●		●		HLE4345A	POWER DISTRIBUTION BOARD, 78W
	●		●		●	HLE4405A	POWER DISTRIBUTION BOARD, 30W
●	●	●	●	●	●	HLE4445A	PA TRANSISTORS, RANGES 3–5
●	●					HLE4447A	PA TRANSISTORS, RANGES 3
		●	●	●	●	HLE4448A	PA TRANSISTORS, RANGES 4 AND 5
●						HLN5014A	PA HARDWARE, RANGE 3, 78W
		●				HLN5015A	PA HARDWARE, RANGE 4, 78W
				●		HLN4939A	PA HARDWARE, RANGE 5, 78W
	●					HLN5017A	PA HARDWARE, RANGE 3, 30W
			●			HLN5018A	PA HARDWARE, RANGE 4, 30W
					●	HLN5019A	PA HARDWARE, RANGE 5, 30W
●		●				HFE4013A	HARMONIC FILTER, RANGES 3 AND 4
				●		HFE4016A	HARMONIC FILTER, RANGE 5
	●		●		●	HFE4017A	HARMONIC FILTER, RANGE 3–5, 30W
●	●	●	●	●	●	HKN4130A	INTERCONNECT CABLE
●	●	●	●	●	●	HLE4175A	DIRECTIONAL COUPLER
●	●	●	●	●	●	HLN4046A	FEEDTHROUGH PLATE
●	●	●	●	●	●	HLN4259A	FRONT HARDWARE
●	●	●	●	●	●	HLN4459A	CHASSIS HARDWARE
●	●	●	●	●	●	HLN4460B	ANTENNA SWITCH
●	●	●	●	●	●	HLN4462B	RF BOARD
●	●	●	●	●	●	HLN5299B	PERSONALITY BOARD
●	●	●	●	●	●	HLN4905B	COMMON CIRCUIT BOARD, 78W
●	●	●	●	●	●	HLN4994A	TRANSFORMER BRACKET
●	●	●	●	●	●	TRN8857B	BUS WIRES

* = used with W12 option

Model Chart for *SYNTOR X 9000* UHF Radio Internal Casting
Range 1: 406–420 MHz
Range 2: 450–470 MHz
Range 3: 470–488 MHz
Range 4: 482–500 MHz
Range 5: 494–512 MHz

model	description
HLE1081A	INTERNAL CASTING, RANGE 1
HLE1603A	INTERNAL CASTING, RANGE 1 W/PREAMP
HLE1082A	INTERNAL CASTING, RANGE 2
HLE1087A	INTERNAL CASTING, RANGE 2 W/PREAMP
HLE1083A	INTERNAL CASTING, RAGNE 3
HLE1088A	INTERNAL CASTING, RANGE 3 W/PREAMP
HLE1084A	INTERNAL CASTING, RANGE 4
HLE1089A	INTERNAL CASTING, RANGE 4 W/PREAMP
HLE1085A	INTERNAL CASTING, RANGE 5
HEL1090A	INTERNAL CASTING, RANGE 5 W/ PREAMP

CODE:

● = ONE ITEM SUPPLIED

HLE1081A	HLE1603A	HLE1082A	HLE1087A	HLE1083A	HLE1088A	HLE1084A	HLE1089A	HLE1085A	HEL1090A	item	description
●	●	●	●	●	●	●	●	●	●	HLE1080B	VCO BUFFER
●	●									HLE4181B	MIXER, RANGE 1
		●	●							HEL4182A	MIXER, RANGE 2
				●	●	●	●			HLE4183A	MIXER, RANGE 3, 4
								●	●	HLE4185A	MIXER, RANGE 5
●	●									HLE4191C	VCO HYBRID, RANGE 1
		●	●							HLE4192B	VCO HYBRID, RANGE 2
				●	●					HLE4193A	VCO HYBRID, RANGE 3
						●	●			HLE4194A	VCO HYBRID, RANGE 4
								●	●	HLE4195A	VCO HYBRID, RANGE 5
●										HLN4757A	INTERNAL CASTING HARDWARE, RANGE 1
	●									HLN4758A	INTERNAL CASTING HARDWARE, RANGE 1 W/PREAMP
		●								HLN4737A	INTERNAL CASTING HARDWARE, RANGE 2
			●							HLN4468A	INTERNAL CASTING HARDWARE, RANGE 2 W/PREAMP
				●		●				HLN5036A	INTERNAL CASTING HARDWARE, RAND 3, 4
					●		●			HLN5037A	INTERNAL CASTING HARDWARE, RANGE 3, 4 W/PREAMP
								●		HLN4940A	INTERNAL CASTING HARDWARE, RANGE 5
									●	HLN4941A	INTERNAL CASTING HARDWARE, RANGE 5 W/PREAMP
	●		●							HLE4187A	PREAMPLIFIER, RANGE 1, 2
					●		●		●	HLE4186A	PREAMPLIFIER, RANGE 3–5
●		●		●		●		●		HLN4467A	RECEIVER LOW PASS FILTER BOARD
●	●	●	●	●	●	●	●	●	●	HLN4251A	VCO INTERCONNECT

SYNTOR X 9000 UHF Radio Option Chart

W12	UHF Pre–amp
W20	Telephone Interconnect
W70	Omit Antenna, UHF
W71	Omit Microphone
W87	Omit Speaker
W90	Omit Accessories, *Smartnet*, UHF
W101	22' Negative Ground Cable
W109	Handset with hang–up
W116	External Alarms
W123	Antenna, 3.5 dB gain, UHF 406–512
W124	Antenna, 5 dB gain, UHF 406–512
W125	External option housing
W239	Noise cancelling microphone
W268	*SECURENET* code storage battery (secure–capable only)
W269	Siren/Public Address
W304	*SECURENET* proper code detect
W305	16 system/8 subfleet/64 modes
W306	15 system/16 subfleet/8 modes
W354	Trunked DEK (8)
W355	Trunked and *MDC–1200* DEK (8)
W370	*MDC–1200* DEK (8)
W373	Trunked DEK (16)
W374	Trunked and *MDC–1200* DEK (16)
W391	*SECURENET* with Physical Security (secure–capable only)
W412	*MDC–1200* Selective Call
W470	Emergency footswitch
W496	10' Negative ground
W496	10' Negative Ground, *SECURENET*
W589	Public Address
W591	Auxiliary Switch Panel
W674	Security Housing Cable
W688	Emergency pushbutton, hidden
W709	25 system/8 subfleet/ 32 modes
W793	*SECURENET*, DVI–XL encryption
W795	*SECURENET*, DES–XL encryption
W797	*SECURENET*, *DVP*–XL encryption
W814	*MDC–1200* PTT ID/Emergency
W820	Unlimited Private Call/Call Alert
W821	Wide area coverage, AMSS
W822	Dynamic regrouping
W826	Omit Emergency Alarm/Call
W829	8 systems/16 subfleets/64 modes
W838	Spare *DVP*–XL encryption
W839	Spare DES–XL encryption
W840	Spare DVI–XL encryption
W941	*MDC–1200* DEK (16)
W946	Conventional phone/DTMF
W995	Zone/Mode control unit
W996	System/Subfleet control unit

SYNTOR X 9000 UHF Performance Specifications

General

Number of Modes	Models available in 32 mode configuration. 64 modes optional.
Channel Resolution	Multiples of 5.0 kHz or 6.25 kHz.
Squelch Options	*Private–Line* and *Digital Private–Line* coded squelch are standard and available in the same radio unit. Carrier Squelch and multiple coded squelch are optional.
Primary Power	±12 VDC with a DC–isolated floating ground system. Radio supplied for operation with negativeground vehicles. Optional Cable kit permits operation with positive ground vehicles.
Radio Unit Dimensions	2.65" H x 11.5" W x 16.0" L (63.5mm x 292mm x 406mm)
Radio Unit weight	Approximately 22.5 lb (10.2 kg). Shipping weight approximately 37.5 lb (17 kg).
Metering	A single scale 0–50 microampere meter or Motorola portable test set can be used to measure all circuits essential to checking and adjustments.

		Maximum Battery Drain (inc. std. accessories)			
Model (series)	**Frequency (MHz)**	**Minimum RF Power Output**	**Standby @ 13.8V**	**Receive at Rated Audio @ 13.8V**	**Transmit @ Rated Power**
T74KEJ/T74KXJ	406–420	100W	1.2A	3.5A	31A
T74KEJ/T74KXJ	450–470	100W Variable to 50W	1.2A	3.5A	31A
T64KEJ/T64KXJ	470–512	78W Variable to 39W	1.2A	3.5A	31A
T34KEJ/T34KXJ	450–512	30W Variable to 15W	1.2A	3.5A	12A

Transmitter

Output Impedance	50 ohms.
Spuious and Harmonic Emissions	More than 70 dB below carrier (for EIA spec. RS152B).
Frequency Stablility	±.0002% of reference frequency form +30°C to +60°C ambient (+30°C reference).
Maximum Frequency Separation	20 MHz without degradation for 450–470 radios, 14 MHz without degradation for 406–420 radios. 18 MHz without degradation for 470–512 MHz (3 ranges).
Modulation	15F2 and 16F3, ±5 kHz for 100% @ 1000 Hz.
Audio sensitivity	0.080V ±3 dB of 60% maximum deviation @ 1000 Hz.
FM Hum and Noise EIA Method	
Companion Receiver Response	–60 dB.
RS152B Response	–50 dB.
Audio Response	+1, –3 dB of 6 dB/octave pre–emphasis characteristic from 300 to 3000 Hz.
Audio Distortion	Less than 2% @ 1000 Hz, 60% maximum deviation.
FCC Designation	T74FDJ: ABZ89FT4633–Licensable under FCC rules Parts 22, 74, and 90 fo r15F2,16F3, and 16 F9 emission. T64FDJ: ABZ89FT4666 T34FDJ: ABZ89FT4687

Control Unit

Dimensions (excluding mounting bracket)	6.5" W x 3.375" H x 1.687" D (166mmm x 87mm x 43mm)
Weight	1 lb (455 g)
Current Drain	300 mA

Speaker

Dimensions (excluding mounting bracket)	5" x 5" x 2.5" (127mm x 127mm x 63mm)
Weight	1.5 lb (680 g)

SYNTOR X 9000 UHF Performance Specifications (continued)

Receiver

Input Impedence	50 ohms.				
EIA Modulation Acceptance	±7.0 kHz minimum.				
Frequency Stability	±.0002% of reference frequency from −30°C to +60°C ambient (±30°C reference).				
Maximum Frequency Separation	Range 1: 14 MHz without degradation. Range 2: 20 MHz without degradation. Range 3–5: 18 MHz without degradation.				
Sensitivity		With Pre–Amp		Without Pre–Amp	
20 dB quieting		0.25 uV		0.50 uV	
EIA SINAD		0.20 uV		0.35 uV	
Intermodulation EIA SINAD		80 dB		85 dB	
Spurious and Image Rejection		90 dB		95 dB	
Selectivity EIA SINAD	Adjacent Channel	Alternate Channel	4th Channel	±400 kHz	
25 kHz Ch.	85 dB	90 dB	100 dB	110 dB	
Audio Output	15 watts @ less than 3% distortion into an 8 ohm load.				
FCC Designation	T74KEJ: ABZ89FT4633 T64KEJ: ABZ89FT4666 T34KEJ: ABZ89FT4687				

Description

1. Radio Features

1. 1 GENERAL

The *SYNTOR X 9000* UHF radio including *Systems 9000* options, provide the following features:

- microcomputer control
- broad–band operation
- frequency synthesis
- programmable time–out timer
- *Private–Line* and *Digital Private–Line* coded squelch
- Talkaround
- operator select *Channel Scan* operation
- mode select *Channel Scan* operation
- wide operating temperature range (from –30°C to +60°C)
- rugged construction that meets MIL–810D environmental specification related to rain, dust, salty atmosphere, shock, and vibration
- all solid–state, compact, modular design that simplifies radio maintenance and troubleshooting

Some of these features are discussed in the following paragraphs. More detailed information about the features and options are included in the appropriate *SYNTOR X 9000* Two–Way Radio Operator's Manual.

1. 2 CONVENTIONAL FEATURES

SYNTOR X 9000 Radio Systems operate in the conventional mode for compatibility with conventional repeater systems. *Digital Private–Line* (DPL) or carrier squelch (CSQ) signalling is available. DPL coding is automatically selected (when available) by the Mode selector.

Talkaround is available in the conventional (non–trunked) mode for mobile–to–mobile communications. In conventional repeater systems, the transmit and receive frequencies are different. When Talkaround is selected, the transmitter frequency changes to the receiver frequency. All mobiles that need to communicate *directly must* select talkaround.

1. 3 MICROCOMPUTER CONTROLLED SYSTEM

Most major radio operations are controlled by an 8–bit microprocessor, a Read Only Memory (ROM) that contains the operating program, and associated support and control circuitry. This sophisticated microcomputer system is designed to simplify mobile operation.

1. 4 BROAD BAND OPERATION

The *SYNTOR X 9000* UHF radio operates over a broad band of frequencies. This band of authorized frequencies is in multiples of 5 kHz or 6.25 kHz in the following ranges.

406–420 MHz (Range 1)
450–470 MHz (Range 2)
470–488 MHz (Range 3)
482–500 MHz (Range 4)
494–512 MHz (Range 5)

The radio operates in these ranges without degradation in performance *and without* special "dual exciter" or "dual front end" circuits that operate on widely separated frequencies. Frequencies can be changed or added without retuning or realigning the radio.

1. 5 FREQUENCY SYNTHESIS

Specific radio frequencies are generated electronically by using a frequency synthesizer rather than individual crystals or channel elements. This simplifies multiple–frequency operation since frequencies can be changed or added by reprogramming the radio. The frequency synthesizer reacts in milliseconds in priority mode scanning.

1.6 IMPROVED TRANSMITTER AND RECEIVER PERFORMANCE

The *SYNTOR X 9000* UHF radio receives and transmits over 14 MHz (Range 1), 20 MHz (Range 2), or 18 MHz (Ranges 3–5) bandwidths without degradation. Its frequency stability is rated at +2 ppm, its transmit audio distortion less that 2%. Receiver sensitivity (without a pre–amplifier) is rated at 0.35 microvolt (EIA SINAD) over the full 14 MHz (Range 1), 20 MHz (Range 2), or 18 MHz (Ranges 3–5) bandwidths.

1.7 PROGRAMMABLE TIME–OUT TIMER

The time–out timer causes the transmitter to stop transmission after the pre–programmed time interval. This prevents repeater or channel tie–up because of prolonged keying of the transmitter.

1.8 *PRIVATE–LINE* OR *DIGITAL PRIVATE–LINE* CODED SQUELCH

The *Private–Line* or *Digital Private–Line* coded squelch is programmed as required. This feature allows mobile units to receive only the messages that use their individual system code. This reduces an operator's listening fatigue as well as the probability of missed or misunderstood messages.

1.9 REPEATER TALKAROUND CAPABILITY

Repeater talkaround allows direct communication between two mobile units or between a mobile radio and a portable unit. Use the Mode select rocker or a separate pushbutton [**Dir**] to select talkaround operation.

1.10 *CHANNEL SCAN* OPERATION

The [**Scan**] button activates a pre–programmed set of *Channel Scan* parameters. This simplifies *Channel Scan* operation since it requires only one button to be used by an operator.

1.11 OPERATOR–SELECT *CHANNEL SCAN*

Operator–select *Channel Scan* allows you to manually select channels for scanning. This suits operators who prefer manual *Channel Scan* operation to a pre–programmed scan list.

1.12 PRE–AMPLIFIER

The optional pre–amplifier improves the 12 dB SINAD receiver sensitivity from 0.35 microvolt to 0.2 microvolt, with a 5 dB decrease in intermodulation protection.

2. Electrical Characteristics

The basic *SYNTOR X 9000* radios come fully equipped for operation. The units operate from a negative–ground, 12–volt DC source. A standard control unit, speaker, microphone with a hang–up bracket, antenna with a 14–foot cable, and a 17–foot negative–ground cable kit are included.

2.1 CIRCUIT BLOCKS

The *SYNTOR X 9000* radio can be grouped into physical blocks: personality board, memory module, common circuits board, transmitter power amplifier, radio frequency (RF) board, directional coupler board, and internal casting. The internal casting includes a voltage–controlled oscillator (VCO), mixer, filter board (or optional pre–amplifier).

2.2 FUNCTIONAL DESCRIPTION

The radio can be functionally divided into five parts: (a) microcomputer, (b) control unit, (c) frequency synthesizer, (d) receiver, and (e) transmitter. The microcomputer circuits are contained on the personality board. The frequency synthesizer circuits are contained on the personality board, RF board, and internal casting. The receiver circuits are contained on the personality board, RF board, and internal casting. The transmitter circuits are contained on the common circuits board and power amplifier. A brief description of each functional segment is provided below; further description is provided in the section associated with the circuit in question.

2.2.1 Microcomputer

The personality board contains the microcomputer system and code plug. The microcomputer consists of an eight–bit microprocessor, a read only memory that contains the operating program, and associated supporting and control circuitry. The microcomputer controls all operations of the radio from lighting the control panel indicators to frequency selection.

2.2.2 Control Unit

The control unit has two circuit boards. One is the controller board and the other is the display board. The display board contains switch contacts and an 11 character, 14 segment display. The display is driven by a driver that receives serial data from the microprocessor on the control board.

The microprocessor contains the operating software. The EEPROM contains re–programmable customer information.

The display board contains the following:

- vacuum fluorescent (VF) display
- VF display driver
- backlight and indicator LEDs
- switch contacts

The controller board contains the following:

- microprocessor and EEPROM
- serial data link receiver and transmitter
- +5 volt regulator
- watchdog timer
- vehicle interface ports (VIPs)

2. 2 .3 Frequency Synthesizer

The frequency synthesizer uses a phase–locked loop (PLL) consisting of a reference oscillator, a voltage controlled oscillator (VCO), a programmable divide by 3–or–4 pre–scaler, a multiplex divider, a sample–and–hold phase detector, a VCO buffer, and a loop adaptive filter.

For frequency generation control, the microcomputer reads the proper information from the memory module and then applies it to the multiplexed–input divider via four data lines. This information is contained in six four–bit words.

A multiplexing sequence passes the six words to the divider. The divider divides the reference oscillator and VCO frequencies and generates four bits. Two of these bits (C0 and C1) control a "C" counter inside the 3–or–4 pre–scaler. The other two bits (S0 and S1) are used by the sample–and–hold phase detector to control the loop adaptive filter. Once the mode of operation and the channel are selected, the six four–bit words stay the same. However, any mode change makes the microcomputer address different memory locations in the memory module. Consequently, the six four–bit words supply different information to the divider via the four data lines.

Microphone audio from the personality board is applied to the IDC circuitry along with the PL/DPL encode signals (if used). The IDC circuits process the audio to ensure the proper level of audio drive is supplied to the frequency synthesizer. In *Private–Line/Digital Private–Line* radios, the low–frequency PL/DPL encode signals from the personality board are combined with the microphone audio signal and routed to the VCO and the synthesizer reference oscillator via the deviation and compensation circuits.

2. 2 .4 Receiver

Incoming RF signals go through the filter board (or optional pre–amplifier), via the antenna relay. The filter output passes through a six–pole preselector filter then goes to the first mixer stage. The selectivity of the two filters prevents high–level out–of–band signals from degrading receiver performance.

The radio does not use receiver channel elements to generate the first mixer injection frequency. Rather, the frequency synthesizer supplies a high–side (Range 1) or low–side (Range 2–5) injection frequency that is applied to the first mixer via a three–pole injection filter.

The second mixer uses the 53.9 MHz signal and a 43.2 MHz signal from an injection tripler to generate a 10.7 MHz IF. The receiver uses two four–pole 10.7 MHz crystal filters to attenuate signals outside the predetermined receiver bandpass range. After filtering and amplification, the 10.7 MHz signal passes to the limiter/detector stage.

The squelch circuit gives the microcomputer two signals (CHANNEL ACTIVITY and SQUELCH TAIL). In the absence of an RF carrier, SQL TAIL is low and CHAN ACT is high. When an RF carrier appears, these signals switch to SQL TAIL high and CHAN ACT low. This tells the microcomputer to enable the audio stages. The faster CHANNEL ACTIVITY line is used as a preliminary indicator during *Channel Scan* operation, while the SQUELCH TAIL line protects the audio signals against fading.

2. 2 .5 Transmitter

The RF output generated by the frequency synthesizer at the required transmit frequency is applied to the controlled stage of the transmitter.

3. Radio Identification Label

The radio identification label identifies information needed for servicing the radio. Each field of information is explained by the following. The numbered items refer to Figure 1.

(1) DATE: this field identifies the date the trunking information was printed.

(2) SERIAL NUMBER (SN): this field identifies the radio's serial number.

(3) MODEL: this field identifies the radio's model number.

(4) FACTORY ORDER NUMBER (FO): this field identifies the factory sales order number.

(5) CONV: this area indicates the conventional mode information.

(6) MODE: this field identifies the specific conventional user mode number.

(7) RX: this field identifies the receive channel frequency in MHz.

(8) TX: this field identifies the transmit channel frequency in MHz.

(9) RX CODE: this field identifies the receiver PL, DPL or CSQ tone assignment.

(10) TX CODE: this field identifies the transmitter PL, DPL or CSQ tone assignment.

(11) T/A: this field identifies the transmit talk around frequency in MHz

(12) TOT: this field identifies the time–out timer value.

(13) PR1: this field identifies the first priority scan selection.

(14) PR2: this field identifies the second priority scan selection.

(15) SQL DATA: This field identifies the squelch data selection.

(16) SCAN: this field identifies the modes scan list.

(17) RADIO NAME: this field identifies the radio name assigned at time of order processing.

(18) RADIO SERIAL NUMBER (RSN): this field identifies the original radio serial number when replacement codeplugs have been ordered.

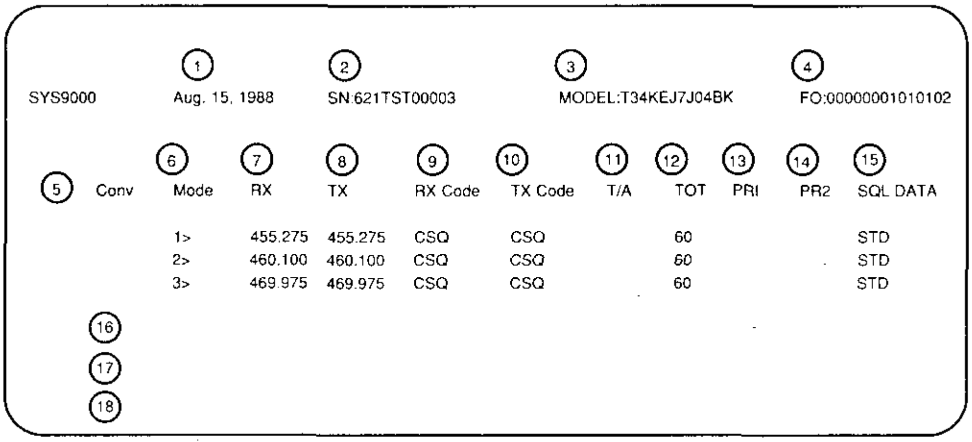

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Figure 1. SYNTOR X 9000 *UHF Radio Identification Label*

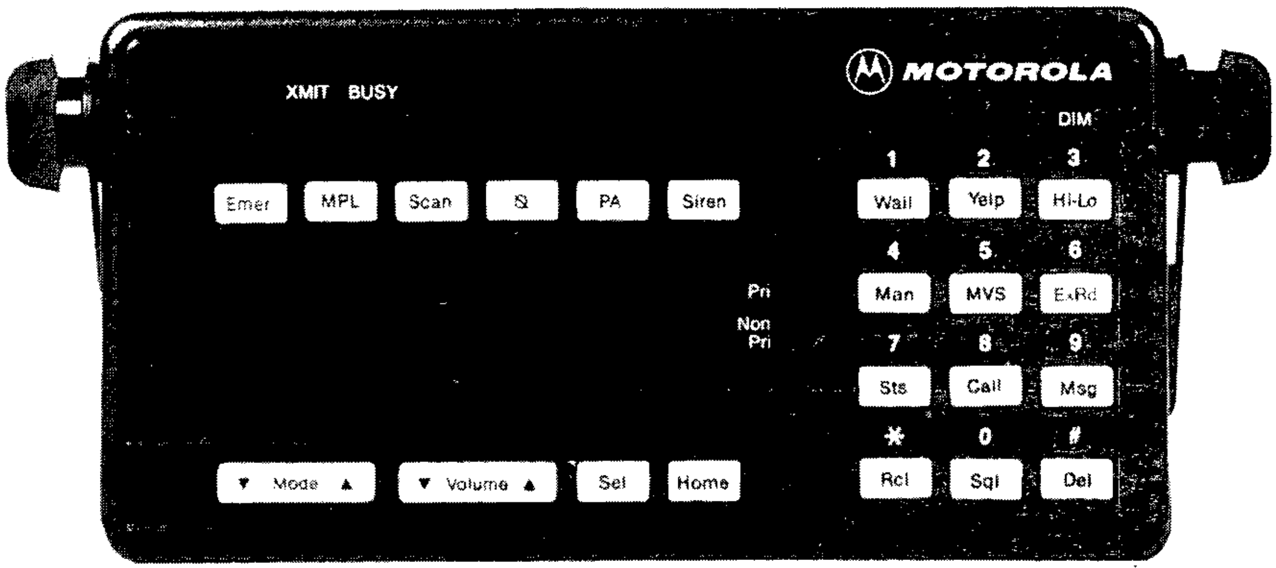

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Figure 1. Typical Systems 9000 *Control Unit*

1. General

The *SYNTOR X 9000* mobile radio system consists of:

- remote mountable radio
- control unit (conventional or dual operation)
- microphone
- speaker
- antenna
- interconnecting cable

The mobile units come with *Systems 9000* control units that meet the basic requirements for conventional or trunking operation.

The *Systems 9000* Control Unit includes the following controls and indicators:

- Power on/off slide switch
- DIM button for display brightness
- Rocker switch volume control
- Rocker and keypad mode–select control
- Channel BUSY indicator light
- XMIT (transmit) indicator light
- Priority channel indicator light
- Nonpriority channel indicator light
- Squelch button to set volume and monitor
- channel activity
- Option control buttons and indicators

2. Radio Operation

2. 1 ALERT TONES

The following alert tones aid the operator by indicating unique system conditions:

- Illegal Mode– A low pitched tone that indicates an invalid button position has been selected.
- Time–Out Timer alert (optional) – A low pitched continuous tone that indicates your present transmission will soon be disabled.

2. 2 TO RECEIVE

Perform the following steps to adjust your radio for operation.

(1) Slide the power ON/OFF switch to the left until it locks in position. The Control Unit display comes on showing "SELF CHECK" for two to three seconds, then displays the current selected mode. If the radio system fails its diagnostics on power up, an error code displays. See the Maintenance and Troubleshooting section of this manual. If the failure is critical, the radio ceases operation.

(2) Select a mode on which to operate.

(3) For modes with PL/DPL, turn squelch on.

(4) Adjust the volume level to a comfortable listening level during an incoming signal.

2. 3 TO TRANSMIT

With the radio switched on, perform the following steps to transmit on your radio system.

(1) Select the desired channel with the [**Mode**] rocker.

(2) Lift microphone off–hook. Press and hold the microphone PTT button.

(3) When the red transmit indicator lights, hold the microphone about two inches from your lips, speak slowly into the microphone in a normal voice, state your FCC call sign, and continue with your message. Release the microphone PTT button to receive.

3. Mode Select

Use the [**Mode**] rocker switch to scroll forward and backward through the list of programmed modes. Modes can be field programmed with user defined names. Mode names may have up to 11 characters. However, if you allow three digits for a mode number and eight digits for the mode name, both name and numeric mode association is possible.

4. *Channel Scan*

The *Channel Scan* feature allows you to scan a previously defined list of conventional modes for activity. If no activity exists, the display shows your selected mode. When a scanned mode becomes active, the display shows the active mode; the appropriate priority (PRI) or non–priority (NON–PRI) indicator lights; and the radio unmutes.

Press the [**Scan**] button to turn *Channel Scan* on or off. With scan on, the previously selected scan list enables, and the red indicator lights.

4. 1 MODE SLAVED SCAN

On mode select scan radios, the scan list is pre–programmed and may not be modified. When scan activity occurs, the currently active mode number or name displays, the appropriate priority (PRI) or non–priority (NON–PRI) indicator lights and the radio unmutes.

Press the [**Scan**] button to turn *Channel Scan* on and off. The internal scan list is enabled for the selected mode when scan is on, and the *Channel Scan* indicator lights.

4. 2 OPERATOR SELECTABLE SCAN

On models with Operator Selectable Scan, you may review the scan list and/or modify it by holding the [**Scan**] button until an alert tone (beep) sounds and the red indicator blinks. Enter your new scan list by using the [**Mode**] rocker to locate the mode name, or by selecting a mode number with the keypad. Once the desired mode displays, press the [**Sel**] button to add it to the list.

Press the [**Sel**] button once to add the new mode as a non–priority list member (NON–PRI lights), press [**Sel**] a second time to add the new mode as a second priority list member (PRI lights), or press [**Sel**] three times to add the new mode as a first priority list member (PRI blinks).

You may remove modes from your list or review your scan list. Press the [**Del**] button to remove modes from your scan list. Review the scan list by pressing the [**Rcl**] button.

Press the [**Home**] button to exit the Scan list entry mode and return to normal operation.

4. 3 DYNAMIC PRIORITIES

The Dynamic Priority feature allows you to modify the priority of a scanned mode using the [**Sel**] button. Press [**Sel**] during mode activity to temporarily assign a NON–PRI mode to second (PRI lights) priority.

Restore the scan list to the normal priority assignments by turning Scan off and on, changing modes, pressing [**Rcl**], or turning the radio off and on.

4. 4 NUISANCE DELETE

A NON–PRI mode in the scan list that becomes too active or you no longer desire may be temporarily deleted by the [**Del**] button during mode activity.

Press the [**Rcl**] button, turn Scan off and on, change modes, or turn the radio off and on to restore a temporarily deleted mode to your scan list.

Priority modes may not be temporarily deleted.

4. 5 TALKBACK SCAN

Talkback Scan allows you to transmit on the last active received mode, regardless of the selected mode on the control unit.

Installation

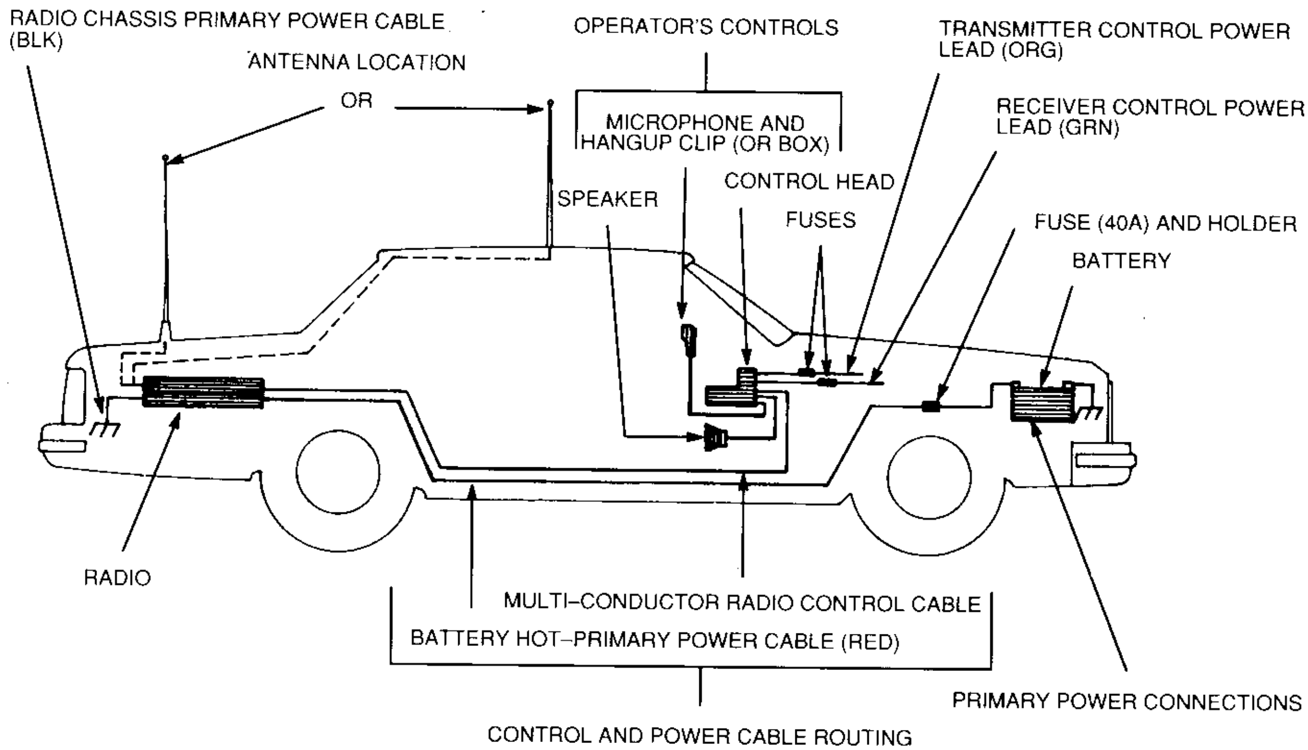

Figure 1. Installation Planning

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1. Pre-Installation Tests

Although the factory aligns the equipment accurately, mishandling in transit may disturb some of the adjustments. In any case, FCC regulations require the checking of transmitter frequency and deviation at the time of installation. Therefore a pre-operational check is mandatory. To make a complete check, follow the sequence of tests presented below. The tests are described in more detail in the Maintenance and Troubleshooting Section of this manual.

(1) Check the highest transmit frequency (highest repeater frequency) and adjust as required. This adjustment also corrects any receive frequency errors caused by the reference oscillator.

(2) Measure the transmitter power output at the highest transmit frequency, and make adjustments as required.

(3) Measure the transmitter deviation at the highest transmit frequency (highest repeater frequency) and make the necessary adjustments.

(4) Measure the transmit frequencies.

(5) Measure the receive frequencies.

(6) Measure the 20 dB-quieting signal levels.

(7) Measure the PL or DPL sensitivity in PL/DPL modes. Repeat Steps 4 through 7 for each mode.

(8) Check the VSWR of the antenna after installing it in the vehicle.

2. Installation Planning

See Figure 1 for information on the antenna location, operator's controls, radio location, control and power cable routing, transmitter control power lead, receiver control power lead, primary power connections, and other accessories.

WARNING

For vehicles equipped with electronic anti–skid braking systems, see the "Anti–Skid Braking Precautions," Motorola publication number 68P81109E34. This document is available free of charge.

2. 1 ANTENNA LOCATION

The best location for the antenna is at the center of the vehicle roof. A good alternate location is at the center of the trunk lid. Be sure that the antenna cable can be acceptably routed to the radio before mounting the antenna. See the antenna instruction manual for details.

CAUTION

Antennas must be installed at least two feet (0.6 meter) from vehicle operators and passengers unless shielded by a metallic surface.

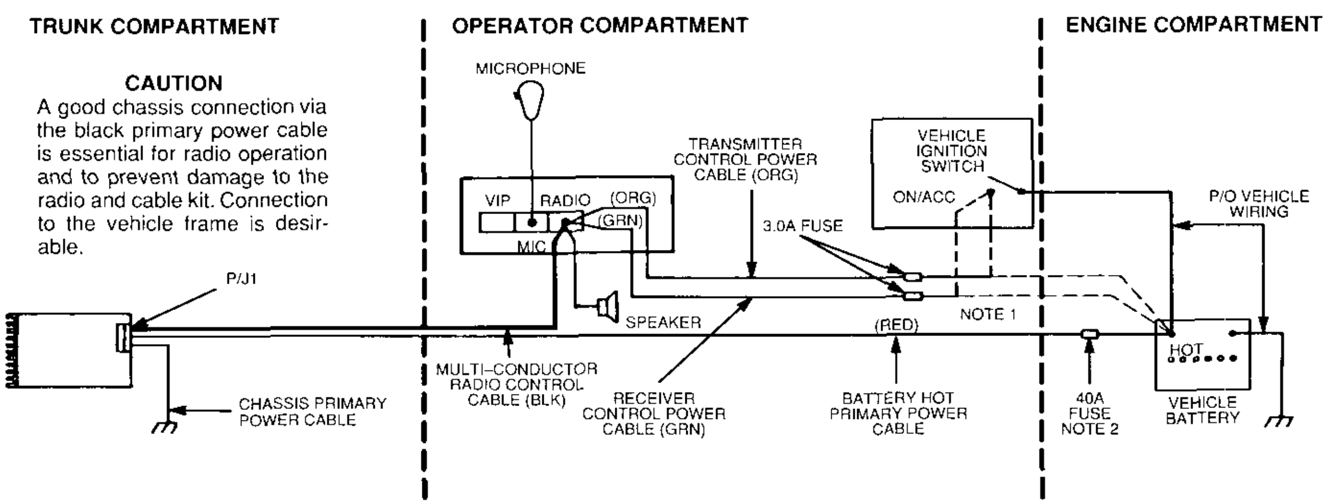
2. 2 RADIO LOCATION

In most vehicles, the best location for the radio unit is the floor of the trunk compartment. When considering location, make sure to protect the radio from dirt and moisture. Make sure there is sufficient space around the radio to allow adequate cooling and permit removal of the unit.

2. 3 OPERATOR'S CONTROLS

Recommended mounting surfaces for the control unit, microphone hang–up clip, and speaker are the following: under the dashboard, on the transmission hump, or on the center console. The speaker may be mounted on the firewall.

Adjustable trunnions are supplied for mounting the control unit and the speaker, allowing a number of mounting positions. The installation must not interfere with the operation of the vehicle or its accessories, nor disturb passenger seating or leg room. The control unit and the microphone hang–up clip must be within convenient reach of the user(s).



1. The orange and green power cables connect to either the vehicle battery or the ignition switch. Connect the green cable directly to the battery. The receiver operates when the control head is on. Connect the orange cable to the ignition switch. The transmitter operates only when the ignition switch is on. Alternate connections—Connecting both green and orange cables to the battery allows the control head to turn the receiver and transmitter on or off. Connecting both green and orange cables to the ignition switch allows the ignition switch to turn the receiver and transmitter on or off. (Alternator whine and other noise problems may occur. Isolate the green cable with a Motorola relay, part #59–00813674.)

2. The radio primary power cable (red) comes in two parts. One is part of the radio control cable kit that goes from the radio to the engine compartment. The other comes with an in–line fuse on one end and a ring lug on the other end.

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Figure 2. Cabling Interconnection Diagram

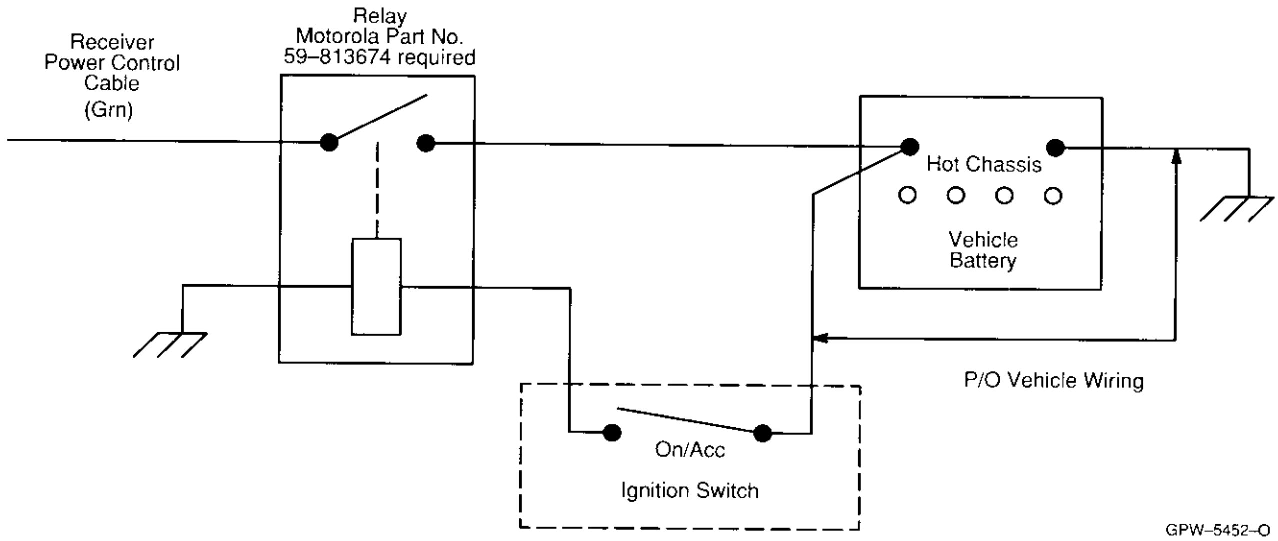


Figure 3. Power Control Isolation Detail

2. 4 CONTROL AND POWER CABLE ROUTING

Many vehicles have wire troughs in the door sills. If the vehicle has this feature, use the troughs to provide maximum protection for the cable and to simplify the cable installation.

In vehicles without wiring troughs, route the control and power cables where they are protected from pinching, sharp edges, and crushing. One suggested route is along one side of the drive shaft hump under the carpet. Use grommets where the cable passes through holes in metal panels.

2. 5 PRIMARY POWER CONNECTIONS (RED)

The best power connection point for the battery hot primary power lead is at the battery hot terminal. Points that connect directly to the battery terminal with sufficient current–handling capabilities may also be used. Make certain that the point chosen remains close to 13.6 volts; some systems switch to a higher–than–normal voltage during starting.

2. 6 TRANSMITTER CONTROL POWER LEAD (ORANGE)

Connect this lead to the ignition switch (recommended) or directly to a battery hot supply. See Figure 2.

2. 7 RECEIVER CONTROL POWER LEAD (GREEN)

Connect this lead to a battery hot supply (recommended) or to the ignition switch. See Figures 2 and 3.

2. 8 RADIO CHASSIS PRIMARY POWER CABLE (BLACK)

The radio chassis primary power cable should connect to a good ground point on the vehicle chassis. See Figure 2.

3. Cable Routing

Note

Cables routed near metal edges or through holes may be damaged. Be sure to use rubber grommets, if necessary, to protect the cables.

(1) Determine the radio's location in the trunk compartment and leave enough slack cable to permit the plug to be easily connected or disconnected from the radio.

(2) Work from the trunk space forward. In some cars there is enough room below the fiberboard trunk partition to admit the cables. If this is not the case, make an opening through the partition. Remove the back seat.

(3) If the vehicle has wire troughs, run the cables in the wire troughs. Otherwise, route the cables under the floor covering alongside the drive shaft hump. Pull the cables into the back seat area, under the floor mats, under the front seat, and under the front mats, exiting up under the dash at the firewall. Pull the control unit end of the multi–conductor cable to the approximate location of the control unit. Route the red power cable into the engine compartment through any convenient hole in the firewall.

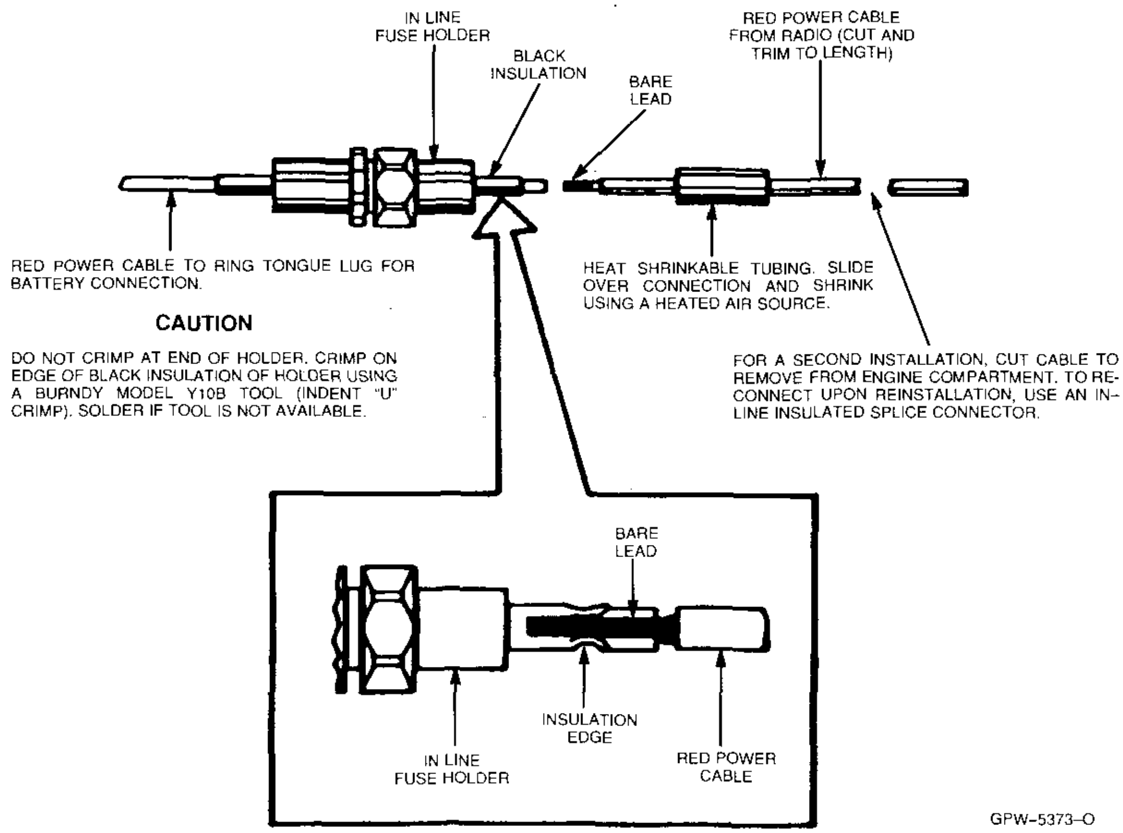
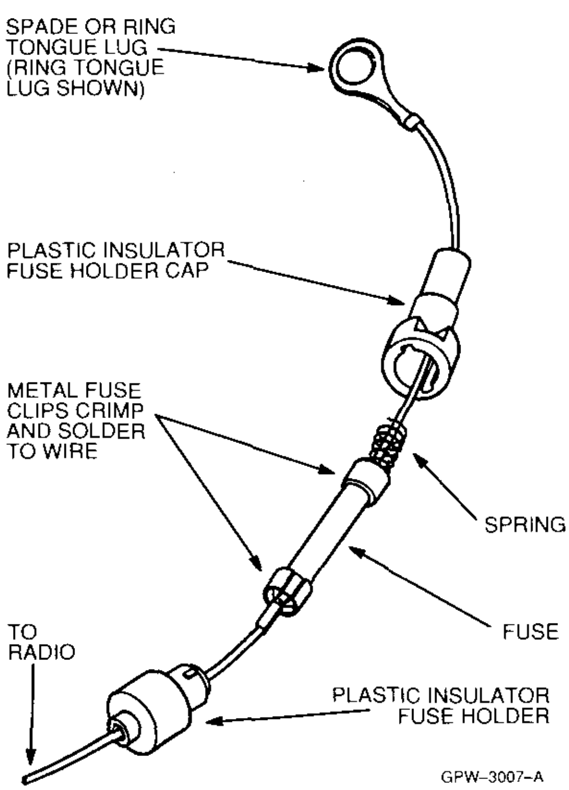


Figure 4. Fuse Installation



parts list

HLN4952A Fuse Kit for Green and Orange Leads — MXW-2273-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	14-82882A01	insulator, fuse hoder body
	14-82883A01	insulator, fuse holder cap
	29-00136968	lug
	29-00824456	ring tongue lug
	29-00865065	ring tongue lug
	41-82885A01	compression fuse spring
	42-82884A01	fuse clip
	65-00020404	3 amp fuse, 250V, (quantity 2)

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Figure 5. Fuseholder Assembly and Parts List

(4) Pull the red power cable into the engine compartment. A cable fuse kit comes with a ring tongue lug on one end and an in–line fuseholder on the other. Each cable includes a small section of heat–shrinkable tubing. Trim any excess length of red cable. Slide the heat–shrinkable tubing over the red power lead from the radio. Slide the strapped portion of the red cable into the end of the in–line fuseholder and crimp the joint using a Burndy Model Y10B (indent "U" crimp). If this tool is not available, solder the joint. See Figure 4.

(5) Slide the heat–shrinkable tubing over the connection and shrink the tubing with a Motorola Model ST697 Heat Gun or equivalent heated air source. Remove the fuse from the fuseholder and reconnect the holder. Fasten the ring–tongue lug on the end of the cable to the battery's ungrounded terminal or to some point directly connected to the ungrounded terminal of the battery (such as the starter solenoid). Move the in–line fuseholder to a convenient location on one of the sheet metal parts of the engine compartment. Center punch and drill a 9/64" (.140") hole through the mounting surface. Then mount the bracket with the #10–16 x 1/4 self–tapping sheet metal screws. Do not install the fuse until the entire radio installation is complete.

(6) The control unit power cable kit contains two separate wires, one orange and the other green. The orange wire is 66 inches long and the green wire is 106 inches long. A fuse kit hardware bag comes with the radio. This bag contains crimp–on type ring tongue lugs and crimp–on type spade lugs. The spade lugs allow connection to hot leads at the fuse block of the vehicle and the ring tongue lugs permit attachment to screws of terminals. Determine from Table 1 which radio functions are to be switched through the vehicle ignition switch. A typical system allows the receiver to operate with the radio switched on while the ignition is off, but the transmitter does not operate unless the ignition is on. In this case, connect the orange wire to the accessory terminal of the ignition switch and the green wire to the ungrounded terminal of the battery or starter solenoid.

NOTE:

RADIO FITS TRAY VERY TIGHTLY FOR GOOD ELECTRICAL PERFORMANCE DURING VIBRATION. TO INSTALL RADIO, SET IT IN TRAY AND PUSH IT TOWARD REAR OF TRAY UNTIL IT ENGAGES REAR TABS FULLY. CHECK THAT FRONT TABS HAVE ENTERED OPENING IN RADIO AND THAT HANDLE PROJECTIONS WILL ENGAGE THEM. PUSH HANDLE CLOSED TO LOCK.

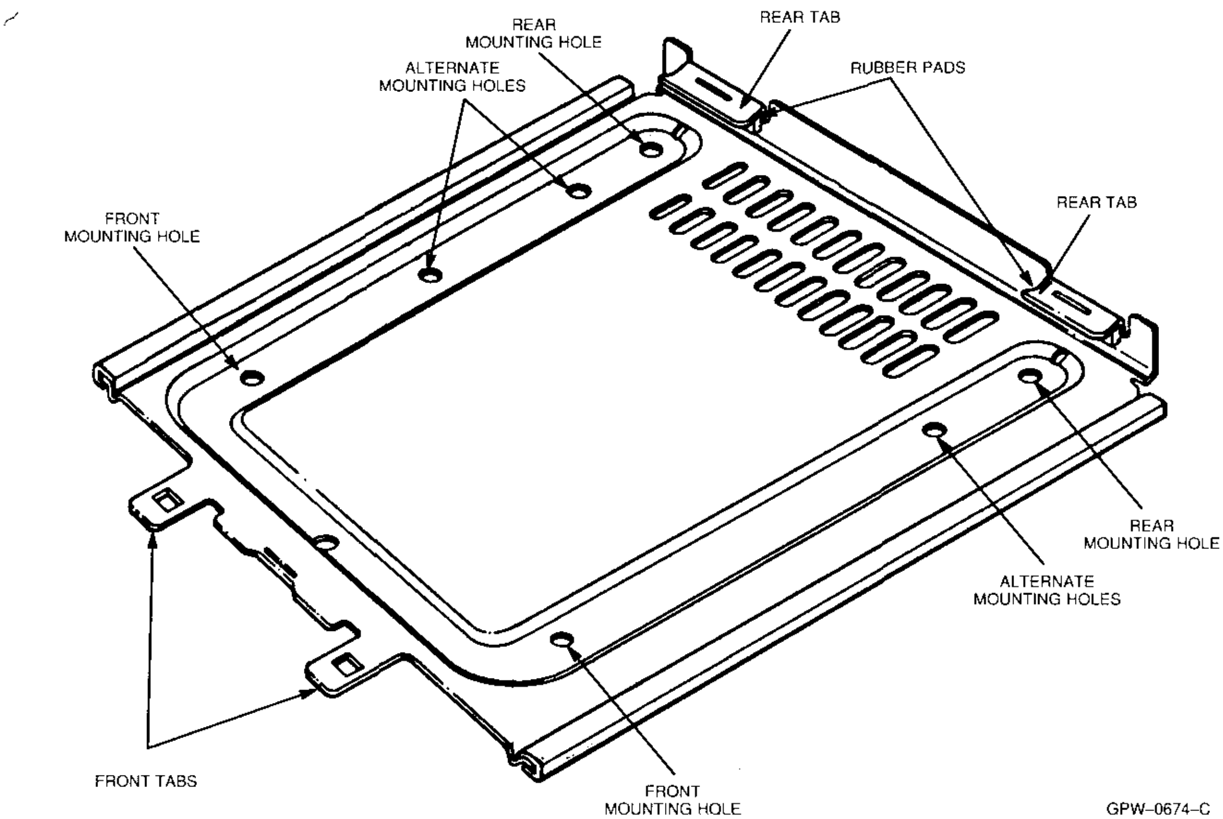

Figure 6. Radio Mounting Tray

CAUTION

Do NOT connect either lead to the ungrounded terminal of the battery at this time.

(7) If either wire is to be connected in the engine compartment, pass the end of the wire through the same firewall hole that the red power cable uses. At this point, install a fuse in both wires.

(8) The following procedures apply to both the green and orange wires. See Figure 5 for more information. Cut the wires about 10 inches from the end. Strip the insulator from both sides so that about 1/8 inch of the wire is exposed. On the end still connected to the cable kit, install the plastic insulator fuse holder cap. On the same wire, crimp one of the metal fuse clips onto the exposed wire and apply solder for a good connection. On the 10–inch loose wire, crimp another metal fuse clip onto the exposed wire and apply solder. Install the fuse (both are three–amp) into the fuse clips on both sides. Slide the spring on the wire to the fuse. Then slide the plastic insulated fuse–holder over the loose end of the wire so that the spring is inside the fuseholder. Now, twist the fuseholders until they lock together.

(9) On the loose ends of the green and orange wires, strip the insulator and crimp either the spade or ring tongue lug on the wire. Solder the crimped connection.

(10) Do not dress the wires at this time. Go to the next procedure.

4. Radio Installation

(1) Choose a location where the mounting screws are not directly above the fuel tank, fuel line, or other vital parts. Permanently install the mounting tray of the radio to a flat surface with a four–point mounting scheme or, if on an uneven surface, with a three–point mounting scheme. (Four–point mounting is strongly recommended over three–point, especially in vehicles subject to extreme vibrations.) The raised shelf in some car trunk compartments makes a good mounting place. Place the radio at one side to allow space for luggage. Leave at least eight inches in front of the radio so that the handle can be opened and the programming cable can be plugged into the radio. Locate the radio so that the black ground lead in the trunk can reach a good chassis ground point in the trunk. Determine the radio's final position, unlock the radio, open the handle and lift the radio assembly away from the mounting tray (pull forward and upward to release the radio assembly). Use the mounting tray as a template to mark the location for drilling four mounting holes in the trunk floor. Use a #11 drill (.191). Mount the mounting tray as illustrated in Figures 6 and 7.

(2) When mounting the radio securely to the trunk floor in some vehicles, the front panel may press against the floor or floor cushioning. Also, some vehicles make it necessary to mount the radio directly over the fuel tank. Always make a preliminary check to see how far the screws will extend below the trunk floor. Do not puncture the fuel tank. If either condition exists, insert one of the thick spacer washers between the bottom of the mounting tray and the thin spacer washer at each of the four mounting holes. The washers help to keep the radio level, especially when the floor is covered with a "spongy" mat such as soft rubber. Replace the radio assembly by sliding the radio onto the tray at about the halfway point. Push straight back until the tray tabs enter the two window areas on the radio front and engage the handle tabs. Close by pushing the handle until it locks. The handle locks the radio to the mounting tray and conceals the top cover release button. Push the multi–conductor plug onto the male connector and rotate the thumbscrew clockwise to fully seat the connector. Reverse the procedure for removing the radio.

(3) Thoroughly clean the trunk floor surface before proceeding. Connect the black ground cable lug to a convenient location on the trunk floor. Center punch and drill a 3/16" (.187") hole through the mounting surface. Use the supplied #14 x 3/4" self–tapping screw and 1/4" lockwasher to mount the cable lug. See Figure 8.

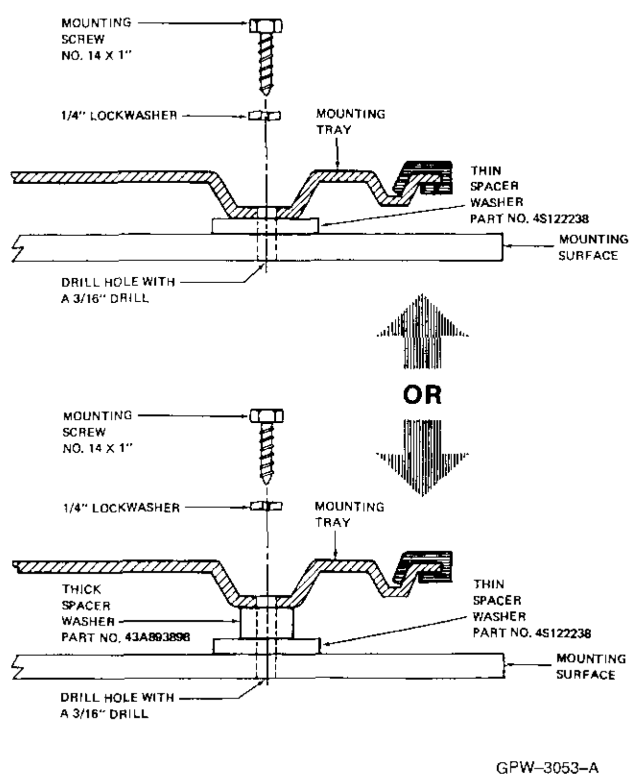

Figure 7. Radio Mounting Tray Installation Detail

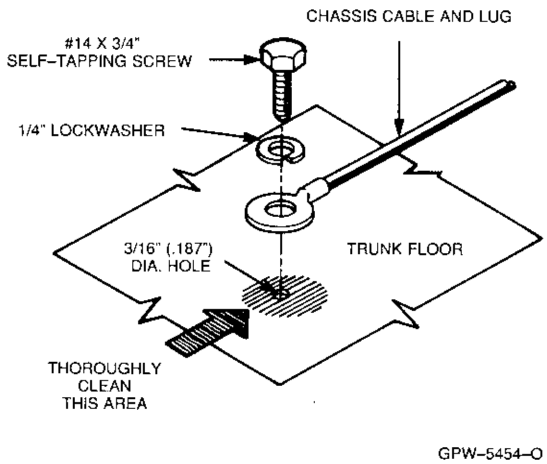

Figure 8. Radio Ground Connection

CAUTION

A good ground connection of the black cable is essential for radio operation and to prevent damage to the radio and cable kit. Grounding to the vehicle frame is desirable. On some late–model automobiles, the ground connection between the vehicle chassis and engine block is inadequate for good mobile radio operation. DO NOT compensate for this problem by connecting the radio ground directly to the battery. Connect a flexible metal ground strap between the engine block and a vehicle chassis point common to the radio ground. Be sure the strap is heavy enough to carry maximum transmitter supply current.

---

(4) All cables (including the antenna lead–in) should be dressed out of the way as much as possible to prevent damage. Mount the radio so the heatsink has the largest available air supply for cooling.

5. Microphone Installation

The microphone bracket must be within arm's reach of the operator. Measure this distance before actually mounting the microphone bracket. Since the bracket has a positive–detent action, the microphone can mount in almost any position. See the microphone instruction manual for more information.

After installation, connect the microphone plug to the receptacle on the control unit. Make sure that the clip on the control unit firmly engages the plug. Connect the microphone cable "S" hook to the proper hole in the strain relief clip on the rear of the control unit.

6. Speaker Installation

6. 1 GENERAL

The speaker kit includes a trunnion bracket that allows the speaker to be mounted in a variety of ways. With the trunnion bracket, the speaker can mount permanently on the dashboard or in accessible firewall areas. The trunnion allows the speaker to tilt for best operation.

6. 2 INSTALLATION WITH TRUNNION BRACKET

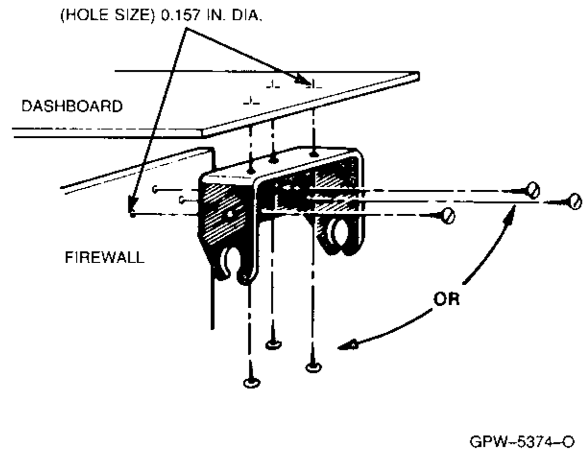

Figure 9. Standard Speaker Mounting

(1) Remove the trunnion bracket by loosening the two wing screws.

(2) Remove the three paper retainers and screws from the trunnion bracket.

(3) Remove the wall–mount bracket from its taped position on the hanger bracket. (Retain for future use.)

(4) Select a mounting position. If space limitations require the removal of the hanger bracket, remove the Phillips screw and slide the bracket out of the speaker housing. You need not disassemble the speaker housing to remove the hanger bracket.

(5) Using the trunnion bracket as a template, mark the location of the three mounting holes.

(6) Center–punch and drill a 0.101–inch (# 38 drill) hole at each location.

(7) Mount the trunnion bracket with the supplied screws.

(8) Remount the speaker in the trunnion bracket and tighten the two wing screws.

(9) Plug the speaker lead into the control unit, making sure that the plug is solidly seated.

(10) Tie up surplus lead cable.

7. Control Unit

7. 1 MOUNTING CONSIDERATIONS

Examine the vehicle to find a suitable mounting location within the operator's reach. Although the trunnion mounting bracket can mount on a plastic dashboard, all four trunnion mounting screws should penetrate the dashboard's supporting metal frame. If that is not possible, use a metal backing plate (not supplied) to strengthen the installation. The location should be convenient to the operator for viewing the display and operating the buttons and on–off switch, but vehicle operation should not be impaired and the driver's vision must not be obstructed.

If necessary, pull more cable into the dashboard area. Be sure all wires are clear of the instrument panel where holes are to be drilled.

7. 2 INSTALLATION

(1) Mark the mounting location (see Figure 9) using the trunnion bracket as a template; drill four 5/32" holes. If mounting into a plastic surface, use a metal backing plate.

(2) Attach the trunnion bracket using all four #10–16 x 5/8" self–tapping screws supplied in the mounting kit.

Note

When the control unit is installed, it must not wobble or feel "spongy" when you press buttons. Use all four mounting screws and be sure they are tightly screwed into metal–either a dashboard support bracket or a backing plate.

(3) Plug in the radio cable connector and microphone cable connector in the proper location on the back of the control unit (see Figure 11). A "click" sounds when the connector snaps into place. Now connect the microphone cable "S" hook into the hole in the cable strain relief bracket on the back of the control unit.

(4) Plug in the Vehicle Interface Port (VIP) connector (see Figure 11) into the remaining location on the back of the control unit.

(5) Install the control unit to the trunnion bracket using the two wing screws. Rotate the control unit to the desired vertical position and tighten the wing screws.

8. Vehicle Interface Port (VIP)

8. 1 GENERAL

The Vehicle Interface Port (VIP) allows the control unit to operate outside circuits and to receive inputs from outside the control unit. There are three VIP outputs which are used for relay control. There are also three VIP inputs which accept inputs from switches. See the cable kit section for typical connections of VIP input switches and VIP output relays.

8. 2 OUTPUT CONNECTIONS

The VIP output pins are on the back of the control unit below the area labeled "VIP." Use these connections to wire control relays. One end of the relay should connect to switched B+, while the other side connects to a software controlled ON/OFF switch inside the control unit. The relay can be normally–on or normally–off depending on the VIP outputs' configuration. The control unit has 3 VIP output connections.

VIP OUTPUT NUMBER	SWITCHED B+ PIN NO.	ON/OFF SWITCHED PIN NO.
1	18	2
2	19	1
3	35	34

The function of these VIP outputs can be field programmed in the control unit. Typical applications for VIP outputs are external horn/lights alarm and horn ring transfer relay control. For further information on VIP outputs, see the control unit programming manual.

8. 3 INPUT CONNECTIONS

The VIP input pins are on the back of the control unit below the area labeled "VIP." These connections control inputs from switches. One side of the switch connects to ground while the other side connects to a buffered input to the control unit. The switch can be normally–closed or normally–open depending on the VIP inputs' configuration. The control unit has 3 VIP input connections.

VIP OUTPUT NUMBER	GROUND PIN NO.	ON/OFF SWITCHED PIN NO.
1	20	4
2	21	3
3	36	37

The function of the VIP inputs can be defined by field programming the control unit. Typical applications for the VIP inputs are for a foot switch or a horn ring switch. For further information on VIP inputs, see the control unit programming manual.

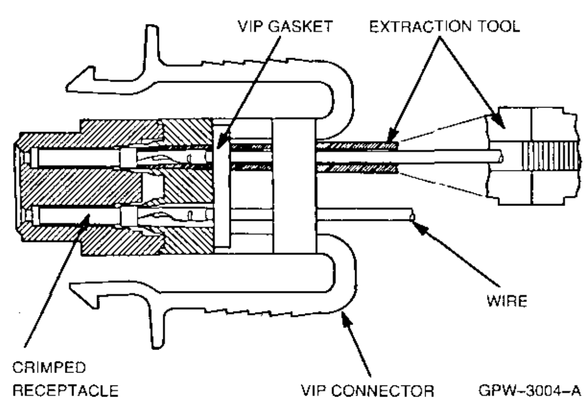

Figure 10. VIP Connector Detail

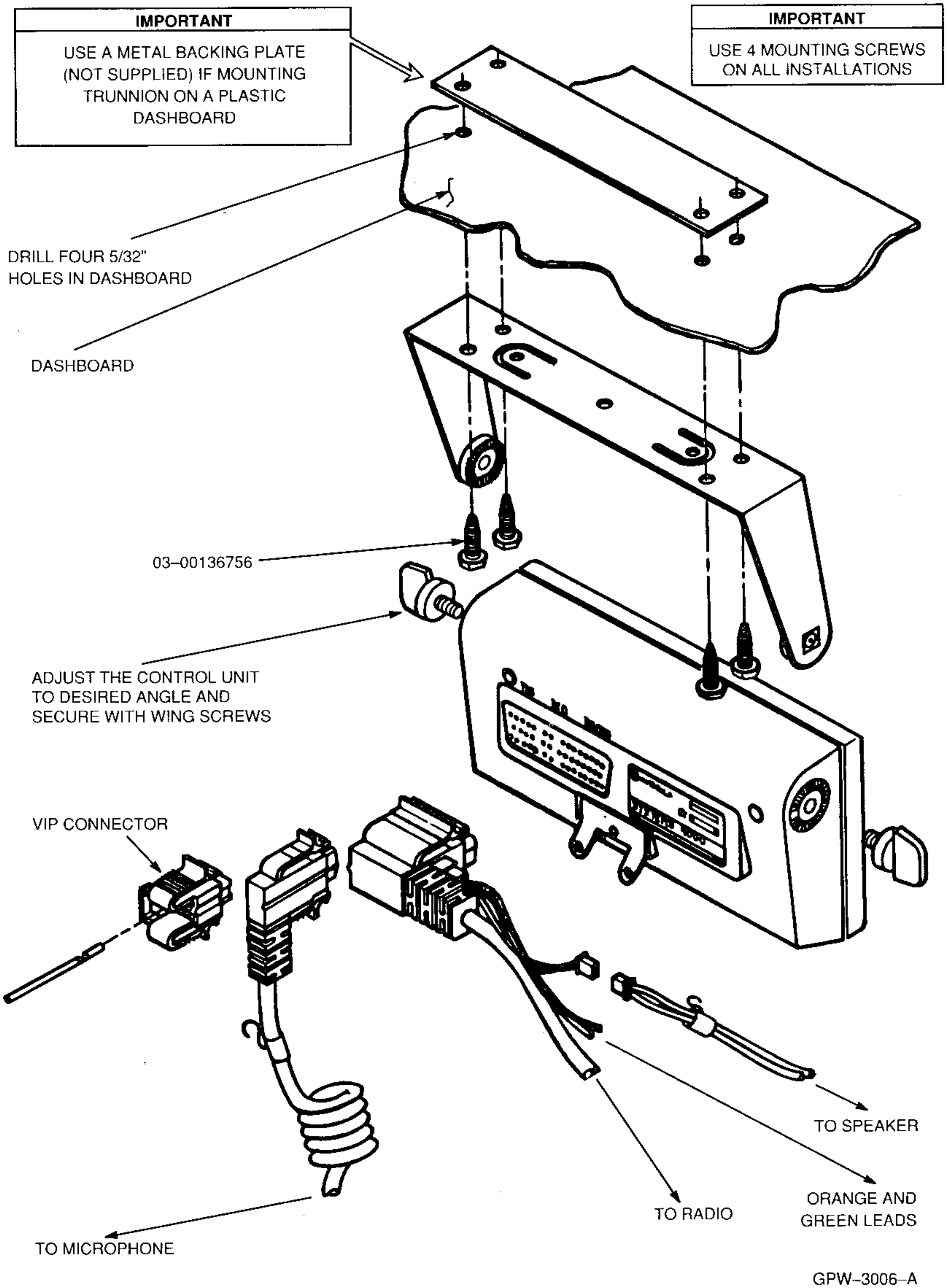

Figure 11. Control Unit Installation Exploded View

9. Power Connections (See Figures 1 and 2.)

(1) Replace the fuse in the in–line fuseholder of the red power cable coming from the radio in the trunk. Connect the green (and/or orange) fused wire(s) coming from the control unit to the ungrounded terminal (or source) of the battery.

(2) Pull all excess cabling into the trunk. Clamp the cables to the vehicle body or chassis with the cable clamps supplied. Drill 1/8" mounting holes and then attach the clamps with four #8 x 3/8" tapping screws and four 1/4" lockwashers. Finally, be sure all in–line fuses are installed.

10. Antenna Installation

A diagram and complete installation instructions are supplied with each antenna ordered. See those installation instructions for pertinent information.

11. Conclusion of Installation

(1) Be sure the control unit and microphone PTT switches are off. Install the 40–amp fuse in the red primary power cable in–line holder. Install the 3–amp fuse in the orange cable in–line holder. Install the 3–amp fuse in the green cable in–line holder.

Note

If alternator or other noise is present in the received signal or in the transmission, see Motorola publications Number 68P81109E33 "Reducing Noise Interference" in Mobile Two–Way Radio Installations."

(2) Turn the radio on at the control unit and verify proper operation of all controls and indicators. Radio operation in some installations requires turning on the ignition. See Table 1. Perform a complete operational check of the radio.

(3) Dress the control and power cables out of the way to prevent damage (pull any excess cable into the trunk area) and secure them where necessary with the clamps and screws supplied. Replace the rear seat if it was removed for installing the cables.

Table 1. Radio Functions Connections

Conductor	Green	Orange	Green	Orange	Green	Orange
Connected to battery	•	•	•			
Connected to ignition switch				•	See Note	•
Ignition switch controls	No ignition switch control		Xmtr ignition switch controlled		Complete radio ignition switch controlled	
In any application, trim and strip wires. Crimp on ring lug for battery connections. For ignition switch connections, crimp on ring or spade lug (whichever is required).						

Note: In cases where alternator whine or interference is a problem, isolate the green lead with a relay (Motorola Part No. 59–00813674).

Ⓜ **MOTOROLA**
Mobile Products Division

Maintenance and Troubleshooting

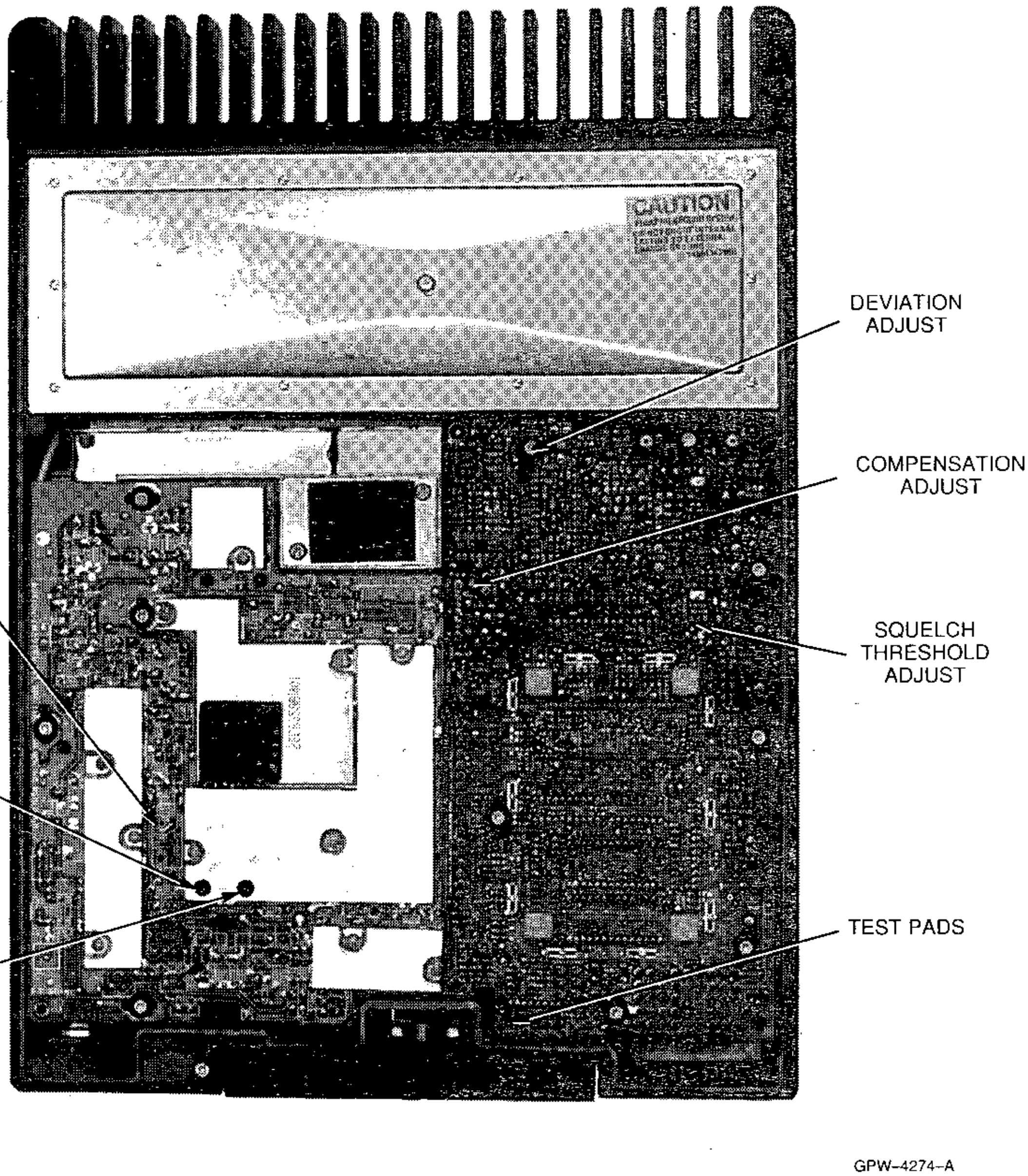

Figure 1. Typical SYNTOR X 9000/9000E *Radio (Top View)*

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1. Recommended Test Equipment

Table 1. Test Equipment

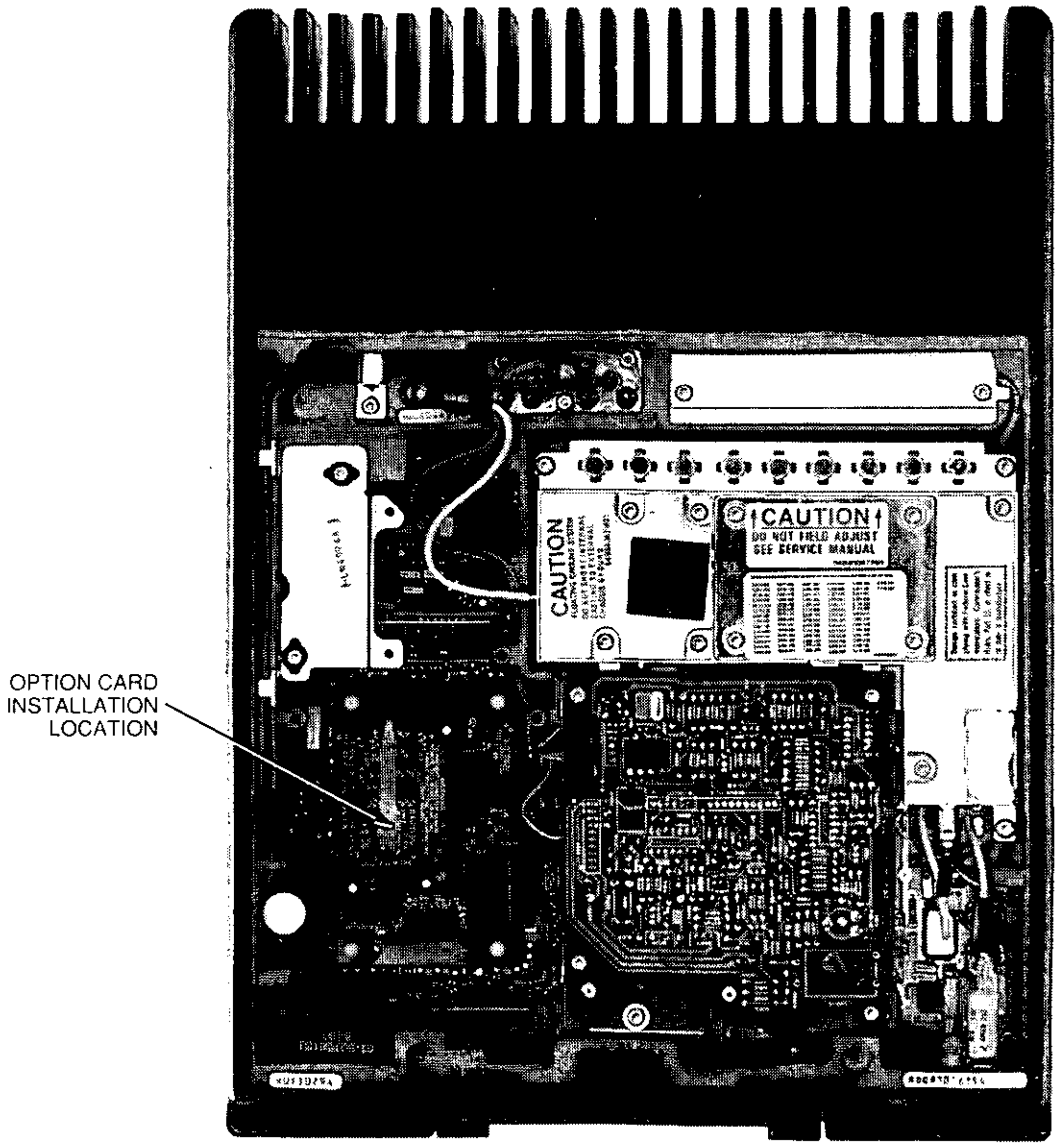
General type	Application	Recommended Model	Minimum Specification
AC–DC VOM	DC Voltage measurements, general	Motorola T1009A	Measurement range: 0–15V dc Sensitivity: 20,000 ohms/volt
DC Multimeter	DC voltage readings requiring an input resistance meter	Motorola S1063B	Measurement range: 0–15 V dc Input resistance: 11 megaohms
AC Voltmeter	Audio voltage measurements	Motorola S1053C	Measurement range: 100 mV ac Input resistance: 1 megaohm
RF Voltmeter	RF voltage measurements	Motorola S1339A	Measurement range:100 µV–3V from 1 MHz–900 MHz Inputs:50 ohm and high impedance
Oscilloscope, Dual–Trace	Waveform observation	Motorola R1004A	Vertical sensitivity: 5 mV–10 V/division Horizontal time base: 0.2 µsec–0.5 sec./division
RF Wattmeter	Transmitter output power measurement	Motorola T1039 with appropriate element and T1013 RF dummy load	Measurement range: 0–50 watts
Frequency Meter	Transmitter frequency measurement	Motorola R1200 Service Monitor with high stability oscillator (X suffix) option. Frequency calibration recommended every 6 months or less.	Measurement range: 806–870 MHz Frequency resolution: 10 Hz
Deviation meter	Transmitter modulation deviation measurement	Motorola R1200 Service Monitor with SLN6350 Deviation Meter.	Measurement range: 0–10 KHz deviation Frequency range: 806–870 MHz
RF Signal	Receiver alignment and troubleshooting	Motorola R1200 Service Monitor with attenuator.	Frequency range: 806–870 MHz Output level: 0.1 µV–100,000 µV Must be capable of at least ± 3 kHz deviation when modulated by a 1 kHz tone
Audio Signal Generator	Audio circuit troubleshooting	Motorola S1067B	Frequency range: 20 Hz–20 kHz Output level: 50 mV–1 V
•Double–Balance Mixer	Receiver front–end adjustment	Mini–Circuits Laboratory Model ZAD–4	—
•Logic Probe	Check various digital devices	Motorola RLT–4014	—
Radio Test set	Meter readings at circuit metering points for alignment and trouble–shooting	Motorola S1056 Portable Test Set with a TEK–37 or TEK–37A Test Set Adapter or a Motorola TEK–5 Meter Panel with a TEK–40 Cable.	—
•Tuning Tool Kit	Receiver and transmitter alignment	Motorola TRN4513A	—
•DC Power Supply	DC power for shop service	Motorola R1011AA	120 v dc 0–40 A
PL Tone Generator*	Tone coded "Private–Line" decoder troubleshooting	Motorola S133B	Frequency range: 10 Hz–9999 Hz Output level: 0–3 V rms
DPL Test Set**	"Digital Private–Line" encoder–decoder troubleshooting	Motorola SLN6413A	—

Note

All the test equipment listed above, with the exception of those marked with (•), can be replaced with the Motorola R2001 System Analyzer

CAUTION

In positive–ground systems, the case of the TEK–5 Meter Panel and portions of the S1056B Portable Test Set are hot with respect to the vehicle chassis due to the nature of the positive–ground installations. Take necessary precautions that the test equipment does not contact the vehicle chassis.



GPW-4199-B

Figure 2. Typical SYNTOR X 9000/9000E *Radio (bottom view)*

2. Radio Alignment and Adjustments

2.1 INTRODUCTION

The following four adjustments can be made to the *SYNTOR X 9000* radio:

- oscillator frequency
- deviation
- compensation
- transmitter power

Perform all adjustments through the holes that are directly accessible on the RF board. (See Figure 1). Readjustment of the receiver is not recommended since the factory adjusts the receiver to allow a wide passband for all frequencies within the radio model's range.

Note

See the list of recommended test equipment provided in this section of the manual.

2.2 OSCILLATOR FREQUENCY

Note

Perform the oscillator frequency adjustment before setting or checking the deviation adjustment.

(1) Use the mode rocker to set the radio on a carrier squelch transmit mode when adjusting the oscillator frequency.

(2) Use the portable test set to key the transmitter without modulation.

(3) Adjust the reference oscillator warp control (Figure 1) until the proper indication is obtained on the frequency meter.

(4) Use the mode rocker to scroll to all the remaining positions and check the proper transmitter frequencies. (No further oscillator frequency adjustments are required.)

2. 3 DEVIATION

Note

Check deviation on all transmit channels when setting deviations; especially if wide transmit separations (more than 5 kHz) are required.

(1a) For PL or DPL radios only: Use Table 2 to determine the target closest to, but less than the customer's PL or DPL transmit frequency. Use the deviation adjust potentiometer, to set deviation on the selected transmit frequency.

Table 2. Deviation Adjustment Target Frequencies

RANGE	TARGET (MHz) FIRST	SECOND
1	412.8	420
2	459.6	470
3	478.7	488
4	490.7	500
5	502.7	512

(1b) For radios without PL or DPL: Use Table 2 to determine the target closest to, but less than the customer's transmit frequency. Use the deviation adjust potentiometer, to set deviation on the selected transmit frequency.

(2) Check the deviation on all transmit frequencies to ensure that it does not exceed 5 kHz on any of them.

2. 4 COMPENSATION

Note

The compensation adjustment potentiometer is set at the factory and does not normally require readjustment.

Use this compensation adjustment procedure when any of the following conditions occur.

- if DPL transmit (encode) performance is poor
- if the VCO reference oscillator or common circuits board is replaced
- if the compensation potentiometer is replaced or inadvertently adjusted.

2. 4 .1 Radios with PL or DPL

This procedure balances the transmit audio signal fed to the VCO and reference oscillator. This insures good DPL waveform fidelity and flat modulation response.

(1) Turn the deviation potentiometer (Figure 1) one-half turn clockwise.

(2) Set the mode selector switch to the PL/DPL customer transmit frequency closest to the radio's first target frequency in Table 2.

(3) Connect the center lead of the shielded cable of an AC voltmeter to the modulation compensation test point and connect the shield to the radio ground(A–). Set the voltmeter to the 1 mV range.

(4) Modulate the PL or DPL and adjust the compensation potentiometer until a null indication is obtained on the voltmeter. Cover the hole with tape to prevent accidental adjustment of this control.

(5) Go to section 2.3, step 1a.

2. 4 .2 Radios without PL or DPL

(1) Set the compensation potentiometer to its midpoint.

(2) Go to section 2.3, step 1b.

2. 5 POWER MEASUREMENT

Important

The following information is to insure accurate measurement of RF power. These instructions should be followed before performing any transmitter power tests. See the Transmitter section of this manual for information about the operation of the VSWR protection circuitry.

See the list of recommended test equipment in this section of the manual. Use only the recommended equipment for making these adjustments to avoid erroneous results. All transmitter adjustments can be performed from the top of the radio.

Connect the wattmeter to the radio antenna connector using a type N–to UHF coaxial adapter cable.

Note

This is the only place that a coaxial adapter cable is acceptable.

Use connectors with a plastic insulating dielectric for the coaxial adapter cable. Connectors using bakelite as the insulating dielectric, or low cost adapters intended for citizens band service, should NOT be used.

The coaxial cable to adapt the UHF antenna connector on the radio to the type N connector on the wattmeter should be of a high quality type. Cable types such as RG400/U (part #30–84173E01) or RG142 B/U (part #30–83278B01) are recommended.

Careful set–up of the measuring system is well worth the extra time and effort. These techniques are recommended for other Motorola radios.

2.5.1 Audit Power Output

After completion of the radio installation you must audit the power output of your radio. Each radio installation may affect the transmitter's power output due to variations in antenna loading. The factory sets each radio to its specific power output using a calibrated 50 ohm load. Your antenna might not present the same load impedance to the radio transmitter, causing changes to system performance.

2.5.2 Verify Power Output

Note

SYNTOR X radios operate over a greater portion of the spectrum than most antennas are resonant. Motorola offers a wideband antenna for each band of *SYNTOR X* model radios. Contact the nearest Motorola center for assistance.

Verify your system has the correct antenna for the frequency range of your radio. Perform the following steps to verify the power output of your radio.

(1) Connect a 50 ohm power meter in series with the coax leading to the antenna.

(2) Measure the VSWR of the radio system for each channel.

(3) Verify power output on the transmit frequency with the lowest VSWR is a least specified output in the instruction manual.

Note

Do not make adjustments to the power output if the measured VSWR is greater than 1.5:1 (2.0:1 for Lowband). Check your antenna for proper installation and ensure it is designed for your operating frequency.

(4) If measured power output using a 50 ohm is within 5% of the recommended power, make NO adjustments to the radio.

(5) If measured power output using an antenna is within 10% of the recommended power, make NO adjustments to the radio.

Should the measured power output differ from expected levels outlined above, see the Power Set Procedure in this manual. Reset the power output to the specified level for your radio model.

2.5.3 Power Set Procedure

(1) Terminate the radio with a wattmeter and a 50 ohm load.

(2) Adjust the DC power supply voltage to 16.1 volts for 100W and 78W models; 16.3 volts for 30W models.

(3) Rotate potentiometers R912 and R901 fully clockwise. For 30W radios, preset R912 fully counterclockwise and R901 clockwise.

(4) Select the channel closest to the radio's first target frequency. See Table 3. Key the transmitter and adjust R912 to obtain a nominal power of 110W for 100W radios; 86W for 78W radios; or 33W for 30W radios. For variable power set, adjust R912 until the power is 10% over the desired power set level (e.g. 55W for a 50W radio).

Table 3. Transmitter Power Adjustment Target Frequencies

RANGE	FULL-RATED POWER (W)	TARGET (MHz) FIRST	TARGET (MHz) SECOND
1	100	420	406
2	100	460	450
	30	460	450
3	78	488	470
	30	488	470
4	78	500	482
	30	500	482
5	78	512	494
	30	512	494

(5) Select a channel close to the radio's second target frequency (Table 3). Key the transmitter and rotate R901 until the power drops slightly. Do not let the power drop below 105W for 100W radios; 82W for 78W radios; or 32W for 30W radios. For variable power set, do not let the power drop by more than 5% when R901 is adjusted (e.g. 53W for a 50W radio).

(6) Adjust the DC power supply to 13.4 volts for 100W and 78W models; 13.6 volts for 30W models.

(7) Select a channel close to the radio's first target frequency (Table 3). Key the transmitter and rotate R912 for a power indication of 105W for 100W radios; 82W for 78W radios; or 32W for 30W radios. Check the power output on all the channels and readjust R912 until all channels indicate a power output no less than 105W for 100W radios; 82W for 78W radios; or 32W for 30W radios. For variable power set, adjust R912 to 5% over the desired setting (e.g. 53W for a 50W radio). Check power on all channels and readjust R912, if necessary, to 5% over the desired setting.

3. Radio Disassembly

3.1 GENERAL

Remove the top cover to access the solder side of the RF board, personality board, and the power amplifier deck. Remove the top cover by turning the key to release the front handle and then press the button under the handle. The top cover pops up and allows access to the boards. Remove the screw that holds the PA deck cover to access the PA deck. This procedure provides access to the metering sockets of the RF board (J2501) and the PA deck (J1101) without removing the radio from its mounting tray.

Remove the radio from the chassis by releasing the handle as described above. Slide the radio forward (about an inch) and lift it out. Disconnect the cables to remove the radio from the chassis.

Note

Mounting screws for the common circuits board, personality board, and RF board are those with the black plastic captivators holding them to the boards.

Access the rest of the radio by removing the four screws that secure the skid plate to the bottom of the radio. Remove the skid plate to access the metering socket of the common circuits board (J951). The common circuits board is hinged so when turned on its hinge, it provides access to its component side as well as to the component side of the RF board. Remove the screws on the board and on the regulator heat sink to turn the common circuits board over on its hinge.

CAUTION

When operating the radio with the regulator head sink screw removed, care should be taken to avoid the exposed hot flange. All serviceable mounting screws use either Posi–drive heads or TORX heads which can be damaged by using standard Phillips screwdrivers. Use the proper screwdriver.

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3. 2 COMMON CIRCUITS BOARD

To turn the common circuits board on its hinges requires the removal of three screws. However, to remove the board, you must remove the two hinge screws, unplug the cable between the common circuits board and the personality board, and unplug the wires between the common circuits board and the PA deck. When installing the board in the radio, take care to pass both the cable and the wires between the two board hinges.

3. 3 PERSONALITY BOARD

Remove the personality board from the radio as follows:

(1) Remove the seven screws that secure the board to the radio.

(2) Disconnect the cable from the front plug.

(3) Disconnect the 10 conductor cable from the common circuits board.

(4) Pull the board away from the radio to disconnect the connectors from the RF board.

When installing the board in the radio, be sure that the front plug gasket is properly seated. (Silicone compound, Motorola Part #11–00834678, can be helpful in this process.)

3. 4 RF BOARD

Remove the RF board as follows:

(1) Remove the personality board as explained in paragraph 3.3.

(2) Remove the six retention screws.

(3) Disconnect the coaxial cable between the RF board and the internal casting.

(4) Disconnect the wires located near the antenna switch.

Access to some segments of the solder side of the RF board requires the removal of shields attached to the board with screws. On the component side of the RF board, remove the two large cans by simply pulling them off the board. However, other cans on the board must be unsoldered to be removed.

Install the RF board back in the radio using care to align the board guide posts with the internal casting. Take care to match the board spring connectors with those of the internal casting.

3. 5 INTERNAL CASTING

3. 5 .1 General

Remove the internal casting from the radio as follows:

(1) Remove three screws to allow the common circuits board to hinge.

(2) Remove four cover mounting screws from the bottom of the radio.

(3) Remove two screws from the RF board (from the other side of the radio).

(4) Disconnect the cable between the internal casting and the RF board.

(5) Disconnect the cable between the internal casting and the PA deck.

(6) Disconnect the RF board wires located near the antenna switch.

Exercise care during the reassembly operation to make the proper connections between the various connectors and to replace all the screws without omission.

3. 5 .2 First Mixer

To remove the first mixer, remove the two screws that secure the first mixer cover and gasket to the internal casting.

CAUTION

Do not use excessive heat. Otherwise, the tap leads will come off the filter.

Carefully unsolder the two tap leads from the first mixer to the filter and remove solder between the feed through and the circuit board. Remove the two screws that hold the circuit board to the internal casting, then remove the first mixer board.

3. 5 .3 Low Pass Filter Board (or Optional Pre–amplifier)

With the cover off, remove the low pass filter board (or optional pre–amplifier) as follows: carefully unsolder and remove the wires from the phono connector, then unsolder and disconnect the coaxial cable from the six–pole filter. If an optional pre–amplifier is used, unsolder the feedthrough leads and remove the two retaining screws to remove the board.

CAUTION

See the Special Repair Procedures for soldering iron use on hybrid substrates. It is imperative that high silver content be used when removing the two insulated wires from the smaller pre–amplifier substrate. Since the smaller substrate is not copper clad, leaching of the pads can become a problem.

Remove the two screws that hold the carrier to the casting. Lift it out, using the handle that forms part of the carrier.

3. 5 .4 VCO Buffer/Doubler

Note

If the VCO assembly is replaced, it will be necessary to readjust the compensation level as explained in the Radio Adjustment Procedures in paragraph 2.

Remove the VCO buffer/doubler as follows: disconnect the coaxial cable to the VCO, disconnect the single wire to the feedthrough, disconnect the coaxial cable to the RF board, and disconnect the coaxial cable to the PA deck.

Remove the coaxial cables from the substrate, using the precautions explained in the Special Repair Procedures. Then, remove both cables from the internal casting. This may require the use of a larger soldering iron to heat the internal casting. However, never use the larger soldering iron on the substrate.

After removing the four mounting screws, the VCO buffer/doubler assembly can be removed by lifting the handle that forms part of the carrier. Lifting the carrier will simultaneously disengage the connector to the three–pole injection filter. This filter is located directly under the carrier.

3. 6 TRANSISTOR MODULE REPLACEMENT

Note

Transistors are replaced as part of a module assembly. There are six module assemblies in each power amplifier: low–level amplifier (control stage), predriver, driver, and three finals.

To remove the low level amplifier (control stage), unsolder the input coax, output strap, and bias pin. Use C805 as a handle to carefully pull the module up until Q802 releases from its heatsink clip. Before installing a new module, apply a light coating of Wakefield compound to Q802. Be careful when installing the new module to avoid breaking the substrate. Align Q802 with the heatsink clip and apply pressure to Q802 until the module is firmly seated.

To remove any of the other modules, unsolder the tabs from the ceramic substrates (8 tabs on the predriver and driver modules; 6 on each of the final stage modules). Remove transistor mounting screw and extract the module. Before installing the new module, apply a thin coating of Wakefield compound to the mounting surface. Be sure that the module output (indicated by the beveled corner) faces in the proper direction.

CAUTION

The transistor mounting screws must be tightened before the transistor tabs are soldered to the circuit board. Do not tighten to more than 6–7 inch pounds, or damage to the transistor may result.

Solder the module tabs to the substrate so that the connection covers the entire surface of the tab.

3. 7 POWER DISTRIBUTION BOARD REMOVAL

Normally there is no need to remove the power amplifier assembly unless you must access the A+ distribution board. Perform the following steps to access the distribution board.

(1) Unsolder the bias pin connections (7) from the substrates.

(2) Unsolder the input and output coaxial cable.

(3) Remove the 10 transistor mounting screws.

(4) Remove the 5 hex–head screws holding the plastic carrier.

(5) Remove the amplifier.

If it is necessary to remove the A+ distribution board, unsolder the 7 feedthrough capacitor connections and remove the 3 mounting screws.

To replace the boards, reverse the removal procedure. When replacing the power amplifier assembly, apply a thin coating of Wakefield compound to the transistor mounting surfaces. Start the transistor mounting screws to insure proper alignment, then insert and tighten the hex–head screws in the plastic carrier. Tighten the transistor mounting screws.

3. 8 FRONT LATCH

Remove the front latch key mechanism by inserting the key into the lock, turning the key about 45° in a clockwise direction, and inserting the special removal tool (Motorola Part #66–84909B01). Insert the tool with the point directed away from the lock while twisting it 180° in a clockwise direction. This releases the key mechanism for removal.

Removal of the black plastic part requires the removal of a single screw.

3. 9 DIRECTIONAL COUPLER

To remove the directional coupler, remove the top cover and unsloder the two coaxial cables. Remove the mounting screws. Swing the common circuits board up, unplug the connector, and lift the carrier from the radio.

3. 10 ANTENNA RELAY

Disconnect the wires to the coil and the connector on the RF board to remove the antenna relay. The coaxial cable to the internal casting can be unplugged at the casting, but the cable to the transmitter PA deck must be unsoldered at the harmonic filter. The antenna relay is secured by means of a nut located outside the radio chassis. Remove the nut with a spanner nut removal tool (Motorola Part #RSX4028A).

4. General System Troubleshooting Guide

4. 1 GENERAL

Tables 4 through 13, provide a general system troubleshooting guide. Table 4 is divided into three sections: symptoms of malfunction, possible cause of failure, and the procedure to be adopted to clear the fault.

The failure symptoms deal with the following conditions: absence of receive audio, distorted receive audio, low audio power, radio does not squelch, radio does not unsquelch, improper squelch sensitivity, no PL/DPL decode, no regulated 9.6 V or 5.0 V, no RF power output, low RF power output, no transmitter modulation, distorted transmitter modulation, improper microphone sensitivity, transmitter frequency shift with high–level modulation, synthesizer does not lock, reference frequency (6.25 kHz) heard in speaker or on transmitted audio, synthesizer locks on wrong frequency, slow synthesizer lock time, poor receive sensitivity, alternator whine.

4. 2 REFERENCE

Depending on the cause of failure, the following troubleshooting charts and schematic diagrams are referred to for consultation:

- Schematic diagram of the audio section of the personality board; this diagram provides various voltage levels and waveforms and is located in the Microcomputer System section of this manual.
- Squelch troubleshooting chart; this is located in the Receiver section of this manual.
- Regulator troubleshooting guide; this is located in the Common Circuits Board section of this manual.
- Synthesizer troubleshooting chart; this is located in the Synthesizer section of this manual.
- Microcomputer troubleshooting chart; this is located in the Microcomputer System section of this manual.
- Power control troubleshooting chart; this is located in the Common Circuits Board section.
- Power amplifier troubleshooting chart; this is located in the Transmitter section.
- IDC troubleshooting chart; this is located in the Synthesizer section.
- Radio alignment and adjustment procedures; this is located in the General Maintenance section.
- Receiver troubleshooting chart; this is located in the Receiver section.

4. 3 SYSTEM SELF CHECK

When the radio system is turned on it displays "SELF CHECK." During this time each processor does a diagnostic check. This includes checking ROM, RAM, EEPROMs, and serial bus circuitry. If no errors are detected, the display shows the selected mode. If there are any errors, they are displayed for two seconds each, after the self check display.

The error code is divided into two parts separated by a " / . " The first part indicates the location of the error. The second part indicates the type of error. While the problem is not necessarily located on the board indicated by the location code, the troubleshooting guide for that board should be used to initially locate the problem. See Tables 5 through 13 for interpretation of these codes.

There are two types of errors. The first type does not stop the system from operating. This error occurs if an option board is not communicating on the serial bus. In this case the display indicates "ERROR __/__." This specifies the error. When this display appears, the operator is alerted by a beep. The system continues to operate without the option.

The second type of error inhibits the operation of the system. This occurs if the radio's EEPROM is corrupted. Since the data needed to operate the radio is stored in the EEPROM (frequencies and PL codes) the system cannot work if that data is invalid. This type of error is indicated by a display of "FAIL __/__." If there is a single error of this type, the display shows it indefinitely. If there are multiple errors, and at least one of them is of this type, each error display is shown for two seconds and the display cycles through them.

A special case exists for error "FAIL 01/90." This error indicates the control unit did not receive a message from the radio. If this error occurs, the control unit resets the system after all the error displays are shown in an effort to correct the failure.

Table 4. General System Troubleshooting Guide

SYMPTOMS	POSSIBLE CAUSE	PROCEDURES
No Receive Audio	Red or green lead fuse	Check the fuses.
	Audio PA malfunction	See audio section of personality board schematic diagram.
	Regulator malfunction	See regulator troubleshooting chart.
	Synthesizer not locking	See synthesizer troubleshooting chart.
	Quad detector malfunction	See receiver section schematic diagram.
Distorted Receive Audio	Audio PA malfunction	See audio section of personality board schematic diagram.
	Quad detector malfunction	See receiver schematic diagram.
	IF malfunction	See receiver schematic diagram.
Low Audio Power	Audio PA malfunction	See audio section of personality board schematic diagram.
	Red lead fuse	Check fuse.
	Quad detector malfunction	See receiver schematic diagram.
	IF malfunction	See receiver schematic diagram.
No Regulated 9.6V or 5.0V	Short on circuit board	—
	Regulator malfunction	See regulator troubleshooting chart.
No RF Power Output	PA enable switch	See microcomputer schematic diagram.
	Keyed 9.4V switch	See microcomputer schematic diagram.
	Synthesizer out–of–lock	See synthesizer troubleshooting chart.
	Red or orange lead fuse	Check fuse.
	Power control malfunction	See power control troubleshooting chart.
	PTT circuit malfunction	See troubleshooting serial data link and control unit. See the control unit and personality board schematic diagram.
	PA malfunction	See PA troubleshooting chart.
No Power Control	Power control malfunction	See power control troubleshooting chart.
Low RF Power Output	Power control malfunction	See PA troubleshooting chart.
	Antenna relay malfunction	See antenna relay test procedure.
No Transmitter Modulation	IDC malfunction	See IDC portion of the personality board schematic diagram.
	Microcomputer malfunction	See microcomputer schematic.
Distorted Transmitter Modulation	IDC malfunction	See IDC portion of synthesizer board schematic diagram.
	Reference oscillator malfunction	See IDC portion of synthesizer board schematic diagram.
	VCO malfunction	See IDC portion of personality board schematic diagram.
Improper Microphone Sensitivity	IDC malfunction	See IDC portion of synthesizer board schematic diagram.
	VCO malfunction	See IDC portion of synthesizer board schematic diagram.
	Reference oscillator malfunction	See IDC portion of personality board schematic diagram.
Transmitter Frequency Shift with High–Level Modulation	IDC malfunction	See IDC portion of personality board schematic diagram.
Synthesizer does not Lock	Is radio scanning?	Out–of–lock LED lights if radio is scanning.
	Synthesizer malfunction	See synthesizer troubleshooting chart.
	Microcomputer malfunction	See microcomputer schematic.
Reference Frequency (6.25kHz) on transmitted audio or in speaker	Adaptive filter malfunction	See synthesizer troubleshooting procedure.
Synthesizer locks on wrong frequency	Synthesizer malfunction	See synthesizer troubleshooting chart.
	Microcomputer malfunction	See synthesizer troubleshooting chart.
	Reference oscillator Out–of–adjustment	See synthesizer troubleshooting chart.
Long Synthesizer lock time	Synthesizer malfunction	See synthesizer troubleshooting chart.
Poor receive Sensitivity	High IF malfunction	See receiver section schematic diagram.
	Low IF malfunction	See receiver section schematic diagram.
	Quad detector malfunction	See receiver section schematic diagram.
	Pre–amp malfunction	See receiver section schematic diagram.
	First mixer malfunction	See receiver section schematic diagram.
	Second mixer	See receiver section schematic diagram.
	Antenna relay malfunction	See antenna relay test procedure.
Alternator Whine	Chassis to A– short	Disconnect control cable and check for a short between chassis and A–.
	Excessive whine in vehicle	See manual number 68P81109E33.
No PL/DPL	Microcomputer malfunction	See microcomputer troubleshooting chart.
	IDC malfunction	See IDC portion of synthesizer troubleshooting chart.

Table 5. Radio Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 01/81 FAIL 01/82 FAIL 01/84	Reprogram EEPROM or check J501/502. If "FAIL" shows after reprogram, replace U502.
FAIL 01/83	Replace U501. Reprogram EEPROM or check J501/502.
FAIL 01/85	If "FAIL" shows after reprogram, replace U502.
FAIL 01/88	Replace U500.
FAIL 01/89	Replace U500 and U501.
FAIL 01/8A	Replace U500. Reprogram EEPROM or check J501/502.
FAIL 01/8C FAIL 01/8B	If "FAIL" shows after reprogram, replace U502. Replace U500 and U501. Reprogram EEPROM or check
FAIL 01/8D	J501/502. If "FAIL" shows after reprogram, replace U502.
FAIL 01/90 (Bus Failure)	Check cable kits. See Personality and Control Unit troubleshooting charts.

Table 6. Control Unit Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 05/82	Control Unit EEPROM corrupted. See Control Unit troubleshooting in this manual.
FAIL 05/84	Control Unit EEPROM blank. See Control Unit troubleshooting in this manual.
FAIL 05/90	Control Unit serial bus failure. See Control Unit troubleshooting in this manual.

Table 7. SECURENET*–Capable Radio Troubleshooting Display Codes*

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 09/90 ERROR 09/10	Option serial bus failure. See the appropriate *SECURENET* instruction manual.

Table 8. Trunking System Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 10/82 ERROR 10/02	Option EEPROM corrupted. See the Trunking troubleshooting chart in this manual.
FAIL 10/84	Option EEPROM blank. See the Trunking troubleshooting chart in this manual.
FAIL 10/10	Option serial bus failure. See the Trunking troubleshooting chart in this manual.

Table 9. Siren/PA Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
ERROR 08/10	Option serial bus failure. See the *Systems 9000* Siren/PA option instruction manual.

Table 10. MDC–600 *PTT ID or* MVS *Troubleshooting Display Codes*

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
ERROR 0D/10	Option serial bus failure. See the appropriate option instruction manual.

Table 11. MDC–600 *Full–Feature Troubleshooting Display Codes*

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
ERROR 0A/10	Option serial bus failure. See the *MDC–600* Full–
ERROR 0B/10	Feature option instruction manual.

Table 12. MDC–1200 *Troubleshooting Display Codes*

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 0A/82	Option EEPROM corrupted. See the *MDC–1200* Signaling option instruction manual.
FAIL 0A/84	Option EEPROM blank. See the *MDC–1200* Signaling option instruction manual.
ERROR 0A/10	Option serial bus failure. See the *MDC–1200* Signaling option instruction manual.

Table 13. DTMF Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
ERROR 0E/10	Option serial bus failure. See the DTMF Option instruction manual.
ERROR 0E/02	Option EEPROM failure. See the DTMF Option manual.

5. Antenna Switch Test Procedure

The antenna switch connects the antenna to the receiver via the receive reed, coaxial cable, and phono plug when the radio is in the receive mode. The antenna switch connects the antenna to the transmitter via the transmitter reed, coaxial cable, harmonic filter, and directional coupler when in the transmit mode.

5. 1 TEST EQUIPMENT

A regular analog VOM is required for checking continuity paths or short circuits. See the list of recommended test equipment provided in Table 1 located in this section.

5. 2 PROCEDURE

This procedure consists of the following two tests:

- receive signal path test
- transmit signal path test

As an initial step, disconnect the coaxial cable from the PA deck input. This allows the antenna switch to change from one condition to the other (i.e., from receive to transmit or vice versa) without causing the generation of PA output power.

5. 2 .1 Receive Signal Path Test

(1) Disconnect the receive cable plug from the internal casting socket. Using an ohmmeter, verify that continuity exists between the plug center pin and the antenna connector center pin. Verify that no continuity exists between the plug center pin and the plug shield (and/or radio chassis).

(2) Place the radio on a conventional mode or into the trunking test mode and key the radio. Under this condition, the receive reed opens. Verify that no continuity exists between the antenna switch center pin and the receive cable plug center pin.

5. 2 .2 Transmit Signal Path Test

(1) Verify that the coaxial cable is still disconnected from the PA deck input.

(2) Remove the PA shield.

(3) Key the transmitter and verify that continuity exists between the directional coupler input and the antenna switch center pin. If no continuity exists, check other points along the transmit signal path to locate any possible open circuits (see Figure 3).

(4) Verify that the transmitter path to the radio chassis is not less than 100 K ohms.

Note

Field servicing of the antenna switch assembly or the microstrip harmonic filter is NOT recommended. A defective unit must be replaced.

(5) Key the transmitter and verify that continuity exists between the harmonic filter output and the antenna switch center pin. If continuity does not exist between these two points during transmitter keyed conditions, or if continuity exists during the receive mode, then the antenna switch assembly is defective and must be replaced.

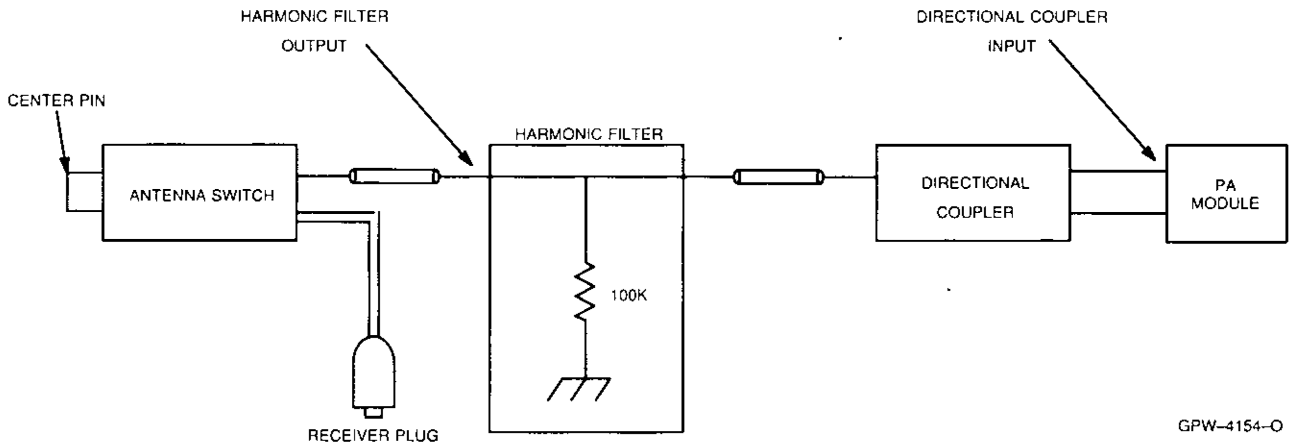
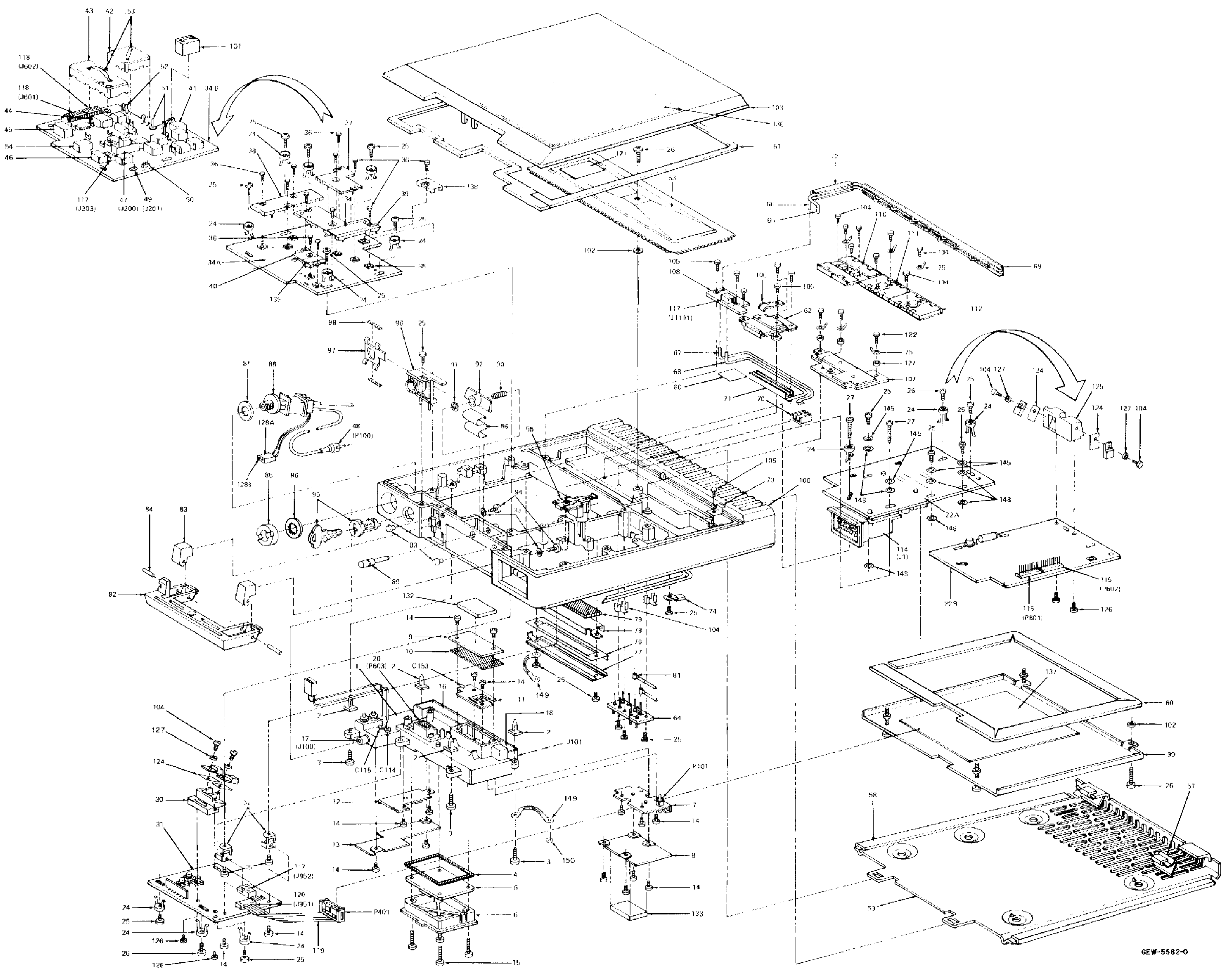


Figure 3. Transmit Signal Path



parts list

SYNTOR X 9000E Dual Operation Radio Mechanical Parts — MXW–5563–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	15 80230B01	internal casting housing
2	14–80206B01	nylon grommet, 4 used
3	03–82002N01	tapping screw, 4.2 x 1.41 x 19mm; 4 used
4	32 82796H01	wire mesh gasket
5	—	VCO substrate
6	15–80206B01	VCO cover
7		VCO buffer substrate
8	15–83501M01	buffer cover
9	15–80208B01	mixer cover
10	32–84486M01	mixer gasket
11	—	mixer circuit board
12	—	preamplifier circuit board
13	15–80207B01	preamplifier cover
14	03–10943C28	tapping screw, 3.5 x 0.6 x 6 mm; 20 used
15	03–10943C34	tapping screw, 3.5 x 0.6 x 25 mm; 4 used
16	15–80209B01	preselector cover, (6 cell)
17	15–80210B01	preselector cover, (2 cell)
18	15–80210B02	preslector (3 cell)
19	15–83894M01	preselector tuning cover
20	—	VCO interconnect
22A	—	personality circuit board (solder side)
22B	—	personality circuit board (component side)
24	42–83503M01	retainer, 12 used
25	03 10943D29	tapping screw, 3.5 x 0.6 x 8 mm; 19 used
26	03–10943D32	tapping screw, 3.6 x 0.6 x 16 mm; 7 used
27	03–82001N02	tapping screw, 3.5 x 0.6 x 28 mm; 2 used
30	26–83398M01	regulator heat sink
31	—	common circuits board
32	55–83493M02	hinge, 2 used
33	04–00007652	external lockwasher (#10), 2 used
34A	—	RF circuit board (solder side)
34B	—	RF circuit board (component side)
35	05–84220B01	grommet, 12 used
36	03–84256M01	tapping screw, 12 used
37	26–83588M01	adaptive filter shield, (solder side)
38	26–83586M01	lower IF shield (solder side)
39	2683585M01	divider/phase detector shield (solder side)
40	2683587M01	quadrature detector shield (solder side)
41	26–83594M01	can shiled (component side), 7 used
42	2683592M01	adaptive filter shield (component side)
43	26–83593M01	divider/phase detector shield (component side)
44	26–83597M01	prescaler shield (component side)
45	26–83595M01	quadrature detector shield
46	26–83596M01	lower IF shield (component side), 4 used
47	26–83814M01	shield fence (component side)
48	28–84282D01	male phono connector
49	28–84324M01	male connector, 2 contact
50	28–84324M02	male connector, 3 contact
51	46–83948M01	guide post, 2 used
52	42–83891L01	mixer clip, 5 used
53	55–84300B02	handle, 2 used
54	42–80134B01	speed clip, 10 used
55	—	PA bus wiring
56	41–80158B01	cover lift spring
57	41–80172B01	spring clip, 2 used
58	07–80173b02	guide rail, 2 used
59	07 80208G03	mounting frame
60	32–80175B01	bottom cover gasket
61	32–80176B01	top cover gasket
62		directional coupler circuit board
63	26–80169B01	PA cover shield
64	01–80723D66	feedthru plate assembly (PA)
65	30 80136B01	bus wire (top positive)
66	30–81037b01	bus wire (top negative
67	30–80121b01	bus wire (bottom negative)
68	30 80120B01	bus wire (bottom positive)
69	52–83927M01	bus bar retainer
70	52–83927M02	bus bar retainer
71	52 83927M02	bus bar retainer
72	52–83927M04	bus bar retainer
73	42–80167B01	top bus clip
74	42080201B01	bus wire clip
76	29–84093M01	solder lug, 6 used
77	15–80124B01	harmonic filter cover
78		harmonic filter substrate
79	32–83926M01	mesh gasket
80	14–83901M01	lower bus insulator
81	29–83897M01	wire receptacle terminal, 2 used
82	55–80107B01	handle
83	07–80152B01	handle pivot bracket 2 used
84	22–83491M01	spring pin
85	02–80006A01	spanner nut
86	04 00114522	lock washer
87	32–80080A01	ring gasket
88	—	antenna switch
89	38–80154B02	cover release button
90	41 80155B01	covert release spring
91	42–80156B01	retainer ring
92	55 80157B01	cover release catch
93	75–00838826	rubber bumper
94	03–10943D48	tapping screw. 5.0 x 0.8 x 16 mm. 2 used
95	55 84101B01	lock with key
96	15–80159B01	lock housing
97	55–80161B01	lock catch
98	41–80160B01	lock spring
99	15–80174B01	bottom cover
100	15–80105B01	radio housing
102	42 10128A18	O ring, 5 used

MXW–5563–O (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
103	15 80106B01	top cover
104	03–10905A05	machine screw, 3.0 x 0.5 x 8 mm, 15 used
105	03–10943D20	tapping screw, 3.0 x 0.5 x 8 mm, 6 used
106	42 83982M01	cable clamp
107	—	power amplifier circuit board
108	—	metering circuit board
109	42 84367M01	wire hold–down clip, 2 used
110	—	final amplifier circuit board
111	—	driver circuit board
112		pre–driver circuit board
113	32–80219B01	front connector gasket
114	01–80726D99	front connector assembly, 37 contact male
115	28 82647K02	10 contact male connector, 2 used
118	09–83445L09	10 contact female connector
119	30–80263K01	20 conductor cable (includes P401)
120	28 84647L04	right–angle 6 contact connector
121	54–83895M01	radio label
123	04–84152B01	shoulder washer, 4 used
124	14–83820M02	transistor insulator (Q148, 149, 1001, 1002)
125	26–83498M01	audio PA heatsink
126	03–82741M01	tapping screw, 3.0 x 8 mm, 4 used
127	04 84180C01	shoulder washer
128A	15–84301K16	2 position connector housing
128B	39–82717M01	receptacle contact, 2 used
131	32 83997M01	feedthru gasket
132	75–82200H13	oscillator pad
133	75–82200H14	oscillator pad
134	14 84690M01	insulator
135	14–84690M02	insulator
136	14–84691M01	insulator
137	14 84691M02	insulator
144	30–83888P01	18 conductor flat cable (with DIP plugs)
145	04–00001719	flat metal washer
146	—	code plug with board
147	30–83776M01	14 conductor flat cable (with DIP plugs)
148	04–84345A12	flat plastic washer

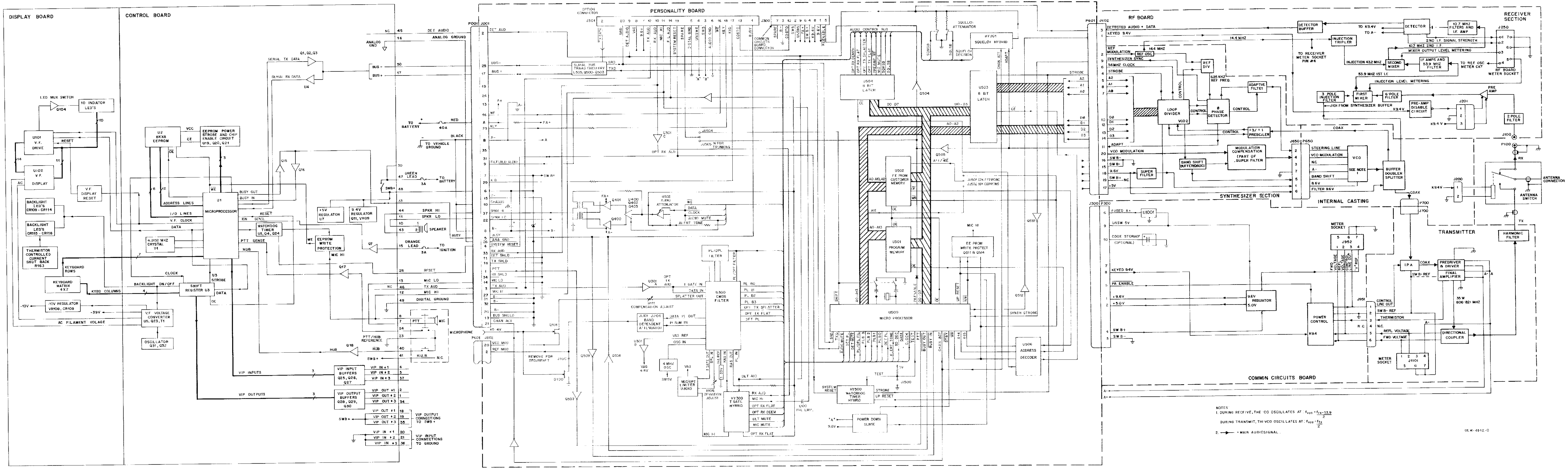
4/31/88

Exploded View, Mechanical Parts List and
Functional Block Diagram for *SYNTOR X 9000* and
SYNTOR X 9000E Radio

PW–4345–A

(Sheet 1 of 2)

5/20/88



Exploded View, Mechanical Parts List and
Functional Block Diagram for *SYNTOR X 9000* and
SYNTOR X 9000E Radio
PW-4345-A
(Sheet 2 of 2)
5/20/88

Special Repair Procedures

1. Ceramic Microstrip Substrates

You should not attempt to repair the ceramic microstrip substrates of the radio. If a module has a faulty component, replace the whole module. Not only are repairs to the substrates and replacements of substrate components difficult to make without damaging the module, but also the factory uses special fixtures in building and testing the radio to make certain that each module operates properly. Field repairs to the microstrip substrates negate that initial factory adjustment.

The ceramic materials of the radio have properties similar to those of glass, and sharp blows and heat affect them the same way they affect glass. Therefore, if you must solder anything to ceramic microstrip modules, use as little heat and pressure as possible. You must also use solder with a high percentage of silver to avoid leaching the capacitors and non–copper runners.

2. Chip Capacitors

The radio uses many chips capacitors as circuit elements. They are extremely sensitive to heat and must not be re–used. Be very careful when making repairs to circuits near these components. Heat from a soldering iron being applied to a nearby component may "leach" the end metalization (terminals) of a chip capacitor. Figure 1 shows what a leached capacitor looks like.

To remove a chip capacitor, apply heat to both connecting terminals simultaneously, either with two soldering irons or a single iron with a special tip (Motorola #ST–1160). When the connecting solder melts, lift the chip. Figures 2 and 3 illustrate this removal technique.

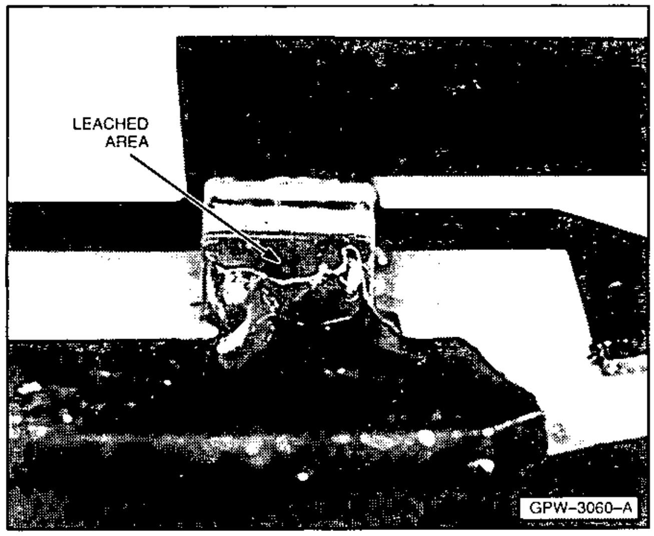


Figure 1. "Leached" Chip Capacitor

3. Replacing Transistors in the Power Amplifier

To remove the power transistors, remove two transistor mounting screws or one stud nut (accessible from the chassis bottom). Unsolder and remove the clamped mica capacitors, then unsolder an remove the transistors. Special soldering iron tips ST1160 and ST1161 (available form Motorola parts offices) make it easier to remove capacitors and transistors.

When replacing RF power transistors, you must take the following steps. First, use a soft cloth or paper towel to remove all thermal compound and residue from *both the chassis and the transistor*. Then apply a thin film of Wakefield thermal compound to the bottom of the transistor mounting flange. Replace the transistor in the center of the printed circuit board cutout, tightening the mounting hardware to a maximum of 7 inch–pounds. With a low power soldering iron (40–60W), solder the leads, using enough solder to completely cover the lead and solder pad. Make sure that the solder is flowing freely both *over* and *under* the lead before removing the heat. If a lead tends to spring away from the circuit board, use the tips of a pair of pliers to hold the far end of the lead down against the board until the solder hardens. After replacing the transistors, replace the clamped mica capacitors, being sure to position them exactly as they were with respect to the transistor body.

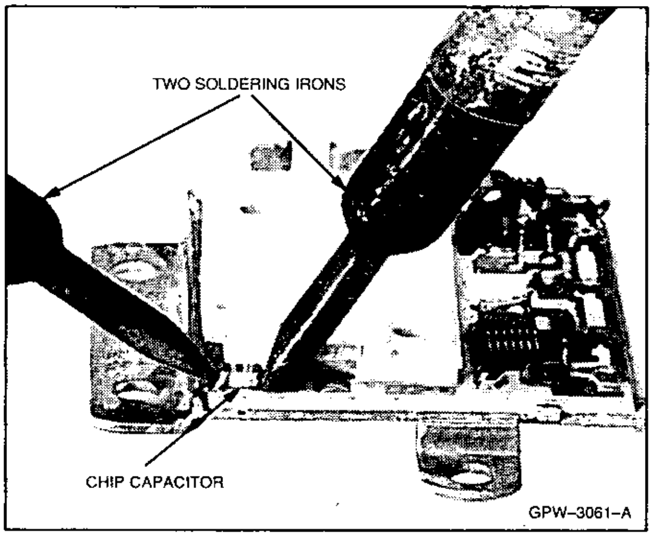


Figure 2. Capacitor Removal with Two Soldering Irons

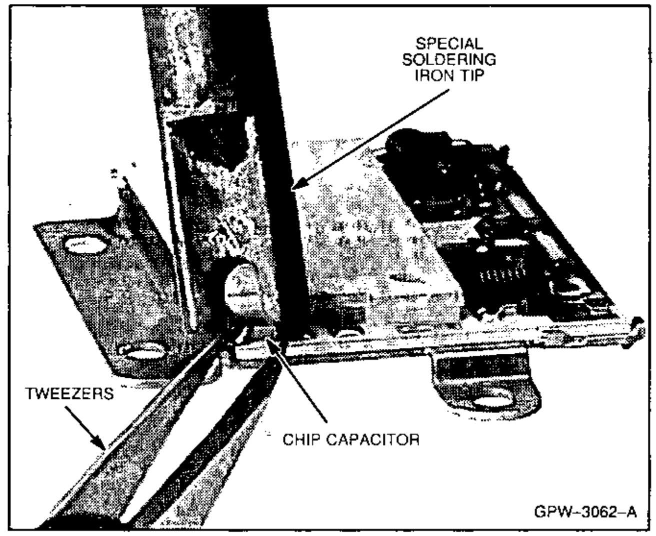


Figure 3. Capacitor Removal with Special Soldering Tip

MOTOROLA
Mobile Products Division

Microcomputer System (Radio)

1. General

This section covers the Microcomputer System section of your radio.

2. Theory of Operation

2. 1 INTRODUCTION

The *SYNTOR X 9000* personality board consists of two major sections; the digital section, and the analog section. The digital section is notated by the 500 series part designators. The analog section is notated by the 100, 200, 300, and 400 series part designators.

2. 2 DIGITAL SECTION

The digital section communicates with the control head and the options over a serial bus link to receive and transmit information. This section also monitors parallel inputs from the radio. The digital section microprocessor uses both serial bus inputs and radio parallel inputs, to decide response to and control of the system. The digital section controls the radio since it controls the parallel outputs.

The outputs are controlled to perform various functions including:

- audio routing
- synthesizer programming
- transmitter enables
- audio volume level control
- PL and DPL detection
- PL and DPL generation
- squelch level control
- alert tone generation

The major blocks in the digital section are:

- U500– microprocessor
- U501– program ROM
- U502– customer system/mode EEPROM
- U503– synthesizer programming latch
- U504– audio control latch
- U506– address decoder
- HY500– watchdog timer hybrid
- U505 and supporting circuitry–serial bus transceiver

2. 3 ANALOG SECTION

The personality board analog section contains all the non–RF analog circuitry in the radio, with the exception of the voltage regulators and the RF power control. The analog section circuitry is grouped by circuit designators as follows:

- 100 series transmit audio circuitry
- 200 series receive audio circuitry
- 300 series circuitry common to receive and transmit
- 400 series audio power amplifier

The analog section provides various audio and sub–audio filtering, summing, and amplifying functions that include:

- receive audio switching
- transmit audio switching
- microphone pre–emphasis and deviation limiting
- VCO compensation adjustment
- discriminator de–emphasis filtering
- received PL/DPL filtering and detection
- PL/DPL D/A converter and filtering (PL/DPL generation)
- RF carrier detect/undetect (squelch)
- digitally controlled audio attenuator
- audio power amplifier
- option receive and transmit summing/buffering

The major blocks of the analog section are:

- U300– custom switched capacitor filter IC
- 4 MHz crystal controlled oscillator (clocks U300)
- U301– quad opamp; microphone pre–emphasis/ limiter; option RX and TX summer/buffer; bias voltage buffer
- HY300– audio switching hybrid
- HY301– squelch hybrid
- U302– pre–amplifier (digitally controlled attenuator)
- 400 series designator parts– audio power amplifier
- jumper selections

3. Detailed Circuit Description

3. 1 DIGITAL SECTION

3. 1 .1 Microprocessor System

The microprocessor (U500) with the program ROM (U501), the programmable EEPROM (U502), address decoder (U507), and output latches (U503 and U504) make up the microprocessor system.

The heart of the system is the high–speed CMOS microprocessor that runs at 1.2288 MHz. The processor uses Y500, a 4.9152 MHz crystal, for its time base. This oscillator is internally divided by four at the processor to obtain its operating frequency of 1.2288 MHz.

3. 1 .2 Address Decoding (U506)

The microprocessor controls the address lines, A14 and A15 output WR, to gain access to U501, U502, U503, and U504. The processor does this through the address decoder U506. The three inputs to U506 on Pins 2, 14, 3, 13, and 15 control U506 outputs to Pins 6, 7, 9, and 11. These signals, zero to five volt logic levels, are active low. When U506–6 is low, the processor is accessing U502 (EEPROM). When U506–7 is low, the processor is accessing U501 (program PROM). When U506–9 is low, U504 is accessed, and with U506–11 low, U503 is accessed.

3. 1 .3 Program Memory (U501)

The program that the processor executes is contained in the 16k by 8 UV–EEPROM. By manipulating the remaining 14 address lines (A13–A0), the processor can read the instructions stored permanently in the EEPROM. The address lines A14 and A15 are used for address decoding.

3. 1 .4 Customer Mode EEPROM (U502)

All radio mode information is stored in U502 (EEPROM). The standard EEPROM is 2k by 8 in a 24–pin package. This package is inserted in the rear 24 pins of the IC socket (Pins 1, 2, 27, and 28 are left open). The board design accepts an optional 8k by 8 EEPROM that is a 28–pin part. The EEPROM is reprogrammable, and is read from like the program memory IC (U501). It is also written to by the EEPROM programming mode, described later.

3. 1 .5 Synthesizer Programming Latch (U503)

The synthesizer programming latch is an eight–bit static latch whose outputs store the digital value (high or low) of its inputs when a low to high transition occurs on U503–11. To load data into the synthesizer, the latch stores correct data (D3#D0) from the customer mode EEPROM, and the corresponding address (A2#A0) with the strobe output high (U503–19). Then the latch stores the same address and data with the strobe output low. This clocks the four bits of data into the synthesizer. For valid programming to occur, this process is repeated for five sets of data with five different addresses. The synthesizer is continually updated to avoid corrupted data passing on a power supply transient condition. The update rate is approximately every 20 milliseconds.

3. 1 .6 Audio Control Latch (U504)

The audio control latch operates in the same manner as the synthesizer programming latch (U503). In addition, the audio control latch provides signals for five audio routing paths, both squelch level controls, and a control line for audio volume programming.

3. 1 .7 Watchdog Timer Hybrid (HY501)

The watchdog timer hybrid performs three functions. This hybrid circuit controls the system reset line, monitors the internal microprocessor reset line, and senses the system reset line.

The first function is performed on power–up of the radio system. The hybrid outputs a reset pulse approximately 30 milliseconds long to allow the crystal oscillators in the system to stabilize. The pulse is high on system reset (HY500–10).

Secondly, the watchdog timer monitors its in put. The synthesizer strobe from U503–19 should toggle every 20 milliseconds. If the strobe pulse fails to toggle, the watchdog timer times out and initiates a 30–millisecond reset pulse. This is a failsafe in the event the radio's microprocessor gets lost due to a power supply transient.

The third function performed by the watchdog timer hybrid is its sensing of the system reset line. This line is bi–directional. If another processor in the system gets lost due to a transient, that processor initiates a reset pulse to recover. If the system reset line is pulsed, the watchdog timer stretches the pulse to a 30–millisecond reset pulse.

3. 1 .8 Serial Bus Transceiver (U505 and supporting circuitry)

Communication between processors in the system is handled by the serial bus at a data rate of 9600 bits per second. The signals generated are bus +, bus –, and busy. Bus + and bus – carry the same serial data. Bus – is bus + inverted (bus + high, bus – low). In using this pair of signals, the comparator U505 can differentiate between noise and valid data. In normal radio transmission, the radio microprocessor reads the line busy in (U500–9). If found to be HI, the processor pulls busy out high (busy in active LO, busy out active HI), and transmits as message out of TX data (U500–13). To further avoid a collision on the serial bus, the radio processor reads serial RX data (U500–12) as it transmits. If the processor does not read back the same data that it sent out, some error occurred and the radio processor attempts to re–transmit the message. When receiving a transmission, (example: control head transmitting), the radio processor would sense busy in (U500–9) going LO and process the incoming message from serial RX data (U500–12).

3. 1 .9 EEPROM Programming

The EEPROM (radio mode information) is programmed by communication over the serial bus. Special commands are sent to and from the radio microprocessor from the IBM PC programmer interface.

Note

An IBM PC and Control Head/Radio Programming Software Version 3.0 (or later) are required to program this radio.

The EEPROM is equipped with an input called "write–enable" that is active LO (LO writes to the EEPROM). This input is at U502–23 for a 2k by 8 EEPROM or at U502–27 for an 8k by 8 EEPROM. To protect the contents of the EEPROM from being inadvertently written over, the write–enable line is held in active by the microphone HI audio input.

The line is protected to eliminate the possibility of corrupting the EEPROM data during power supply transients or other temporary battery supply conditions that could possibly alter the data. The microphone HI audio input is normally biased up to 9.6 volts while receiving, and pulled to approximately 4 volts when transmitting to power the active element microphone cartridge. When connected to either of the programmers, the microphone input is shorted to ground and allows access to the EEPROM write–enable line.

The microphone line is input to the digital section by R530 pulling the base of Q513 HI and forcing Q513 to pull the base of Q514 LO. With Q514 conducting, the input write–enable (U502–23 for 2k by 8 and U502–28 for 8k by 8) is held HI by Q514. Note that CR502 and CR503 protect the write–enable line in the same manner. The diode CR502 protects the EEPROM write line the instant the radio loses power (switched off) since this signal senses when the 9.6 volt supply falls off. The diode CR503 protects the EEPROM when the system is being reset due to power supply transients.

3. 1 .10 Power Down Sequence

With the power off, the radio microprocessor is put in its sleep mode. This mode requires to cut back the current drain on the unswitched five–volt regulator from 15 milliamps to a few micro–amps. The unswitched five–volt regulator remains powered up while the radio is off so that the radio microprocessor retains its memory and powers up in the last mode used. The radio processor retains the last mode, volume level, squelch level, and other operator–selected functions.

This eliminates the need for resetting all the controls every time the radio is turned on. For the radio processor to remember its last configuration, inputs are required that allow the processor to store this information be fore power is shut off to its memory and supporting circuitry (switched five volts turning off). The inputs NMI and STBY are generated to tell the processor that power is coming down.

The signals NMI and STBY are generated by the transistor circuits involving Q516 and Q517. Both signals are active LO, so when NMI is LO, the processor is put in the sleep mode (standby). The transistor Q516 remains off while the 9.6–volt supply is powered up. This is done through R542 that pulls the base of Q516 HI. When the 9.6 volt supply begins to fall off (radio is turned off), Q516 begins to conduct, since its emitter is connected to the unswitched five–volt supply (this supply remains powered). As Q516 begins to conduct, the base of Q517 is pulled HI, and the collector is pulled LO. The collector is connected to U500–8, the NMI input to the processor. The signal STBY is generated by the R–C circuit made by R547 and C521. This signal goes LO approximately 500 microseconds after the NMI signal goes LO. The STBY input is at U500–7.

3. 1 .11 Test Mode

The radio test mode allows finer audio volume steps to be input to the audio preamp. In standard operation, you can set volume in 30 discrete steps. These steps increment the audio level by approximately 3.2 dB. In the test mode, increments are approximately .4 dB. This allows setting the volume closer to rated audio, more accurately setting the audio volume level, and measuring receive parameters such as RX audio distortion, received FM hum and noise, squelch sensitivity, and other receive parameters.

Enter the test mode by shorting the two pins of jumper J500, and turn the radio on. The radio processor reads this input (U500–21). By shorting this input, the processor reads this port LO, enters the test mode, and enables the finer volume increments. Jumper J500 3 also disables the watchdog timer. This is useful for troubleshooting. If a malfunction causes the watchdog timer to time out, the timer sends out reset pulses until the system recovers. By shorting J500, the reset pulses stop and the system resumes operation. This allows you to troubleshoot and find the source of a problem with out resetting the system.

3. 2 ANALOG SECTION

The analog section of the personality board consists of four groups of circuitry. They are transmit audio, receive audio, common circuitry, and the audio power amplifier.

3. 2 .1 Transmit Audio Circuitry

To handle hardware options more efficiently, there are three possible paths for audio to pass through while transmitting. The first, the normal microphone path, follows the standard pre–emphasis curve of +20 dB per decade from 300 Hz to 3 kHz, and rolls off sharply at frequencies above 3 kHz.

The second two transmit–audio routing paths are available for hardware options. Both of these paths are accessed through the option TX buffer at J301–12 or J1–3. The input at J301–12 provides for options internal to the radio, and J1–3 provides for options in the external options box. This input is the null port of the opamp U301–1. The input allows summing of multiple option outputs without interference.

The first transmit audio route is TX splatter. This port, when enabled, displays a flat response from 300 Hz to 3 kHz, and rolls off sharply at frequencies above 3 kHz.

The other transmit route available to the options is TX flat. This port shows a flat response from approximately 2 Hz to above 6 kHz, and does not roll off sharply.

3. 2 .2 Microphone Transmit Audio

The microphone path enters the radio through J1–27. The resistors R101 and R102 with the capacitor C108 provide DC bias for the active microphone element. This signal is available as an input to the options at J301–11.

Microphone HI, after entering the radio, goes to C100. This capacitor blocks DC, and sets the pre–emphasis required to an 18–kHz high–pass corner. The high–pass filter provides the required +20 dB/decade pre–emphasis response. The microphone path is switched in or out by the transmission gate on HY300. The signal is input at HY300–6 and output at HY300–4. The control line to turn the microphone path on is at HY300–11, and microphone mute is active HI. HY300–6 and HY300–4 are the summing node of the opamp unless the path is open (HY300–11 HI).

The microphone signal is amplified by U301 by a factor of 24 (at 1 kHz), so the nominal 80 mV input from the microphone almost sends the opamp output into clip. A slightly stronger signal causes the output to clip. The signal can never be greater than the output swing of the opamp. The output of the opamp is attenuated by the deviation potentiometer R108. This adjustment is used to set deviation of the overall system to below 5 kHz.

After the microphone signal has been pre–emphasized, limited, and the level set through R108, the signal enters the splatter filter at U300–11. The splatter filter provides the sharp roll–off required to frequencies above 3 kHz. The output of the splatter filter (at U300–13) travels to the compensation potentiometer R111. The compensation potentiometer is used to adjust the sensitivity of the VCO modulation port to equal the reference modulation port.

The VCO modulation port response has a high–pass response, and the reference modulation port has a low–pass response. The compensation potentiometer sets the sensitivity of the VCO modulation port so that the overall response of the VCO is flat.

The correct tuneup procedure is to set the compensation potentiometer (R111) first, and then set the deviation potentiometer (R108).

Then the audio signal travels through the series FET (Q101) to the RF board where it is input to the VCO circuitry to modulate the RF carrier during transmit. The series FET (Q101) provides isolation to the VCO mode line during the VCO's receive mode of operation.

3. 2 .3 Option Transmit through Splatter

This option path is one of two paths that a hard ware option is able to route audio to be transmitted. The path is enabled by the latch U504 from Pin 6. In normal operation, the port is enabled when the option sends a command over the serial bus. The radio processor then enables the port and keys the radio. The option (for example PTT–ID) enables its audio port to send an audio signal into TX audio. This audio signal is amplified by the opamp U301–A. The output of U301–A at U301–3 appears at the switch input on U300–9. The switch on U300 functions as an analog transmission gate.

The switch control is at U300–10, and closes the switch when this input is low. The output of this switch is at U300–14. Once routed through this switch, the signal is input to the same limiter opamp used by the microphone path (U301–D). The signal is amplified to almost clip the output at nominal levels (just as the microphone path), but it is not pre–emphasized. The output of the opamp follows the same path as the micro phone path: through the deviation limit potentiometer, through the splatter filter, and then to the VCO modulation port through the compensation potentiometer.

3. 2 .4 Option Transmit Flat

This is the second of the TX audio paths available to the hardware options. It is enabled by commands over the serial bus in the same manner as the option transmit through splatter path. This port is enabled by the output of the latch U504–5.

This audio port is named the flat TX port due to the extended response it provides. The flat TX port displays a flat frequency response from approximately 2 Hz to above 6 kHz. This response is required for digital signaling schemes such as the *SECURENET* option.

The audio for this path is input from the option the same as the TX splatter path (through U301–A). In this case, the splatter port is not enabled (the switch on U300–14 is open), and the flat port is enabled. The switch enables when the control at U300–22 is high. The audio input to the switch is at U300–21, and the output is at U300–15. The IC provides +7.5 dB of gain from input to output, and also sums with the IC's internal D/A converter.

The D/A converter is used to generates PL and DPL transmit signals with the data lines D3 through D0 at Pins 32, 31, 30 and 29 of U500. These outputs of the processor drive the inputs of the D/A on U300 at Pins 25, 26, 27, and 28. The D/A on U300 requires the reference voltage at U300–1 to function properly. The reference voltage is a resistive divider, formed by R307 and R308, and provides the required 1.3 volts DC to this input. The output of the D/A is at U300–15. As discussed in the option TX flat section, the D/A is summed with the TX flat path.

PL and DPL are used only when the micro phone path or the option TX through the splatter path are enabled. The only signal present at U300–15 is a TX flat signal or a PL/DPL, but not both. The output of U300–16 is normally 500 mV above the analog ground voltage (Vag) at U300–7. The output, when generating PL or DPL, swings symmetrically about this normal voltage (Vag + 500 mV). The output at U300–15 follows the same paths as those described in the TX flat path section, and the signal is input to both the VCO modulation input and the reference modulation input to the RF board.

The output of the TX flat switch (U300–15) is routed to two different inputs to the VCO. The first is the VCO modulation port, and the second is the reference modulation port.

The TX flat signal routing to the VCO modulation port is from the output of the TX flat switch (U300–15). The signal is attenuated by R116 and R117. The attenuated signal is input to U300–8. The input is summed internally with the splatter filter input, and is output at U300–13. This summing node allows PL or DPL to be summed with normal audio from the micro phone path, and, in this case, allows the TX flat audio to reach the VCO modulation port. The output of U300–13 travels to the VCO modulation port via the compensation adjust potentiometer. The TX flat signal routing to the reference modulation port is through resistive attenuators. The jumpers JU101, JU102, JU103, and JU104 select the proper attenuation required for low–band, VHF, UHF, and 800–MHz bands respectively. The TX flat signal passes through the DC blocking capacitor C105, and then to the reference modulation port. The transistor Q100 shunts the reference modulation port to ground when the radio is powered up, and allows the VCO to lock more quickly when first powered up.

Due to the high deviation required by *SECURENET*, the transistor Q100 is removed from the circuit by removing JU100 on *SECURENET* model radios. If not removed from the circuit, the transistor Q100 begins to conduct, and distorts the signal.

3. 2 .5 Receive Audio Circuitry

There are four paths in the receive audio circuitry for audio output through the speaker. These paths are the discriminator path, the option through receive audio filter path, the option through flat response path, and the alert tone path.

The discriminator path is the recovered audio out put from an RF signal at the antenna input. This path exhibits a –20 dB/decade response from 300 Hz to 3 kHz. The response falls off sharply with frequencies below 300 Hz and above 3 kHz.

The Personality Board provides two inputs in the receive audio path for hardware options for the receive audio string. First is RX through received audio shaping that follows the same response as the discriminator path, –20 dB/decade from 300 Hz to 3 kHz. Second is the RX flat that displays frequency response from 200 Hz to 10 kHz. The final path in the receive audio string is the alert tone path. This path allows the radio microprocessor to sound alert tones through the speaker.

3. 2 .6 Discriminator Audio

The discriminator audio path is input to the personality board from the RF board via P601–3. The discriminator path is then input to the transmission gate hybrid (HY300) through C201. C201 provides DC blocking. The input to HY300 is at HY300–7, and the output is at HY300–8. The control line for disc mute is controlled by the output of U500–26. The control line is input to HY300–11, and is active HI (HI mutes the audio). The output of HY300–8 inputs to the receive audio shaping filter on U300. The receive audio shaping filter input is at U300–20, and is not switched. An input between 300 and 3 kHz always causes an output at U300–17. The filter provides the standard de–emphasis response of –20 dB/decade from 300 to 3 kHz. The received audio shaping filter provides band–pass filtering. The pass band is approximately 270 Hz to 3.5 kHz. The filter exhibits a loss of –3 dB at 1 kHz.

The radio microprocessor decodes received PL or DPL, and determines if the proper code is present. The radio bases this decision on its input from the comparator on U300. The discriminator output from the RF board (P601–3) is input to the PL/DPL filter on U300 through C200. Input to the PL input filter is at U300–19. The PL filter has a low pass response, and changes its response when the selected mode is a PL mode or a DPL mode. The PL filter, when input PL/DPL is low (PL response), rolls off at approximately 250 Hz. When on a DPL mode (U300–23 is high), the PL filter rolls off at approximately 150 Hz. The output of the PL filter (U300–16) is averaged by R205 and C209 for PL, and R205 and C210 for DPL. The DC averaged signal is input to the negative input of the comparator on U300. The negative input is at U300–4 and the positive input is at U300–5. The PL filter output connects to the positive input of the comparator. This causes the output of the comparator (U300–3) to swing high when a positive going signal is output from the discriminator. The comparator output swings low when the discriminator output has a negative going signal. The output of the comparator attenuates by R208 and R209, and is read by the processor input at U500–24.

The output of the receive audio shaping filter inputs to the audio preamp (U302) through the audio summing node via R200. The audio summing node consists of R200, R201, R202, R203, and C202. The summing node provides attenuation for the receive audio shaping path, RX flat path, and the alert tone input. The summing node inputs to the audio preamplifier U302–15. The preamp is a digitally–controlled, variable gain buffer whose gain can vary from –70 to +18 dB. The gain is controlled by U500 and U503 through the control lines, UCS data, UCS write–enable, and UCS clock. The preamp gain is programmed with a serial data stream that controls the volume. The serial data appears on the UCS data line, and is clocked in bit by bit by the UCS clock when write–enable is low. The preamp has another control to force its output to mute at U302–13. The mute line is an output of U500–25, and is active LO (LO mutes the preamp). The output of U302 next feeds into the audio power amplifier through C400 that blocks DC. The audio power amplifier is a class A/B amplifier stage, and runs approximately 200 milliamps of bias to the collectors of final output transistors (Q400 and Q401) while idling with no audio input. The audio power amplifier provides +34 dB of gain and presents an output impedance of 8 ohms to drive an 8–ohm speaker. At the nominal battery voltage of 13.8 volts, the power amp delivers over 15 watts of power with total harmonic distortion below 3%.

3. 2 .7 Option Play through Receive Audio Shaping

The first option path available to the hardware options is RX through receive audio shaping filter or RX–RAS. The internal options access the RX audio ports through J301–10, and the options residing in the external options box access the RX audio ports through J1–33. Both RX audio ports, RX–RAS and RX flat, are enabled in the same manner as TX audio ports, by commands over the serial bus.

The RX audio signals are input through J301–10 and/or J1–33, and are summed and buffered by the option RX buffer opamp U301–C. The input is the null port at U301–8, and allows options access without interference. The output of the option RX buffer is connected to two inputs to HY300.

The input at HY300–9 is the input for RX–RAS. The control input for RX–RAS is at HY300–2, and comes from the output of U504–2. The control is active low (HI when the switch is open). With the control low, the RX–RAS enables, and the signal output drives the input of the receive audio shaping filter. The signal path follows the same path as the discriminator audio path discussed earlier.

3. 2 .8 Option Play Flat Response

The option play flat response is input to the option RX buffer, the same as the option play through RAS. The option RX buffer output (U301–10) connects to the RX flat switch (HY300–9). This switch is controlled by U504–5, and is active low (HI when the switch is open). The control line input to the hybrid is at HY300–13. When enabled (closed), the RX option buffer connects directly to the audio summing node by R201. The summing node sets the correct attenuation for the input to the audio pre–amplifier. The remainder of the path is the same for the discriminator audio path.

3. 2 .9 Alert Tones

The alert tones are generated by the radio microprocessor by toggling its output at U500–15. This output is AC coupled by C208, and is summed directly into the audio summing node through R202.

3. 2 .10 Power Amplifier

The power amplifier is biased to 5.0 volts at its positive input by resistors R400 and R401. The dual output opamp U400 drives the pre–driver transistors (Q403 and Q402). The outputs of the opamp are approximately 2.1 volts apart, and U400–4 is higher than U400–1. The banded transistor pairs, Q403 and Q402, are graded NPN pairs and graded PNP pairs respectively. The pairs are graded to match base to emitter voltage drops. This transistors Q403–A and Q402– A form a current mirror into transistors Q403–B and Q402–B. The current is fixed through Q403–A and Q402–A by resistor R406.

When unmuted transistor Q404 is conducting, the bias current is higher than when muted. The mirrored current through Q403–B and Q402–B provides the base drive for the final output 6 transistors. The DC feedback for the opamp U400 comes from the tap between R407 and R408. The feedback DC biases the entire feedback winding of the transformer (Pins 7, 8 of T400). The transformer input windings (Pins 1, 6; Pins 2, 5) are driven by the final output transistors Q401 and Q400 respectively. The output winding of the transformer is routed from J1–37 and J1–22 in the radio, through the cable kit, into the control head, and finally to the speaker.

3. 3 SUPPORT CIRCUITRY COMMON TO RECEIVE AND TRANSMIT

Supporting circuitry appears throughout the analog section of the personality board. All of the 300 series designators provide functions such as supply by–passing, etc. Two of the supporting sections are worthy of special note, the 4–MHz oscillator and the analog ground buffer opamp.

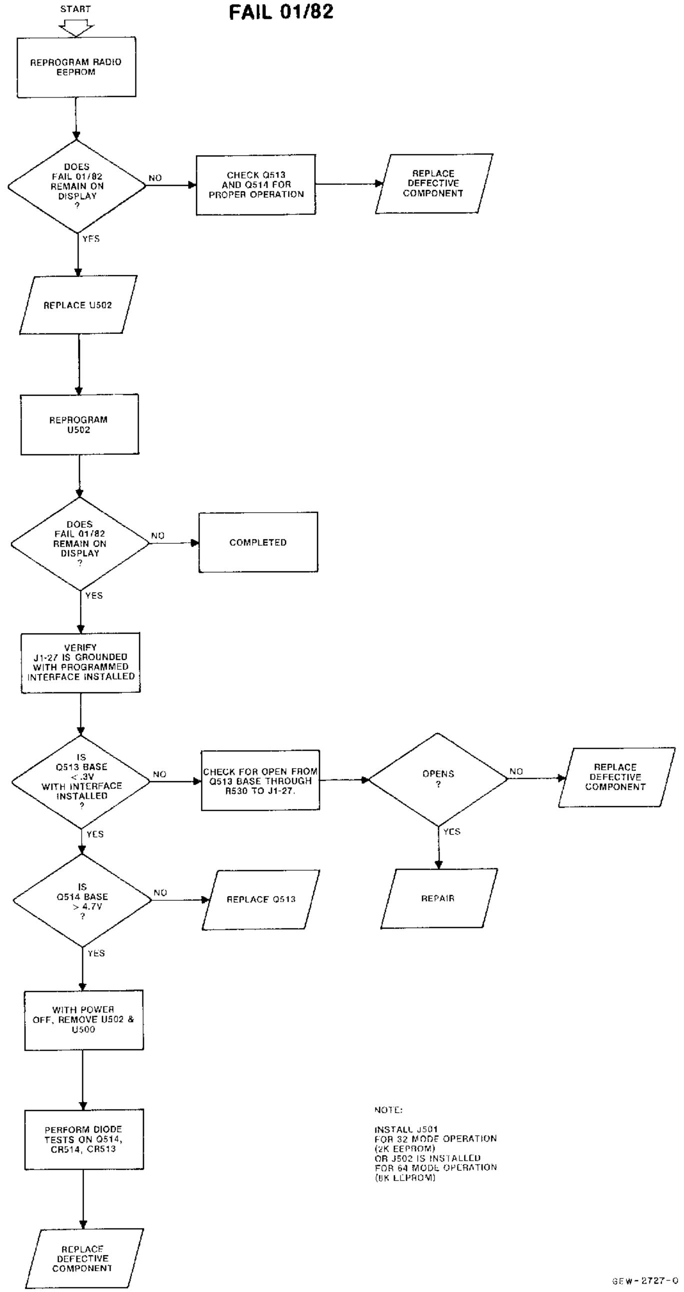
3. 3 .1 4–MHz Oscillator

The linear crystal oscillator provides the switched capacitor filter IC (U300) with its clocking rate. The oscillator provides a 4–MHz sine wave (distorted) at an amplitude of approximately 700 mV peak–to–peak to the clock input (U300–24). The oscillator uses Q300 and Y300 to produce the signal.

3. 3 .2 Analog Ground Voltage Buffer

The opamp U301–B is a unity gain voltage follower. The opamp output buffers the output of the Vag reference output (U300–7). IC U300 biases internally to approximately half of its 9.6–volt supply. To reduce audio transients when switching an audio path in or out, the buffered analog ground voltage biases all audio circuitry except the audio power amplifier. The analog ground voltage is presented to the internal hardware options via J301–8, so the options can use this DC potential to bias their analog circuitry.

FAIL 01/82

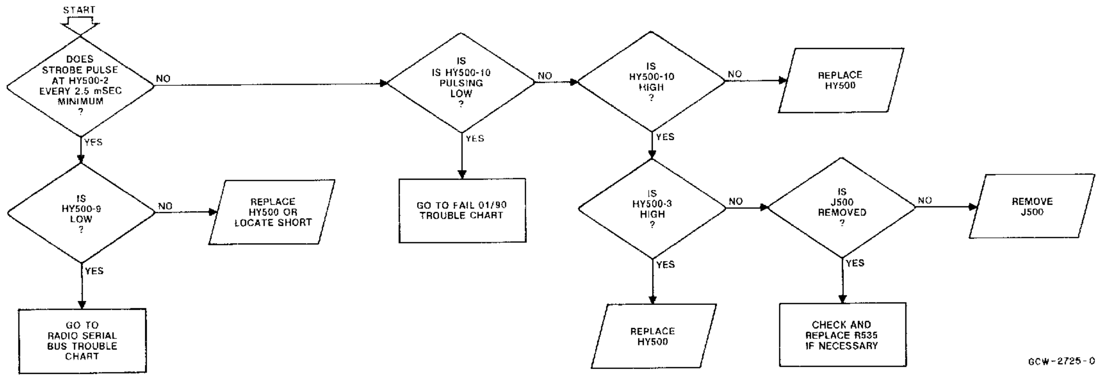


NOTE:

INSTALL J501
FOR 32 MODE OPERATION
(2K EEPROM)
OR J502 IS INSTALLED
FOR 64 MODE OPERATION
(8K EEPROM)

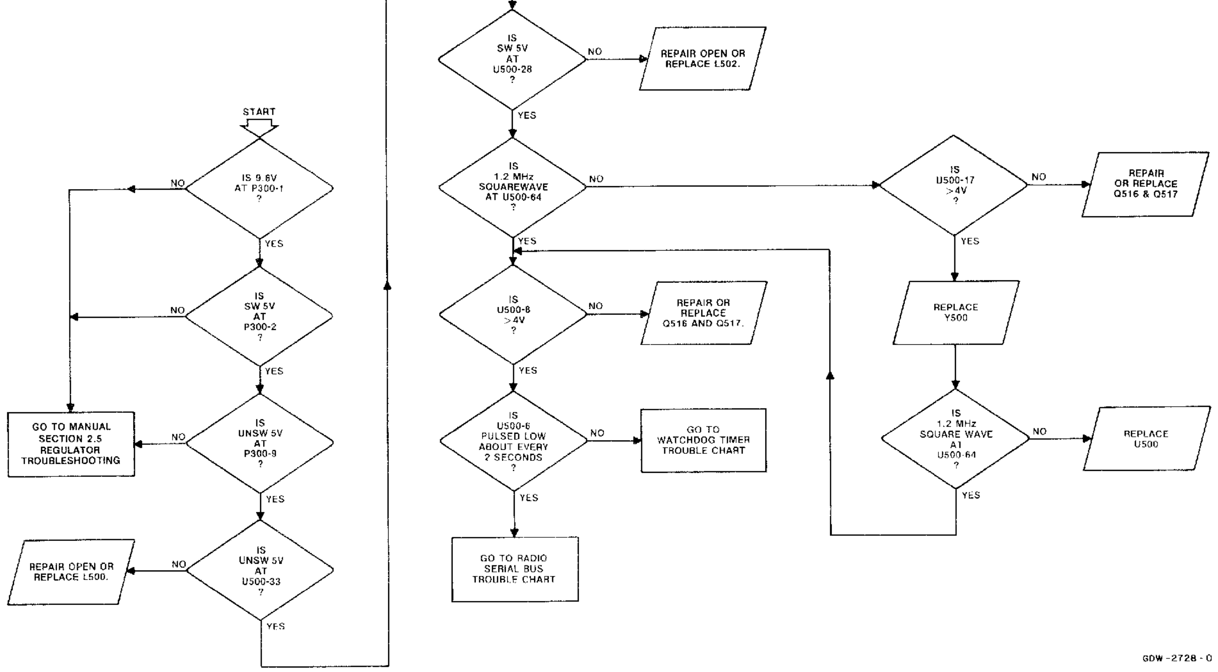
GEW-2727-0

WATCHDOG TIMER FAILURE



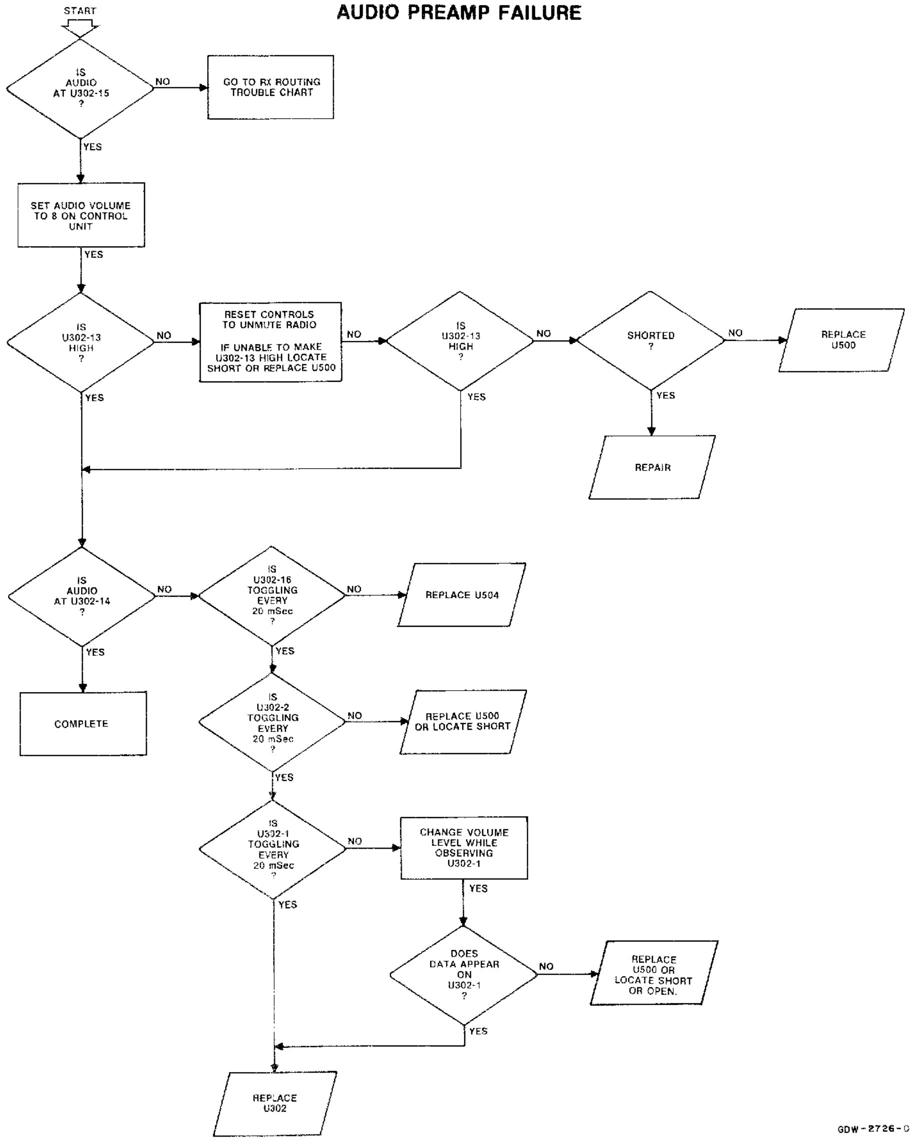
GCW-2725-0

FAIL 01/90



GDW-2728-0

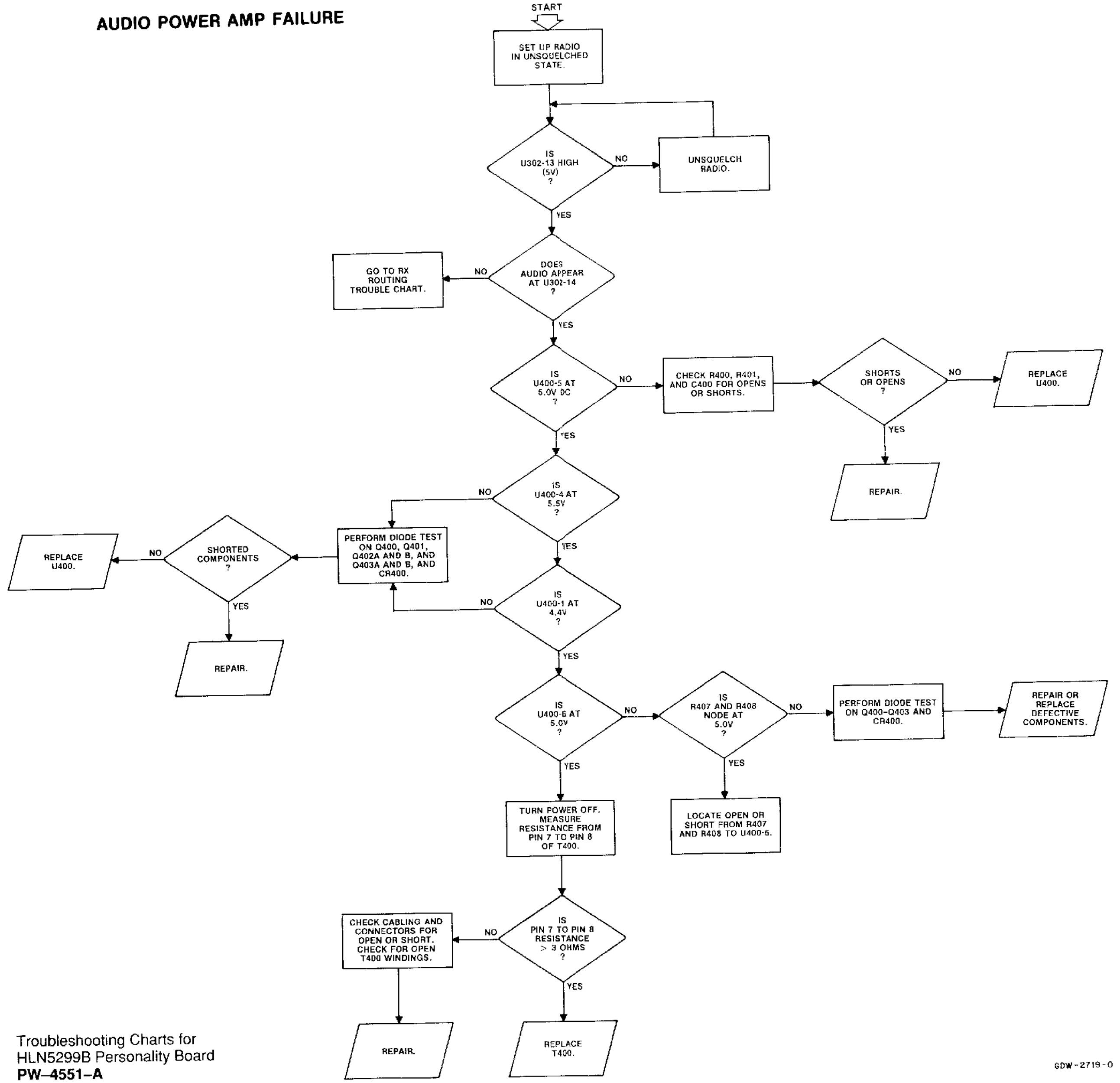
AUDIO PREAMP FAILURE



GDW-2726-0

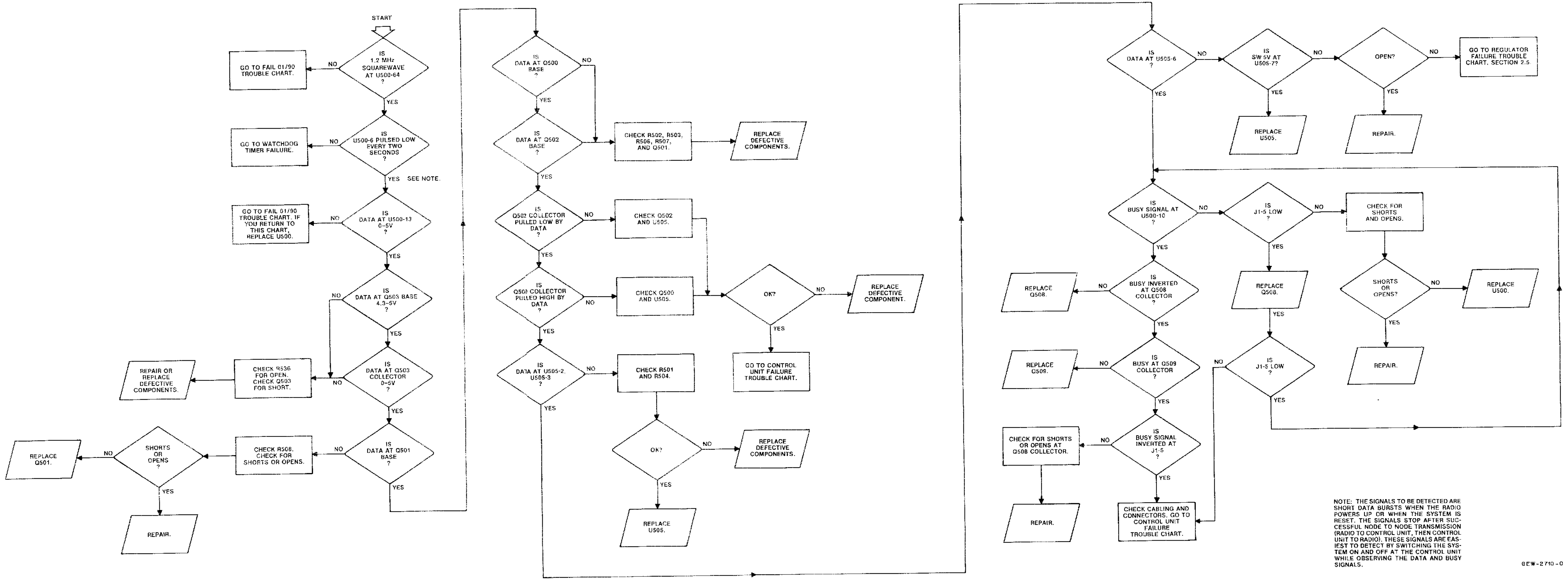
Troubleshooting Charts for
HLN5299B Personality Board
PW-4551-A
(Sheet 1 of 4)
5/10/88

AUDIO POWER AMP FAILURE

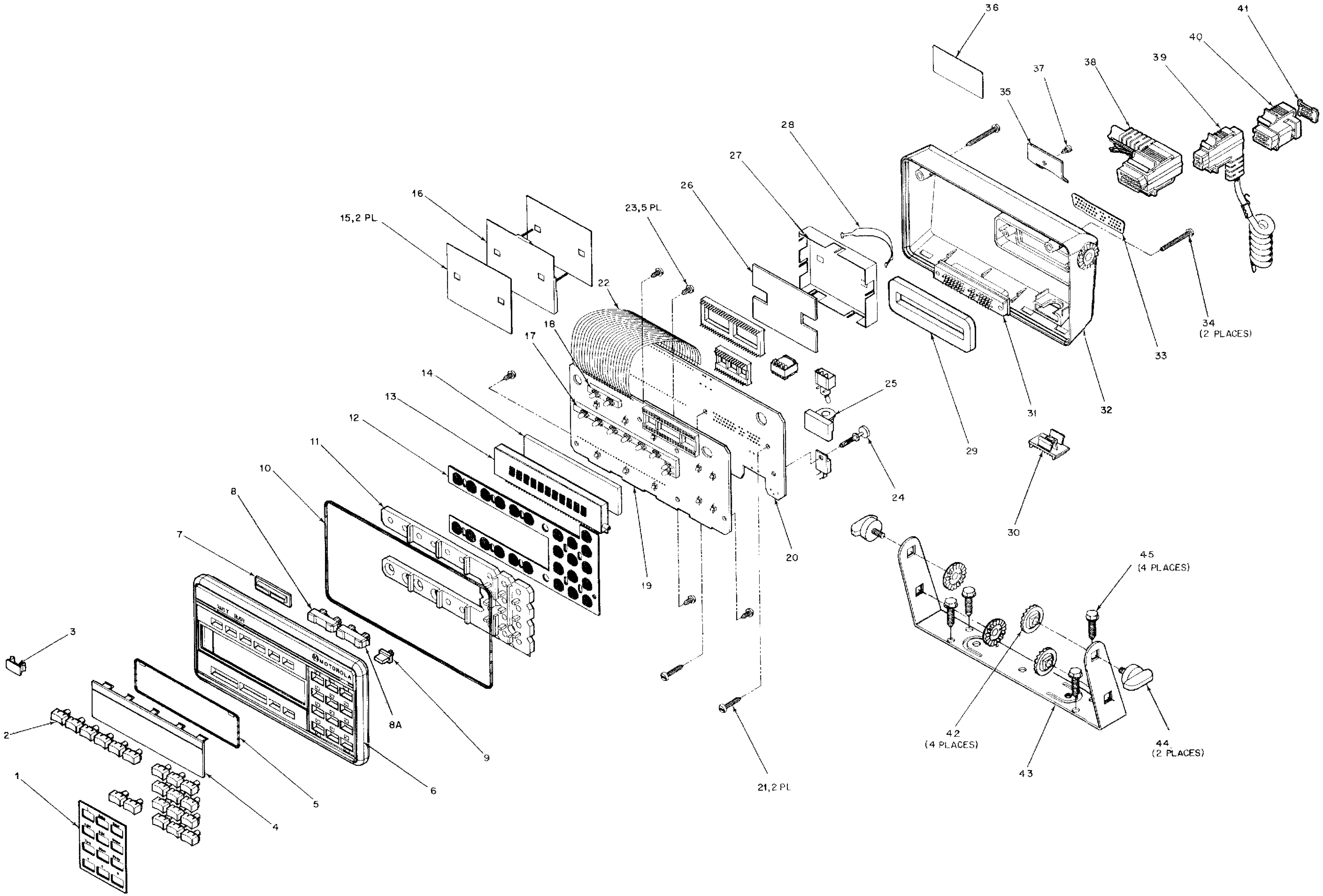


Troubleshooting Charts for
HLN5299B Personality Board
PW–4551–A
(Sheet 2 of 4)
5/10/88

SERIAL BUS FAILURE



NOTE: THE SIGNALS TO BE DETECTED ARE SHORT DATA BURSTS WHEN THE RADIO POWERS UP OR WHEN THE SYSTEM IS RESET. THE SIGNALS STOP AFTER SUCCESSFUL NODE TO NODE TRANSMISSION (RADIO TO CONTROL UNIT, THEN CONTROL UNIT TO RADIO). THESE SIGNALS ARE EASIEST TO DETECT BY SWITCHING THE SYSTEM ON AND OFF AT THE CONTROL UNIT WHILE OBSERVING THE DATA AND BUSY SIGNALS.



GDW-2365-B

parts list

Mechanical Parts List for *Systems 9000* Control Unit MXW–2293–E

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	13–80087J01	escutcheon
2	38–80090J01	push–in key top (specify legend required)
3	38–80253K01	plug key
4	61–80095J01	VF lens
5	32–80057K01	lens gasket
6	15–08088J01	front housing
7	61–80097J01	LED lens
8	38–80091J02	mode rocker top
8A	38–80091J02	volume rocker top
9	38–80092J01	dimmer key top
10	32–80180J01	housing gasket
11	61 80185J01	keyboard lightpipe
12	75–80098J01	elastomeric keypad
13	72–80242J01	VF display
14	75 80184J01	VF shock pad
15	14–80269K01	insulator
16	26–80220K01	solder side shield
17	73 80011L01	LED 8 position spacer
18	43–80012L01	LED 2 position spacer
19	84–80117J01	display PCB
20	84 80104J01	controller PCB
21	03–10945A14	TORX plastite screw, 3.12 x 1.27 x 16
22	30–80034K01	22 position flex cable
23	03–10945A11	TORX plastite screw, 2.12 x 1.27 x 8
24	05–80200K01	nylon rivet
25	32–80178J01	on/off gasket
26	75–80268K01	IC shock pad
27	26–80003K01	component side shield
28	55 84300B02	shield handle
29	32–80179J01	D connector gasket
30	38–80128J01	on/off key top
31	28 80228J01	50 position D connector
32	15–80089J01	back housing
33	32–80181J01	connector face gasket
34	03–10908A33	TORX machine screw, 3.0 x .6 x 30, 2 used
35	07–84323C01	strain relief bracket
36	33–80178M01	nameplate
37	03–10908A18	TORX machine screw, 3.0 x .5 x 6
38	30–80229N01	radio cable
39	30–80223J01	microphone cable
40	15–80221K01	vehicle interface port connector
41	32–80275K01	VIP gasket
42	43–80127J01	trunnion spacer
43	07–80263L01	trunnion bracket
44	03–80160E01	wing screw, 2 used
45	03–00136756	mounting screw, 4 used

5/10/88

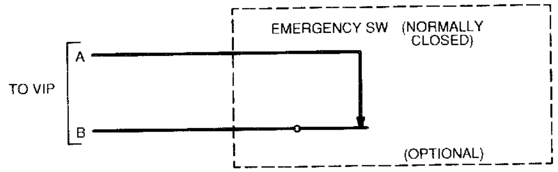
Exploded View and Parts List
for Control Unit
PW–2425–D
5/10/88

parts list

HKN4241A 17' Negative Ground Cable Kit MXW-2046-A

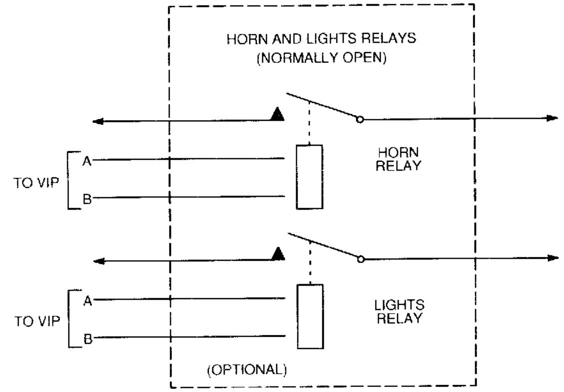
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	01-80739T54	17' cable assembly
	29-84528B05	lug
	30-00851875	battery cable, black
	01-80701T89	66" black lead and lug assembly
	09-84151B03	contact receptacle
	09-84151B05	contact receptacle
	30-80229N01	radio cable
	39-10184A44	contact receptacle, 2 used
	15-10183A17	2 contact receptacle housing
	36-80220B06	connector knob
	03-00140079	tapping screw, 6 x 19 x 1/2, 4 used
	42-10217A02	tie strap, 2 used
	42-80156B01	retainer ring
	09-80227B01	power contact, female, 2 used
	15-80217K01	front cable housing
	15-80216B01	back cable housing
	32-80004L01	cable connector gasket
	30-00812505	8 gage cable, red
	30-10286C79	20 strand wire, white/blue
	30-10286F21	20 strand wire, black/violet
	54-80072G01	circuit board label
	54-84032M02	label

5/10/88



NOTE:
VIP INPUTS ARE PROGRAMMABLE. THIS MEANS VIP IN #1, VIP IN #2, OR VIP IN #3 COULD BE MADE AN EMERGENCY SWITCH DEPENDING ON HOW THE CONTROL HEAD IS PROGRAMMED.
THE OTHER SWITCH CONTACT SHOULD BE CONNECTED TO DIG GND PINS 20, 21, OR 26.

GPW-3002-B

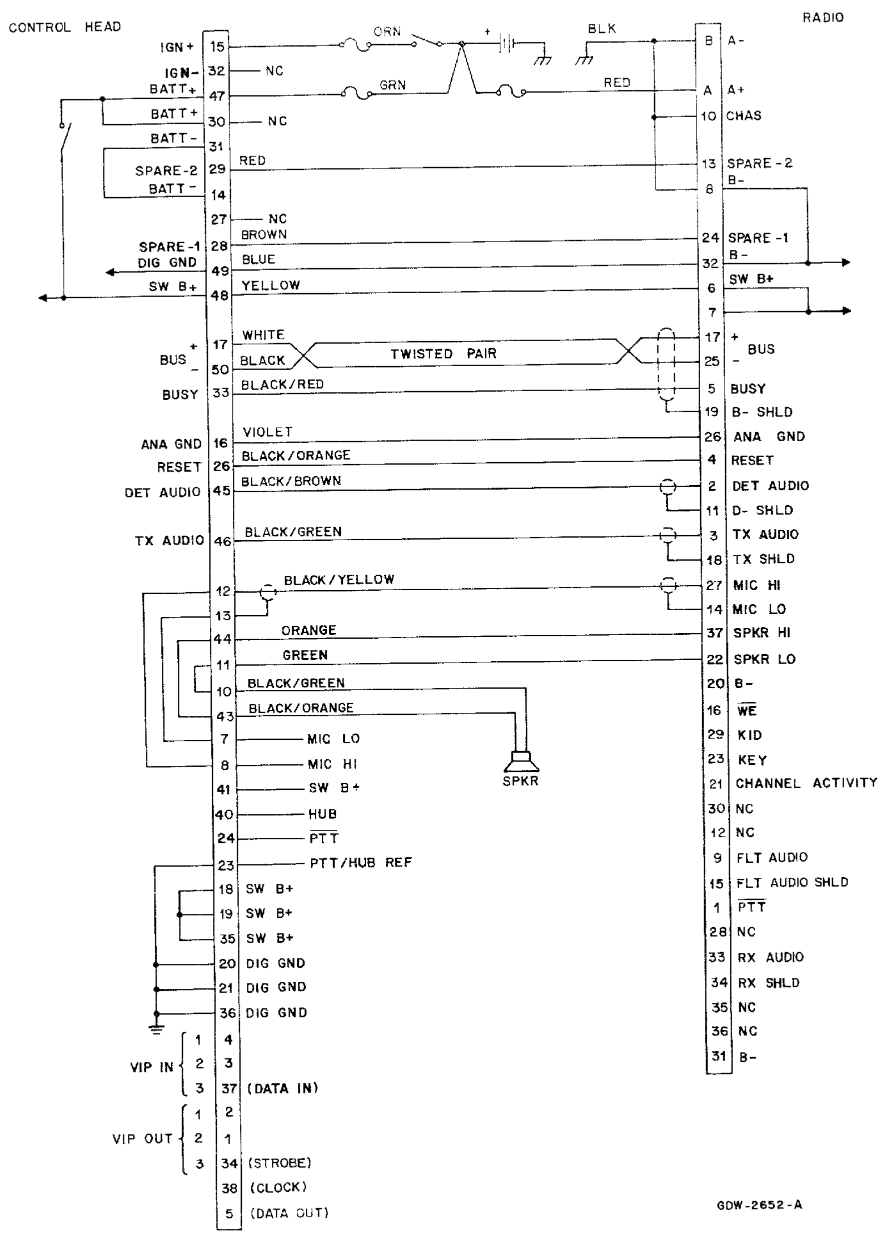


NOTE:
VIP OUTPUTS ARE PROGRAMMABLE. ONE CONTACT OF THE RELAY SHOULD BE CONNECTED TO THE VIP OUTPUT PROGRAMMED FOR THE RELAY AND THE OTHER CONTACT TO SW B+ PINS 18, 19, OR 35.

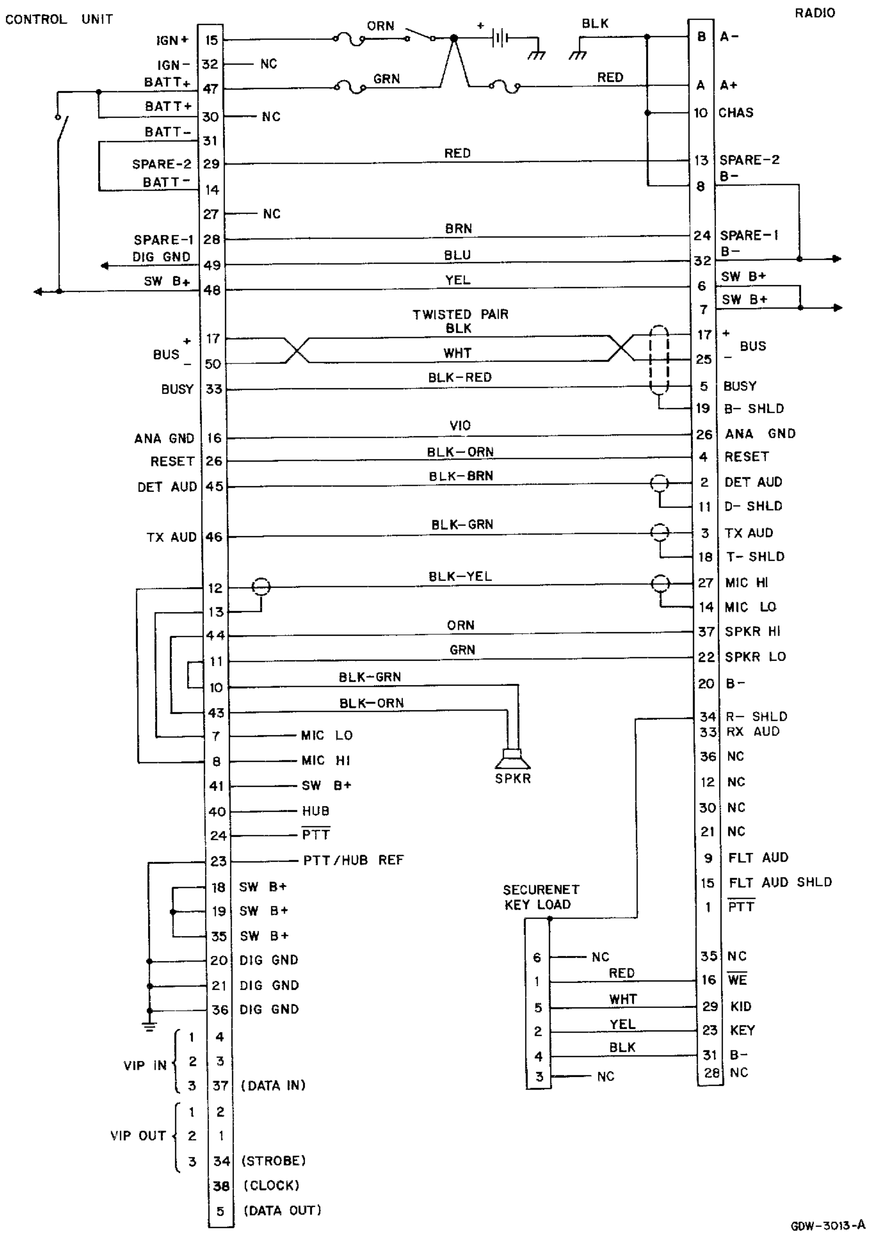
GPW-3003-A

Negative Ground Cable
Wiring Diagrams
PW-2779-C
5/10/88

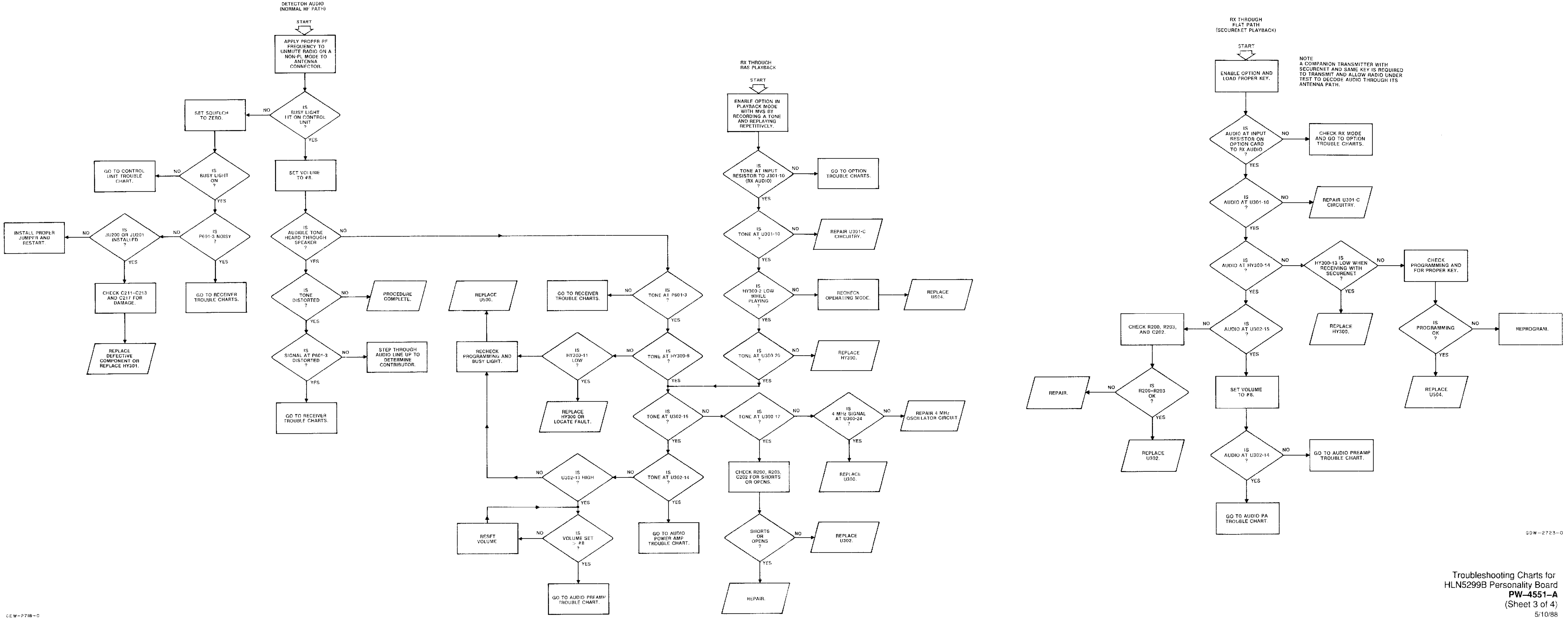
STANDARD CABLING



SECURENET CABLING

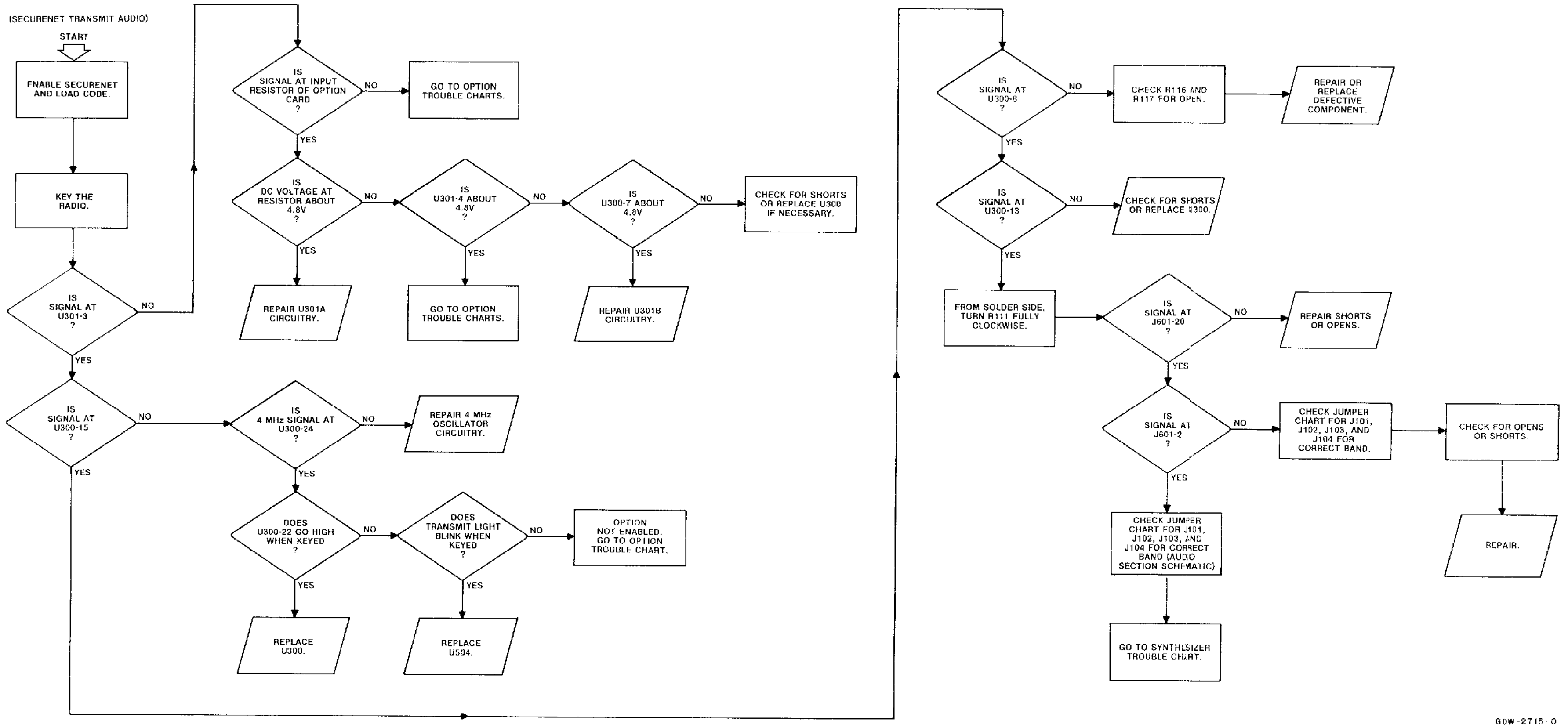


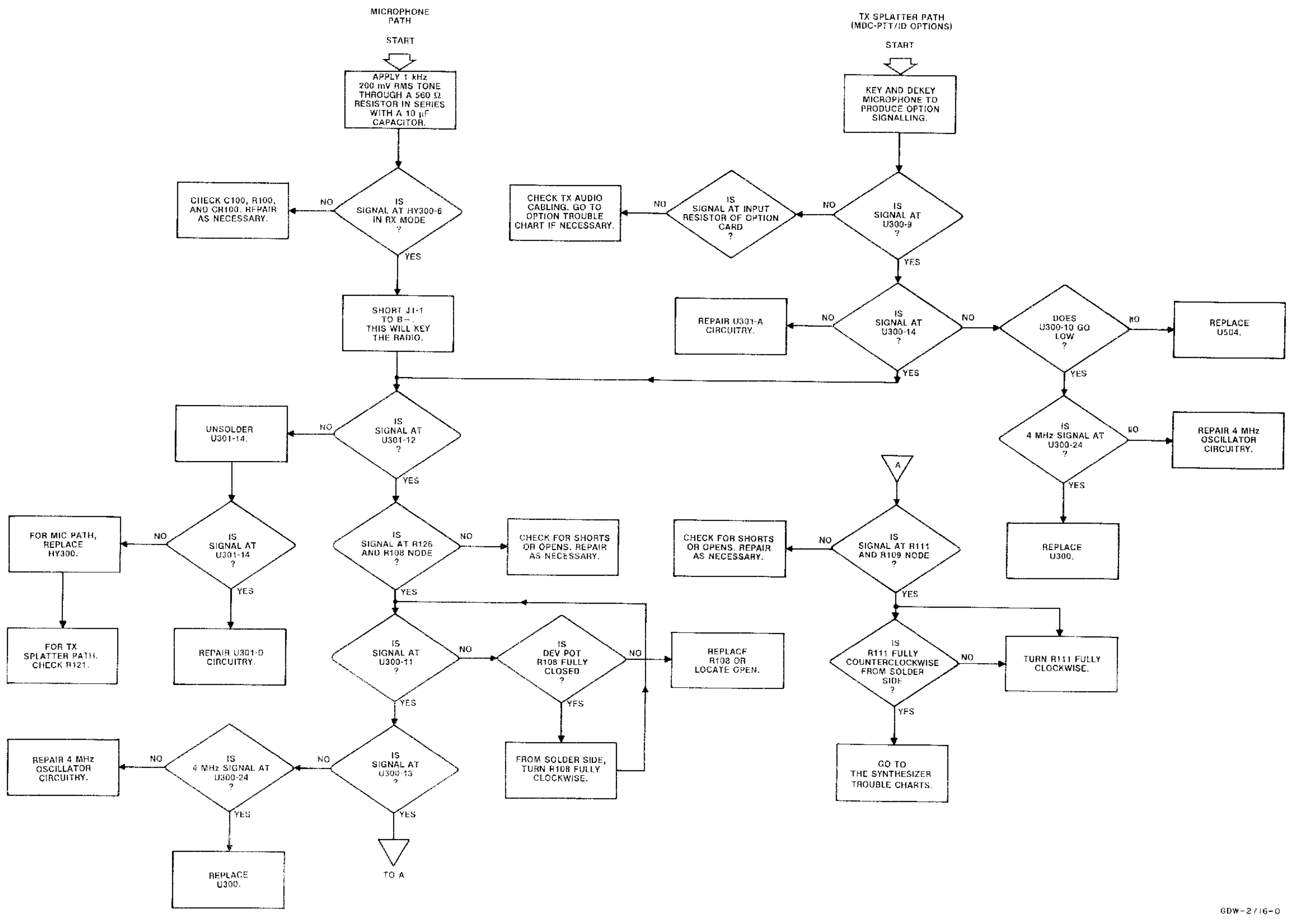
RX ROUTING



Troubleshooting Charts for
HLN5299B Personality Board
PW–4551–A
(Sheet 3 of 4)
5/10/88

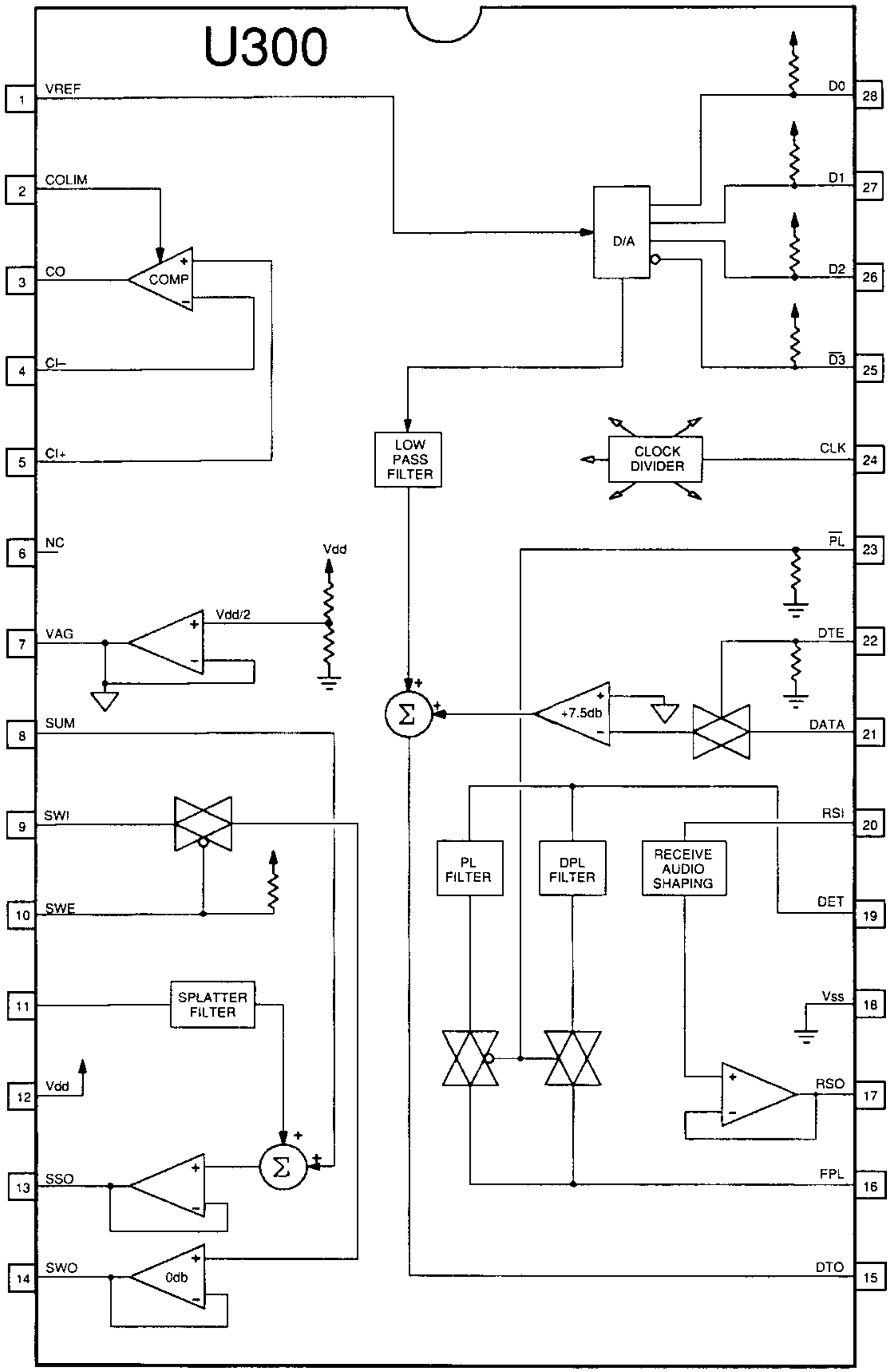
TX ROUTING





Troubleshooting Charts for
HLN5299B Personality Board
PW–4551–A
(Sheet 4 of 4)
5/10/88

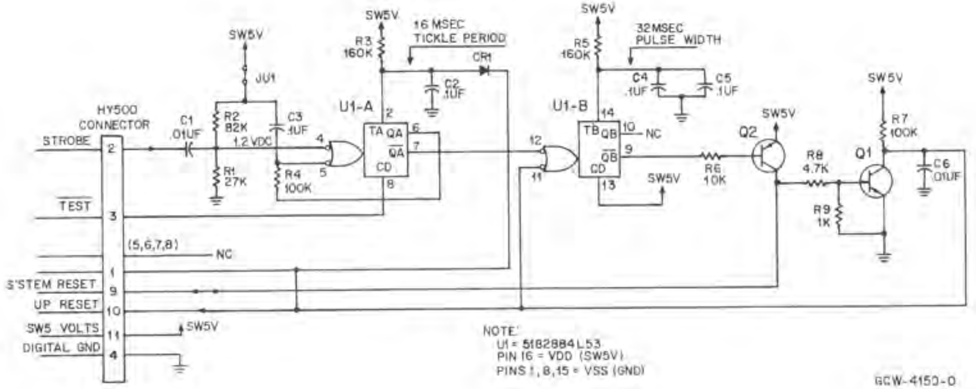
U300 BLOCK DIAGRAM



GPW-2585-A

U300 Functional
Block Diagram
PW-4552-A
8/30/88

WATCHDOG TIMER



parts list

Watchdog Timer (p/o HLN5299B Personality Board) MXW-4564-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
HY500	01-80739T60	includes the following
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C1	21-13741B45	.01, ±10%
C2	21-13741C17	.1, ±20%, 25V
C3	21-11032B13	.1, +80, -20%, electrolytic
C4,5	21-13741C17	.1, ±20%, 25V
C6	21-13741B45	.01, ±10%
diode (see note)		
CR1	48-80236E08	silicon
jumper		
JU1	06-11024B23	0 ohm
transistor (see note)		
Q1	48-80141L04	NPN
Q2	48-80141L03	PNP
integrated circuit (see note)		
U1	51-82884L53	monostable multivibrator

8/15/88

note: For best performance order diodes, transistors, and integrated circuit devices by Motorola part number.

SQUELCH HYBRID

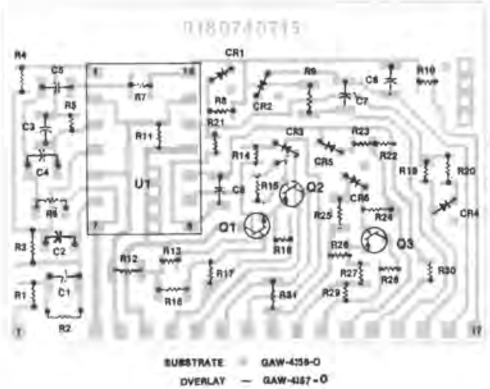
parts list

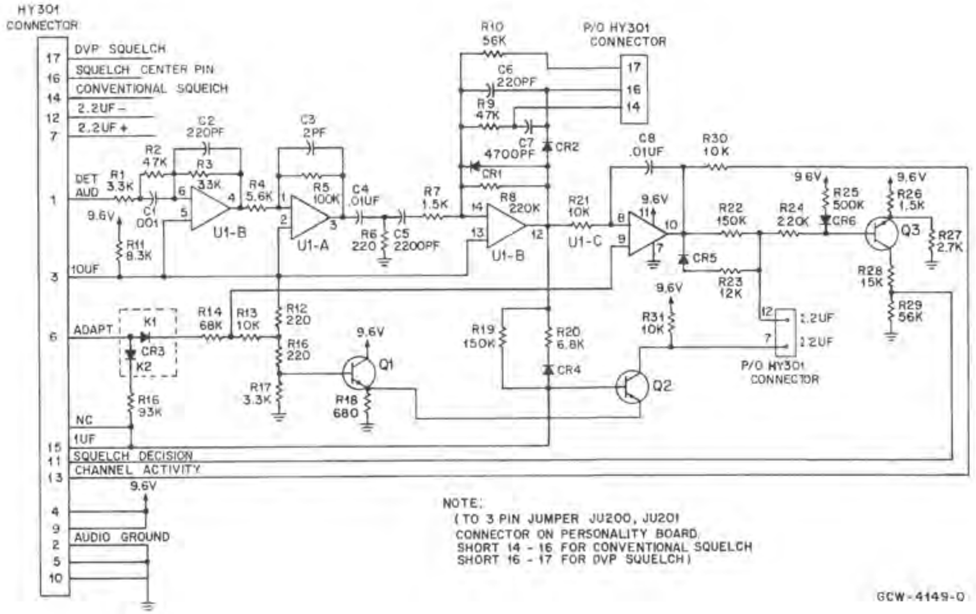
Squelch Hybrid (p/o HLN5299B Personality Board) MXW-4563-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
HY301	01-80740T15	includes the following
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C1	21-13740B73	.001
C2	21-13740B57	220 pF
C3	21-13740B47	82 pF
C4	21-13741B45	.01
C5	21-13741B29	.0022
C6	21-13740B57	220 pF
C7	21-13741B37	.0047, ±10%
C8	21-13741B45	.01
diode (see note)		
CR1-6	48-80236E08	silicon
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R6	06-11077A58	220
R9	06-11077B17	47k
R12	06-11077A58	220
R16	06-11077A58	220
R25	06-11077B45	820k
R31	06-11077A98	10k
transistor (see note)		
Q1,2	48-80141L04	NPN
Q3	48-80141L01	PNP
integrated circuit (see note)		
U1	51-80067C06	quad opamp

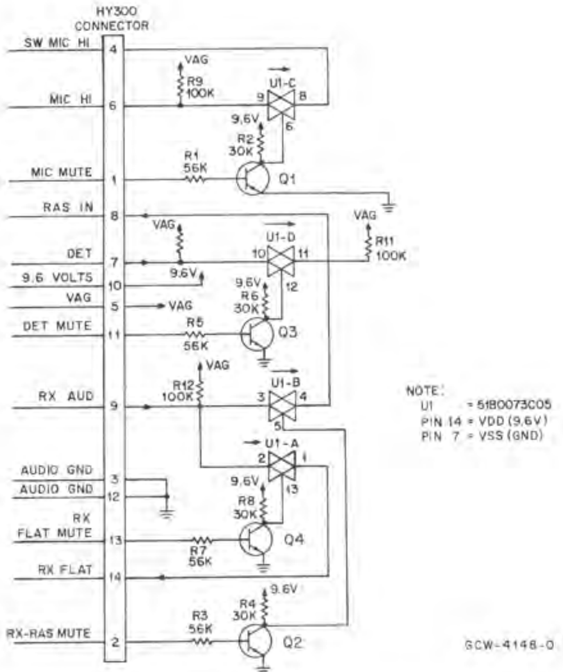
8/15/88

note: For best performance order diodes, transistors, and integrated circuit devices by Motorola part number.





TRANSMISSION GATE HYBRID



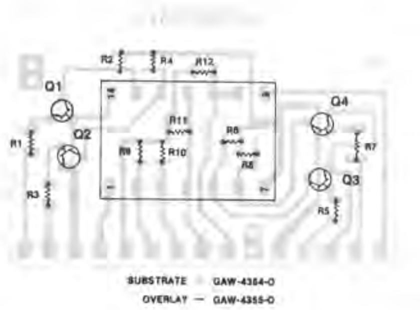
parts list

Transmission Gate (p/o HLN5299B Personality Board) MXW-4562-A

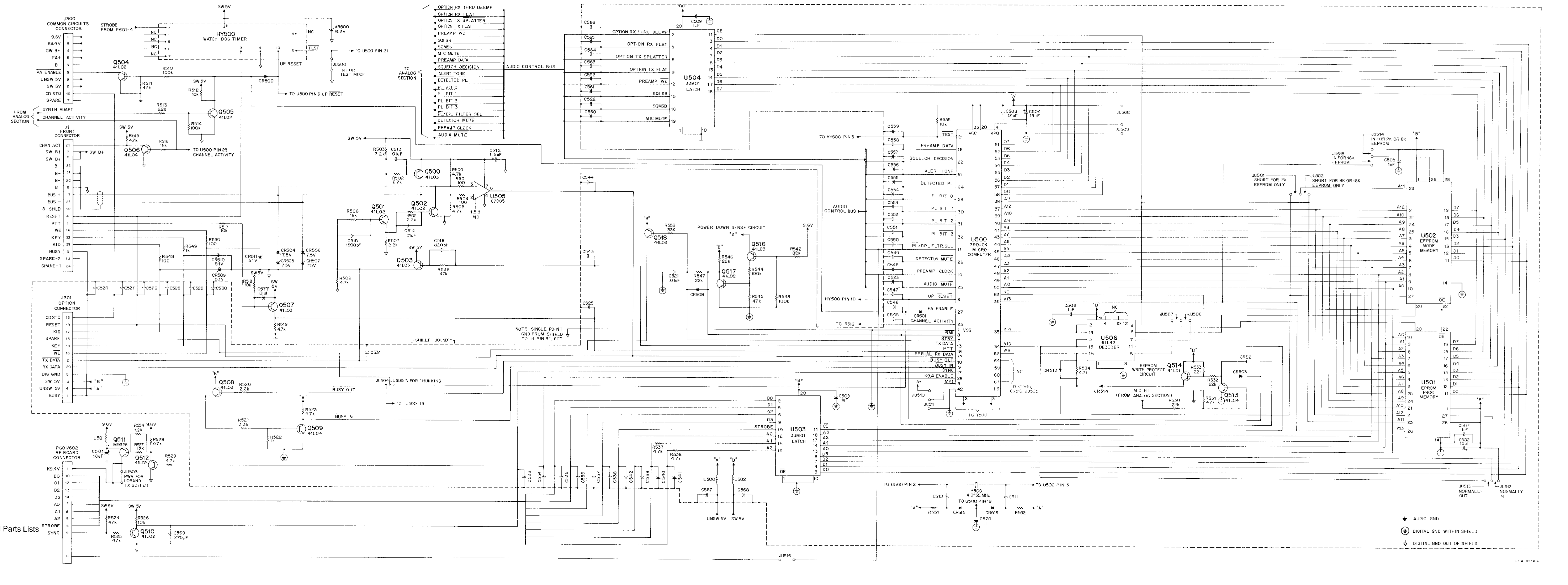
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
HY300	01-80739T59	includes the following
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R7	06-11077B17	56k
transistor (see note)		
Q1-4	48-80141L02	NPN
integrated circuit (see note)		
U1	51-80073C05	analog t-gate

5/4/88

note: For best performance order diodes, transistors, and integrated circuit devices by Motorola part number.

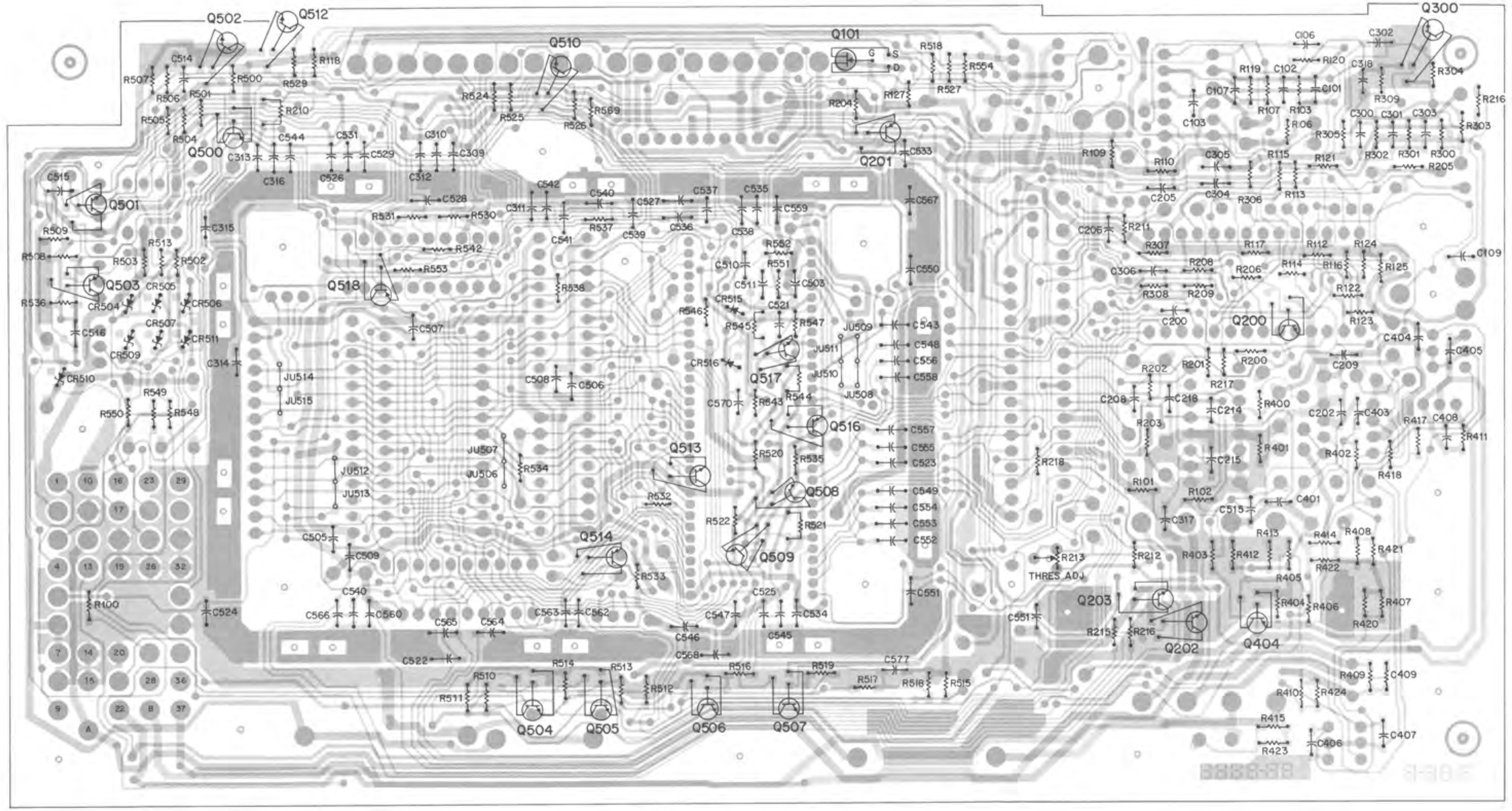


Schematics, Circuit Board Diagrams, and Parts Lists for the Transmission Gate, Squelch, and Watchdog Timer Hybrids
PW-4561-B
8/30/88



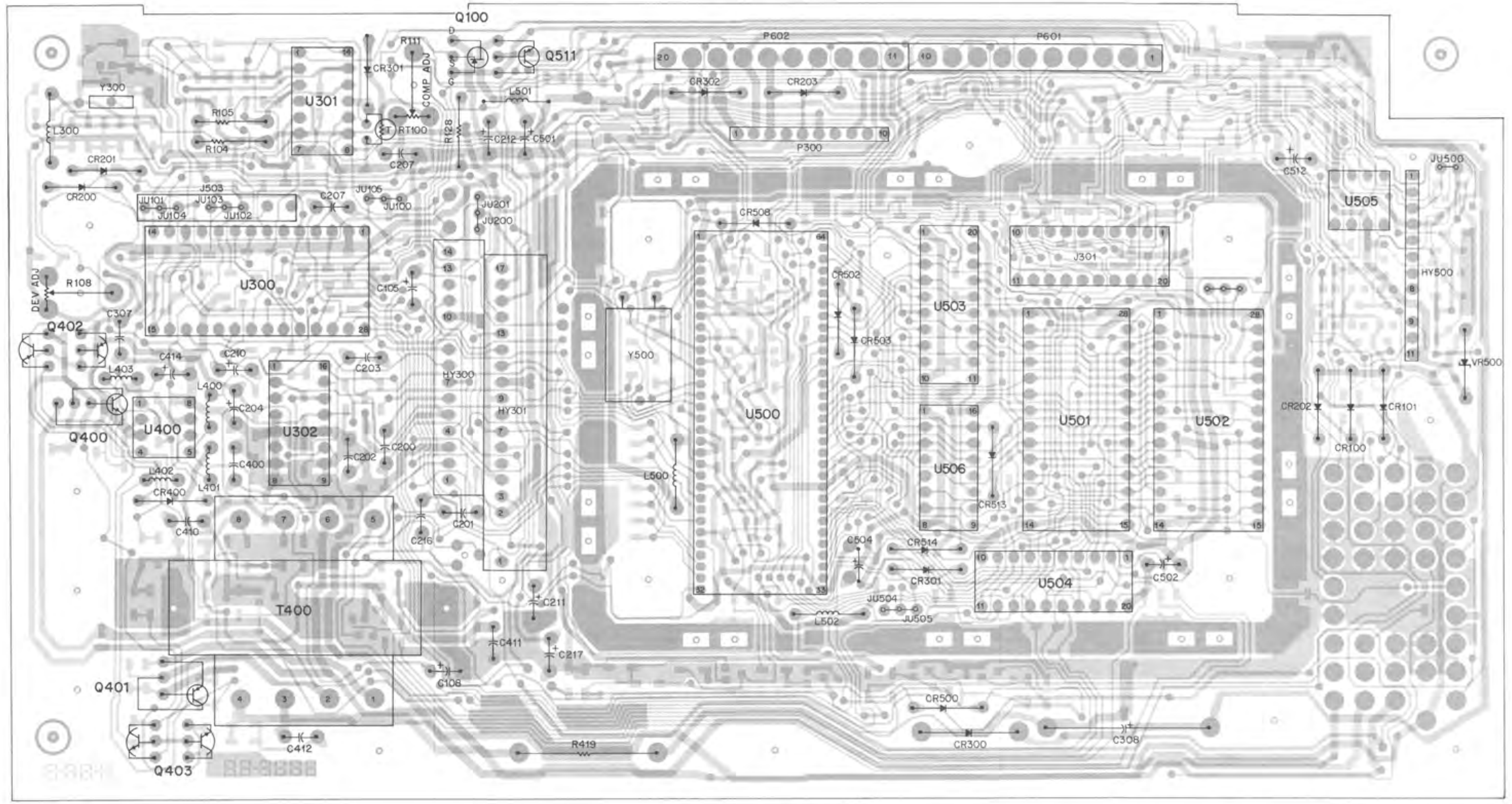
JUMPER	NORMALLY	COMMENTS
JU500	OUT	IN FOR TEST MODE
JU501	—	IN FOR 2K EEPROM
JU502	—	IN FOR 8K OR 16K EEPROM
JU503	OUT	IN FOR LOWBAND TX BUFFER
JU504	IN	OUT FOR TRUNKING
JU505	OUT	IN FOR TRUNKING
JU506	IN	OUT FOR SP APPLICATIONS ONLY
JU507	OUT	IN FOR SP APPLICATIONS ONLY
JU508	IN	OUT FOR SP APPLICATIONS ONLY
JU509	OUT	IN FOR SP APPLICATIONS ONLY
JU510	OUT	IN FOR SP APPLICATIONS ONLY
JU511	IN	OUT FOR SP APPLICATIONS ONLY
JU512	IN	OUT FOR SP APPLICATIONS ONLY
JU513	OUT	IN FOR SP APPLICATIONS ONLY
JU514	IN	IN FOR 2K OR 8K EEPROM
JU515	OUT	IN FOR 16K EEPROM
JU516	OUT	IN FOR UHF TRUNKING

Schematics, Circuit Board Diagrams, and Parts Lists
for the HLN5299B Personality Board
PW–4553–B
(Sheet 1 of 3)
8/30/88



SHOWN FROM SOLDER SIDE

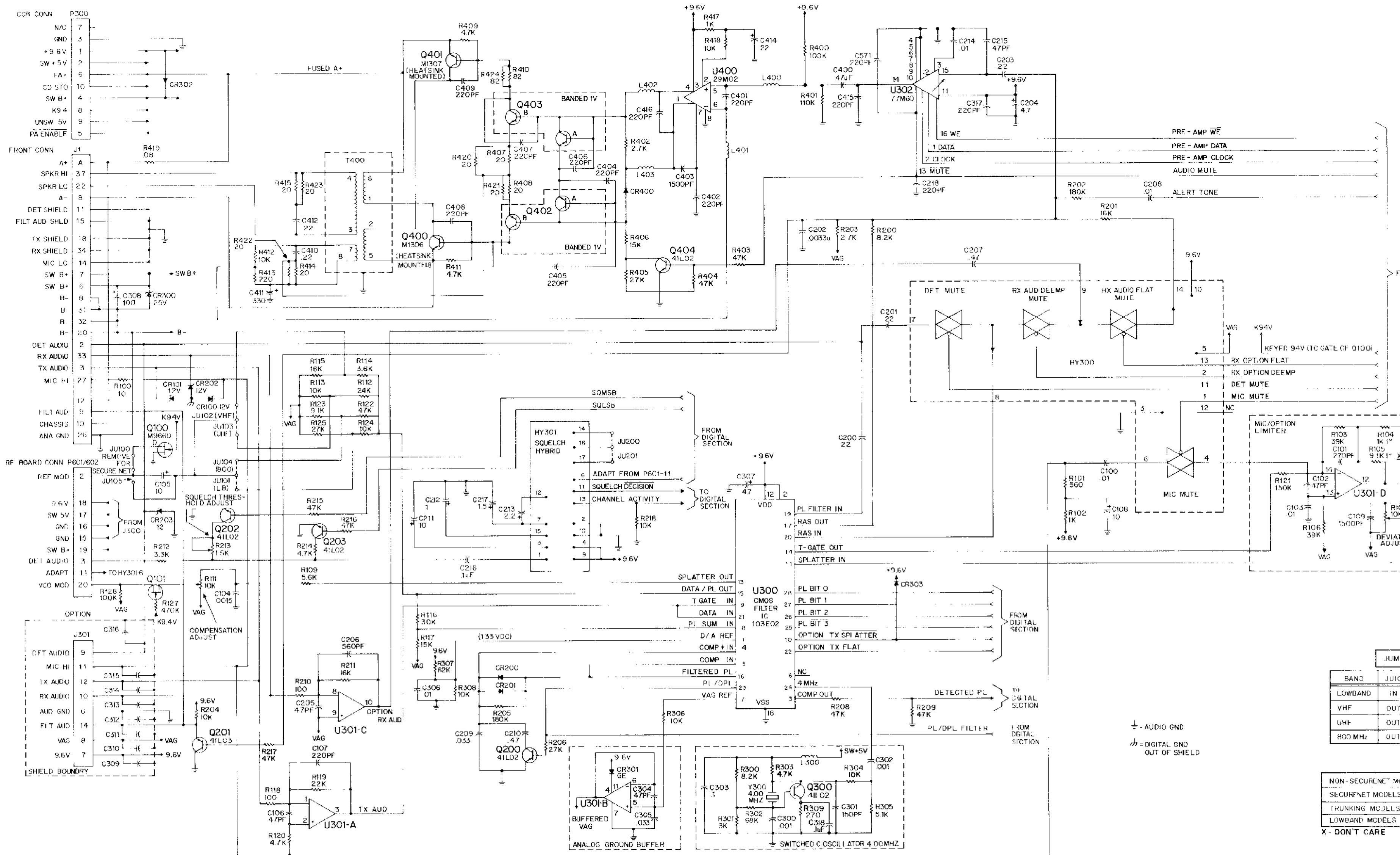
SOLDER SIDE GEW-4555-A
COMPONENT SIDE GEW-4556-A
OVERLAY — GEW-4557-A



SHOWN FROM COMPONENT SIDE

SOLDER SIDE GEW-4555-A
COMPONENT SIDE GEW-4556-A
OVERLAY — GEW-4558-O

Schematics, Circuit Board Diagrams, and Parts Lists
for the HLN5299B Personality Board
PW-4553-B
(Sheet 2 of 3)
8/30/88



JUMPER TABLES

BAND	JU101	JU102	JU103	JU104	JU105
LOWBAND	IN	OUT	OUT	OUT	IN
VHF	OUT	IN	OUT	OUT	OUT
UHF	OUT	OUT	IN	OUT	OUT
800 MHz	OUT	OUT	OUT	IN	OUT

	JU100	JU200	JU201	JU505
NON-SECURENET MODELS	IN	IN	OUT	X
SECURENET MODELS	OUT	OUT	IN	X
TRUNKING MODELS	X	X	X	IN
LOWBAND MODELS	OUT	X	X	X

X - DON'T CARE

GFW-4560-B

Schematics, Circuit Board Diagrams, and Parts Lists for the HLN5299B Personality Board
PW–4553–B
(Sheet 3 of 3)
8/30/88

parts list

HLN5299B *SYNTOR X 9000* Personality Board — MXW–4559–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±10%, 50V (unless otherwise stated)		
C100	08-11051A07	.01, ±5%, 63V
C101	21-13740B59	270 pF, ±5%
C102	21-13740B41	47 pF, ±5%
C103	21-13741B45	.01
C104	08-11051A02	.0015, ±5%, 63V
C105	23-11048C11	10, ±20%, 35V, electrolytic
C106	21-13740B41	47 pF, ±5%
C107	21-13740B57	220 pF, ±5%
C108	23-11048C11	10, ±20%, 35V, electrolytic
C109	21-13740B76	.0015, ±5%
C200	21-11032B15	.22, +80, −20%
C201	08-11051A15	.22, ±5%, 63V
C202	08-11051A04	.0033, ±5%, 63V
C203	08-11051A15	.22, ±5%, 63V
C204	23-11013D55	4.7, ±20%, 20V, tantalum
C205	21-13740B41	47 pF, ±5%
C206	21-13740B67	560 pF, ±5%
C207	08-11051A17	.47, ±5%, 63V
C208	21-13741B45	.01
C209	21-13741B57	.033
C210	08-11051A17	.47, ±5%, 63V
C211	23-11048C11	10, ±20%, 35V, electrolytic
C212	23-11048C05	1, ±20%, 35V, electrolytic
C213	23-11048C06	2.2, ±20%, electrolytic
C214	21-13741B45	.01
C215	21-13740B41	47 pF, ±5%
C216	08-11051A13	.1, ±5%, 63V
C217	23-11013C01	1.5, 15V, tantalum
C218	21-13740B57	220 pF, ±5%
C300	21-13741B21	.001
C301	21-13740B53	150 pF, ±5%
C302	21-13741B21	.001
C303	21-11032B13	.10, +80, −20%
C304	21-13740B41	47 pF, ±5%
C305	21-11032B15	.22, +80, −20%
C306	21-13741B45	.01
C307	23-84538G06	47, ±20%, 20V, tantalum
C308	23-84669A08	100, +150, −10%, 25V, electrolytic
C309–316	21-13740B49	100 pF, ±5%
C317	21-13740B57	220 pF, ±5%
C318	21-11032B13	.10, +80, −20%
C400	08-11051A17	.47, ±5%, 63V
C401,402	21-13740B57	220 pF, ±5%
C403	21-13740B76	.0015, ±5%
C404–409	21-13740B57	220 pF, ±5%
C410	08-11051A15	.22, ±5%, 63V
C412	08-11051A15	.22, ±5%, 63V
C414	23-11013C56	22, ±20%, 15V, tantalum
C415,416	21-13740B57	220 pF, ±5%
C474	23-82747L01	330, +100, −10%, electrolytic
C501	23-11048C11	10, ±20%, 35V, electrolytic
C502	23-11013C55	15, ±20%, 15V, tantalum
C503	21-13741B45	.01
C504	23-11013C55	15, ±20%, 15V, tantalum
C505–509	21-11032B13	.1, +80, −20%
C510,511	21-13740B46	75 pF, ±5%
C512	23-11013C01	1.5, 15V, tantalum
C513,514	21-13741B45	.01
C515	21-13740B78	.0018, ±5%
C516	21-11031G61	820 pF, ±5%
C521	21-11032B13	.10, +80, −20%
C522–569	21-13741B07	.00027
C570	21-11032B13	.10, +80, −20%
C571–576	21-13740B57	220 pF, ±5%
C577	21-13741B45	.01
diode (see note)		
CR100,101	48-80007E02	silicon
CR200,201	48-83654H01	silicon
CR202,203	48-80007E02	silicon
CR300	48-80236E07	28V zener
CR301	48-82178A01	germanium
CR302	48-80008E01	rectifier
CR303	48-82178A01	germanium
CR400	48-83654H01	silicon
CR500–503	48-83654H01	silicon
CR504–507	48-80140L11	7.5V zener
CR508	48-83654H01	silicon
CR509–511	48-80140L06	5.1V zener
CR513,514	48-83654H01	silicon
CR515,516	48-80013E02	silicon
connector receptacle		
J1	01-80746T79	front connector assembly
J100,101	28-84318M07	3 pin
J103	28-84318M07	3 pin
J200	28-84318M07	3 pin
J301	09-80269B05	dual socket
J500	28-84318M06	2 pin
J501	28-84318M07	3 pin
J504	28-84318M07	3 pin
J516	28-84318M06	2 pin
jumper		
JU100,101	09-80080L01	jumper
JU200	09-80080L01	jumper
JU501	09-80080L01	jumper
JU504	09-80080L01	jumper

MXW–4559–B (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
JU506	06-11077A01	0 ohm
JU508	06-11077A01	0 ohm
JU511,512	06-11077A01	0 ohm
JU514	06-11077A01	0 ohm
coil, rf		
L300	24-80293D02	ferrite
L400,403	24-80036A01	ferrite, 1/2 turn
L500	24-80138G04	560 nH
L501	24-80036A01	ferrite, 1/2 turn
L502	24-80138G04	560 nH
connector plug		
P300	28-80264K01	top entry
P601,602	28-82647K02	10 pin
transistor (see note)		
Q100	48-00869660	P–channel, JFET
Q101	48-05128M66	N–channel, JFET
Q200	48-80141L02	NPN
Q201	48-80141L03	PNP
Q202,203	48-80141L02	NPN
Q300	48-80141L02	NPN
Q402	01-80734T95	PNP, matched pair
Q403	01-80734T96	NPN, matched pair
Q404	48-80141L02	NPN
Q448	48-84413L07	PNP
Q449	48-84413L06	NPN
Q500	48-80141L03	PNP
Q501,502	48-80141L04	NPN
Q503	48-80141L03	PNP
Q504,505	48-80141L02	NPN
Q506	48-80141L04	NPN
Q507,508	48-80141L03	PNP
Q509	48-80141L04	NPN
Q510	48-80141L02	NPN
Q511	48-00869328	PNP
Q512,513	48-80141L04	NPN
Q514	48-80141L01	PNP
Q516	48-80141L03	PNP
Q517	48-80141L02	NPN
Q518	48-80141L03	PNP
thermistor		
RT100	06-80176D03	thermistor
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R100	06-11077A26	10
R101	06-11077A68	560
R102	06-11077A74	1k
R103	06-11077B13	39k
R104	06-11049B94	1k, ±1%, 1/4W
R105	06-11049C87	9090, ±1%, 1/4W
R106	06-11077B13	39k
R107	06-11077A92	5.6k
R108	18-80087E08	10k potentiometer
R109	06-11077A92	5.6k
R110	06-11077B13	39k
R111	18-80087E08	10k potentiometer
R112	06-11077B08	24k
R113	06-11077A98	10k
R114	06-11077A87	3.6k
R115	06-11077B04	16k
R116	06-11077B10	30k
R117	06-11077B03	15k
R118	06-11077A50	100
R119	06-11077B07	22k
R120	06-11077A90	4.7k
R121	06-11077B27	150k
R122	06-11077B15	47k
R123	06-11077A97	9.1k
R124	06-11077A98	10k
R125	06-11077B09	27k
R126	06-11077A96	8.2k
R127	06-11077B29	180k
R128	06-11009A97	100k, 1/4W
R200	06-11077A96	8.2k
R201	06-11077B04	16k
R202	06-11077B29	180k
R203	06-11077A84	2.7k
R204	06-11077A98	10k
R205	06-11077B29	180k
R206	06-11077B09	27k
R208	06-11077B15	47k
R209	06-11077B15	47k
R210	06-11077A50	100
R211	06-11077B04	16k
R212	06-11077A86	3.3k
R213	18-05500L17	1.5k, ±20%, potentiometer
R214	06-11077A90	4.7k
R215–217	06-11077B15	47k
R218	06-11077A98	10k
R300	06-11077A96	8.2k
R301	06-11077A85	3k
R302	06-11077B19	68k
R303	06-11077A90	4.7k
R304	06-11077A98	10k
R305	06-11077A91	5.1k
R306	06-11077A98	10k

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REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R307	06-11077B18	62k
R308	06-11077A98	10k
R309	06-11077A60	270
R400	06-11077B23	100k
R401	06-11077B24	110k
R402	06-11077A84	2.7k
R403,404	06-11077B15	47k
R405	06-11077B09	27k
R406	06-11077B03	15k
R407,408	06-11077A33	20
R409	06-11077A90	4.7k
R410	06-11077A48	82
R411	06-11077A90	4.7k
R412	06-11077A98	10k
R413	06-11077A58	220
R414,415	06-11077A33	20
R417	06-11077A74	1k
R418	06-11077A98	10k
R419	17-82350A14	.08, ±20%, 1W
R420–423	06-11077A33	20
R424	06-11077A48	82
R500	06-11077A90	4.7k
R501	06-11077A50	100
R502,503	06-11077A82	2.2k
R504	06-11077A50	100
R505	06-11077A90	4.7k
R506,507	06-11077A82	2.2k
R508	06-11077B05	18k
R509	06-11077A90	4.7k
R510	06-11077B23	100k
R511	06-11077B15	47k
R512	06-11077A98	10k
R513	06-11077B07	22k
R514	06-11077B23	100k
R515	06-11077A90	4.7k
R516	06-11077B03	15k
R517,518	06-11077A98	10k
R519	06-11077A90	4.7k
R520	06-11077A82	2.2k
R521	06-11077A86	3.3k
R522	06-11077A74	1k
R523	06-11077A90	4.7k
R524,525	06-11077B15	47k
R526	06-11077A98	10k
R527	06-11077A76	1.2k
R528	06-11077B15	47k
R529	06-11077A90	4.7k
R530	06-11077B07	22k
R531	06-11077B15	47k
R532,533	06-11077B07	22k
R534	06-11077A90	4.7k
R535	06-11077A98	10k
R536	06-11077B15	47k
R537,538	06-11077A90	4.7k
R542	06-11077B21	82k
R543,544	06-11077B23	100k
R545	06-11077B15	47k
R546	06-11077B07	22k
R547	06-11077A94	6.8k
R548	06-11077A50	100
R549	06-11077A74	1k
R550	06-11077A50	100
R551	06-11077A94	6.8k
R552	06-11077A90	4.7k
R553	06-11077B07	22k
R554	06-11077A76	1.2k
transformer		
T400	25-84083B03	audio
integrated circuit (see note)		
U300	51-80103E02	switch filter
U301	51-80067C06	opamp
U302	51-83977M60	special
U400	51-84621K14	driver
U500	51-80290J04	1.5 MHz microprocessor
U503,504	51-05133M01	octal latch
U505	51-80067C05	bipolar FET opamp
U506	51-84561L42	bipolar
voltage regulator (see note)		
VR500	48-83696E07	6.2V zener
crystal (see note)		
Y300	48-80173D01	4 MHz
Y500	48-80173D12	4.9152 MHz
	mechanical parts	
	09-80269B03	dual socket, 3 used
	09-80269B01	dual socket
	09-80002K01	socket
	14-80179N01	crystal base pad, 2 used
	75-80144H01	vibration pads
	37-00132526	heatshrink tubing
	01-80708T20	heat sink assembly w/Q448 & Q449
	01-80740T26	handle & shield assembly

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note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

Frequency Synthesizer

1. General

The *SYNTOR X* frequency synthesizer generates directly the first receive injection frequency and transmitter carrier. In the receive mode, the synthesizer locks on a frequency in Range 1 that is 53.9 MHz higher or a frequency in Ranges 2–5 that is 53.9 MHz lower than the receive frequency.

In the transmit mode, the synthesizer locks on the transmit output frequency. The synthesizer has a phase–locked loop (PLL) that operates at the output frequency and consists of a 14.4–MHz reference oscillator, low–noise voltage–controlled oscillators (VCO), a high–speed programmable divide–by–3–or–4 variable–modulus prescaler, a low–speed programmable divider, a sample–and–hold phase detector, and an adaptive loop filter. The 14.4–MHz reference oscillator output is applied, via an injection tripler, to the second mixer of the receiver, where it serves as the low–side second injection frequency. The synthesizer circuits are on the common circuits board and RF board, and in the RF internal casting.

2. Theory of Operation

2. 1 INTRODUCTION

The PLL synthesizer is a single negative–feedback loop that uses the relationship between the phase of the input signals as the controlling variable. The output of a high–accuracy, temperature–compensated crystal reference oscillator (U608) is divided down in frequency by the reference divider (part of U602). The reference divider puts out a high–stability 6.25–kHz (5.00–kHz for some customer frequencies) squarewave signal that is routed from the reference divider to the phase detector (U603–2) to serve as the reference frequency input.

The loop frequency input of the phase detector (U603–23) receives the negative feedback for the PLL. This comes from the VCO, at a frequency proportional to the voltage on the VCO's steering line (P650–2).

The VCO, an FET RF oscillator (Q1401), multiplies the frequency up to the transmit frequency or the receive injection frequency (53.9 MHz below the designated frequency). A programmable N divider divides the VCO frequency down to the loop frequency as follows:

$$f_{(loop)} = F_{(VCO)}/N$$

where: $f_{(loop)}$ = N divider loop frequency output

$f_{(VCO)}$ = VCO output frequency

N = integer

The loop frequency and the reference frequency are applied to the phase detector (U603–23 and U603–2, respectively), whose function is to generate a DC output voltage proportional to the phase difference between these two frequencies. Phase is the controlling variable, since there may be small phase errors in the locked loop, but frequency errors cannot occur. The AC output voltage of the phase detector (PHASE DET OUT at U603–15) goes via the loop adaptive filter to the VCO steering line, thus completing the feedback loop. The loop filter controls the PLL closed loop response and removes noise from the phase detector output.

If the VCO output frequency goes high, the N divider loop frequency output also goes high, thus causing a leading phase displacement at the phase detector loop input. Since the reference signal phase does not change, the internal circuits of the phase detector detect this condition and lower the DC voltage output U603–15. This signal goes to the VCO steering line via the loop adaptive filter, causing a reduction in frequency. This compensates for the original frequency difference.

2. 2 LOOP PROGRAMMING AND CONTROL

For frequency generation and control, the microcomputer reads the programming information from the personality board memory module, combines it with the synthesizer control information, and multiplexes this information to the programmable divider (U602). The programming information, contained in six four–bit words, goes to the multiplex programmed divider via four data lines (D0, D1, D2, and D3) and via three data word address lines (A0, A1, and A2).

Address lines A0, A1, and A2 in the multiplexing sequence tell the divider which of the six four–bit words the microcomputer is sending on the data lines.

Of the bits sent to the divider, one selects either the transmit or the receive VCO operation. This bit is transferred from the divider (U602–19) to the transmit–receive VCO band switching network, which supplies TX +9.4V to the VCO transmit switching circuitry via P650–3. Another bit determines the frequency range of the VCO. This bit is transferred from the divider (U602–20) to the range shift network, which gives the proper range shift information to the VCO's via P650–5 and P650–6. Sixteen bits program the A and B counters, which are inside the programmable divider. Two bits program a reference divider. Two latched bits ($\overline{C0}$ and $\overline{C1}$) go from the multiplex programmed divider to the programmable variable–modulus prescaler (U602–15 and U602–16, respectively) to control its operation during the divide cycle. Two other latched outputs from the divider, $\overline{S0}$ and $\overline{S1}$, are used by the sample–and–hole phase detector to control the loop adaptive filter. When set high, $\overline{S1}$ indicates a change in frequency. In this case, a seventh word clears the frequency change indication by setting $\overline{S1}$ low, thus generating a control pulse. $\overline{S0}$ switches between the transmit and receive loop filters (high for transmit filter).

The six four–bit words on the data lines remain the same once the condition of synthesizer operation and the frequency have been selected. Any change in radio mode makes the microcomputer address different memory locations in the memory module. Consequently, the six four–bit words may send different information to the divider via the data lines. The microcomputer notifies the divider, via the STROBE line, when the binary information on the data and address lines can be read into the divider and latched in without any chance of error.

2. 3 DIVIDER

The programmable N divider works by "dual–modulus prescaling." It uses two dual–modulus prescalers, a divide–by–3–or–4 prescaler (with its own internal programmable C counter) and a divide–by–63–or–64 prescaler. The divide–by–63–or–64 prescaler, with programmable counters A and B, is inside divider U602. The output frequency of each prescaler is first divided by one divisor to obtain a fixed number of counts, then divided by a second divisor to obtain a different number of counts. The total division performed by this system may be set to an integral value N by the programming of counters A, B, and C. This system of division allows the basic division function of programmable divider U602 to be expanded to a higher operating frequency with no loss of resolution.

Each output frequency requires that a different value of N be programmed into the programmable counters. On the positive–going loop pulse edge, the divide–by–3–or–4 prescaler starts dividing by four and continues to do so until the C counter reaches zero. At this time, the prescaler enters into the divide–by–3 mode. Once the loop pulse goes low, the C counter is preset to the value determined by the $\overline{C0}$ and $\overline{C1}$ bits. This causes a new cycle to begin on the positive–going edge of the next loop pulse.

The divide–by–63–or–64 variable–modulus prescaler works in a similar fashion. When a loop count begins, it initially divides by 64 for the number of times programmed into the A counter. When the A counter counts to zero, the loop pulse goes low and the prescaler changes to the divide–by–63 mode. It stays in this mode until the B counter reaches zero. At this time the loop pulse goes high and the cycle repeats.

Another programmable divider acts on the 14.4–MHz reference oscillator input frequency at U602–2 to produce one of two reference frequencies: 5 kHz or 6.25 kHz. One word of the frequency select data contains two bits (D0 and D1) that select one reference frequency, as shown in Table 1.

Table 1. Reference Frequency Selection

D0	D1	REFERENCE FREQUENCY
0	0	unused
1	0	6.25 kHz
1	1	5.00 kHz

The frequency select data also contains bits TX and $\overline{RANGE}$. Bit $\overline{RANGE}$ selects the VCO range shift window for the selected operating frequency. (Refer to the VCO paragraph for details on the range shift windows.) When the VCO bit is latched into the divider, $\overline{RANGE}$ is forwarded from U602–20 as a RANGE SHIFT signal to the range shift switching network. It is then routed via the feedthrough plate to the VCO. An NPN transistor on U600 compensates for the differing modulation characteristics of the VCO windows. When the RANGE SHIFT signal is low (at U602–20), the transistor turns on, sending a lower–amplitude audio signal to the VCO. (The VCO requires less audio input to fully modulate the RF signal when U602–20 is low than when it is high.)

2. 4 PHASE DETECTOR

Phase detector U603 compares the reference and loop frequency outputs of the divider circuit and uses this information to generate a DC output signal that controls the VCO frequency. The phase detector also monitors the FREQUENCY CHANGE line ($\overline{S1}$) and the LOW BANDWIDTH SELECT line ($\overline{S0}$) and uses this information to generate control signals for the adaptive filter.

The phase detector output signal level is controlled by the length of time between the positive transition of the reference signal and the positive transition of the loop signal. When the reference signal goes high (at U603–2), ramp generator Q603 turns on, maintaining a constant current through C630. This constant current generates a linear rise (ramp) in the voltage at U603–24. The rise of the ramp voltage halts when the LOOP signal (at U603–23) switches to a high level, causing Q603 to turn off.

The positive transition of the loop signal, in addition to halting the ramp generator, resets an internal sample timing circuit. The ramp voltage is held constant for a time determined by sample timing capacitor C631. During this time, the two hold capacitors (C632 and C633) are charged to a level determined by the ramp voltage. At the end of the sample time, the ramp capacitor is discharged in preparation for the next cycle.

The accumulated charge on the hold capacitors controls the conduction of a push–pull output driver. The output driver consists of an internal NPN transistor and an external PNP transistor controlled by the signal at U603–17. The PHASE DETECTOR OUTPUT signal at U603–15 is coupled, via the adaptive filter, to the VCO, where it controls the generation of injection frequencies.

The phase detector also generates control signals for the adaptive filter. It decodes the FREQUENCY CHANGE signal at U603–5 and the LOW BAND WIDTH SELECT signal at U603–3 to generate four control signals that are coupled to the adaptive filter. These four control signals are: ADAPT, $\overline{\text{ADAPT}}$, RSW, and TSW (appearing at U603–10, –7, –9, and –8, respectively).

When operating channels are being changed in the receive mode or the mode is being changed from transmit to receive, the FREQUENCY CHANGE pulse at U603–5 causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BAND WIDTH SELECT line is low, the RSW line is driven high, the TSW is driven low, and the adaptive filter is forced into the receive–adapt mode. The $\overline{\text{ADAPT}}$ line returns to a high level and the ADAPT line returns to a low level after approximately 2.4 milliseconds under phase detector control, forcing the adaptive filter to enter into the normal receive mode.

When the PTT pushbutton is pressed, the FREQUENCY CHANGE pulse causes the ADAPT line to go high and the $\overline{\text{ADAPT}}$ line to go low. Since the LOW BANDWIDTH SELECT line is high, the TSW line is driven high, the RSW is driven low, and the adaptive filter is forced into the transmit–adapt mode. The ADAPT and $\overline{\text{ADAPT}}$ lines switch states after approximately 12 milliseconds under control of the phase detector, and the adaptive filter is forced to enter into the normal transmit mode.

While the ADAPT line is high during the transmit–adapt mode, the power amplifier is disabled. (This line connects to the personality board via J602–11.) Moreover, the ADAPT line is forced to switch to a high state when the synthesizer cannot achieve lock, thus preventing the radio from transmitting unstable or off–frequency signals.

For maximum switching speed, the microcomputer sends new data to the synthesizer at the appropriate time of the divide cycle. The phase detector forwards a SYNTHESIZER SYNC signal, from U603–4 via J602–9, notifying the microcomputer of the appropriate time to send new frequency programming information.

2. 5 ADAPTIVE FILTER

2. 5 .1 General

The adaptive filter is a low–pass filter in the steering line between the phase detector and the VCO. It removes noise and variations in the steering line level to prevent unwanted modulation of the VCO.

The phase detector controls the adaptive filter through PHASE DETECTOR OUTPUT line U603–15 to operate in one of the four selectable modes, depending upon the state of the synthesizer at a given time. The modes are transmit adapt, receive adapt, transmit, and receive. The transmit adapt mode and the receive adapt mode differ only in the amount of time spent in the adapt condition, whereas the transmit mode and receive mode each require different filter characteristics. These characteristics are selected by transmission gates that switch the filter components into and out of the steering line signal path, as required.

2. 5 .2 Filter Mode Selection

Each of the four selectable modes, transmit, receive, transmit–adapt, and receive–adapt, is selected by a unique combination of states on two complementary pairs of lines. The TSW and RSW lines make up one such pair, and the ADAPT and $\overline{\text{ADAPT}}$ lines make up the other. These lines are coupled from the phase detector to the adaptive filter and are connected to the input pins of the mode–select gates (U604 A and B). The ADAPT line is also connected to transmission gates U605 and U606.

The low–input AND gates (U604 A and B) have two output lines, TRANSMIT MODE–SELECT and RECEIVE MODE–SELECT. For each filter operation mode selected, one of these output lines is switched into a high state (between +8.6 and +9.6V). Since these gates use low–level inputs, the output of a gate goes high whenever both of its inputs go low. Or, expressed as a Boolean expression, the input/output signals of, say U604A, are:

$$\text{TRANSMIT MODE–SELECT} = \overline{\text{ADAPT}} \bullet \overline{\text{RSW}}$$

In conjunction with the ADAPT line, the out–put lines of the mode–select gates (U604 A and B) control transmission gates U605 and U606. When a selector output is forced high, the associated transmission gates turn on, passing the signals like a closed switch. Transmission gates U605A–D have ON impedances of less than 200 ohms, and gates U606A–D have ON impedances of less than 500 ohms.

2. 5 .3 Transmit Mode

When the synthesizer is in the normal transmit mode, the phase detector drives the TSW and ADAPT lines high and their complements, RSW and $\overline{\text{ADAPT}}$, low. The output of gate U604A goes high, turning on transmission gates U605A, U606A, and U606D. The natural loop frequency of the synthesizer in this mode is approximately 15 Hz. The adaptive filter stays in this mode as long as the radio is transmitting.

In this mode, the steering line is filtered by R652 and a shunt path to ground consisting of C649, C641, C634, and R653. (The ON impedance of the transmission gates is neglected.) This signal passes to the VCO via a test jumper (JU600) and J650–2.

2. 5 .4 Receive Mode

When the synthesizer is in the receive mode, the phase detector drives the RSW and $\overline{\text{ADAPT}}$ lines high and their complements, TSW and ADAPT, low. The output of gate U604B goes high, turning on transmission gates U605C and U606C. The natural loop frequency of the synthesizer in this mode is approximately 75 Hz. The adaptive filter remains in this mode while the radio is in the receive mode.

In this mode, the steering line is filtered by R635, a shunt path consisting of R636, C640, and C641, and R637 and C654. (The ON impedance of the transmission gates is neglected.) The signal passes through the test jumper to the VCO via J650–2.

2. 5 .5 Transmit–Adapt Mode

When the synthesizer is in the transmit–adapt mode, the TSW and ADAPT lines are driven high by the phase detector, and their respective complements, RSW and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, and U606D are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change frequencies rapidly. The adaptive filter is switched into this mode for approximately 15 milliseconds while the radio changes from the receive mode to the transmit mode. The transmitter is inhibited in this mode by the SYNTHESIZER ADAPT line.

In this mode, transmission gate U606B by–passes the greater part of the adaptive filter. A grounded capacitor, C641, is connected to the steering line. (The ON impedance of the transmission gates is neglected.) While the filter is in this mode, C641 and C654 are being charged. The charge on C654 prevents the VCO from changing frequency during the transition from the transmit–adapt mode to the transmit mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper via J650–2.

2. 5 .6 Receive–Adapt Mode

When the synthesizer is in the receive–adapt mode, the RSW and ADAPT lines are driven high by the phase detector, and their respective complements, TSW and $\overline{\text{ADAPT}}$, are driven low. Transmission gates U605B, U605D, and U606B are directly turned on by the ADAPT line. The synthesizer has a high natural loop frequency in this mode, allowing it to change injection frequencies rapidly. The adaptive filter switches into this mode for approximately three milliseconds while the radio changes from the transmit mode to the receive mode or from one receive frequency to another (such as when changing the operating channel of the radio).

In this mode, the greater part of the adaptive filter is shorted by transmission gate U606B, and the steering line is connected to C641. (The ON impedance of the transmission gates is neglected.) When the filter is in the receive–adapt mode, C641 and C654 are being charged. The accumulated charge on C654 prevents the VCO from changing frequencies during the transition from the receive–adapt mode to the receive mode. C654 always remains connected to the steering line. The steering line passes to the VCO through the test jumper and J650–2.

When the frequency is changed (or if, for any reason, the loop falls out of lock), the phase detector makes the adaptive filter switch to the ADAPT mode. Consequently, the $\overline{\text{ADAPT}}$ line switches to a low state, causing the OUT–OF–LOCK indicator LED to turn on. Therefore, in normal operation of the frequency synthesizer, the OUT–OF–LOCK indicator LED turns on for a brief period whenever the frequency is being changed. During Channel Scan operation, the radio can be continuously changing frequencies at a fast rate, causing the OUT–OF–LOCK indicator LED to give a dim indication. A brightly lighted indicator LED points to the presence of an out–of–lock fault in the frequency synthesizer. Thus this indicator LED is useful for troubleshooting.

Various radio functions are deactivated each time the frequency synthesizer goes into the ADAPT mode. First the high ADAPT output disables the radio audio stages via the squelch circuits on the common circuits board. In addition, the transmitter and IDC circuits are disabled via the personality board. This fail–safe feature prevents transmitter key–up (if a loss–of–lock malfunction occurs), thus preventing the generation and transmission of uncontrolled RF signals.

2. 5 .7 Super Filter

Because the VCO requires a very pure DC sup–ply voltage, an ultra–low–pass filter (U600) supplies the VCO with a very–low–noise +8.6 output voltage. The filter removes any ripple or noise present on the +9.6V supply line, thus preventing unwanted modulation of the VCO. A one–volt drop across the filter lowers the output voltage from +9.6 to +8.6V.

The super filter consists of a low–pass filter, an error amplifier, and an external series–pass transistor (Q601). The +9.6V supply is connected to U600–1 as well as to the emitter of Q601. Internally, the input from U600–1 passes through a low–pass filter to the non–inverting input of the error amplifier. C603, connected to U600–2, forms part of the low–pass filter. The output line (also connected to the collector of Q601) is fed back to the inverting input of the error amplifier through U600–4.

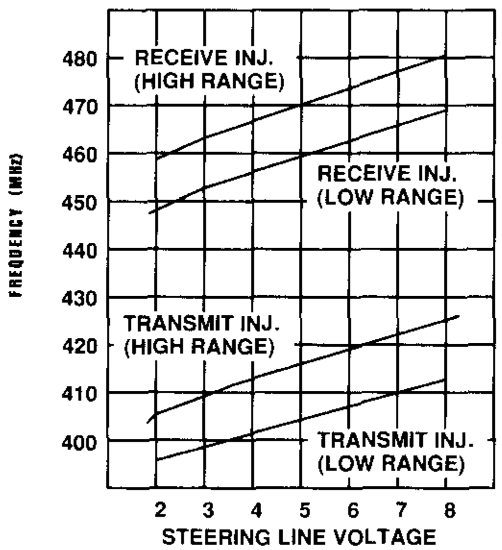
The error amplifier output, connected to the base of Q601 via U600–3, controls the conduction of the transistor. These connections enable the super filter to compare the output line voltage with the filtered input line voltage and to increase or decrease the conduction of Q601 to remove any ripple or noise from the VCO supply line.

The VCO supply is further filtered by C604, which is connected to ground. This filtered supply is then forwarded to the transmit–receive VCO switching network. Depending on the state of U602–19, transmit 8.4V or receive 8.4V is sent to the appropriate VCO through the VCO interconnect plate via J650–3 and J650–1. The filtered 8.6V supply is also forwarded to the bandshift switching network, which selects the proper state of the Bandshift 1 and Bandshift 2 lines, depending on the state of U602–20.

2. 5 .8 Feedback Buffer

A signal at the transmit or receive injection frequency is fed back from the VCO buffer to the main board. The divider/ phase detector circuits use this frequency to monitor the oscillator frequency.

The feedback buffer, Q602, accepts an input from a tap network between the two VCO buffer stages. This input signal is forwarded via a coaxial cable and connector P/J600. The feedback amplifier output is coupled to the divide-by-3–or–4 prescaler (U601) via C607.



GPW–1056–A

Figure 1. Injection Frequency vs. DC Voltage for Range 1

2. 6 VOLTAGE–CONTROLLED OSCILLATOR (VCO) AND BUFFER

2. 6 .1 General

The VCO and buffer amplifier, which supply the receive injection frequencies and frequency–modulated transmit injection frequencies, are mounted in separate compartments in the internal casting. The VCO output goes to the buffer input via a short coaxial cable. Both VCO and buffer are constructed on alumina thick–film substrates.

The VCO output frequency range for transmit and receive are listed in Table 2. A PIN diode switches the oscillator between the transmit and receive bands within a particular range. An additional PIN diode switch allows each range to be covered in two sub–ranges, the transmit and the receive frequency ranges.

Table 2. VCO Output Frequency Ranges

RANGE	TRANSMIT (MHz)	RECEIVE (MHz)
1	406–420	459.9–473.9
2	450–470	396.1–416.1
3	470–488	416.1–434.1
4	482–500	428.1–446.1
5	494–512	440.1–458.1

2. 6 .2 Oscillator Circuit

The VCO has a grounded–gate Colpitts oscillator that uses a JFET Q1401 as the amplifying element. The oscillator operates at half the desired transmit or receive injection frequency. The transmit or receive band is selected by U602 Pin 19 (BAND SHIFT) on the RF board. When Pin 19 is high, Q608 and Q609 in the RF board's TX/RX bandshifting circuit are both on. The TX/RX bandshifting circuit produces RX +8.4V for Range 1, or TX +9.4V for Ranges 2–5. The bandshifting circuit output switches on the RF PIN diode switch (CR1408 and CR1409) on the VCO via P/J650–3 and connects the TX/RX band shift resonator in parallel with the main resonator. This changes the oscillator frequency by 26.95 MHz to half the desired TX/RX frequency.

Each of these two bands is further split up into two contiguous ranges. When U602 Pin 20 ($\overline{\text{RANGE}}$) on the RF board is high, Q600 pulls the W/ W/ RANGE line (P/J650–6) low. This makes Q606 pull the $\overline{\text{RANGE}}$ line (P/J650–5) high, and RF PIN diode CR1407 on the VCO then switches C1412 across the oscillator resonator. This lowers the oscillator frequency for low–range operation. For high range, the situation is reversed. Within either range, the oscillator is tuned via the steering line as described in Section 2.6.4 below.

The VCO's transmission line resonator has microstrip capacitors plated on the substrate and interconnected with wires. These are trimming capacitors for the oscillator tank circuit. They are adjusted at the factory, and do not depend on the customer's frequencies.

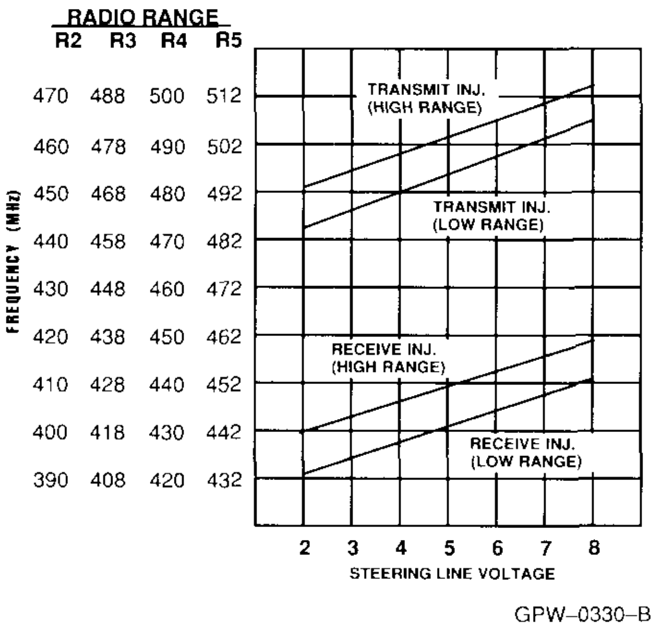


Figure 2. Injection Frequency vs. DC Voltage for Ranges 2, 3, 4, and 5

The oscillator signal is coupled to frequency doubler Q1404, which processes the desired transmit or receive injection frequency. After being filtered to reduce the half–carrier–frequency component, the doubler output goes to the buffer.

2.6.3 Buffer

The buffer is a two–stage amplifier (Q1450 and Q1451) that sends a signal either to the LLA (Low–Level Amplifier) interface board via P700 during transmit, or to the receive injection filter via P101 during receive. Keyed +9.4V, coming by wire from the RF board, turns on RF PIN diode switch CR1450 and turns off PIN diode CR1451 (by turning off Q1452). This switches the buffer output to P700 for the transmitter. In receive, keyed +9.4V is low and the two PIN diodes switch roles to deliver receive injection power to P1450.

The buffer also sends a signal via P600 to the RF board in both the transmit and receive modes to drive the prescaler to send feedback to the synthesizer. Note that the +9.6V to turn the buffer's second stage comes from the RF board via the center conductor of P600. The buffer's first stage is powered by +8.6V coming via a wire from the RF board.

2.6.4 Steering Line Circuit

The steering line, in conjunction with the rangeshift and TX/RX bandshift lines, determines the operating frequency of the VCO. The steering line is driven by the phase detector (U603) and is coupled to the VCO via the adaptive filter. The phase detector supplies a DC output voltage to maintain the VCO output at the desired frequency. When the frequency is changed, the phase detector DC output volt age shifts to change the oscillator frequency and then maintain this new frequency. Figure 1 shows the transmit and receive oscillator frequencies as functions of the steering line DC voltage.

The steering line is coupled from the RF board via J650–2 and the VCO interconnect plate. The plate contains the RF filters that shield the VCO. The steering line DC voltage level determines the capacitance of diodes CR1402, CR1403, CR1404, and CR1405. An increase in the steering line voltage causes the capacitance of these diodes to decrease and the corresponding oscillator frequency to increase. On the other hand, a decrease in the steering line voltage causes an increase in the capacitance of the diodes and a reduction in the oscillator frequency.

2.6.5 Modulation Line

During transmit, the transmit audio signals modulate the VCO directly, using varactor diode CR1408. The transmit audio signal is coupled, via Pin 4 of the VCO interconnect plate, to CR1408, which modulates the oscillator frequency.

2.7 TRANSMIT AUDIO CIRCUITS

Note

While reading the following, refer to the IDC portion of the Common Circuits Board Schematic Diagram attached to the Common Circuits Board section of this manual.

The transmit audio circuits consist of four stages that condition the microphone audio signal for direct frequency modulation of the transmit injection signal. The greater part of the audio path is controlled by the IDC ENABLE signal that is coupled to the IDC (instantaneous deviation control) circuitry via J401–6. This signal controls transmission gate U510A, which enables the transmit audio circuits only when the radio is in the transmit mode. (Transmit +9.5V is applied to the IDC ENABLE line.)

The MIC HI signal is coupled into pre–emphasis amplifier U502D via J401–5. This amplifier has a frequency response that enhances the audio frequencies toward the high end of the transmit audio frequency range (approximately 300–3000 Hz). The amplifier output (at U502–12) is coupled to U501–1. When PTT is activated, the transmission gate control line (at U501–13) switches to a high level and the signal passes through the gate to limiter/amplifier U502A.

The limiter/amplifier clips the audio signals at seven volts peak–to–peak, thus preventing excessive audio modulation of the transmitted signal. (With lower audio input levels, this amplifier acts as a linear gain stage.) The limited transmit audio signal is coupled from U502–3 to splatter filter stage U502C.

The splatter filter is a 3–kHz low–pass filter that removes higher–order harmonics from the audio signal. With unity gain, this filter attenuates high–frequency harmonics on the clipped audio signal from the limiter stage. The splatter filter output passes from U502–10 to the deviation adjust potentiometer (R517).

External modulation, such as PL or DPL, passes through gates U501B and U501C. These gates are connected in series with the external modulation inputs, and can therefore disable these modulation inputs to circuits that may require such a function. Normally, these enable lines are pulled high by the HY501 resistors. The output of each gate passes to U502B via the resistors that form part of HY502.

An output of combiner U502B is coupled to the compensation adjust potentiometer R543 and the reference oscillator. PL and DPL signals frequency–modulate the reference oscillator, thus preventing the phase detector output from defeating the direct low–frequency modulation of the VCO generated by the PL/DPL signal. (The reference oscillator and phase detector form part of the synthesizer schematic diagram.)

The audio signal at the wiper of R517 is combined with the PL/DPL signals at the compensation adjust potentiometer (R543). This combined signal then passes to the transmit VCO. The compensation adjust potentiometer, R543, is adjusted at the factory and should be readjusted only if the common circuits board, reference oscillator, or VCO is changed. R543 can be readjusted by the procedure presented in the Radio Alignment and Adjustments part of the Maintenance and Troubleshooting Section of this manual.

Reference Modulation Inhibit Switch Q502 is allowed to conduct while the radio is in the receive mode, effectively shorting the reference modulation signal line to ground. This prevents any noise induced on the line in receive mode from affecting the reference oscillator and, consequently, the receive injection frequency. During initial turn–on, C508 is charged through Q502. This action allows a stable receive frequency to be attained almost immediately. Q502 is turned off by TX +9.5V during transmit, enabling the reference modulation signal line.

3. Synthesizer Troubleshooting Procedure

3. 1 GENERAL

The troubleshooting chart at the end of this section gives a comprehensive procedure for troubleshooting the frequency synthesizer.

Major problems that may occur in the frequency synthesizer are:

- Synthesizer does not lock.
- Synthesizer locks on wrong frequency.
- Excessive reference frequency feeds through (spurs).
- Frequency lock is noisy.
- Switching response is slow.

Table 5 summarizes these problems and their possible causes. Tables 6, 7, 8, and 9 show pin connections and voltages for the phase detector, divider, prescaler, and super filter.

The frequency synthesizer troubleshooting chart mentions an open–loop test and the checking of the divider programming. The following paragraphs describe these procedures without using a flowchart.

3. 2 OPEN–LOOP TEST

3. 2 .1 Introduction

This test requires a variable power supply, a frequency counter, a dual–trace oscilloscope, a DC voltmeter, and an RF voltmeter. The Maintenance and Troubleshooting Section of this manual recommends specific models of some of these.

The open–loop test consists of four procedures:

- VCO frequency test
- loop and reference waveforms check
- phase detector check
- adaptive filter check

3. 2 .2 VCO Frequency Test

(1) Remove jumper JU600 to open the STEERING LINE loop. Connect a one–kilohm resistor to the plus terminal of a 0–10V adjustable power supply and connect the free end of the resistor to the VCO side from which JU600 was removed (the side not connected to C637). Connect the negative terminal to B–. This power supply serves as a steering line in this test.

(2) Connect a frequency counter to the divider port P600 of the internal casting. To check the VCO on transmit, press the PTT switch and monitor the frequency while slowly changing the steering voltage from 2.0V to 9.0V. Verify that changing the steering voltage results in the transmit frequencies listed in Table 3 for the appropriate RANGE/ $\overline{\text{RANGE}}$ condition. The rangeshift lines to the VCO are at J650–6 (RANGE) and J650–5 ($\overline{\text{RANGE}}$).

Table 3. VCO Output Frequencies During Transmit (MHz)

Range	RANGE = high (8.3V) $\overline{\text{RANGE}}$ = low (0.2V)	RANGE = low (0.2V) $\overline{\text{RANGE}}$ = high (8.3V)
1	406.0–412.8	412.805–420.0
2	450.0–459.6	459.605–470.0
3	470.0–478.7	478.705–488.0
4	482.0–490.7	490.705–500.0
5	494.0–502.7	502.705–512.0

If the rangeshift lines are normal, but the VCO fails to operate, the VCO is faulty and should be replaced. Also check the output level at the VCO divider port (P/J600) and verify that it is greater than −15 dBm for the specified steering line voltage range (2.0 to 9.0V).

(3) For receive, check the VCO as in Step 2. The VCO output frequency should be 53.9 MHz higher in Range 1 and 53.9 MHz lower in Ranges 2–5 than the receive frequency. Verify that changing the steering voltage results in the receive frequencies listed in Table 4 for the appropriate RANGE/$\overline{\text{RANGE}}$ condition.

Table 4. VCO Output Frequencies During Receive (MHz)

Range	$\overline{\text{RANGE}}$ = high (8.3V) RANGE = low (0.2V)	$\overline{\text{RANGE}}$ = low (0.2V) RANGE = high (8.3V)
1	459.9–466.7	466.705–473.9
2	396.1–406.1	406.105–416.1
3	416.1–424.7	424.705–434.1
4	428.1–436.8	436.805–446.1
5	440.1–448.8	448.805–458.1

Also check the output level at the VCO divider port P/J600 and verify that it is greater than −15 dBm for the specified steering line voltage range (2.0 to 9.6V). If the rangeshift lines are normal and the output level to the divider port is adequate, but the desired receive injection frequency cannot be tuned with the steering line voltage, the VCO is faulty and should be replaced.

3. 2 .3 Loop and Reference Waveforms Check

(1) Connect one channel of a dual–trace oscilloscope to U602–5 (REF OUT) and the other to U602–9 (LOOP OUT). Adjust the oscilloscope so that it triggers on the REFERENCE waveform. The oscilloscope trace should be in the chopped mode.

(2) Observe the LOOP waveform and verify that it is moving smoothly across the screen without any jitter when the steering line is varied from 1.0V to 9.6V.

Table 5. Frequency Synthesizer Problems and Possible Causes

PROBLEM	POSSIBLE SOURCE OF TROUBLE
Synthesizer does not lock.	See the Synthesizer Troubleshooting Chart.
Synthesizer locks on wrong frequency. **Note** Frequency errors of 12.5 or 18.75 kHz can be caused by a defective prescaler or by shorted or open programming from lines the divider to the prescaler (U601–7,U601–6).	Reference oscillator (U608) frequency off (should be 14.4 MHz +29 Hz).
	Divider programming from microcomputer erroneous (possible defective memory module, or code plug, or microcomputer).
	Divider U602 is defective.
	Prescaler U601 is defective.
Reference frequency feedthrough (spurs) excessive.	Hold capacitors C632, C633 defective (open is or leaky).
	Ramp capacitor C630 defective.
	Phase detector U603 defective.
	Adaptive filter in ADAPTIVE mode or shorted input to output; guard band shorted to VCO steering line or other adaptive filter mode.
Frequency lock is noisy.	Input level to prescaler (U601–1), loop divider (U602–25), or reference divider (U602–2) is marginal.
	Loose connection, cold solder joint, or faulty component.
	Noisy Q603.
	Defective phase detector U603.
	Defective divider U602 or prescaler U601 (jittery).
	Noisy 5V or 9.6V supplies.
	Defective adaptive filter (open capacitors).
Switching response is slow.	Improper synchronization from microcomputer: check divider programming.
	Malfunctioning adaptive filter: check U604, U605, U606.
	Phase detector U603 gain too low (overdamped response) or too high (underdamped response): check R625, R626, RT600, C630, Q603.
	Leaky adaptive filter capacitors or transmission gates (U605, U606, C641).
	Leaky VCO varactor diodes.

(3) Observe the REFERENCE signal and verify that its period is correct, that it has no jitter, and that one steering line voltage from 2.5 to 9.0V does not exactly yield this period on the loop divider output. (The period depends on the customer's programming requirements. In most cases, it is 160 microseconds for a 6.25–kHz reference.)

(4) If the conditions specified in Steps 2 and 3 are met, then check the divider buffer (Q602 and associated components), the prescaler (U601), the divider (U602), the reference oscillator (U608), and the divider programming. The prescaler can be checked by capacitively coupling a 200–MHz frequency counter to its output and verifying that the output is approximately one–third of the input frequency (or one–sixth the desired loop output frequency). A frequency counter does not give an exact indication of one–third of the input frequency, since the prescaler is dividing by four part of the time. The difference should not exceed 50 ppm.

3. 2 .4 Phase Detector Check

Check the phase detector (U603) by adjusting the steering line voltage for a loop period slightly longer than the reference period and then for a slightly shorter period. With a longer loop period, the phase detector output (U603–15) should switch to a high state (greater than 9V); with a shorter loop period, the phase detector output should switch to a low state (1.2V). If this does not happen, then check the phase detector and associated circuitry.

3. 2 .5 Adaptive Filter Check

Check the adaptive filter for short or open circuits by removing jumper JU600 and then checking for a high voltage on the adaptive filter side when the base detector output is high. The absence of a high voltage is an indication of a faulty condition.

3. 2 .6 VCO Steering Line Leakage

Note

Be sure to use a shielded cable with the voltmeter when making these measurements.

Check the VCO steering line leakage by removing jumper JU600 and connecting a one–megohm resistor to the VCO side. Connect the free end of the resistor to an adjustable power supply set to 9.5V. Use a high–impedance voltmeter (impedance greater than 10 megohms) to verify that the voltage drop across the resistor is less than 18 mV. A higher voltage drop (greater than 18 mV) is an indication of either a leaky VCO interconnection plate or defective VCO steering line varactors (CR1401–1404, CR1409, and CR1411–1414). To determine which is defective, re move the VCO from the RF internal casting and per form the test again. If the voltage drop is greater than two millivolts, replace the interconnection plate.

3. 3 DIVIDER PROGRAMMING TEST

The synthesizer troubleshooting chart refers to the divider programming test. For this test, use a dual–trace oscilloscope. The Maintenance and Troubleshooting Section of this manual recommends specific models. Table 8 gives the pin numbers and functions of the divider (U602). The timing diagram on the synthesizer troubleshooting chart shows the waveforms generated.

(1) Connect Channel 1 of a dual–trace oscilloscope to the STROBE line (U602–27) of the divider. Trigger the oscilloscope on the rising edge of the strobe signal.

(2) Connect Channel 2 of the oscilloscope to the A0 line (U602–23) of the divider.

(3) The waveforms on the oscilloscope should be similar to the example timing diagram. The pulse lengths depend on the frequency programmed into the memory module.

(4) Connect Channel 2 of the oscilloscope to the A1 line (U602–24) and compare the pattern on the oscilloscope with the one in the timing diagram.

(5) Repeat the procedure until A2 (U602–26), D0 (U602–11), D1 (U602–12), D2 (U602–13), and D3 (U602–14) have been checked and verified.

(6) Verify that the prescaler C inputs are as shown in Table 8. If these indications are incorrect, look for a short circuit, repair the circuit board runner, or replace the prescaler (U601).

Note

To check the programming in another way, use a single–trace oscilloscope with an external trigger input. Connect the external trigger to the strobe line and display the strobe signal on the oscilloscope to verify proper triggering. (See the timing diagram on the troubleshooting chart.) Each of the address and data lines can then be checked as in Steps 1 through 5, above.

Table 6. Super Filter Pin Connections and Voltages

PIN	FUNCTION	TO/FROM	NOMINAL VOLTAGE
1	VCC	From 9.6V regulator.	9.6V.
2	FILTER CAP.	C603.	7.1V.
3	EXT. DRIVER CONTROL	Q601 base.	8.9V.
4	8.6V OUT	To VCO.	8.6V.
5	Ground (internal NPN emitter)	From regulator.	0V.
6	Internal NPN collector	To VCO compensation potentiometer R602.	—
7	Internal NPN base	From VCO bandshift, R604, R605.	0.2V, transmit high, 0.7V, transmit low.
8	No connection	—	—

Table 7. Phase Detector (U603) Pin Connections and Voltages

PIN	FUNCTION	TO/FROM	NOMINAL VOLTAGE
1	High current ground.	---	0V.
2	REFERENCE IN	From U602–5.	0V to 4.3V square wave (200 us period).
3	LOW BANDWIDTH	From U602–17.	0V receive; 5V transmit.
4	SYNTHESIZER SYNC.	To microcomputer.	60 us positive pulse 0 – 5V at loop pulse rate; equal to pin 2 if pin 11 is low.
5	FREQUENCY CHANGE	From U602–18.	0.5 VS 11.1 us when frequency changes.
6	not connected.		
7	$\overline{\text{ADAPT}}$	To adaptive filter.	9.6 to 0.6V single pulse, 3.0 ms (Rx) dekey; 15 ms (Tx) key.
8	TSW	To adaptive filter.	0V receive, 9.6V transmit.
9	RSW	To adaptive filter.	9.6V receive, 0V transmit.
10	ADAPT	To adaptive filter.	0 – 9.0V single pulse, 3.0 ms (Rx) dekey; 15 ms (Tx) key
11	LOCK		0V when out of lock; 8V when in lock.
12	HOLD 1	CS11	1.4 to 8V (use high input impedance voltmeter).
13	HOLD 2	CS12	1.4 to 8V (use high input impedance voltmeter).
14	A+	—	9.6V.
15	PHASE DET OUTPUT	To adaptive filter.	1.2 to 9.5V (depending on loop output freq.).
16	Low Current Ground	—	0V.
17	EXT PNP BASE	To PNP Q604 base.	8.9V.
18	VCC	From regulator.	9.6V.
19	RAMP BASE	To PNP Q603 base (ramp generator).	9.1V.
20	FILTERED 9.1V	To R624, R625, RT600, C629.	9.1V.
21	RAMP RES.	To R626, PNP Q603 emitter.	8.0 to 8.7V. Rectangular wave @ reference rate.
22	SAMPLE TIMING CAP.	To C631.	0 to 2V sawtooth wave at loop pulse rate.
23	LOOP IN PULSE	From U602–9 via C628.	1.4V pulse riding on 1.6V (160 us, typical period).
24	RAMP CAP.	From C630 and ramp PNP Q603 collector.	Flat top ramp waveform at reference rate, top voltage 1.4 to 7V (depending on loop output frequency).

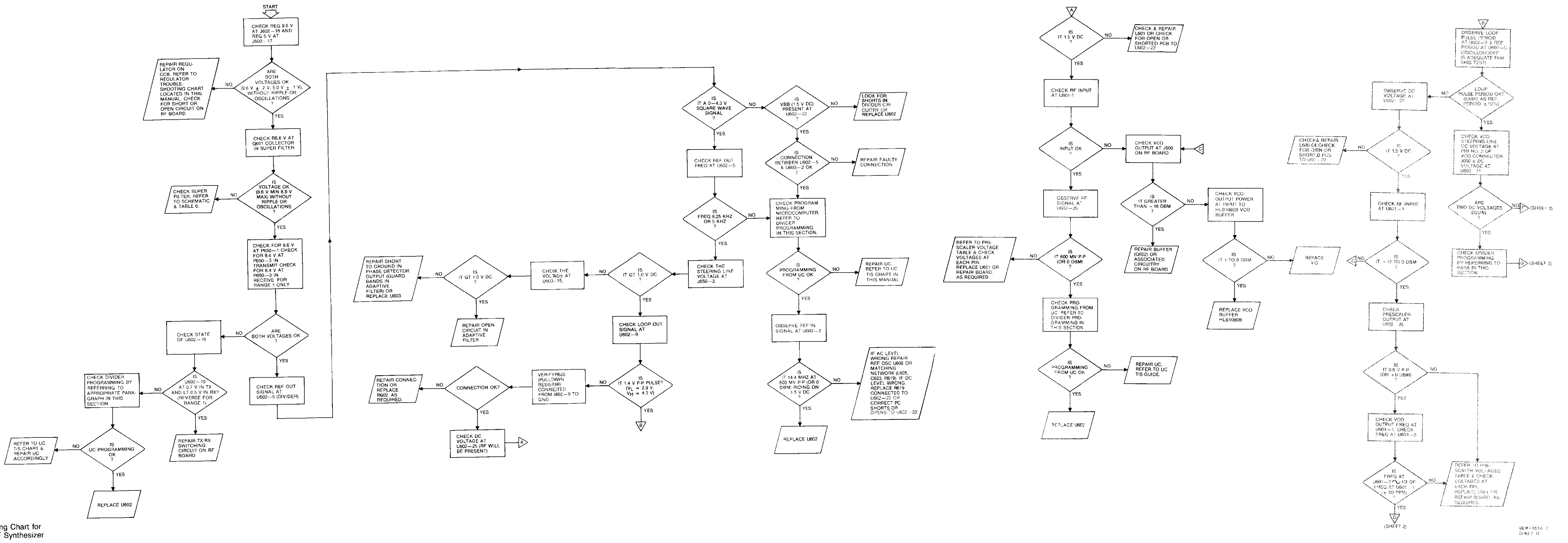
Table 8. Divider (U602) Pin Connections and Voltages

PIN	FUNCTION	TO/FROM	NOMINAL VOLTAGE
1*	GND		0V.
2	REFERENCE IN	From U608 (reference oscillator).	1.5V + 0.6V pp ac (14.4 MHz).
3*	3.6 MHz OUT	To microcomputer.	1V pp (3.6 MHz).
4	GND		0V.
5*	REFERENCE OUT	To U603–2 (phase detector).	0 to 4.3V square wave (4.16, 5, or 6.25 kHz).
6	not connected	—	—
7	not connected	—	—
8	not connected	—	—
9*	LOOP OUT	To phase detector & prescaler.	2.9V to 4.3V narrow pulse (1.4V pp) (200 us nominal period).
10*	VCC	From regulator.	5V.
11	D0	From microcomputer.	0 to 5V pulse train.
12	D1	From microcomputer.	0 to 5V pulse train.
13	D2	From microcomputer.	0 to 5V pulse train.
14	D3	From microcomputer.	0 to 5V pulse train.
15	C0	To prescaler.	0 to 5V.
16	C1	To prescaler.	0 to 5V.
17	LOW BANDWIDTH	To phase detector.	0 to 5V.
18	FREQ CHANGE	To phase detector.	0 to 5V.
19	VCO1 (TX)	To TX–RX switching.	0 to 0.7V.
20	VCO2 ($\overline{\text{RANGE}}$)	To bandshift driver.	0 to 0.7V.
21	not connected	—	—
22	VBB	To divider.	1.5V.
23	A0	From microcomputer.	0 to 5V pulse train.
24	A1	From microcomputer.	0 to 5V pulse train.
25	PRESCALE IN	From prescaler.	1.5V + 0.7V pp ac (approx. 50–80 MHz).
26	A2	From microcomputer.	0 to 5V pulse train.
27*	STROBE	From microcomputer.	0 to 5V pulse train (7 pulses/train).

*Should be checked first

Table 9. Prescaler (U601) Pin Connections and Voltages

PIN	FUNCTION	TO/FROM	NOMINAL VOLTAGE
1	FIN	from VCO buffer.	–12 to 0 dBm (at half carrier or half first injection frequency) riding on 3.8V.
2	VBB		3.8V, bypassed for RF.
3	PRESCALE OUT	to divider (U602).	0 dBm (0.6V pp) riding on level of 3.6V at approximately one–third VCO frequency (+/–50 ppm).
4	GND		0V.
5	FV	from divider (U602).	1.4V p narrow pulse at reference frequency riding on 3.4V.
6	$\overline{\text{C1}}$	from divider level (programming bit).	0 or 5V; test memory module mode 4– 0V, mode 5– 5V.
7	$\overline{\text{C0}}$	from divider level (programming bit).	0 or 5V; test memory module mode 4– 5V; mode 5– 0V.
8	VCC	from regulator.	+5.0V +/–0.1V.



Troubleshooting Chart for
Syntor X UHF Synthesizer
PW-3533-0
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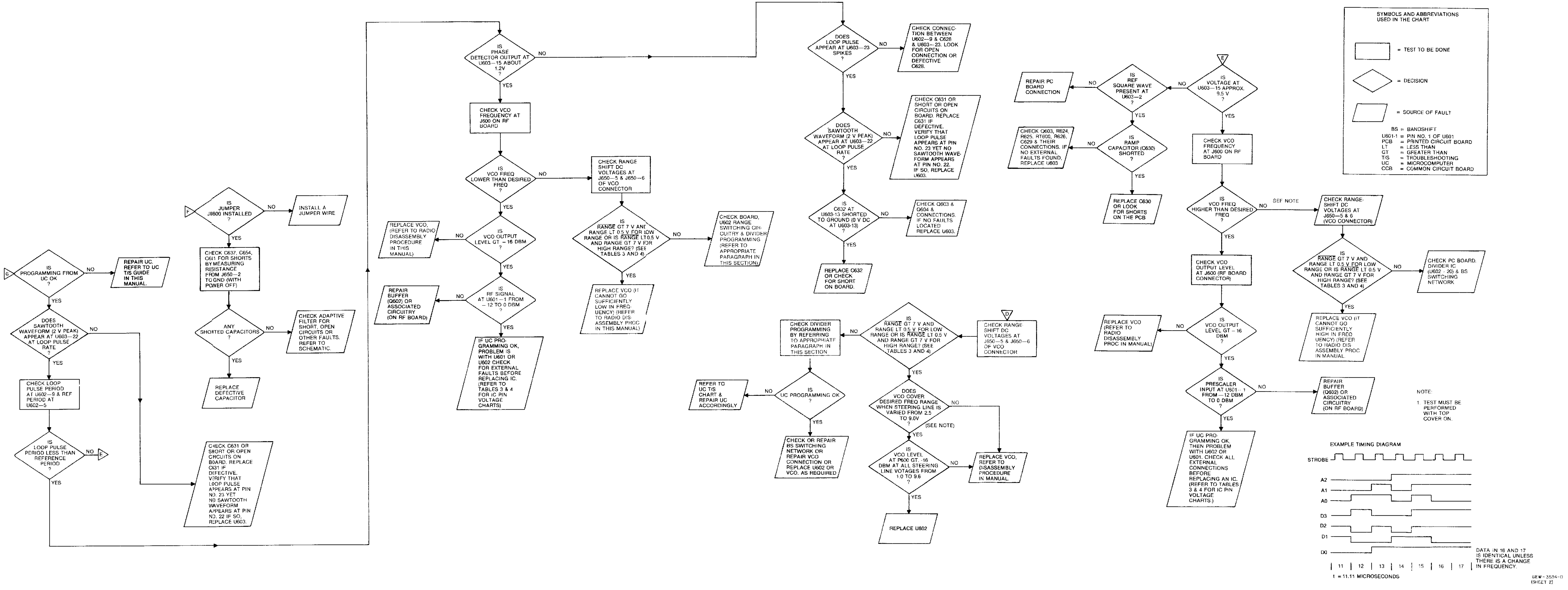
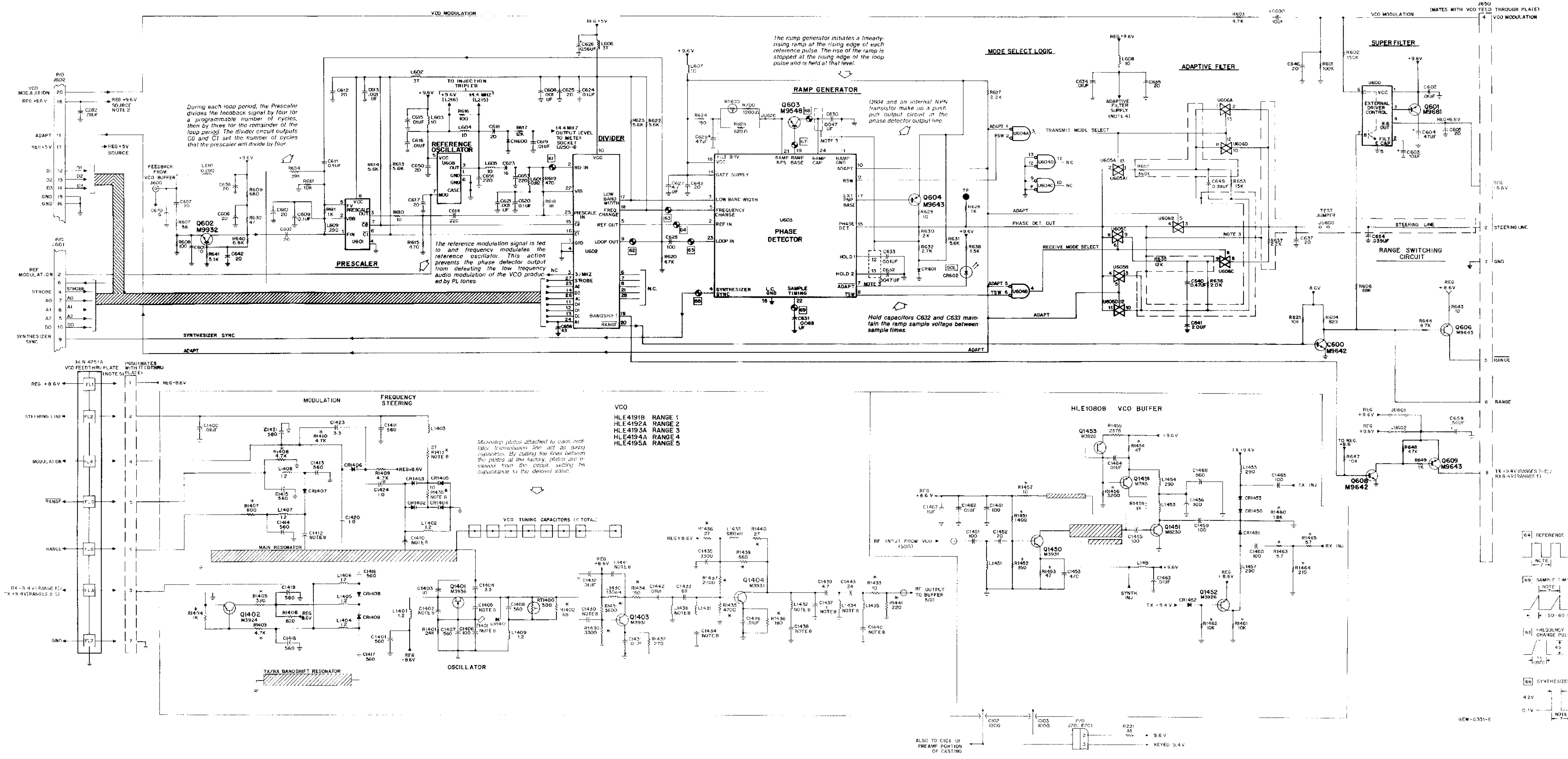


Troubleshooting Chart for
Syntor X UHF Synthesizer
PW-3533-0
(Sheet 2 of 2)
9/9/86

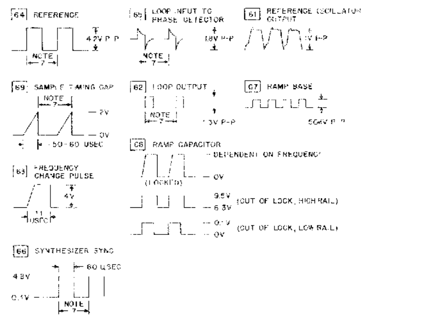
Frequency Synthesizer
Schematic



JUMPER	NORMALLY	REMARKS
JU600	IN	OUT FOR SERVICE
JU601	IN	OUT FOR RANGE 2-5
JU602	IN	OUT FOR RANGE 1

NOTES:

1. Unless otherwise stated, all resistor values are in ohms, all capacitor values are in picofarads, and all inductor values are in microhenries.
2. Pins J602-15, J602-16, and J602-18 and capacitor C282 are common to the receiver and synthesizer sections of the radio. These components are shown on both the receiver and synthesizer schematic diagrams.
3. Foil shields (guard bands) connected to the phase detector output circuit (denoted by dashed lines) surround pins U603-12, 13, and 24 as well as much of the adaptive filter section.
4. Integrated circuits within the adaptive filter section are supplied power from the regulated 9.6 V source through L608 with capacitors C635 and C634 to ground. The supply pins for these circuits are U604-14, U605-14 and U606-14. Ground for these circuits is U604-7, U605-7, and U606-7.
5. The Model HLN4251A VCO Interconnect (Feedthrough Plate) is mounted on the radio internal casting. J650 (on the RF board) is connected to one side of the plate and P650 (on the VCO board) is connected to the other. Feedthrough Filters FL1-FL7 act as π-type filters in the lines connected through the plate.
6. Resistors marked with an asterisk (*) are screened directly upon the substrate and are not field replaceable.
7. Period for waveforms at test points 62, 64, 65 & 69 is 200 usec for 5 KHZ reference and 160 usec for 6.25 KHZ reference.
8. Component value is range dependent & may not be used in every range. Refer to parts list.



Schematic, Circuit Board Diagram, and Parts Lists for Frequency Synthesizer
PW-0332-G
(Sheet 1 of 3)
8/30/88

RF BOARD, VCO, AND VCO BUFFER

Circuit Board Diagram and Parts Lists

parts list

HLN4462B RF Board Ranges 1, 3, 4, & 5 (Receiver section)
HLN5215A RF Board Range 2 (Receiver section)
HLN5424A RF Board Ranges 1, 3, 4, & 5 (Receiver section)
HLN5423A RF Board Range 2 (Receiver section) MXW–1114–D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C600	23–11013E57	10 uF, ±20%, 25V, tantalum
C601	21–11014H25	10, ±.5pF
C602	08–11051A07	.01 uF, 63V
C603	23–11013E57	10 uF, ±20%, 25V, tantalum
C604	23–82783B31	47 uF, 20V
C605–607	21–11014H32	20
C608	08–11051A01	.001 uF, 63V
C609	08–11051A13	.1 uF, 63V
C610	21–11014H32	20
C611	08–11051A13	.1 uF, 63V
C612	21–11014H32	20
C613	08–11051A01	.001 uF, 63V
C614	21–11015B05	220, ±10%
C615,616	08–11051A07	.01 uF, 63V
C617,618	21–11014H32	20
C619	08–11051A07	.01 uF, 63V
C620	08–11051A13	.1 uF, 63V
C621	08–11051A01	.001 uF, 63V
C623	21–11014H30	16
C624	08–11051A13	.1 uF, 63V
C625	21–11014H32	20
C626	23–11013F10	.56 uF, ±10%, 35V, tantalum
C627	23–11013D55	4.7 uF, ±20%, 20V, tantalum
C628	21–11015B01	100, ±10%, 100V
C629	23–11019A39	47 uF, ±20%, 16V, electrolytic
C630	08–80027B02	.0047 uF
C631	08–11017B07	.0068, ±10%, 50V
C632	08–11051A05	.0047 uF, 63V
C633	08–11017B01	.001 uF, ±10%, 50V
C634	08–11051A07	.01 uF, 63V
C635,637	21–11014H32	20
C640	08–84637L42	.47, ±10%
C641	08–83862M02	2 uF, ±10%
C642–643	21–11014H32	20
C646	21–11014H32	20
C649	08–84637L39	.39 uF, ±10%
C650	21–11014H32	20
C651,653	21–11015B05	220, ±10%
C654	08–80027B04	.039 uF
C655,656	21–83406D87	43, 500V
C657,658	21–11014H32	20
C659	23–84538G24	.56 uF, ±10%, 35V, tantalum
C670	21–82204B03	6, ±.5 pF, 500V (HLN5251A Only)
diode (see note)		
CR600	48–82139G01	germanium
CR601	48–83329G02	silicon
CR602	48–84404E01	LED
connector receptacle		
J600	09–80001F01	phono jack, female (board mounting)
J601–602	09–83445L09	10 contact, female
J650	09–83730M01	7 contact, female
jumper		
JU600	06–11009D23	0 ohm
JU601	06–11009F23	0 ohm (HLN4462B Only)
JU602	06–11009D23	0 ohm
JU626	06–11009B23	0 ohm
coil, rf		
L601	24–83397L13	.82 uH, choke
L602	24–83961B01	3 turns, coded brown
L603–604	24–82723H45	10 uH, choke
L605	24–83397L07	10 uH, choke
L606	24–83961B01	3 turns, coded brown
L607–608	24–82723H45	10 uH, choke
L609–610	24–82723H28	.29 uH
transistor (see note)		
Q600	48–11043C05	NPN, type M9642
Q601	48–11043C10	PNP, type M9681
Q602	48–11043C16	NPN, type M9932
Q603	48–00869548	PNP, type M9548
Q604, 606	48–11043C06	PNP, type M9643
Q608	48–11043C05	NPN, type M9642
Q609	48–11043C06	PNP, type M9643
thermistor		
RT600	06–80275N01	1k
resistor, fixed, ohm, ± 5%, 1/4 watt (unless otherwise stated)		
R601	06–11009A97	100k
R602	06–11009B02	150k
R603	06–11009A73	10k
R604	06–11009A47	820
R606	06–11009A93	68k
R607	06–11009A19	56
R608	06–11009C25	100
R609	06–11009A45	680
R610	06–11009A01	10
R611	06–11009A49	1k
R612	06–11009A73	10k
R613–614	06–11009A67	5.6k
R615	06–11009A41	470
R616	06–11009A25	100
R617	06–11009A75	12k

MXW–1114–D (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R618	06–11009A49	1k
R619	06–11009A41	470
R620	06–11009A65	4.7k
R621	06–11009A73	10k
R622–623	06–11009A67	5.6k
R624	06–11009A29	150
R625	06–11009A44	620
R627	06–11009A57	2.2k
R628	06–11009A49	1k
R629	06–11009A01	10
R630	06–11009A56	2k
R631	06–11009C67	5.6k
R632	06–11009A59	2.7k
R635	06–11009A75	12k
R636	06–11009A56	2k
R637	06–11009A57	2.2k
R638	06–11009A53	1.5k
R639	06–11009A17	47
R640	06–11009C69	6.8k
R641	06–11009C66	5.1k
R643	06–11009A01	10
R644	06–11009A65	4.7k
R647	06–11009A73	10k
R648	06–11009A89	47k
R649	06–11009A49	1k
R652	06–11009B11	360k
R654	06–11009C87	39k (HLN5423A, HLN5424A only)
R653	06–11009A77	15k
R700	06–11009C51	1.2k
integrated circuit (see note)		
U600	51–84768F65	super filter, type M6865
U601	51–80235C10	prescaler, type M3510
U602	51–84768F63	divider, type M6863
U603	51–83977M36	phase detector, type M7736
	or	
	51–84768F59	type M6859
U604	51–80072C01	two–input quad NOR gate, type M7201
U605	51–80073C02	quad analog switch, type M7302
U606	51–80073C03	quad analog switch, type M7303
U608	51–80291B02	reference oscillator, type M9102
mechanical parts		
E600	26–80284G01	component side shield
E601	05–84220B01	snap in rivet
E601	26–83597M01	component side prescaler shield
E602	26–83814M01	fence shield
E603	26–84978M01	shield
E604	26–83593M01	synthesizer, component side shield
E605	26–80207D02	synthesizer shield
E606	26–84862M02	solder side shield
MP600	46–83948M01	board stud

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note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

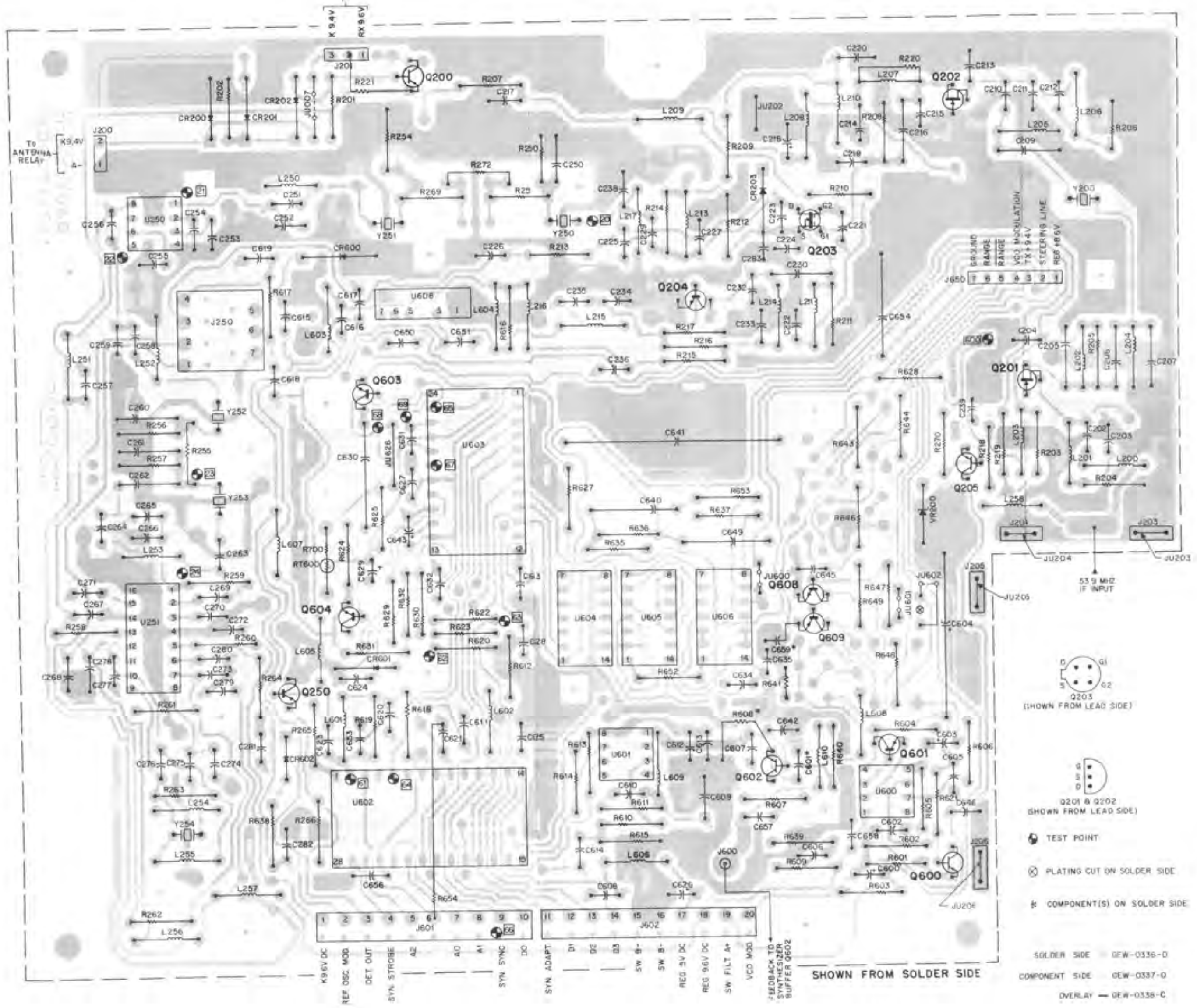
HLE4190B VCO Buffer MXW–0343–E

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±20% 50V (unless otherwise stated)		
C1451	21–13740A55	100, ±5%, 25V
C1452	21–13740A36	20, ±5%
C1453	21–13740A71	470, ±5%
C1455	21–13740A55	100, ±5%, 25V
C1456	21–84873H70	100, ±2%
C1459–1461	21–13740A55	100, ±5%, 25V
C1462–1464	21–13741A45	.01
C1465–1466	21–13740A55	100, ±5%, 25V
C1467	21–13741C17	.1, 25V
C1468	21–84873H14	560
diode (see note)		
CR1450–1451	48–84622E02	silicon pin
CR1452	48–84939C29	silicon
CR1453	48–84622E02	silicon pin
coil, rf		
L1451	24–80091G21	airwound
L1453	24–80091G01	airwound
L1458	24–80091G36	airwound
transistor (see note)		
Q1450	48–84939C31	NPN, type 39C31
Q1451	48–80182D30	NPN, type M8230
Q1452–1454	48–84939C26	PNP, type 39C26
mechanical parts		
	29–84407M01	lug connector

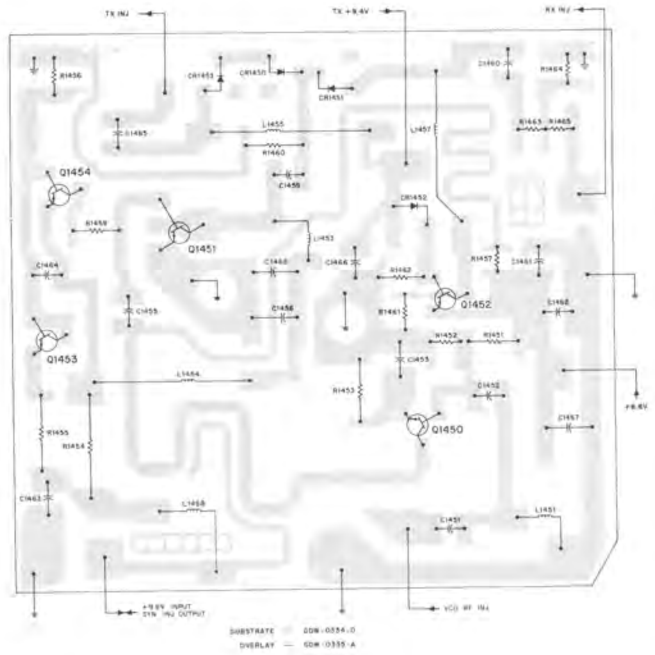
8/15/88

note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

RF BOARD



HLE1080B VCO BUFFER



HKN4157A VCO Buffer Cable MXW–2758–A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	05–00136977	eyelet (2 used)
	28–82365D02	coax plug
	37–00132251	heat shrink tubing
	76–83466K01	ferrite bead core (2 used)

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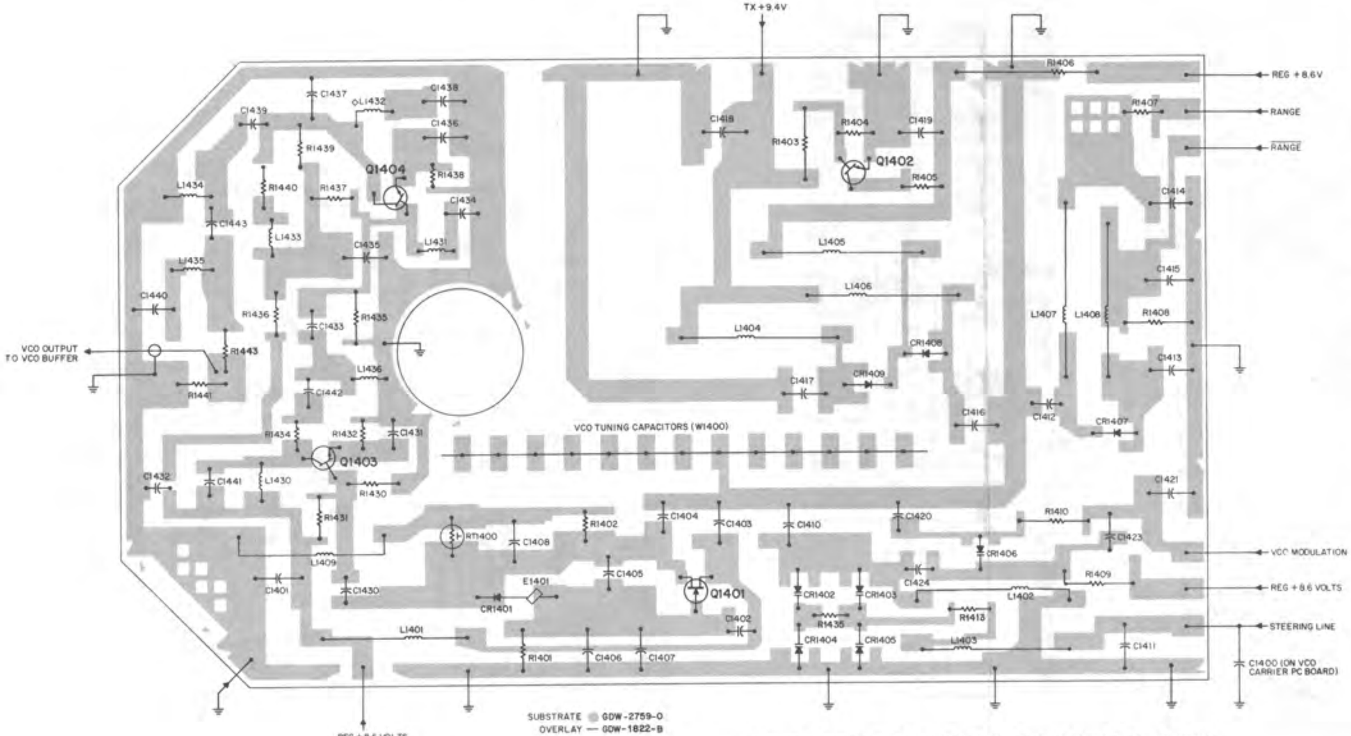
VCO
HLE4191C RANGE 1
HLE4192B RANGE 2
HLE4193A RANGE 3
HLE4194A RANGE 4
HLE4195A RANGE 5



* SCREENED ON RESISTOR, WHEN NOT USED, IS REPLACED BY COPPER RUNNER ON THE SUBSTRATE.

parts list

HLE4191C VCO (Range 1)
HLE4192B VCO (Range 2)
HLE4193A VCO (Range 3)
HLE4194A VCO (Range 4)
HLE4195A VCO (Range 5)

MXW-0342-G

RANGE 1	2	3	4	5	REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
					capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
●	●	●	●	●	C1400	21-83162H36	.01 uF, 50V
●	●	●	●	●	C1401	21-13740C11	560, 50V
●	●				C1402	21-11078A17	3.3, ±.25 pF
		●	●	●	C1402	21-11078A21	4.7, ±.25 pF
●	●	●	●	●	C1403	21-11078B13	10, ±.5 pF
●	●	●	●	●	C1404	21-11078A17	3.3, ±.25 pF
●					C1405	21-11078A21	4.7, ±.25 pF
	●	●	●	●	C1405	21-11078A13	2.2, ±.25 pF
●	●	●	●	●	C1406	21-11078B42	100
●	●	●	●	●	C1407,1408	21-13740C11	560, 50V
●		●	●		C1410	21-11078B15	12
				●	C1410	21-11078B13	12
	●				C1410	21-11078B16	13
●	●	●	●	●	C1411	21-13740C11	560, 50V
●			●	●	C1412	21-11078A17	3.3, ±.25 pF
	●	●			C1412	21-11078A21	4.7, ±.25 pF
●	●	●	●	●	C1413-1419	21-13740C11	560, 50V
●	●	●	●		C1420	21-11078A01	1.0, ±.25 pF
●	●	●	●	●	C1421	21-13740C11	560, 50V
●	●	●	●	●	C1423	21-11078A17	3.3, ±.25 pF
●	●	●	●	●	C1424	21-11078A01	1.0, ±.25 pF
●	●	●	●		C1430	21-11078A15	2.7, ±.25 pF
				●	C1430	21-11078A13	2.2, ±.25 pF
●	●	●	●	●	C1431,1432	21-13741M45	.01 uF, ±10%, 50V
●	●	●	●	●	C1433	21-05157A88	69, 50V
●	●				C1434	21-13740A33	15, 50V
		●			C1434	21-13740B28	16, 50V
			●	●	C1434	21-13740A31	12, 50V
●	●	●	●	●	C1435	21-84547A17	3300, ±20%, 25V
●	●	●	●	●	C1436	21-13741M45	.01 uF, ±10%, 50V
●					C1438	21-13740A39	27, 50V
		●	●		C1438	21-13740B33	22, 50V
				●	C1438	21-13740B32	20, 50V
	●				C1438	21-05157A83	22, ±2%, 50V
●	●	●	●	●	C1439	21-11078A21	4.7, ±.25 pF
●	●	●	●		C1440	21-11078B09	6.8, ±.25 pF
				●	C1440	21-11078B07	5.6, ±.25 pF
●	●				C1441	21-11078A21	4.7 pF, ±.25 pF
		●	●	●	C1441	21-11078A17	3.3, ±.25 pF
●	●	●	●	●	C1442	21-13741M45	.01 uF, ±10%, 50V
●	●	●	●	●	C1443	21-13740A38	24, 50V
					diode (see note)		
●	●	●	●	●	CR1401	48-84616A11	hot carrier
●	●				CR1402-1406	48-80006E10	silicon
		●	●	●	CR1402-1406	48-80006E11	silicon
●	●	●	●	●	CR1407-1409	48-84622E02	PIN, silicon
					ferrite bead		
●		●	●	●	E1401	76-80178D02	core
					connector receptacle		
●	●	●	●	●	J1400	09-83729M01	7-contact
●	●	●	●	●	P1400	07-80162D01	lead frame
					RF coil		
●	●	●	●	●	L1401-1409	24-82723H27	1.2 uH, green
●	●	●	●	●	L1430	24-80140E06	130 nH
●	●	●	●	●	L1431	24-80091G09	airwound
●					L1432	24-80091G05	airwound
	●	●	●	●	L1432	24-80091G24	airwound
●	●	●	●	●	L1433	24-80140E07	680 nH
●	●				L1434	24-80091G05	airwound
		●	●	●	L1434	24-80091G21	airwound
●	●	●	●	●	L1435	24-80091G06	airwound
●	●	●			L1436	24-80091G05	airwound
			●	●	L1436	24-80091G21	airwound
					transistor (see note)		
●	●	●	●	●	Q1401	48-84939C36	FET
●	●	●	●	●	Q1402	48-84939C24	NPN
●	●	●	●	●	Q1403,1404	48-84939C31	NPN
					resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
●	●	●	●	●	R1401	06-11077B08	24k, 1/8W
●	●	●	●	●	R1406	06-11009C47	820
					thermistor		
●	●	●	●	●	RT1400	06-00865641	300

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number. 9/30/88

Schematic, Circuit Board Diagram, and Parts Lists for Frequency Synthesizer
PW-0332-G
(Sheet 3 of 3)
8/30/88

1. Description

The *SYNTOR X* radio is a dual–conversion radio with intermediate frequencies of 53.9 MHz and 10.7 MHz. The factory–tuned preselector filter is wide enough to accommodate all frequencies in the receiver bandwidth without retuning.

The receiver circuits are in the RF internal casting, on the RF board, the personality board, and the common circuits board.

2. Theory of Operation

2. 1 INTRODUCTION

The *SYNTOR X* radio does not use channel elements to generate the first mixer injection frequency. Instead, the radio applies the frequency synthesizer RF output to the first mixer via a three–pole injection filter. The first mixer is a balanced JFET (junction field–effect transistor) device for Range 2; Ranges 1, 3, 4, and 5 use a single–ended mixer. Range 1 uses high–side injection while Ranges 2 to 5 generate a first intermediate frequency (IF) of 53.9 MHz using low–side injection.

The output of the frequency synthesizer's 14.4 MHz reference oscillator splits and applies part of the signal to the injection tripler. The injection tripler uses a Class C bipolar transistor amplifier to generate the required harmonics. The injection tripler output is tuned at a fixed injection frequency of 43.2 MHz. The second mixer uses the two input signals to generate a second intermediate frequency of 10.7 MHz. The second mixer also uses low–side injection.

2. 2 SECOND IF CIRCUITRY

The second IF circuitry uses several stages of filtering and amplification. Selective IF filtering is done with dual–resonator, mode–coupled monolithic crystals cut to a fundamental frequency of 10.7 MHz. No tuning is required in the second IF or detector circuitry.

The second mixer's output is applied to the four–pole filter (Y250 and Y251) via a matching network, and the output of the first six–pole filter is applied to a matching network, then to a high–gain (approximately 45dB) second IF amplifier (U250). The output of the second IF amplifier goes to a matching network, a four–pole filter (Y252 and Y253), a final matching circuit, and the limiter/detector (U251).

2. 3 LIMITER/DETECTOR

The limiter/detector (U251) generates a limiting function and a means for recovering audio from the frequency–modulated carrier. Audio is recovered form the second IF signal by means of a quadrature detector in the limiter/detector and an external two–pole dual–resonator crystal. The recovered audio from the limiter/detector output posses through an emitter–follower buffer (Q250), then goes to the audio stages on the personality board (via the personality board and the control unit). The detector buffer supplies approximately 650 millivolts rms to the control unit.

2. 4 AUDIO AND SQUELCH

Detected audio goes to the optional PL/DPL circuitry, then to the control unit for application to the volume and squelch controls. The adjustable outputs for these voltage dividers go to the radio for application to the respective audio and squelch circuits.

The incoming signals are buffered and filtered by the PL–filter/audio–shaping stages to remove any receive PL tones. These stages consist of quad operational amplifier U440 and associated circuitry up to the input of the audio driver (U441). The audio power amplifier consists of audio driver U441, the driver transistor pairs, and the Class B complementary audio finals, Q448 and Q449. The audio power amplifier amplifies the filtered audio signals, and the amplified audio signal is then transformer–coupled to the external speaker. The transmit time–out timer tone and any tones from option boards are also injected at the input of the audio power amplifier stage.

Squelch muting is controlled at two points: at series–connected FET Q442 in the PL filter and shunt transistor Q441

W10001S05–E
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on the volume wiper line. Q442 is used for squelch muting as well as for muting in the priority Channel Scan mode while the priority channel is being sampled. The MUTE line drives not only transistor Q441, but also the audio driver enable switch, Q447. When the audio driver is disabled, the bias current to the audio finals is removed, thus reducing substantially the current drawn by the radio in the standby mode.

2.5 SQUELCH OPERATION

The squelch control on the control unit varies the signal level of the buffered detector output. This signal, a combination of noise and recovered audio, is shaped by the squelch circuitry, which has good squelch characteristics because of:

- a high–pass filter ahead of the first amplifier to attenuate the audio frequencies to a specific level,
- capacitors C403 and C404, which attenuate noise at frequencies above 22 kHz to leave a band of noise susceptible to detection,
- an input network to the detector that further attenuates audio and any harmonics generated by audio limiting at the output of the second amplifier/limiter.

The filtered noise routes to a positive–peak detector, which adds negative–going spikes at its output. These spikes are forwarded to the integrator and the variable squelch–tail control circuitry. The integrator compares the average DC level of the detector's output with a reference level and generates a fast–responding output signal, VO, as follows: V is greater than 4.5V for squelched, and less than 4.5V for unsquelched.

The detector's output also goes to Q402 via a dual–time constant network consisting of R416, CR403, and R417. If the signal is weak, or in the absence of a signal, the noise spike rate becomes high enough to keep C410 discharged below the turn–on voltage of Q402. The collector of Q402 therefore has a potential of +9.6V. When the signal level increases, Q402 turns on and its collector voltage, VO, begins to decrease. With a strong signal, the collector voltage reaches a minimum level of approximately 4V. For a given level at the integrator output, the voltage across C411 varies directly with VO of Q402.

Q403 generates an output signal (SQUELCH TAIL) that is a delayed and inverted version of the integrator output. The microcomputer mutes the audio when the SQUELCH TAIL signal goes low (0V) and unmutes the audio when the signal goes high (4.8V). The Q403 turn–on voltage at the node between R418 and R422 is approximately 4.5V. This voltage is determined by the 9.6V supply, R420, C411, and the dual–time constant network comprised of R418, R419, and CR404.

With loss of signal, the greater the voltage across C411, the longer it takes the node voltage (R418 and R422) to increase above 4.5V, and thus the longer the SQUELCH TAIL signal remains high after loss of signal. Since C411 charges through R419 and CR404, the SQUELCH TAIL detect time is very short. The integrator output is inverted by Q404 and suppled as a CHANNEL ACTIVITY signal. This is a fast–responding output signal that is used only in Channel Scan operation.

2.6 RECEIVER METERING SOCKET

Use the receiver metering socket (J250) to monitor the performance of the receiver as follows;

- MS1 (pin 1 of the metering socket) shows the IF signal frequency relative to the center frequency of the quadrature detector.

Note

This should not be used for "warping" the radio onto frequency.

- MS2 shows the level of the IF signal at the input of the limiter/detector.
- MS3 shows the second mixer bias current, the proper injection level, and the high–level RF signals at the second mixer output.
- MS4 show the strength of the 14.4 MHz signal generated by the reference oscillator.
- MS5 shows the DC current to the first mixer.

2.7 MEASURING QUIETING

When making 20dB quieting measurements on a radio equipped with internal scan (W492), use the following procedure:

(1) Unsquelch the radio and set the volume control so there are 5.5Vms of noise at the speaker.

(2) Squelch the radio.

(3) Turn the signal generator on at one of the scan frequencies. The radio should stop scanning.

(4) Adjust the RF level until there is 0.55Vms of noise at the speaker (20dB).

3. Receiver Troubleshooting Procedure

This procedure leads to the cause of sensitivity loss in the *SYNTOR X* radio. Use equipment form the Recommended Test Equipment list in the Maintenance and Troubleshooting Section of this manual.

(1) Perform the preliminary checks of Table 1. If all the meter indications are correct, go to step 2.

(2) Apply a 20 millivolt signal to the antenna connector. If the meter indication at J250–3 rises above 35 uA, check the low IF amplifiers, filters, and quadrature detector.

Note

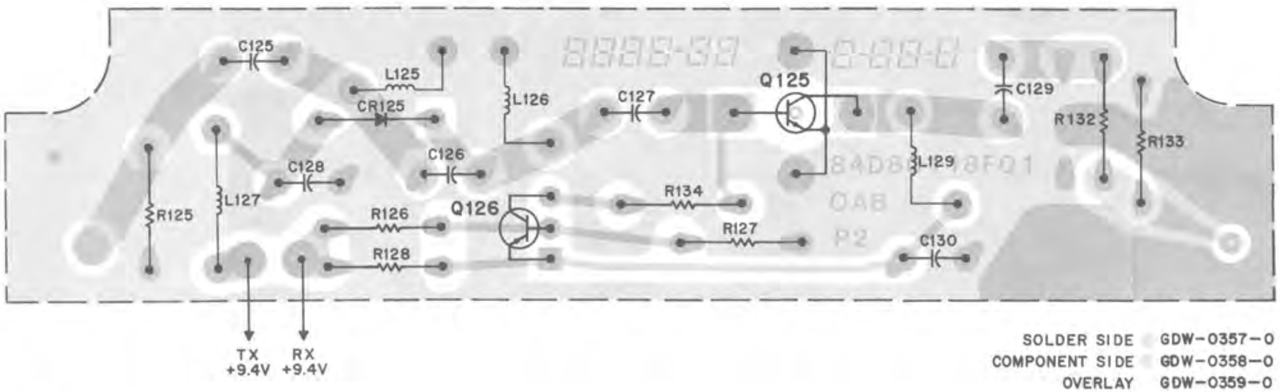
Troubleshooting of the low IF and detector is easier when you refer to the meter voltages, RF voltages, and DC voltages shown on the receiver schematic diagram at the end of this section.

If the meter indication at J250–3 is less than 35 uA, check the DC voltages of the high IF (Q201, Q202, Q203, and Q204).

Table 1. Receiver Preliminary Checks

METERING SOCKET PIN	NORMAL INDICATION	IF INDICATION IS INCORRECT
J250–1	25 ±5 uA.	Check the low IF and quad detector. See Note after step 2.
J250–2	a. (without signal): 20 +5 uA. b. (with 20dB quieting signal): should be 2 to 5 uA above first signal.	Go to step 2 of section 3.
J250–3	a. 27 +5 uA. b. (when Q204 base is	a. Check Q203 DC voltages. b. Check Q203 and Q204 shorted: should drop DC voltages 2–3uA.
J250–4	Greater than 10 uA.	Check reference oscillator output level.
J250–5	a. 10–20 uA Range 1, Range 2. b. Shorted (injection output to ground): should drop at least 20%.	a. Check first mixer 25–40 uA for proper DC voltage. b. Insufficient low filter output drive; check VCO and buffer.

SHOWN FROM SOLDER SIDE



SOLDER SIDE GDW-0357-0
COMPONENT SIDE GDW-0358-0
OVERLAY GDW-0359-0

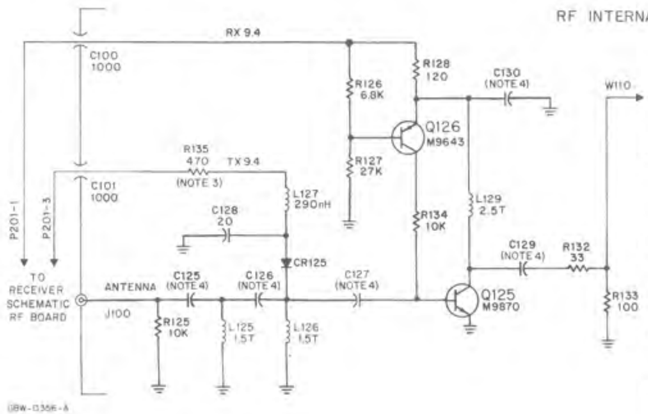
parts list

HLE4187A Preamplifier Kit (Ranges 1 and 2)
HLE4186A Preamplifier Kit (Ranges 3, 4, and 5) MXW-0360-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, μF ± 10%, 100V unless otherwise stated
C125	21-11014H16	4.3μF (Ranges 3, 4 and 5 only)
C125	21-11014H18	5.1 ± .5 μF (Ranges 1 and 2 only)
C126	21-11014H12	3 μF (Ranges 3, 4 and 5 only)
C126	21-11014H13	3.3 ± .25 μF (Ranges 1 and 2 only)
C127	21-11014H17	4.7 μF (Ranges 3, 4 and 5 only)
C127	21-11014H18	5.1 ± .5 μF (Ranges 1 and 2 only)
C128	21-11014H32	20 ± 5%
C129	21-11014H08	2 μF (Ranges 3, 4 and 5 only
C129	21-11014H13	3.3 ± .25 μF (Ranges 1 and 2 only)
C130	21-11014H29	15 μF (Ranges 3, 4 and 5 only)
C130	21-11014H36	30 ± 5% (Ranges 1 and 2 only)
		diode (see note)
CR125	48-83510F04	current control
		coil
L125, 126	24-83884G03	choke, 1½ turns
L127	24-82723H28	290 nH
L129	24-83884H07	choke, 2½ turns
		transistor (see note)
Q125	48-00869870	NPN, type M9870
Q126	48-00869643	PNP, type M9643
		resistor, ± 5%, ¼ W unless otherwise stated
R125	06-11009C73	10k
R126	06-11009C69	6.8k
R127	06-11009C83	27k
R128	06-11009C27	120
R132	06-11009C13	33
R133	06-11009C25	100
R134	06-11009C73	10k

12/08/87

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.



PRESELECTOR

NOTES:

1. Unless otherwise stated, all resistor values are in ohms, all capacitor values are in picofarads, and all inductor values are in nanohenries or T = number of turns.
2. When the optional preamplifier is ordered, it is substituted for the low-pass filter (HLN4250A). The latter is hence removed from the receiver. (Refer to EEPS-32264.)
3. R135 is connected from the preamplifier PC board to C101 in the internal casting.
4. See parts list for component values.

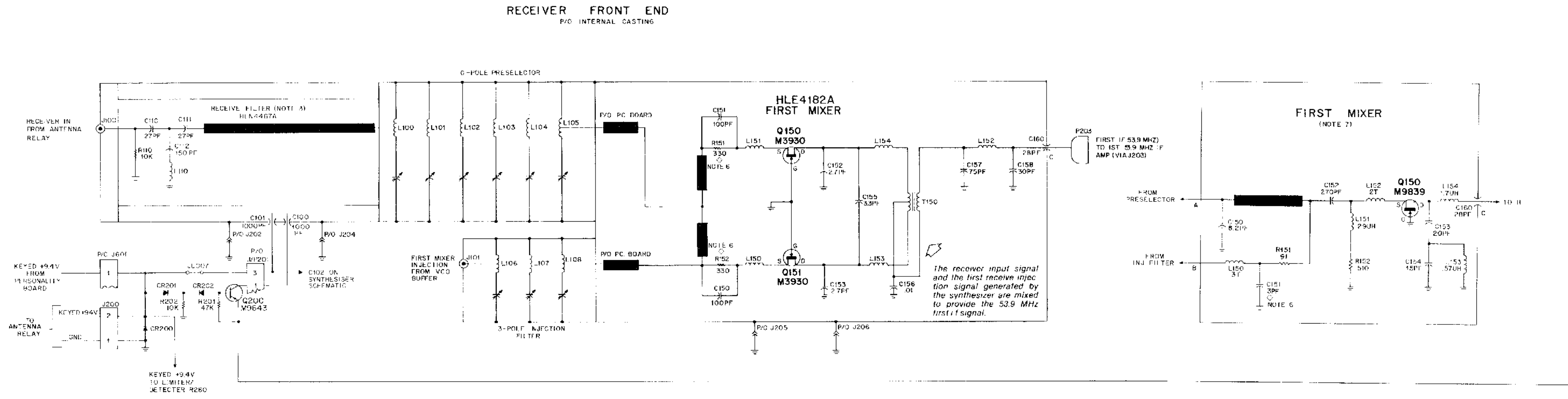
FUNCTIONAL DESCRIPTION

The HLE4187A preamplifier consists of a five-pole, high-pass filter, a PIN diode switch, a bipolar RF amplifier, and an output pad. The high-pass filter, which receives an input signal from the antenna relay via J100, prevents out-of-band interfering signals from degrading receiver performance.

The RF amplifier consists of a bipolar device (Q125) connected in a common emitter configuration. Q126 stabilizes the bias point of the amplifier, and the output pad (R131, R132, and R133) prevents interaction between the amplifier and the preselector. The amplifier runs off a switched +9.4 V supply.

The PIN diode switch (CR125), enabled by the keyed 9.4 V supply, prevents power fed back through the antenna switch during transmit from overdissipating the RF amplifier.

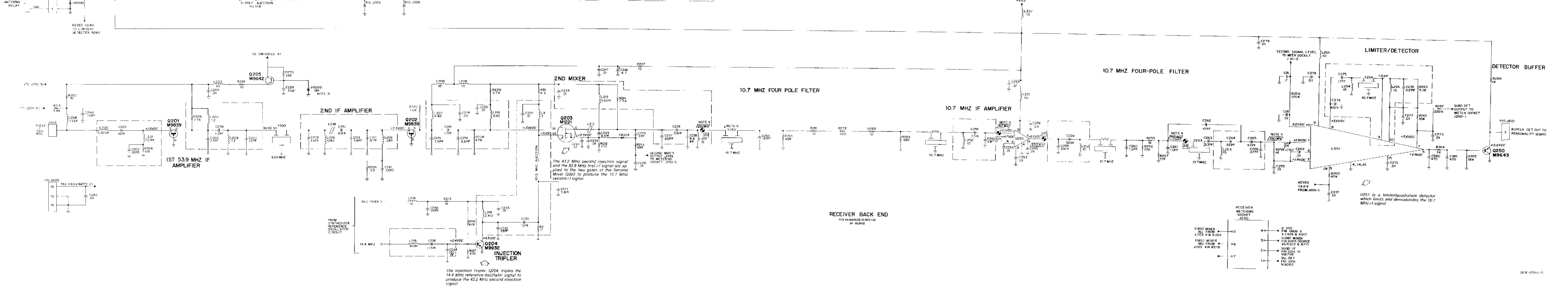
RECEIVER
Schematic



Meter Number	Meter Reading Function	Normal Indication (Approximate)
1	Quadrature detector center frequency	25 µA
2	Second i-f signal level into limiter/detector	Idle 15 µA @ 20 dBq Increases 5 µA
3	Second mixer with injection	27 µA
	Without injection (Q204 base shorted to GND)	Increases 5 µA
4	Reference oscillator	15 µA
5	First Mixer Injection level	25–40 µA for Range 2 10–20 µA for Range 1
	With injection input grounded to Mixer	20% decrease minimum

NOTES:

1. Unless otherwise stated, all resistor values are in ohms, all capacitor values are in microfarads, and all inductor values are in microhenries.
2. Pins J602-15, J602-16, and J602 18 and capacitor C282 are common to the receiver and synthesizer sections of the radio. These components appear on both the receiver and synthesizer schematic diagrams.
3. When the optional preamplifier is ordered, it is placed in this location, and the Receive Filter board is, consequently, removed.
4. Contains the rms RF voltage at these test points. These voltages should be measured with an RF voltmeter with the RF signal generator adjusted for 1 mV into the antenna connector.
5. X indicates the direction of the polarity dot on these crystals.
6. Resistors or capacitors marked with a diamond (◇) are screened directly upon the substrate or PC board, and are not field replaceable.
7. All capacitors and resistors are range sensitive parts. Values shown are fo Range 1 only. See the parts list for Ranges 3–5
8. VR200 s a 13V Zener for Range 2 Radios.



RF BOARD, FIRST MIXER AND RECEIVE FILTER

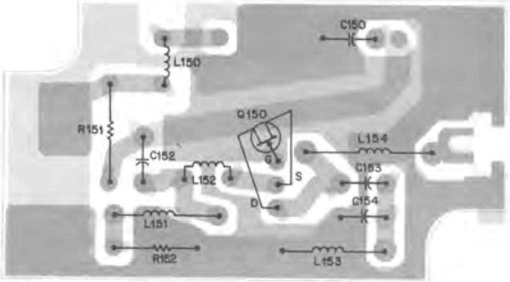
Schematics, Circuit Board Diagrams, and Parts List

HLN4467A RECEIVE FILTER

SHOWN FROM SOLDER SIDE

SOLDER SIDE GDW-0349-0
COMPONENT SIDE GDW-0350-0
OVERLAY GDW-0351-0

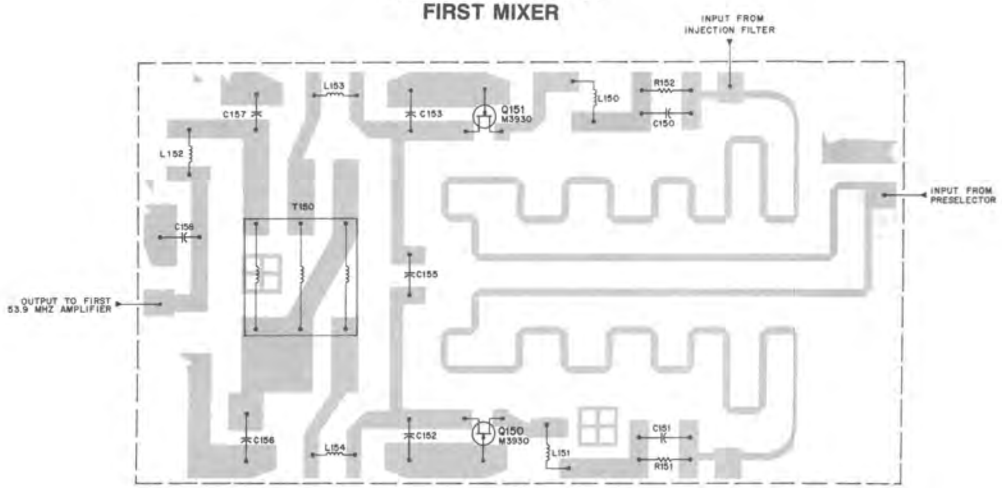
HLE4181B RANGE 1
HLE4183A RANGE 3, 4
HLE4185 RANGE 5
FIRST MIXER



SHOWN FROM SOLDER SIDE

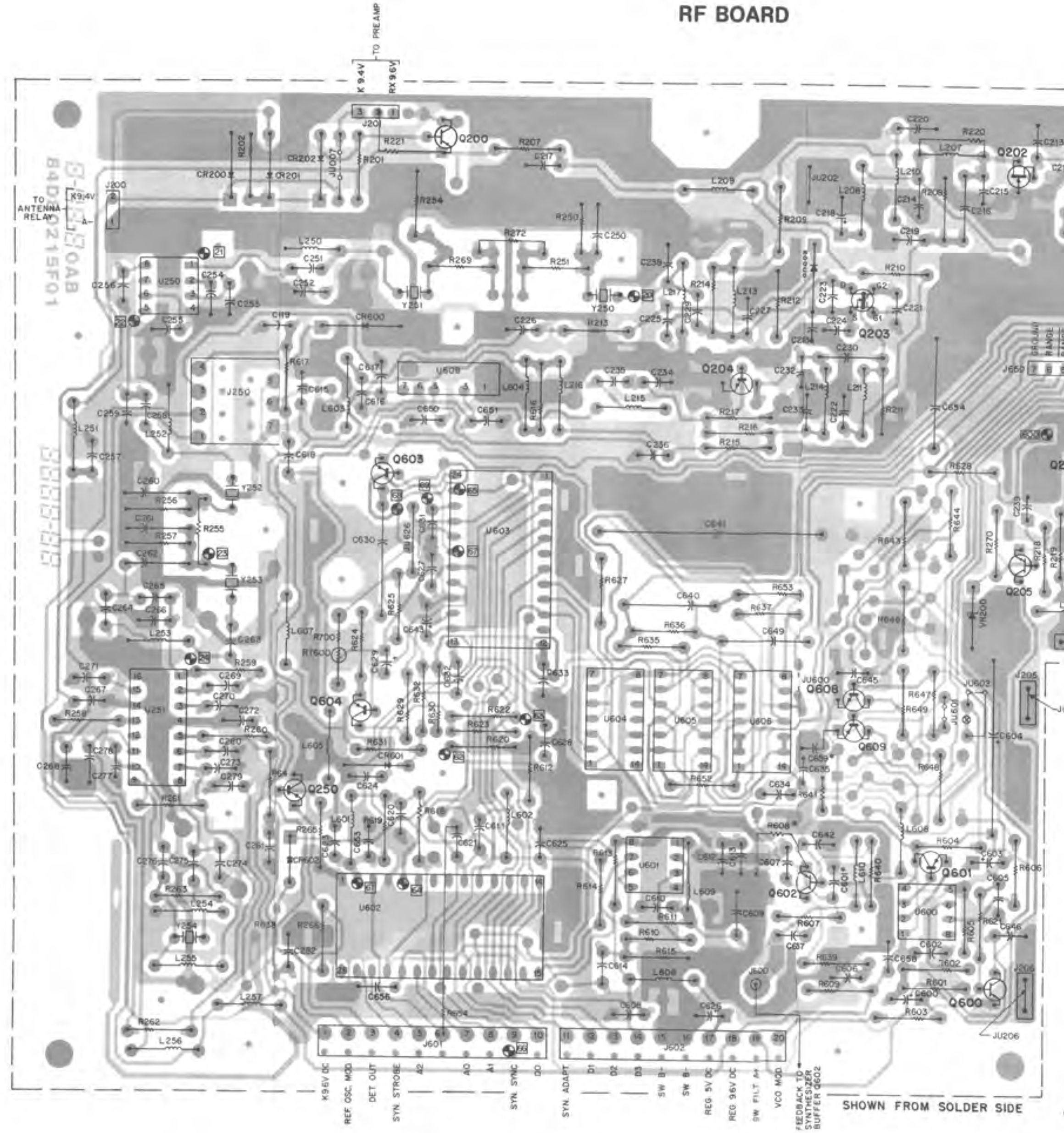
SOLDER SIDE GBW-2672-0
COMPONENT SIDE GBW-2673-0
OVERLAY — GBW-2674-0

HLE4182A RANGE 2
FIRST MIXER

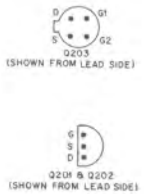


SUBSTRATE: GDW-0354-0
OVERLAY: GDW-0355-0

RF BOARD



SHOWN FROM SOLDER SIDE



TEST POINT

PLATING CUT ON SOLDER SIDE

∗ COMPONENT(S) ON SOLDER SIDE

SOLDER SIDE GEW-0336-0
COMPONENT SIDE GEW-0337-0
OVERLAY — GEW-0338-C

RECEIVER

parts list

HLN4757A/HLN4758A (with Preamp) Internal Casting (Range 1)
HLN4737A/HLN4468A (with preamp) Internal Casting (Range 2)
HLN5036A/HLN5037A (with preamp) Internal Casting (Ranges 3 and 4)
HLN4940A/HLN4941A (with preamp) Internal Casting (Range 5) MXW-0348-C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	RANGE 1 PARTS	
		connector receptacle
J100, 101	09-84135B02	phono
		coil, RF
L100	24-80134F01	coded red
L101-104	24-80134F02	coded blue
L105	24-80134F07	coded natural
L106	24-80134F06	coded orange
L107	24-80134F04	coded yellow
L108	24-80134F05	coded violet
		resistor, fixed, ±5%, ¼ W unless otherwise stated
R135	06-11009C41	470 (used with HLN4758A only)
	mechanical part	
	15-84776M07	casting
	RANGE 2 PARTS	
		connector receptacle
J100, 101	09-84135B02	phono
		coil, RF
L100	24-80134F03	coded green
L101-104	24-80134F04	coded yellow
L105	24-80134F03	coded green
L106	24-80134F01	coded red
L107	24-80134F04	coded blue
L108	24-80134F01	coded red
		resistor, fixed, Ω ±5%, ¼ W unless otherwise stated
R135	06-11009C41	470 (used with HLN4468A only)
	mechanical part	
	15-84776M09	casting
	RANGES 3 AND 4 PARTS	
		connector receptacle
J100, 101	09-84135B02	phono
		coil, RF
L100	24-80134F16	coded orange
L101-104	24-80134F14	coded violet
L105	24-80134F15	coded red
L106	24-80134F13	coded blue
L107	24-80134F12	coded green
L108	24-80134F13	coded blue
		resistor, fixed, Ω ±5%, ¼ W unless otherwise stated
R135	06-11009C41	470 (used with HLN5037A only)
	mechanical part	
	15-84776M09	casting
	RANGE 5 PARTS	
		connector receptacle
J100, 101	09-84135B02	phono
		coil, RF
L100	24-80134F08	coded blue
L101-104	24-80134F11	coded red
L105	24-80134F08	coded blue
L106	24-80134F10	coded brown
L107	24-80134F04	coded yellow
L108	24-80134F09	coded yellow
		resistor, fixed, Ω ±5%, ¼ W unless otherwise stated
R135	06-11009C41	470 (used with HLN4941A only)
	mechanical part	
	15-84776M09	casting

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HLN4467A Receive Filter Board MXW-0347-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, pF ±10% 100V unless otherwise stated
C110-111	21-11014H35	27 ±5%
C112	21-11015B03	150
		coil, rf
L110	24-83884G09	choke, 6½-turns, coded orange
		resistor, fixed, ω ±5%, ¼ watt unless otherwise stated
R110	06-11009C73	10k
	mechanical parts	
	42-80259A01	coaxial terminal clip

HLE4182A (Range 2) First Mixer MXW-0352-D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ± 5%, 100V		
C150,151	21-84873H70	100, ± 2%
C152	21-13740A13	2.7, ± 0.25 pF
C155	21-84873H01	3.3
C156	21-13741A45	.01 uF, ± 20%, 50V
C157	21-13740A52	75, 50V
C158	21-13740A40	30, 50V
coil, RF		
L150,L151	24-80091G05	air wound
L152	24-80140E06	130 nH
L153,155	24-80140E07	680 nH
transistor (see note)		
Q150, 151	48-84939C30	N-channel FET, type M3930
transformer		
T150	24-80138F01	toroid

8/30/88

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

HLE4181B (Range 1) First Mixer
HLE4183A (Ranges 3 and 4) First Mixer
HLE4185A (Range 5) First Mixer MXW-0948-B

RANGE 1	3	4	5	REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
						capacitor, fixed, pF ± 5% 100V unless otherwise stated
•	•	•	–	C150	21-11014H20	6.2 ±0.5 pF
–	–	–	•	C150	21-11014H12	3 ±0.25 pF
•	–	–	–	C152	21-11015B06	270 ± 10%
–	•	•	•	C152	21-11015B08	390 ± 10%
•	–	–	–	C153	21-11014H32	20
–	•	•	•	C153	21-11014H31	18
•	–	–	–	C154	21-11014H29	15
–	•	•	•	C154	21-11014H31	18
						coil, RF
•	•	•	•	L150	24-11030D02	choke
•	•	•	•	L151	24-82723H28	0.29 µH
•	•	•	•	L152	24-11030D01	choke
•	•	•	•	L153	24-82835G36	0.57 µH
•	•	•	•	L154	24-82835G12	1.7 µH
						transistor (see note)
•	•	•	•	Q150	48-00869839	N-channel FET, type M983
						resistor, fixed, ±5%, ¼ W unless otherwise stated
•	–	–	–	R151	06-11009A24	91
–	•	•	•	R151	06-11009A22	75
•	–	–	–	R152	06-11009A42	510
–	•	•	•	R152	06-11009A43	560

4/01/86

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

HLN4462B RF Board Ranges 1, 3, 4, & 5 (Receiver section)
HLN5215A RF Board Range 2 (Receiver section)
HLN5424A RF Board Ranges 1, 3, 4, & 5 (Receiver section)
HLN5423A RF Board Range 2 (Receiver section) MXW-1115-D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C202	21-11014H30	16
C203	08 11051A02	.0015 uF, 63V
C204	08-11051A07	.1 uF, 63V
C205-206	21-82450B13	1.5, 500V
C207	21-82450B08	1.2, 500V
C209	21 82450B47	1.0, 500V
C210	21-11014N14	6.8, ±.5 pF
C211	21-11014H48	91
C212	08-11051A02	.0015 uF, 63V
C213	21 11014H19	5.6, ±.5 pF
C214	08-11051A07	.1 uF, 63V
C215	21-11014H22	7.5, ±.5 pF
C216	21-82450B08	1.2, 500V
C217	08 11051A07	.1 uF, 63V
C218	23-11013D55	4.7 uF, ±20%, 20V, tantalum
C219	21-11014H14	3.6, ±.25 pF
C220	08-11051A07	.1 uF, 63V
C221	21 11014H19	5.6, ±.5 pF
C222	08-11051A07	.1 uF, 63V
C223	21-11014H16	4.3, ±.25 pF
C224	08-11051A07	.1 uF, 63V
C225	21 11014H08	2, ±.25 pF
C226	08-11051A07	.1 uF, 63V
C227	21-11014H32	20
C228	08-11051A07	.1 uF, 63V
C229	21 11014H19	5.6, ±.5 pF
C230	21-82450B08	1.2, 500V
C232	21-11014H37	33
C233	08-11051A07	.1 uF, 63V
C234	21 11015B03	150, ±10%
C235	21-80067A30	11.5, ±2. pF, 500V
C236	08-11051A02	.0015 uF, 63V
C238	21-11014H19	5.6, ±.5 pF
C239	23 11019A21	10 uF, ±20%, 35V, electrolytic
C240	21-11014H32	20
C250	21-82450B37	.47, 500V
C251	21 11014H35	27
C252	21-11014H40	43
C253-255	08-11051A07	.1 uF, 63V
C256	08-11051A13	.1 uF, 63V
C257	08 11051A07	.1 uF, 63V
C258	21-11014H36	30
C259	21-11014H39	39
C260-261	21-82450B47	1, 500V
C262	21 82450B37	.47, 500V
C263	21-11014H13	3.3, ±.25 pF
C264	21-11014H33	22
C265	21-11014H41	47
C266	21-11014H35	27
C267-273	08-11051A07	.1 uF, 63V
C274	21-11014H40	43
C275	21-11014H28	13
C276	21 11014H20	6.2, ±.5pF
C277	08-11051A07	.1 uF, 63V
C278	08-11051A13	.1 uF, 63V
C279	08-11051A07	.1 uF, 63V
C280 281	21 11015B09	470, ±10%
C282	08-11051A07	.1 uF, 63V
C283	21-83406D71	33 pF ±5% 500V (HLN5215A only)
diode (see note)		
CR200-203	48 11034A01	silicon
connector receptacle		
J200	28-84324M01	male, 2 contact
J201	28-84324M02	male, 3 contact
J202-206	42 83891L01	mixer clip
J250	09-84207B01	female, 7 contact
coil, rf		
L200	24-83397L13	.82 uH
L201-202	24-83397L12	1.2 uH
L203	24-82723H45	10 uH
L204	24-83397L12	1.2 uH
L205	24-83397L13	.82 uH
L206	24 82723H48	.085 uH
L207	24-83397L13	.82 uH
L208-209	24-82723H45	10 uH
L210	24 83397L13	.82 uH
L211	24-83397L12	1.2 uH
L212	76-83960B01	ferrite core
L213	24-82835G41	5.6 uH
L214	24-82723H36	.41 uH
L215	24-83397L07	10 uH
L216	24-82723H45	10 uH
L217	24-83397L08	15 uH
L218	76-83960B01	ferrite core
L250	24-83397L07	10 uH
L251	24-82723H45	10 uH
L252	24-83397L07	10 uH
L253	24 83397L08	15 uH
L254-255	24-82549D24	15 uH

MXW-1115-D (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
L256-257	24-82723H45	10 uH
L258	24-83397L12	1.2 uH
transistor (see note)		
Q200	48-11043C06	PNP
Q201-202	48-11043C12	N-Channel, FET
Q203	48-84412L21	dual gate MOS FET
Q204	48 11043C16	NPN
Q205	48-11043C05	NPN
Q250	48-11043C06	PNP
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R200	06 11009B23	jumper
R201	06-11009A89	47k
R202	06-11009A73	10k
R203	06-11009A01	10
R204	06-11009A27	120
R205	06-11009A59	2.7k
R206	06-11009A27	120
R207	06-11009A01	10
R208	06-11009A65	4.7k
R209	06-11009A59	2.7k
R210	06-11009A69	6.8k
R211	06-11009A75	12k
R212	06-11009A35	270
R213	06-11009A93	68k
R214	06-11009A59	2.7k
R215	06 11009A49	1k
R216	06-11009A65	4.7k
R217	06-11009A41	470
R218	06-11009A01	10
R219	06 11009A63	3.9k
R220	06-11009C53	1.5k
R250	06-11009A93	68k
R251	06-11009A01	10
R254	06 11009A93	68k
R255	06-11009A49	1k
R256-257	06-11009A81	22k
R258	06-11009A99	120k
R259	06 11009A49	1k
R260	06-11009A89	47k
R261	06-11009A73	10k
R262	06-11009B06	220k
R263	06 11009A66	5.1k
R264	06-11009A49	1k
R265	06-11009A79	18k
R266	06-11009A49	1k
R269	06 11009A01	10
R270	06-11009A53	1.5k
R272	06-11009C41	470
integrated circuit (see note)		
U250	51 83977M55	IF amplifier
U251	51-80069C05	quad detector
voltage regulator (see note)		
VR200	48-82256C53	18V zener (R1,3,4,5)
	48-82256C50	13V zener (R2 only)
crystal (see note)		
Y200	48-83742M02	filter
Y250	91 80011E04	10.7 MHz resonator
Y251-254	91-80011E05	10.7 MHz resonator
	mechanical parts	
	26-84898M01	circuit board shield (2 used)
	26 83594M01	component side shield (4 used)
	26-80055K01	can shield (4 used)
	26-83595M01	detector shield, component side
	26-83587M01	detector shield, solder side
	26 83586M01	solder side filter shield

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note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

MOTOROLA
Mobile Products Division

Transmitter

Section Contents

MOTOROLA
Mobile Products Division

Transmitter

1. Theory of Operation

The transmitter uses microstrip design with ceramic substrate board. All the transmitter stages consist of 50–ohm blocks with Class C amplifier circuitry. The transmitter has two major sections; the low level amplifier (LLA), and the power amplifier (PA).

The frequency synthesizer generates an RF output of 150 mW at the required transmit carrier frequency. The RF signal goes to the controlled stage of the LLA. The gain of the controlled stage and the output power of the radio change with variations in the control voltage. The controlled stage drives the LLA output stage (Q802). The IPA module has a rated output power of 2.2 watts.

The RF signal passes from the LLA to the final power amplifier via a coaxial cable. The signal then goes to amplifier stage Q803 and to stage Q804. These two stages, which are mounted on separate microstrip assemblies, can output 14W and 45W respectively.

For the 30W radio, Q803 functions as the driver stage and Q804 functions as the final amplifier. For the 78W and 100W radios, Q803 is the predriver stage and Q804 is the driver stage. The 78W and 100W final amplifiers contain three power transistors (Q805, Q806, and Q807) that operate in parallel.

The transmitter has temperature–sensing circuitry that protects the final power amplifier against high temperatures. This circuitry works in conjunction with the power control circuits to reduce the radio output power whenever the transistor temperature exceeds 80°C. The voltage drop across R801 in the power control circuitry measures the current in the final PA stage. The RF drive to the PA is reduced whenever it exceeds a safe level.

The RF power output from the final amplifier module goes to the harmonic filter, then to the directional coupler. The directional coupler measures both the forward and reflected power. Information related to the forward and reflected power is relayed to the power control circuitry on the common circuits board. The power control circuits react to any change in power by changing the RF drive to restore the RF power output to its original level.

When the reflected power at the radio output connector reaches a level that can damage the final power transistors, the power control circuitry reacts by reducing the RF power output to a safe level. The reflected power should always be less than 40% of rated output power. The directional coupler RF output goes to the antenna via a harmonic filter and the antenna switch.

2. Transmitter Tests

Note

See the Synthesizer section of the manual for information on transmit frequency, audio deviation, and modulation troubleshooting.

2.1 PRELIMINARY TEST

Connect the radio to a proper wattmeter, dummy load, and 13.4V supply.

CAUTION

Key the transmitter only while making adjustments. Make adjustments from the bottom of the radio and through the common circuits board.

2.2 CONTROL AND PROTECTION TESTS

2.2.1 Current Limiting

(1) Set POWER SET fully clockwise.

(2) Set CURRENT LIMIT fully counterclockwise.

(3) Key the transmitter and observe the radio current drain. Drain should be less than 5 uA. Rotate CURRENT LIMIT clockwise. The current drain should increase to a maximum reading of less than 30 uA before you reach the maximum clockwise position.

2.2.2 Power Set

(1) Set CURRENT LIMIT fully clockwise.

(2) Set POWER SET fully counterclockwise.

(3) Key the transmitter and observe the wattmeter. Rotate POWER SET clockwise to set the maximum power output level. See Table 1 for correct meter readings.

Table 1. Power Set Levels

RATED OUTPUT	SET OUTPUT TO:
100 watts	120 watts
78 watts	94 watts
30 watts	36 watts

2.2.3 Thermal Protection

(1) Set CURRENT LIMIT fully clockwise.

(2) Rotate POWER SET until the power reading is approximately 87.5% of the maximum. See Table 2.

Table 2. Output Levels for Thermal Protection

MAXIMUM OUTPUT	SET OUTPUT TO:
120 watts	105 watts
94 watts	82 watts
36 watts	32 watts

(3) Touch a soldering iron the RT801 (near the flange of the last final device). The power output should decrease as RT801 heats up.

2.2.4 Reflected Power Protection

(1) Set CURRENT LIMIT fully clockwise.

(2) Key the transmitter and adjust POWER SET for normal power.

CAUTION

Since the following test requires transmission without a dummy load, the transmitter should be keyed only long enough to allow verification of proper operation of the equipment.

(3) Remove the 50–ohm load from the radio. Briefly key the transmitter and verify the output power indicates less than 50%.

2.3 RF AMPLIFICATION TESTS

2.3.1 Injection

(1) Disconnect the RF drive signal to the exciter from the synthesizer (J700).

(2) Connect a 50–ohm terminated RF milli–voltmeter to the synthesizer's transmitter injection plug (P700). Residual RF drive to the exciter in the receive mode should be less than –5 dBm. Transmitter injection in the transmit mode should be greater than +22 dBm.

2.3.2 Low Level Amplifier

(1) Disconnect the LLA from the PA and re–connect it to a wattmeter and dummy load.

(2) Set POWER SET and CURRENT LIMIT to mid–rotation.

(3) Key the transmitter. The minimum output power should be greater than 2.2 watts.

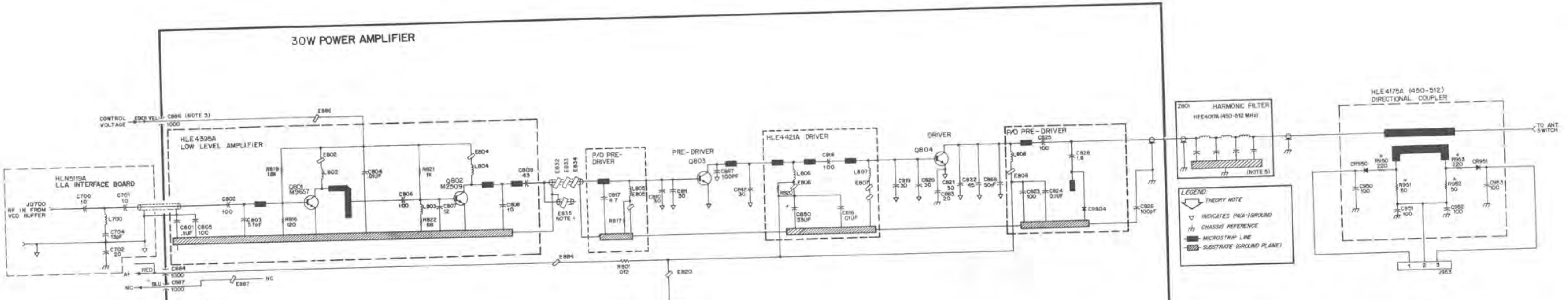
Table 3. Transmitter Troubleshooting Procedures

STEP	SYMPTOM	PROCEDURE	NORMAL INDICATION	NOT NORMAL	ACTION
1	Suspected Transmitter Failure.	Measure RF output at antenna connector.	Rated power.	Transmitter operational.	High power– perform transmitter Control & Protection Circuit Troubleshooting. No power– Go to 2. Low power– Go to 3.
2	No Output Power.	a. Set CURRENT LIMIT & POWER SET fully clockwise. Check Meter 5.	> 5 uA.	Go to b.	Go to 3.
		b. Measure DC voltage across antenna relay coil during TX.	5VDC.	Go to c.	Check coil continuity (DC resistance = 160 ohms); If good, troubleshoot relay drive circuitry.
		c. Check reed switch continuity.	Continuous during TX.	Go to d.	Replace switch.
		d. Check harmonic filter and output cable for shorts and discontinuities.	See schematic.	Go to 3.	Repair defect.
3	Low Output Power.	a. Measure DC level at collector of Q802.	> 11VDC	Go to b.	Perform Transmitter Power Control & Protection Circuit Troubleshooting Procedure
		b. Measure RF signal level at VCO buffer output.	$\pm$22dBm minimum.	Perform Power Amplifier Troubleshooting Procedure.	Perform Synthesizer Troubleshooting Procedure.

Table 4. Transmitter Control and Protection Circuitry Troubleshooting Procedures

STEP	SYMPTOM	PROCEDURE	NORMAL INDICATION	NOT NORMAL	ACTION
1	Little or No power; (POWER SET & CURRENT LIMIT) fully clockwise.	a. Disconnect LLA from controls synthesizer at J700. Check for keyed at U900–4.	9.5 VDC.	Go to step 1b.	a. Check PA ENABLE at J300–5. b. Check for synthesizer lock. c. Check PA ENABLE switch (Q902).
		b. Measure output voltage of U900D–1.	> 5 VDC.	Repair control voltage amplifiers Q900 & Q901.	Go to step 1c.
		c. Measure voltages to input of U900D–2 & –3.	pin 3 > pin 2	U900 defective.	Check for shorts or opens in resistive feed circuits of J950–2 & 3.
2	All controls inoperative.	a. Disconnect LLA from synthesizer at J700.	3V to 120V.	Go to step 3b.	Repair control voltage amplifiers Q900 & Q901.
		b. Set all controls clockwise. Measure U900B–9 & –10 in TX mode.	pin 10 > pin 9.	U900 defective.	Perform VSWR shutback Troubleshooting.
3	Current Limit inoperative.	Disconnect exciter from synthesizer at J700. Unsolder CURRENT SENSE (orange) from C887. Check drain current.	10 A.	Check for short on A+ of current sense line.	Check for fault in current limit circuit U900C and repair.

STEP	SYMPTOM	PROCEDURE
4	Reflected power (VSWR) protection inoperative.	Check and repair defect in reflected power detector components U900B, CR902, etc.
5	Thermal protection inoperative.	Check and repair defect in thermal protection components U900A, CR903, RT801, etc.
6	Power set inoperative.	Check and repair defect in forward power detector components R902, CR902, etc.



NOTES:
1. E835 IS USED IN R2 ONLY.
2. C867 IS USED IN R4 AND R5 ONLY.
3. UNLESS OTHERWISE STATED, ALL RESISTORS ARE IN OHMS, AND ALL CAPACITOR VALUES ARE IN PICOFARADS.
4. COMPONENTS MARKED WITH AN ASTERISK ARE SCREENED DIRECTLY UPON THE SUBSTRATE AND ARE NOT FIELD REPLACEABLE.
5. SEVEN FEEDTHRU CAPACITORS (C881–887) AND ONE HARMONIC FILTER ARE UNDERNEATH THE CIRCUIT BOARD, AND CAN BE REACHED ONLY FROM THE BOTTOM OF THE RADIO.

HLN4465B PA Hardware Kit — MXW-2438-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
C703	21–82428B36	.002 uF, 200V
C861,862	21–82187B44	.0016 uF
C863	21–83406D81	20, ±5%, 500V
C864	21–82187B44	.0016 uF
C865	21–83406D75	1.5, ±.25%, 500V
C866	21–82187B44	.0016 uF
C880	21–84873H66	4.7, ±.5%
C881	21–82187B44	.0016 uF
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R818	06–11045A25	100, 1/2W
mechanical parts		
	14–80142A02	power distribution
	26–80254A01	heat sink low level amp
	76–83466K01	ferrite core
	29–80218D01	grounding lug
	76–84069B04	ferrite core bead (7 used)
	29–80218D01	grounding lug
	29–80218D01	grounding lug
	32–80084A02	stud device gasket
	07–80078A01	thermistor mounting bracket
	32–80074B01	harmonic filter gasket (2 used)
	32–80084A02	stud device gasket (2 used)
	42–10283A19	cable clip
	15–84827M01	cover
	32–83896M01	gasket
	03–10911A11	machine screw M3X0.5X8
	29–84093M01	solder lug (3 used)
	37–00132057	heat shrink tubing
	42–84510M04	PA strap
	42–80137A02	substrate clip

5/9/88

HLN4046A Feedthru Plate — MXW-4502-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, 500V (unless otherwise stated)		
C881–887	21–82812H03	100, +100, –0%
mechanical parts		
	64–80005A01	feedthru plate
	04–83755H01	solder washer, 7 used

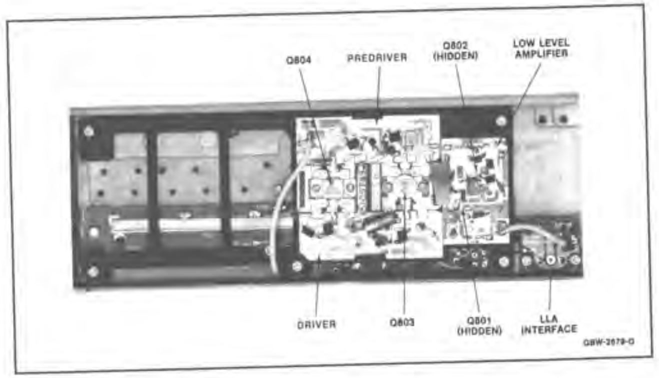
5/9/88

parts list

Associated Parts for 15/30 W Power Amplifier — MXW-2688-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		capacitor, fixed, μF ±20%, 25V unless otherwise stated
C867	21-82187B44	.001 (used in Range 2 only)
	or 21-82372C08	.02 +80, –20% (used in Range 5 only)
C868	21-82372C10	.05 μF (used in Range 1 only)
		ferrite bead
E832–834	76-80164C01	core
E835	76-83466K01	core (used in Range 2 only)
E881–887	76-84069B04	core
mechanical parts		
	42-10283A19	nylon cable clip (Range 2 only)
	75-80054F01	compression pad
	14-80142A02	power distribution board insulator
	26-80254A01	low-level amp heatsink
	07-80078A01	thermistor bracket
	32-80074B01	harmonic filter gasket
	32-80084A01	stud device gasket, 2 used
	15-84827M01	harmonic filter cover
	32-83896M01	RF gasket
	32-80211F01	harmonic filter cover gasket
	42-80137A02	substrate clip
	42-84510M02	PA strap, 4 used
	03-10943M15	tapping screw (TT3.5 × 0.6 × 8), 8 used
	01-80244H01	PA shield
	03-10911A11	machine screw (M3 × 0.5 × 8), 5 used
	15-80001G01	directional coupler cover form
	55-84300B04	handle
	03-10943M16	tapping screw (TT3.5 × 0.6 × 10), 5 used
	14-80135H01	PA hybrid insulator, 2 used

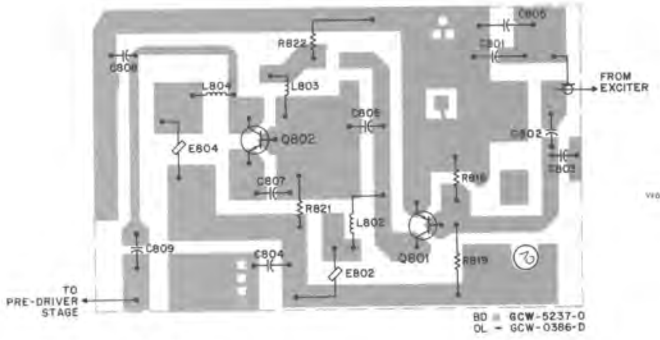
4/01/86



Schematic, Circuit Board Diagrams, and Parts Lists for 15/30 Watt Power Amplifier
PW–2675–C
(Sheet 1 of 2)
8/30/88

Power Amplifier
15/30 Watt UHF
450–512 MHz

HLE4395A LOW LEVEL AMPLIFIER (LLA)



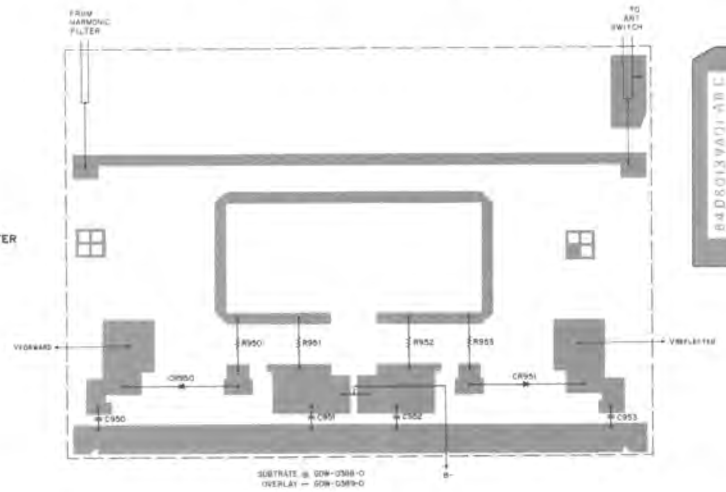
parts list

HLE4395A Low Level Amplifier		MXW–2692–B
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
C801	21–13741C17	.1, 20%, 25V
C802	21–13740A55	100 ±20
C803	21–84873H21	5.1, ±5%
C804	21–84547A05	.1, ±20%, 50V
C805	21–11078B42	100, ±5%
C806	21–13740A55	100, ±20
C807	21–84873H36	12
C808	21–84873H76	10, ±5%, 50V
C809	21–05157A86	43, ± 2%, 50V
coil, rf		
L802	24–80092G60	airwound
L803,804	24–80090G02	airwound
transistor (see note)		
Q801	48–00869657	NPN, type M9657
Q802	48–80225C09	NPN, type M25C09
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R816	06–11009C27	120
R819	06–11009C55	1.8k
R821	06–11009C49	1k
R822	06–11009C21	68
	mechanical parts	
	76–83960B01	ferrite core (2 used)

8/15/88

note: For best performance, order diodes, transistors, and integrated–circuit devices by Motorola part number.

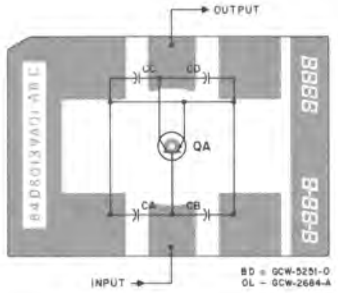
HLE4175A DIRECTIONAL COUPLER



HLE4175A Directional Coupler		MXW–0396–D
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
capacitor, fixed, pF, ±20%, 100V (unless otherwise stated)		
C950–953	21–13740A55	100
connector plug		
P952	15–84301K01	3–contact
	mechanical parts	
	07–80168F01	directional coupler frame
	29–83208M01	solder lugs (3 used)
	64–83403M01	substrate
	39–82717M01	receptacle contact
	42–10217A02	tie strap .091X3.62

8/15/88

TRANSISTOR SUBSTRATE



RANGE 1 (406–420 MHz)

QA	CA	CB	CC	CD	CF
Q803	C810	C811	N.U.	C812	C867
Q804	C819	C820	C821	C822	C868
Q805	C829	C830	C835	C836	C872
Q806	C831	C832	C837	C838	C873
Q807	C833	C834	C839	C840	C874

RANGE 2–5 (450–512 MHz)

QA	CA	CB	CC	CD	CE*
Q803	C810	C811	N.U.	C812	N.U.
Q804	C819	C820	C821	C822	N.U.
Q805	C829	C830	C835	C836	C851
Q806	C831	C832	C837	C838	C852
Q807	C833	C834	C839	C840	C853

* CE IS PART OF HLN4040A CAPACITOR KIT.

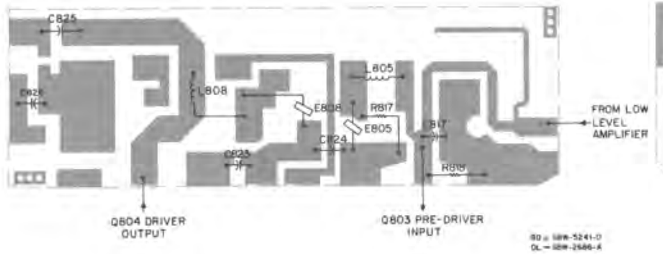
HLE4445A Transistor Kit 14W
HLE4447A Transistor Kit 50W, Range 2 & 3
HLE4448A Transistor Kit 50W, Ranges 2, 3, 4, & 5 — MXW–5488–O

REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
C810,811	21–84366F04	30, ±5%, 250V (HLE4445A only)
C812	21–11078B27	30, ±5% (HLE4445A only)
C890–892	21–84366F04	30, ±5%, 250V
C893	21–84366F06	45, ±5%, 250V
transistor (see note)		
Q803	48–84411L36	NPN, type M1136 (HLE4445A only)
Q890	48–80225C02	NPN (HLE4447A only)
Q890	48–84411L29	NPN, type M1129 (HLE4448A only)
	mechanical parts	
	07–80195B01	frame lead (2 used) (HLE4445A Only)
	07–80195B02	frame lead (2 used)
	04–80141B02	solder preform (2 used)

5/9/88

note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

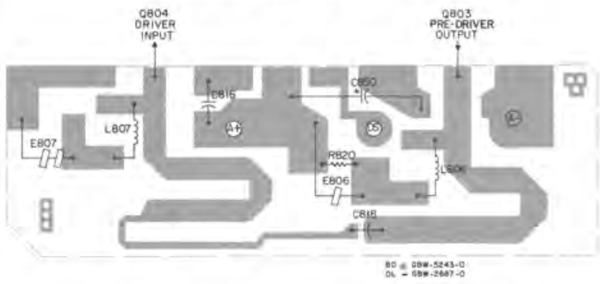
HLE4409A PREDRIVER



HLE4409A Pre–Driver		MXW–2691–B
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C817	21–11078B05	4.7, ±.25 pF
C823	21–13740A55	100, 50V
C824	21–84547A13	10 uF, ±10%, 50V
C825	21–11078B42	100
coil, rf		
L805	24–80090G01	airwound
L808	24–80090G01	airwound
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R817	06–11009C03	12
	mechanical parts	
	76–83960B01	ferrite core

8/15/88

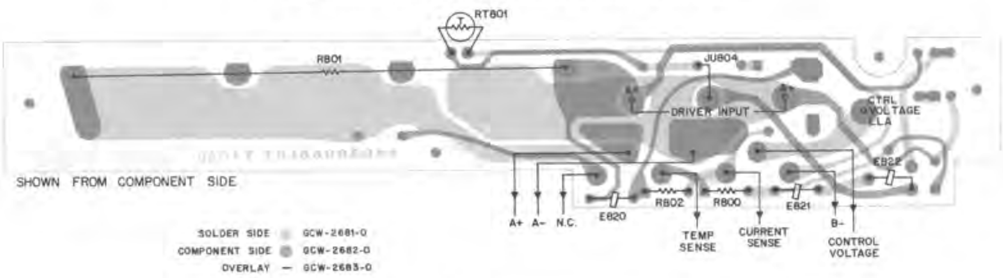
HLE4421A DRIVER



HLE4421A Driver		MXW–2689–A
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
capacitor, fixed, pF ± 20%, 50V (unless otherwise stated)		
C816	21–13740A55	.01 uF
C818	21–05157A07	100
C850	23–82783B07	33 uF, 25V
coil, RF		
L806,807	24–80090G01	air wound
resistor, fixed, ohm, ±5%, 1/4 W (unless otherwise stated)		
R820	06–11009C18	51
	mechanical parts	
E806	76–83960B01	ferrite core
E807	76–80178D02	ferrite core, 2 used

8/30/88

HLE4405A POWER DISTRIBUTION BOARD

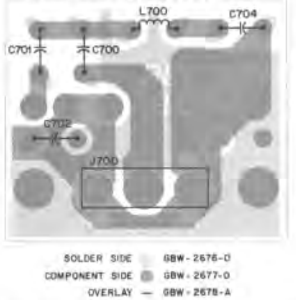


HLE4405A Power Distribution Board		MXW–2694–A
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
connector plug		
P804–807	09–80155A02	flat wafer connector (6 used)
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R800	06–11009C49	1k
R801	17–82155M01	.012 shunt
R802	06–11009C50	1.1k
thermistor		
RT801	06–83600K09	100K green
	mechanical parts	
	24–80036A02	1/2 turn ferrite choke (3 used)

5/9/88

HLN5119A LLA INTERFACE

SHOWN FROM SOLDER SIDE



HLN5119A Low Level Amplifier Interface Board		MXW-2690-O
REFERENCE SYMBOL	**MOTOROLA PART NO.**	**DESCRIPTION**
		capacitor, fixed, pF ±5%, 100V unless otherwise stated
C700, C701	21-11014H25	10 ± .5 pF
C702	21-11014H32	20
C704	21-11014H28	13
		connector receptacle
J700	09-80001F01	phono jack
		coil, rf
L700	24-11030D02	coded orange
	mechanical parts	
	29-80014A01	coaxial terminal clip

4/01/86

Schematic, Circuit Board Diagrams, and Parts Lists for 15/30 Watt Power Amplifier
PW–2675–C
(Sheet 2 of 2)
8/30/88

parts list

Associated Parts for 78/100 Power Amplifiers — MXW–0394–F

RANGE 1	RANGE 2	RANGE 3	RANGE 4	RANGE 5	REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
					capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
				•	C705	21–82372C08	.02 uF, +80, –20%, 25V
				•	C706	21–83596E37	.01 uF, +70, –30%
•		•		•	C861	21–83596E13	.001 uF, 500V
	•				C861	21–82187B44	.001 uF
•	•				C862	21–82187B44	.001 uF
•	•				C863	21–83406D81	20, ±5%, 500V
•	•				C864	21–82187B44	.001 uF
				•	C864	21–13740A55	.01 uF
•					C865A	23–82783B08	1 uF, ±20%, 35V, tantalum
•	•				C865B	21–83460D75	1.5, ±.25 pF, 500V
•	•				C866	21–82187B44	.001 uF
•					C867	21–83596E10	220, ±20%, 500V
•				•	C867	21–11015B01	100
•		•			C868	21–82187B44	.001 uF
•					C869–871	23–82783B08	1 uF, ±20%, 35V
		•			C871	21–83596E18	.0015 uF, 500V
	•				C872–874	21–83406D69	30
				•	C875	21–82187B44	.001 uF
	•				C880	21–84873H66	4.7, ±.5 pF, 50V
	•				C881	21–82187B44	.001 uF
					ferrite bead		
•	•				E830–831	76–83466K01	core
•	•	•	•	•	E832–834	76–80164C01	core
•	•				E835	76–83466K01	core
•	•	•	•	•	E681–887	76–84069B04	core
					resistor, fixed, ohm, ±5%, 1/2 watt (unless otherwise stated)		
	•				R818	06–11045A25	100
			•		R818	06–11009C29	150, 1/4W
•					R818	06–00125A33	220
	•	•			R830	06–11045A09	22
	•				R860	06–80036611	2.7, 1/4W
					mechanical parts		
•	•	•	•	•		01–80244H01	PA shield assembly
•	•	•	•	•		03–10911A11	machine screw (M3 x .5 x 8), 10 used
•	•					03–10943M15	tapping screw (TT3.5 x .6 x 8), 5 used
•	•	•				03–10943M15	tapping screw (TT3.5 x .6 x 8), 8 used
•						03–10943M16	tapping screw (TT3.5 x .6 x 10), 3 used
	•	•	•	•		03–10943M16	tapping screw (TT3.5 x .6 x 10), 5 used
		•	•	•		03–80254F01	tapping screw (3.5 x 1.27 x 8)
•	•	•	•	•		07–80078A01	thermistor bracket
•	•	•	•	•		14–80135H01	insulator, PA hybrids, 2 used
•	•	•	•	•		14–80142A02	insulator, power distribution board
•	•	•	•	•		15–80001G01	directional coupler cover form
•	•	•	•	•		15–84827M01	harmonic filter cover
•	•	•	•	•		26–80254A01	low level amplifier heatsink
•						29–00005227	solder lug
•						29–00005294	solder lug, 2 used
•	•			•		29–80218D01	grounding lug, 2 used
			•			29–00005261	solder lug
	•					29–80218D01	grounding lug, 3 used
•	•					29–84093M01	solder lug, 3 used
				•		29–84093M01	solder lug, 1 used
•	•	•	•	•		32–80074B01	harmonic filter cover gasket
•	•	•	•	•		32–80084A01	stud device gasket, 3 used
•	•	•	•	•		32–80211F01	harmonic filter cover gasket
•	•	•	•	•		32–83896M01	RF gasket
•	•					42–10283A19	nylon cable clip
•	•	•	•	•		42–80137A02	substrate clip
•	•	•	•	•		42–84510M02	PA strap, 4 used
•	•	•	•	•		55–84300B04	handle
•	•	•	•	•		55–84300B05	directional coupler cover handle

8/25/88

note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

HLN5145A Stability Kit — MXW–2936–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
C8721	21–11015A07	.01 uF, +80, –20%
coil, rf		
L830	24–82723H44	.039 uH
resistor, fixed, ohm, ±5%, 1/2 watt (unless otherwise stated)		
R831	06–00125A18	51

5/9/88

HLN4040A Capacitor Kit (Range 2 Only) — MXW–5490–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 200V (unless otherwise stated)		
C851–853	21–84493B31	57

5/9/88

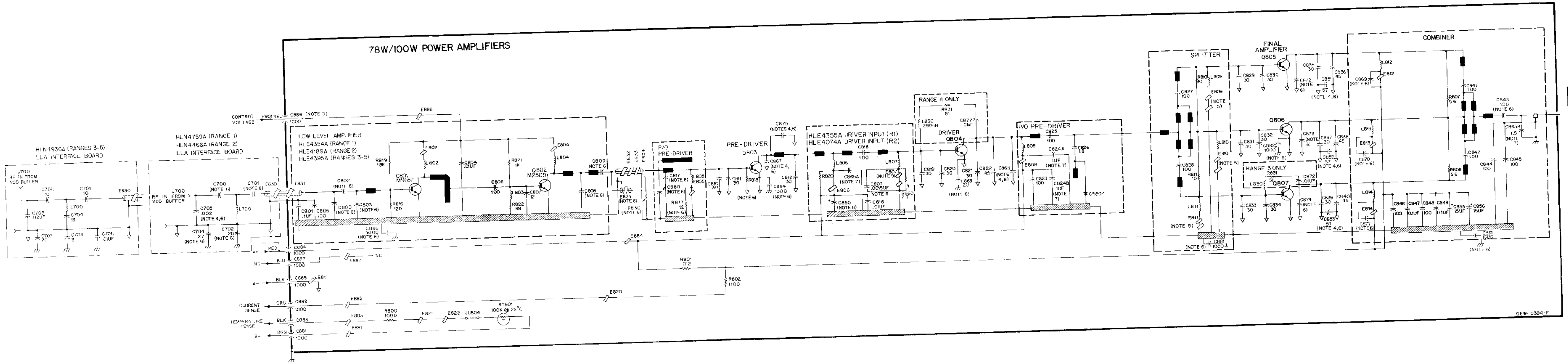
HLN4046A Feedthru Plate — MXW–4502–A

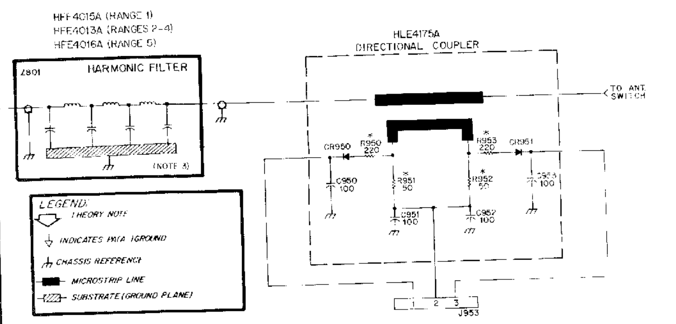
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, 500V (unless otherwise stated)		
C881–887	21–82812H03	100, +100, –0%
mechanical parts		
	64–80005A01	feedthru plate
	04–83755H01	solder washer, 7 used

5/9/88

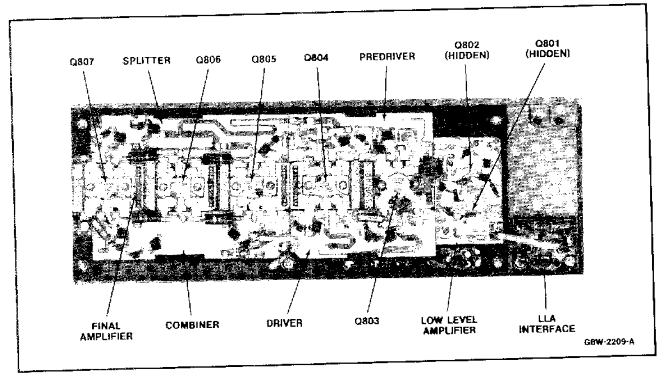
Power Amplifier

100 Watt: Range 1 (406–420 MHz)
Range 2 (450–470 MHz)
78 Watt: Range 3 (470–488 MHz)
Range 4 (482–500 MHz)
Range 5 (494–512 MHz)





NOTES:
1. UNLESS OTHERWISE SPECIFIED, ALL RESISTOR VALUES ARE IN OHMS, AND ALL CAPACITOR VALUES ARE IN PICOFARADS.
2. COMPONENTS MARKED WITH AN ASTERISK ARE SCREENED DIRECTLY UPON THE SUBSTRATE AND ARE NOT FIELD REPLACEABLE.
3. SEVEN FEEDTHRU CAPACITORS (C881–C887) AND ONE HARMONIC FILTER ARE UNDERNEATH THE CIRCUIT BOARD, AND CAN BE REACHED ONLY FROM THE BOTTOM OF THE RADIO.
4. IF CAPACITORS C705, C706, C851–853, C867, AC868, OR C875 HAVE TO BE REPLACED, MAKE CERTAIN THAT THE LEADS OF THE REPLACEMENT CAPACITOR ARE THE SAME LENGTH AS THOSE OF THE CAPACITOR BEING REPLACED.
5. E807 THROUGH E811 ARE FERRITE BEADS. RANGE 1 USES TWO (MOTOROLA PART NO. 76–80178D02) AND RANGES 2–5 USE ONLY ONE (MOTOROLA PART NO. 76–83960B01).
6. COMPONENT VALUE IS RANGE SENSITIVE AND MAY NOT BE USED IN EVERY RANGE. SEE THE PARTS LIST.
7. COMPONENT LOCATION IS RANGE DEPENDENT. SUFFIX A IS FOR RANGE 1 ONLY AND SUFFIX B IS FOR RANGE 2 ONLY.



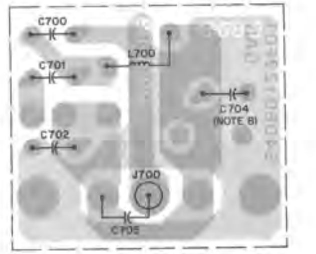
Schematic, Circuit Board Diagrams, and Parts Lists for 78/100 Watt Power Amplifier
PW–0871–G
(Sheet 1 of 2)
8/30/88

Power Amplifier

100 Watt: Range 1 (406–420 MHz)
Range 2 (450–470 MHz)
78 Watt: Range 3 (470–488 MHz)
Range 4 (482–500 MHz)
Range 5 (494–512 MHz)

LLA INTERFACE
HLN4759A (RANGE 1)
HLN4466A (RANGE 2)
HLN4936A (RANGES 3-5)

SHOWN FROM SOLDER SIDE



SOLDER SIDE = GBW-0429-O
COMPONENT SIDE = GBW-0430-O
OVERLAY GBW-0431-C

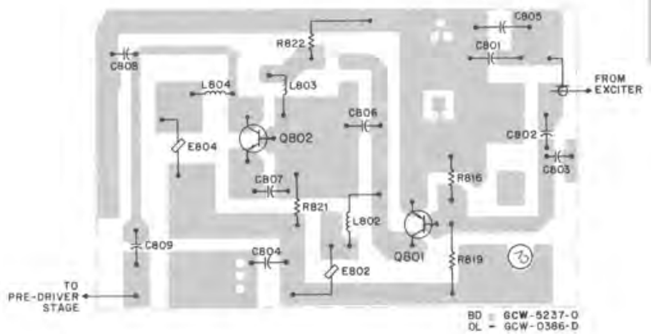
HLN4759A Low-Level Amplifier Interface Board (Range 1)
HLN4466A Low-Level Amplifier Interface Board (Range 2, 100W)
HLN4936A Low-Level Amplifier Interface Board (Ranges 3-5, 78W) — MXW-0395-D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF ±0.25 pF, 100V (unless otherwise specified)		
C700	21-11014H15	3.9
C700	21-11014H16	4.3
C700	21-11014H25	10 ±0.5 pF
C701	21-11014H12	3.0
C701	21-11014H16	4.3
C701	21-11014H25	10 ±0.5 pF
C702	21-11014H32	20
C703	21-11014H12	3
C704	21-11014H35	27
C704	21-11014H28	13
C705	21-82428E06	.002 µF ±10%, 200V
C705	21-82372C06	.02 µF +80, −20%, 25V
C706	21-83596E37	.01 µF +70, −30%
connector receptacle		
J700	09-80001F01	phono jack
coil, RF		
L700	24-83884G07	choke
L700	24-83884G03	choke
L700	24-11030D02	coiled orange
mechanical part		
	29-80014A01	coaxial terminal clip

8/19/88

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

LOW LEVEL AMPLIFIER
HLE4354A (RANGE 1)
HLE4189A (RANGE 2)
HLE4395A (RANGE 3-5)



BD = GCW-5237-O
OL = GCW-0386-D

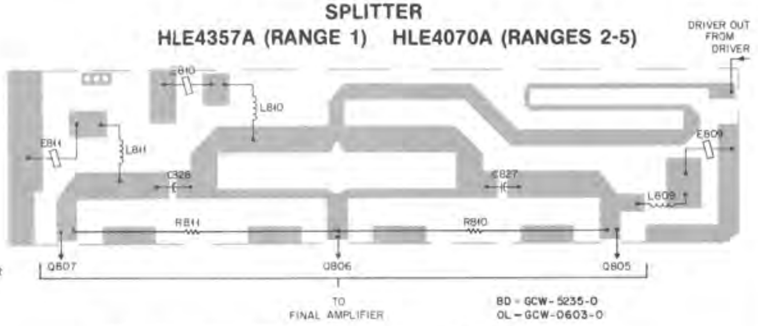
HLE4354A Low Level Amplifier (Range 1)
HLE4189A Low Level Amplifier (Range 2, 100W)
HLE4395A Low Level Amplifier (Ranges 3-5, 78W) — MXW-0390-D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF ±5%, 50V (unless otherwise stated)		
C800	21-84873H75	7. ±.25 pF
C801	21-84547A24	0.1uF, ±20%, 25V
C802	21-13740A64	240
C802	21-13740A55	100
C803	21-84873H75	7. ±.25 pF
C803	21-05632D37	240, 25V
C803	21-84873H21	5.1
C804	21-84547A05	0.01 uF, ±20%
C805	21-11078B42	100, 100V
C806	21-13740A55	100, ±20%
C807	21-13740A31	12, ±10%
C808	21-05632D37	7.7, 25, 25V
C809	21-13740A55	100
C809	21-05157A86	43
C893	23-84762H04	2.2uF, +20%, 25V, tantalum
coil, RF		
L802	24-80092G60	airwound
L803-804	24-80090G02	airwound
transistor (see note)		
Q801	48-00869657	NPN, type M9657
Q802	48-80225C09	NPN, type M25C09
resistor, fixed, Ω ±5%, 1/4 watt (unless otherwise stated)		
R816	06-11009C27	120
R819	06-11009C55	1k
R821	06-11009C49	1k
R822	06-11009C21	68
mechanical parts		
	76-83960B01	ferrite bead, 2-used

8/30/88

note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

SPLITTER
HLE4357A (RANGE 1) HLE4070A (RANGES 2-5)



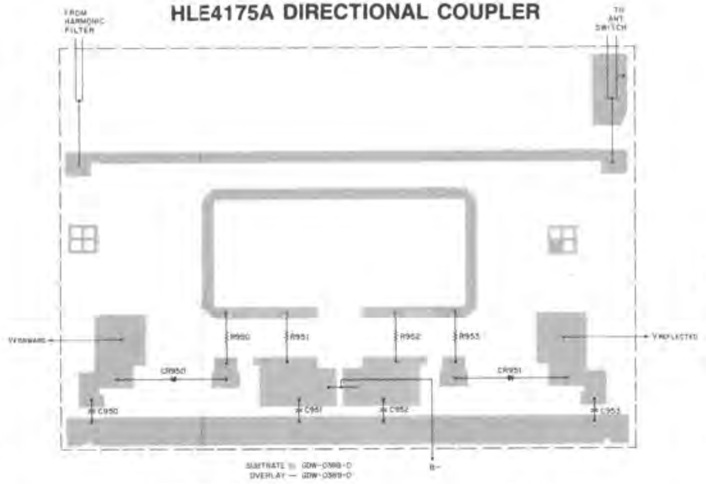
BD = GCW-5235-O
OL = GCW-0603-O

HLE4357A Splitter Substrate (Ranges 2, 3, 4, & 5) — MXW-0892-C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C827-828	21-11078B42	100
coil, rf		
L809-811	24-80090G01	airwound
resistor, fixed, ohm, ±10%, 1 watt (unless otherwise stated)		
R811	06-00126C01	10 (Ranges 2, 3, 4, 5)
mechanical parts		
E809-E811	76-83960B01	ferrite core (Ranges 2, 3, 4, & 5)
	76-80187D02	ferrite core (Range 1)

5/12/88

HLE4175A DIRECTIONAL COUPLER

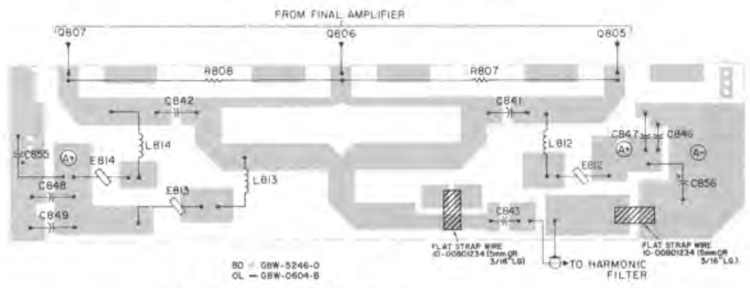


HLE4175A Directional Coupler — MXW-0396-D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±20%, 100V (unless otherwise stated)		
C950-953	21-13740A55	100
connector plug		
P952	15-84301K01	3-contact
mechanical parts		
	07-80168F01	directional coupler frame
	29-83208M01	solder lugs (3 used)
	64-83403M01	substrate
	39-82717M01	receptacle contact
	42-10217A02	tie strap .091X3.62

8/15/88

COMBINER
HLE4155A (RANGE 1)
HLE4065A (RANGES 2 AND 3)
HLE4066A (RANGES 4 AND 5)



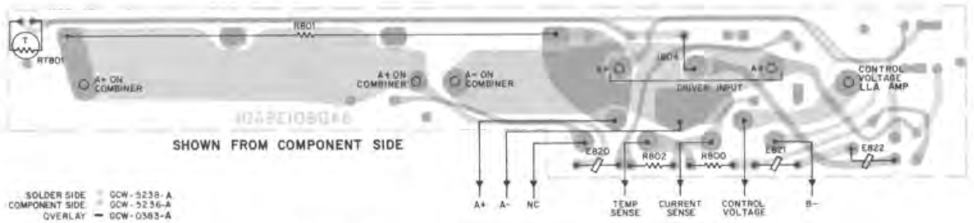
BD = GBW-5246-O
OL — GBW-0604-B

HLE4155A Combiner Substrate (Range 1)
HLE4065A Combiner Substrate (Ranges 2, & 3)
HLE4066A Combiner Substrate (Ranges 4, & 5) — MXW-0391-E

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C841-842	21-11078B42	100
C843	21-11078B36	56 (HLE4155A only)
C843	21-11078B42	100 (HLE4065A & HLE4066A only)
C844-845	21-11078B42	100
C846	21-13740A55	100. 50V
C847	21-84547A13	.1 uF, 10% 50V
C848	21-13740A55	100. 50V
C849	21-84547A13	.1 uF, 10% 50V
C855-856	23-82783B24	15 uF, ±10%, 25V, tantalum
resistor, fixed, ohm, ±10%, 1 watt (unless otherwise stated)		
R807-808	06-00126D63	5.6 (HLE4066A & HLE4155A only)
coil, rf		
L812-814	24-80090G01	airwound
mechanical parts		
	76-83960B01	ferrite core (3 used)

8/15/88

HLE4345A POWER DISTRIBUTION BOARD



SHOWN FROM COMPONENT SIDE

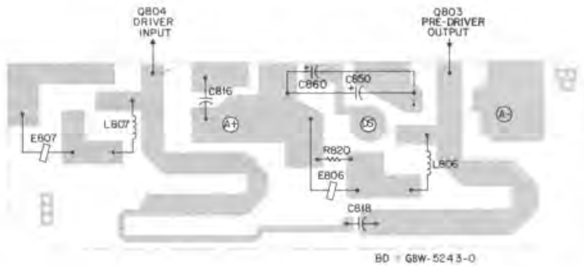
SOLDER SIDE = GCW-5235-A
COMPONENT SIDE = GCW-5236-A
OVERLAY = GCW-0583-A

HLE4345A Power Distribution Board — MXW-0869-C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
connector plug		
P801-807	09-80155A02	flat wafer
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R800	06-11009C49	1k
R801	17-82155M01	shunt, .012
R802	06-11009C50	1.1k
thermistor		
RT801	06-83600K09	100k, ±15%
mechanical parts		
	24-80036A02	1/2 turn ferrite choke (3 used)
	75-80054F01	compression pad

5/9/88

DRIVER INPUT
HLE4355A (RANGE 1)
HLE4074A (RANGES 2,3,5)
HLE4421A (RANGE 4)



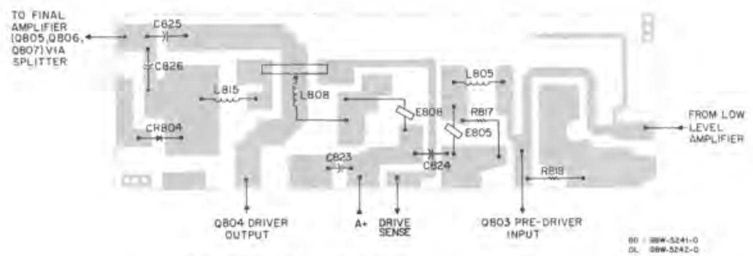
BD = GBW-5243-O
OL — GBW-5244-O

HLE4074A Driver Input Substrate (Ranges 2, 3, & 5)
HLE4355A Driver Input Substrate (Range 1)
HLE4421A Driver Input Substrate (Range 4) — MXW-5489-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±20%, 50V (unless otherwise stated)		
C816	21-84547A05	.01 uF
C818	21-13740A55	100
C850	23-82783B24	15 uF, ±10%, 25V, tantalum (HLE4074A)
C850	23-82783B07	33 uF, ±20%, 25V, tantalum (HLE4355A/4421A)
C860	23-82783B24	15 uF, ±10%, 25V, tantalum (HLE4074A)
C865	23-82783B08	1 uF, 35V, tantalum (HLE4355A)
coil, rf		
L806-807	24-80090G01	airwound
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R820	06-11009C18	51 (HLE4421A)
mechanical parts		
E806	76-83960B01	ferrite core
E807	76-83960B01	ferrite core (HLE4074A)
E807	76-80178D02	ferrite core (HLE4355A/4421A)

8/15/88

PREDRIVER
HLE4356A (RANGE 1)
HLE4079A (RANGES 2,3,5)
HLE4422A (RANGE 4)



BD = GBW-5241-O
OL = GBW-5242-O

HLE4356A Pre-Driver Substrate (Range 1)
HLE4422A Pre-Driver Substrate (Range 4)
HLE4079A Pre-Driver Substrate (Ranges 2, 3, & 5) — MXW-0393-F

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C817	21-11078B05	4.7, ±.25 pF, 100V
C817	21-11078B15	12, 100V (Range 1 only)
C823	21-13740A55	100
C824	21-84547A13	.1 uF, 10%
C825	21-11078B42	100, 100V
C825	21-11078B10	7.5, ±.25 pF, 100V (Range 1 only)
C826	21-05632D43	1.6, ±.25 pF
diode (see note)		
CR804	48-84616A11	hot carrier (Range 1 only)
coil, rf		
L805,808	24-80090G01	airwound
mechanical parts		
	76-83960B01	ferrite core (Ranges 2,3,5 only)
	76-80178D02	ferrite core (Range 1 & 4 only)
	76-83960B01	ferrite core
	55-80065B01	driver/limiter strap

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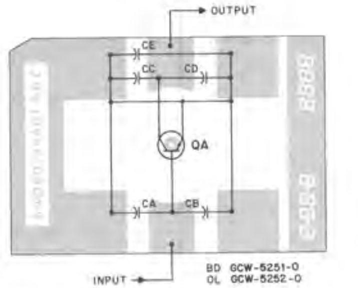
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

TRANSISTOR SUBSTRATE



BD GCW-5251-O
OL GCW-5252-O

HLE4452A

QA	CA	CB	CC	CD	CE
[illegible]	[illegible]	[illegible]	N.U.	C812	N.U.
[illegible]	[illegible]	[illegible]	[illegible]	C822	N.U.
[illegible]	[illegible]	[illegible]	[illegible]	C836	C851
[illegible]	[illegible]	[illegible]	[illegible]	C838	C852
[illegible]	[illegible]	[illegible]	[illegible]	C840	C853

HLE4446A Power Transistor Kit 50W (Range 1)
HLE4447A Power Transistor Kit 50W (Ranges 2 &3)
HLE4448A Power Transistor Kit 50W (Ranges 2, 3, 4, & 5) — MXW-5063-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 250V (unless otherwise stated)		
C890-892	21-84366F04	30
C893	21-84366F06	45
transistor (see note)		
Q890	48-80225C01	NPN (HLE4446A)
Q890	48-80225C02	NPN (HLE4447A)
Q890	48-84411L29	NPN, type M1129 (HLE4448A)
mechanical parts		
	07-80195B02	lead frame (2 used)
	04-80141B02	solder preform (2 used)

5/9/88

note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

Schematic, Circuit Board Diagrams, and Parts Lists for 78/100 Watt Power Amplifier
PW-0871-G
(Sheet 2 of 2)
8/30/88

MOTOROLA
Mobile Products Division

Common Circuits Board for *SYNTOR X 9000* and *SYNTOR X 9000E*

Section Contents

technical publication services
5555 North Beach Street, Fort Worth, Texas 76137

Common Circuits Board

1. Description

Common board circuitry performs two functions: voltage regulation and RF amplifier power control. The circuit description, theory of operation, and troubleshooting chart for the RF power control are in the transmitter section of your manual. This section covers the voltage regulators.

2. Regulator Theory of Operation

The voltage regulators consist of the 1000 series part designators. The regulator voltages are: switched 9.6 volts, switched 5 volts, and unswitched 5 volts. The power switch at the control unit controls the switched supplies (9.6 and 5 volts). The unswitched 5 volt supply remains powered up as long as the A+ lead to the radio is live, and the B– lead provides a ground return path.

2.1 9.6 VOLT REGULATOR

The 9.6 volt regulator obtains its reference from the zener diode on HY1000. The reference voltage input of U1000B at pin 5 is approximately 7.0 volts DC. The output of U1000B at pin 4 is the 9.6 volt reference. U1000C, Q1001, and the output transistor Q1000 amplifies this reference voltage. If a short circuit occurs on the 9.6 volt supply line, the diode CR1001 forward biases, removes base drive to Q1001, and shuts down the regulator to prevent further damage.

2.2 UNSWITCHED 5 VOLT REGULATOR

The TO220 packaged device U1001 contains the unswitched 5.0 volt regulator. The device generates its own reference, and is internally current limited and thermally protected. The switched 5 volt supply uses this unswitched voltage as reference, so the two regulated voltages closely track each other.

2.3 SWITCHED 5 VOLT SUPPLY

The switched 5 volt supply obtains its reference voltage from the unswitched 5 volt supply. The switched 5 volt supply is protected against excessive output current drain. Excessive current drain is sensed by the output resistors R1021 and R1022. If the drop across these resistors is .6 volts or more, the transistor Q1005 begins to conduct. This begins starving base drive to the output Darlington transistor Q1006.

2.4 SHUTBACK CIRCUIT

Both the switched supplies (5 and 9.6 volt) switch on and off by the shutback circuit. The shutback circuit senses the SW B+ line voltage, and turns the regulators off if line voltage is irregular. The shutback circuit senses over and under voltage conditions on the SW B+ line. The 9.6 volt regulator shuts back through Q1002. The base of Q1002 normally pulls low through R1006 and allows a path for Q1001 emitter current. When shut back, the base of Q1002 is pulled high by Q1004 and turns the 9.6 volt regulator off. The switched 5.0 volt regulator is shut back in a similar manner. The 5.0 volt supply is shut back through the diode CR1003. The diode is normally reverse biased and has no effect on the circuit. When shut back, the diode conducts and forces the op–amp output (U1000D) low. This causes the regulator to shut off completely. The shutback circuit senses the low–line shutback condition through the op–amp U1000A. The op–amp compares the unswitched 5.0 voltage on its positive input with the resistively divided SW B+ input on its negative input.

The circuit shuts back the regulators when SW B+ falls to approximately 8.5 volts, and turns on when SW B+ is over 9.4 volts. The high line shutback is sensed by 18–volt zener diode VR1000. This diode is presented with the SW B+ line voltage by Q1003. VR1000 has no effect to the circuit until SW B+ reaches about 20.5 volts. The 18–volt zener then conducts and clamps the base voltage of Q1004 to 19 volts. As SW B+ rises, the transistor Q1004 conducts and shuts back the switched regulators at high SW B+ voltages.

3. Regulator Troubleshooting

The following situations are explained to help troubleshoot the regulators in the *SYNTOR X 9000* radio.

- Failure of the switched 5.0 and 9.6 volt regulators
- Failure of the unswitched 5.0 volt regulator ONLY
- Failure of the 9.6 volt regulator ONLY
- Failure of the switched 5.0 volt regulator ONLY

3.1 BOTH 5 AND 9.6 VOLT REGULATOR FAILURE

(1) Inspect P300 and J1 and verify that they are properly installed.

(2) Measure SW B+ on the common circuits board. This voltage range is 10.7 to 16.2 volts. If SW B+ is outside of this range, the regulator shutback circuitry disables the regulators.

(3) Measure the voltage at the collector of Q1004. It should be .6 volts or less. If the collector is above .6 volts, repair the shutback circuit.

3.2 UNSWITCHED 5 VOLT REGULATOR FAILURE

(1) Measure the input to U1001 pin 1. This range is 10.7 to 16.2 volts. If not, repair the open path A+ or B– to the common circuits board.

(2) Measure the resistance from U1001 pin 2 to J1–B on the personality board. This should be below .1 ohms. If not, locate the resistive path or connector and repair.

(3) Measure the output of U1001 pin 3. If not between 4.75 to 5.25 volts, unsolder pin 3 to determine if the supply is shorted. If the unconnected output is not five volts, replace U1001.

3.3 9.6 VOLT REGULATOR FAILURE

(1) Measure the voltage at the emitter of Q1000. It should be between 10.7 to 16.2 volts. If not, find the open path supplying the collector.

(2) Check the op–amp output at U1000B pin 4. It should be 6.65 to 7.35 volts. Next, check U1000B pins 5 and 6. Reading should be 6.2 volts. If not, repair the reference circuit.

(3) Measure the base voltage on Q1001. This point is normally at 3.1 volts. If this point is below 2 volts or above 6 volts, repair the driving op–amp circuit involving U1000A.

(4) Measure the voltage on the base of Q1000 (output pass transistor). The base voltage should be .5 to .8 volts below the SW B+ voltage on the emitter of Q1000. If this voltage is out of range, repair the output driver involving Q1000 and Q1001.

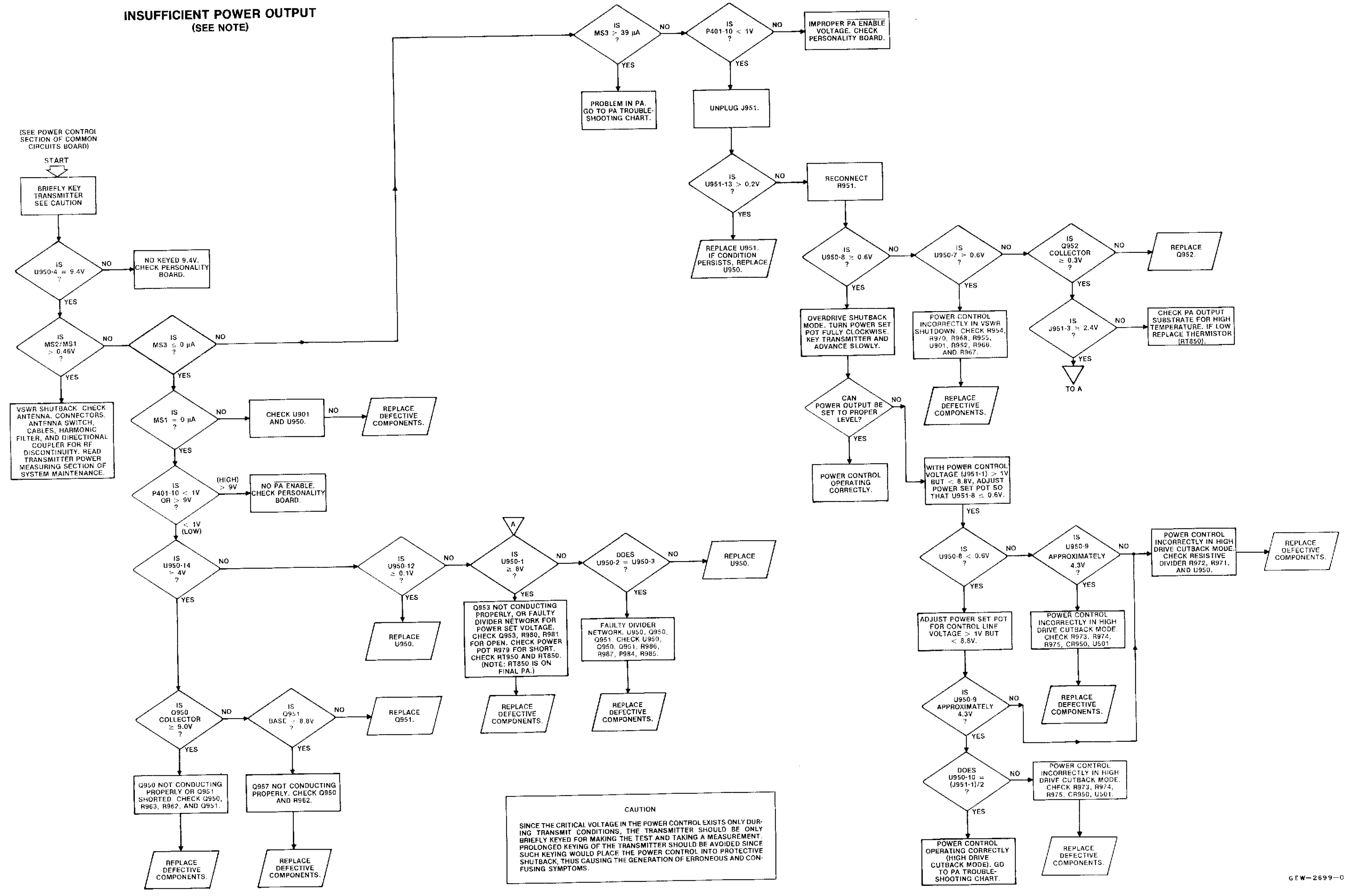
3.4 SWITCHED 5 VOLT REGULATOR FAILURE

(1) Measure the input reference voltage at U1000D pin 13, This should be 4.75 to 5.25 volts. If not, recheck the unswitched 5.0 volt regulator output. If the unswitched 5.0 supply is present, unsolder U1000 pin 13 to check if U1000 is faulty.

(2) Check the collector voltage of Q1005. Acceptable range is 10.7 to 16.2 volts. If not, find the open path to the common circuits board.

(3) Measure the driving op–amp U1000 pin 12 to determine if sufficient base drive is present for Q1006. U1000 pin 12 should be 6.4 to 7 volts. If this voltage is more than 7 volts, check the voltage drop across R1016. The drop is approximately .2 volts. If there is little or no drop across R1016, replace Q1006. If the voltage drop is excessive, remove Q1005 to disable the current shutback circuit, and recheck. Should the drop still be excessive, measure the drop across R1021. If R1021 drop is more than .7 volts, locate the fault on the switched 5.0–volt line. This fault is probably on another circuit board in the radio. If the R1021 voltage drop is less than .7 volts, replace Q1006. If the voltage on U1000 pin 12 is below 6.4 and pin 14 is less than pin 13 of U1000, replace U1000. If U1000 pin 14 is more than pin 13, check for an open R1017 or shorted CR1003.

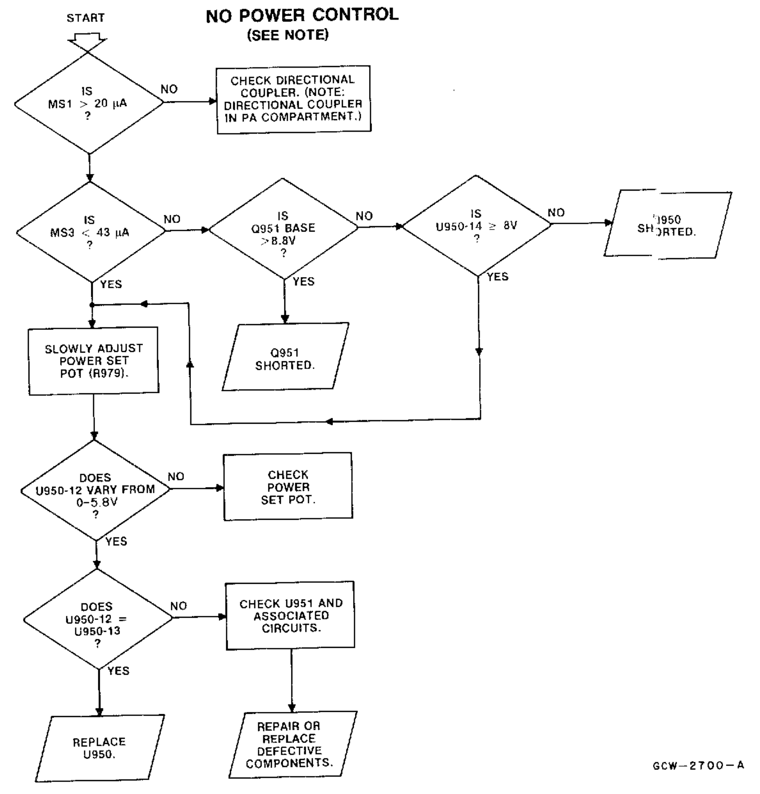
INSUFFICIENT POWER OUTPUT
(SEE NOTE)



CAUTION

SINCE THE CRITICAL VOLTAGE IN THE POWER CONTROL EXISTS ONLY DURING TRANSMIT CONDITIONS, THE TRANSMITTER SHOULD BE ONLY BRIEFLY KEYED FOR MAKING THE TEST AND TAKING A MEASUREMENT. PROLONGED KEYING OF THE TRANSMITTER SHOULD BE AVOIDED SINCE SUCH KEYING WOULD PLACE THE POWER CONTROL INTO PROTECTIVE SHUTBACK, THUS CAUSING THE GENERATION OF ERRONEOUS AND CONFUSING SYMPTOMS.

NO POWER CONTROL
(SEE NOTE)



NOTE

WHEN THE POWER AMPLIFIER FAILS, IT IS VERY PROBABLE THAT THE POWER CONTROL PROTECTION FUNCTIONS ARE NOT OPERATING PROPERLY. CONSEQUENTLY, IT IS RECOMMENDED THAT THE FOLLOWING THREE CHECKS ILLUSTRATED ON THE FLOW CHART BE PERFORMED WHENEVER THE POWER AMPLIFIER FAILS.

(A) VSWR PROTECTION

(B) LOW-LINE CUTBACK

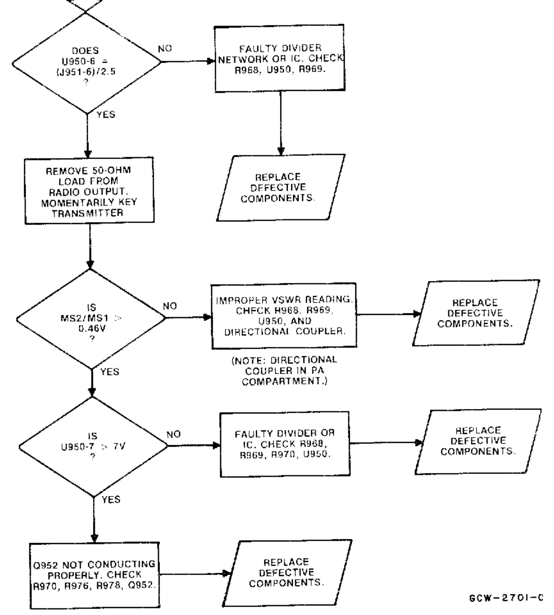
(C) HIGH-DRIVE PROTECTION

IT IS ALSO RECOMMENDED THAT THESE CHECKS BE PERFORMED AFTER COMPLETING EITHER OF THE TWO OTHER CHECKS, INSUFFICIENT POWER OUTPUT AND LACK OF POWER CONTROL.

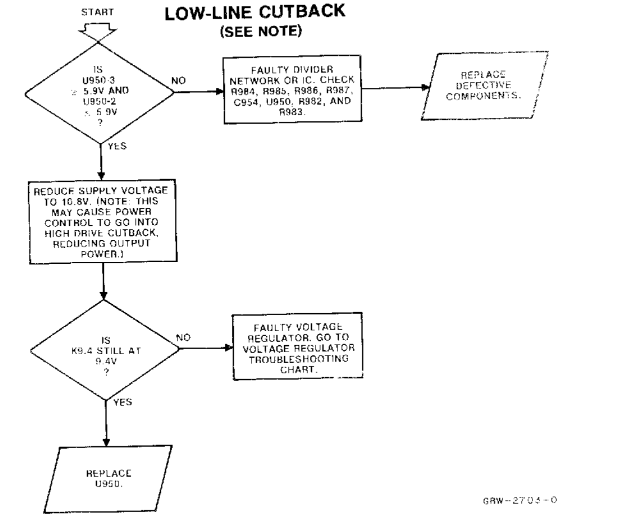
NOTE

ALL VOLTAGE VALUES ARE REFERENCED TO A–.

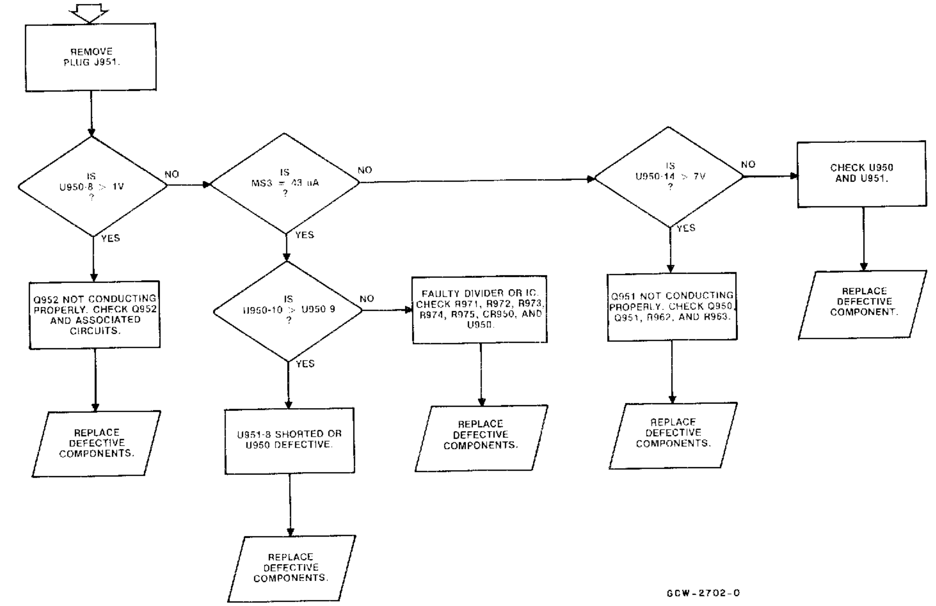
VSWR PROTECTION



LOW-LINE CUTBACK
(SEE NOTE)



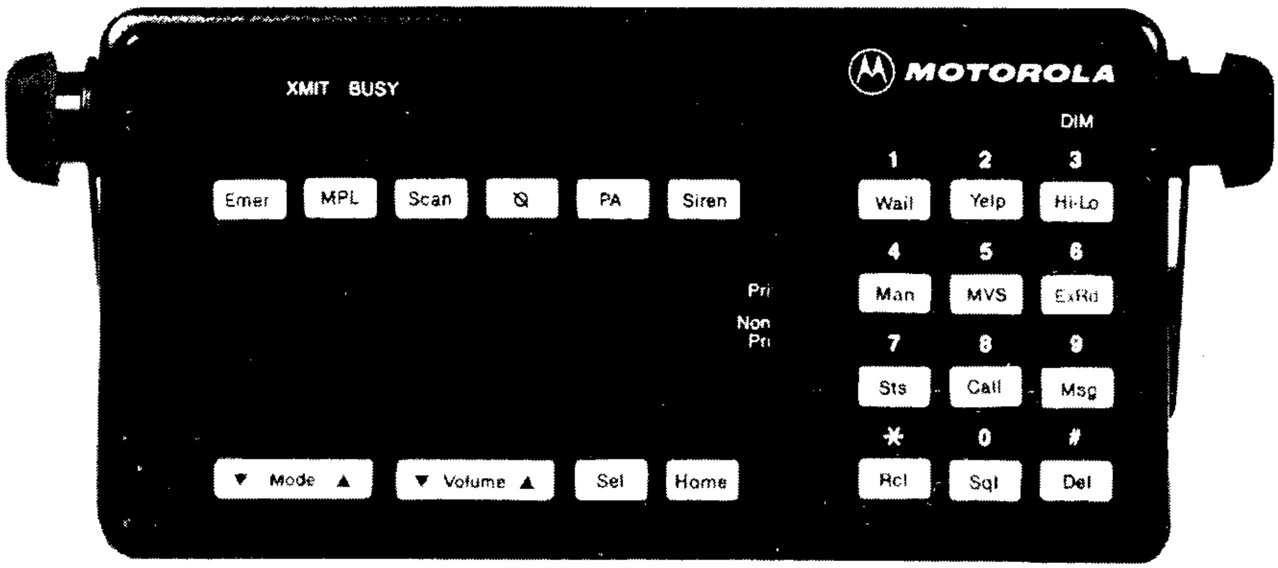
HIGH-DRIVE PROTECTION



RF Power Control
Troubleshooting Charts
PW–2767–A
5/20/88

MOTOROLA
Mobile Products Division

Control Unit, Cable Kits and Accessories



GPW–2538–A

Figure 1. Typical Systems 9000 *Control Unit*

1. Description

1. 1 GENERAL

Note
A variety of Motorola's *SYNTOR X 9000* radio systems use the *Systems 9000* Control Unit. The differences between control units is in the programming software and button legends.

The *Systems 9000* control unit is a microcomputer based unit that processes all the button inputs and displays used by the radio and the options. It also interfaces with the vehicle via the vehicle interface ports (VIP).

1. 2 CONTROLS AND INDICATORS

1. 2 .1 Power Switch

The power switch is a slide switch on the right–hand bottom surface of the control unit. It turns the radio and its accessories on and off.

1. 2 .2 Display

The eleven–character vacuum fluorescent display's primary function is to display mode numbers, mode names, volume level, and the status of options. It also functions as an on–off indicator for the entire system, and plays an integral role in the operator's reconfiguration of options.

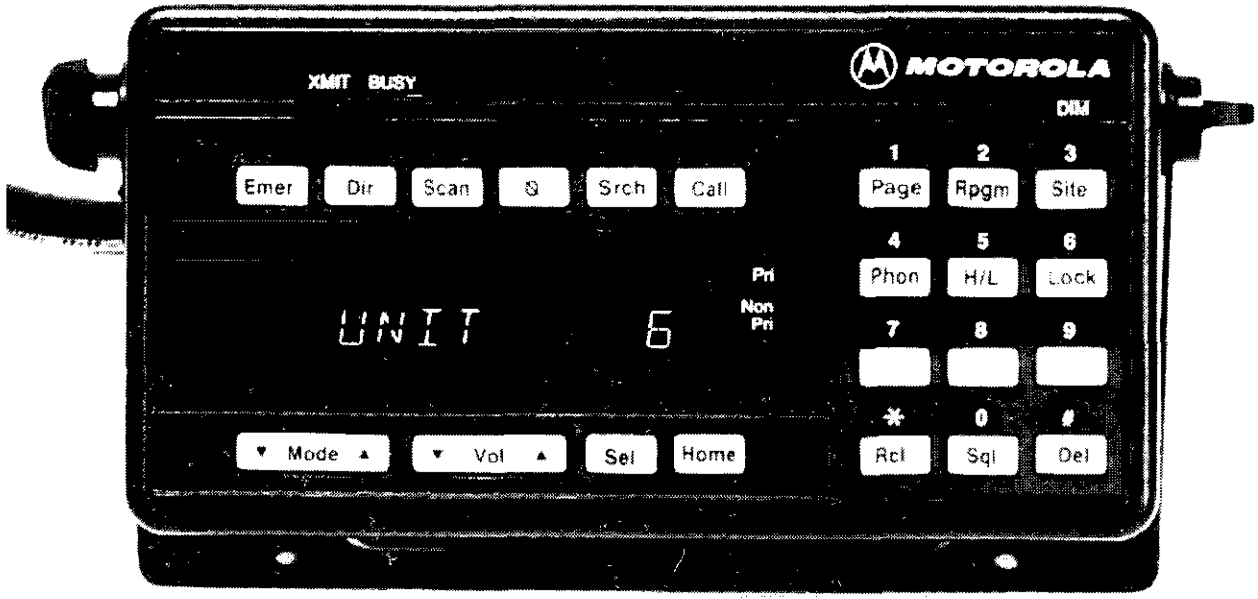


Figure 2. Systems 9000 *Control Unit for* SYNTOR X 9000E *Radios*

GPW-4141-A

1.2.3 Option Buttons

Located above the display window is a row of six buttons for turning options on and off. Below each is a small indicator light to show the status of the option.

1.3 XMIT and BUSY Indicators

Above the six option buttons are XMIT and BUSY indicators. The XMIT indicator lights when the radio is transmitting. The BUSY indicator lights when the selected channel is busy.

1.3.1 Scan Indicators

In the right–hand side of the display window are the NON–PRI and PRI indicator lights. When scan operation detects activity on a non–priority (NON–PRI) channel, the NON–PRI light comes on. Activity on a second priority channel causes PRI to light. First priority channel activity causes PRI to flash.

1.3.2 Mode Rocker Switch

Below the display window is the Mode rocker. Pressing the right side of this rocker switch increases the mode number. Press the left side to decrease the mode number. If you press and hold the switch, it scrolls the mode numbers up or down. The mode names appear in the display window.

1.3.3 Volume Rocker Switch

Below the display window, beside the Mode switch is the Volume rocker. Press and release to check volume setting. Your display shows "VOLUME _ _" and a number value (0–15). Press and hold the right side of the rocker to increase the volume setting. Press and hold the left side to decrease volume. The number value scrolls up or down to your desired level.

The volume rocker also controls the volume level of the public address (PA) and external radio speaker (ExRd) options when they are enabled. The display window shows "PA VOL_ _" when public address is on and the volume rocker is pressed.

1.3.4 Home and Sel Buttons

Press the Home button to go to the radio's pre–programmed "Home" mode. You may use Home instead of Mode to change modes. Hold Home until a beep sounds to enter the configuration state. The display shows an entry prompt. Use the keypad to enter your new mode choice and press Home again. Your mode is now changed without scrolling.

Use the Sel button when configuring an option. See the descriptions of the options for more specific information.

1.3.5 DIM Button

Above the keypad, on the right side of the control unit, is the control for the brightness of the display and button backlighting. When you turn on the system, the display comes on at the highest level. Press DIM once to reduce the brightness of the display to medium level, and twice for low brightness level. Press DIM a third time to turn the display and button backlighting off. This is called the "surveillance" mode.

1. 3 .6 Keypad

The keypad is for changing the status of options and entering numbers to the display. See the Operator's Manual for a complete description of button operation.

2. Theory of Operation

2. 1 GENERAL

The *Systems 9000* control unit has solid state microprocessor circuitry that operates the standard and optional features built into the system. The control unit design allows installation in even the smallest of down–sized vehicles. Systems that have many options simply require more control unit buttons, not larger control units.

The control unit may be field programmed to alter the information stored in certain areas of its electronic memory. Some options are also added by field programming.

2. 1 .1 Display

The control unit has an eleven–character alphanumeric vacuum fluorescent display for indicating the following:

- Mode Names
- Squelch Level
- Volume Level
- Status Codes
- Message Codes
- Telephone Numbers
- Identification Numbers
- Alarm Displays
- Option Status

2. 1 .2 Controls and Indicators

A twelve button keypad contains traditional alphanumeric keys. These keys double as function keys for *SYNTOR X 9000* options. All buttons are backlit to allow operation in low–light. Six ON/OFF option buttons and indicator lights above the display window tell whether these options are on or off.

Other indicators include BUSY, TRANSMIT, PRIORITY, and NON–PRIORITY. BUSY lights when activity is detected on the channel. The XMIT (transmit) indicator lights when you are transmitting.

When activity occurs during a Scan sequence, the NON–PRI (non–priority) or PRI (priority) light is on. If the detected activity be on a NON–PRI mode, the NON–PRI light is on. If the activity is on PRI mode the PRI indicator lights for second priority modes, and flashes for first priority modes.

2. 2 CONTROL BOARD

The control board's microprocessor (MPU) communicates on the serial bus, receives and interprets keypad data, and controls the volume. The MPU sends ASCII data to a decoder to control the display, and sends data to turn the LEDs on or off. The control board has a watchdog timer that senses the need for a system reset. The vehicle interface ports are also controlled on this board.

2. 2 .1 Microprocessor (MPU)

The MPU operates in mode 2 (expanded bus with internal ROM active). Table 1 gives jumper placements for different modes. The clock frequency is 4.9152 MHz that results in an internal operating frequency of 1288 kHz. The limited number of I/O ports is augmented by using a serial–to–parallel shift register (U3) to scan the keyboard, and to switch the VIP drivers (Q28, Q29, Q30, and Q33).

Table 1. Mode Jumper Placement

Microprocessor Mode	JU3	JU6
No. 1–Expanded mode with external ROM only.	IN	OUT
No. 2–Expanded mode with internal ROM active.	OUT	IN
No. 3–Single Chip.	OUT	OUT

2. 2 .2 Watchdog Timer

The watchdog timer consists of U5 (comparator) and Q4 (SCR). On system power–up, C06 pulls the inverting input of U5 high while R10 and R11 hold the non–inverting input at VCC/2. The output goes low and the microprocessor resets.

As C06 charges through R14, the voltage on the inverting input drops below that of the non–inverting input, the output goes high, and the microprocessor can start operating. R14 is now pulling up on C06, and the inverting–input voltage begins to rise.

During this interval, the processor generates tickle pulses to periodically fire Q4, preventing the inverting–input voltage from rising above the non–inverting input voltage and repeating the reset cycle. If the tickle pulses stop for more than 150 mSec, the reset cycle is repeated.

2. 2 .3 EEPROM

The EEPROM stores customer data including mode names, button functions, and VIP settings. The customer data can be altered only by enabling the "STORE" function (grounding the MIC HI line); an automatic function of the control unit programmer. Power strobing minimizes EEPROM power consumptions. Jumpers configure the EEPROM for the uses shown in Table 2.

Table 2. EEPROM Jumper Table

JUMPER	USE/PLACEMENT
JU1	Used for future options
JU2	IN for 6301X Microprocessor
JU4	IN for 2K EEPROM; OUT for 8K EEPROM (option W930)
JU5	IN for 8K EEPROM (option W930) OUT for 2K EEPROM

2. 2 .4 Bus Transceiver

The serial bus transceiver consists of Q1, Q2, Q3, and U4 (CA3140). Q1, Q2, and Q3 transmit data on the bus while U4 acts as a comparator to receive data from the bus.

2. 2 .5 Vacuum Fluorescent Voltage Converter

Voltage for the vacuum fluorescent display is generated by a fixed frequency, variable–duty cycle driven, flyback voltage converter. Q31 and Q32 form an emitter–coupled astable multivibrator that runs at about 150 kHz. The square wave output from this circuit is integrated by R71 and C39 to form a triangle that is applied to the non–inverting input of half of U5.

During start up, the inverting input is biased at 3.7 volts by R66 and R67. Q23 is on while the non–inverting input voltage is below 3.7 volts. This allows current to flow the T1, building a magnetic field. When the triangle wave exceeds 3.7 volts, Q23 turns off and the magnetic field collapses, inducing negative current in T1.

This current flows through either CR13 or CR14, charging C27 and C28. As the voltage on C28 increases beyond –35 volts, CR13 begins to conduct, pulling U5's inverting input below 3.7 volts. This decreases the cycle time that Q23 is on to the time needed to produce –35 volts on C28. The –41 volt sup ply is not regulated, but it tracks the –35 volt supply.

Similarly, the AC supply for the vacuum fluorescent filament is not regulated, but is controlled to within one volt by and inductor on the display board.

2. 2 .6 Vehicle Interface Ports (VIP)

The VIP outputs are driven by a serial–to–parallel shift register. Output transistors (Q28, Q29, Q30) can sink 300 mA current. Primarily, these transistors control external relays. The relay is connected between the collector and switched B+.

Each VIP input transistor (Q25, Q26, Q27) is connected to a dedicated input port through transistors used for input protection. These VIP inputs are connected to ground with either normally–open or normally–closed switches.

2. 2 .7 Power Supplies

Both the +5 and the +9.4 volt supplies are linear regulators. The +9.4 supply is built with a discreet transistor (Q11). The regulation is provided by VR09. The +5 volt supply is a 7805, three–terminal regulator IC.

2. 2 .8 Ignition Sense Circuits

Q7 senses the vehicle ignition's state, disabling transmit when the ignition is off. For negative–ground systems, the orange lead is typically connected to the fuse box (+12V). For more information, see the cable kit section.

2. 2 .9 EEPROM Write–Protect Circuit

Q12, Q13, and associated circuitry guard against inadvertently writing into the EEPROM. When MIC HI is grounded, Q21 (normally on) is turned off. A hot–carrier diode (CR24) ensures that Q21 turns off. CR24 is normally off so it does not interfere with the MIC HI line.

CR19 forces the system to be write–protected during reset; this is especially crucial during system power–up.

2. 3 DISPLAY BOARD

This board contains the main operator interface points of the system, including the vacuum fluorescent display, the status indicator LEDs, and the user keypad.

2. 3 .1 Vacuum Fluorescent Display

The vacuum fluorescent (VF) display is an eleven digit, 14–segment display that needs three separate voltages to operate: the cathode needs –35 volts to accelerate electrons to the anode; the grid needs –40 volts to totally shut off current flow; the filament needs 3.8 volts AC at 80 mA. These voltages are obtained from the VF up–converter on the controller board.

2. 3 .2 Vacuum Fluorescent Display Driver

This IC (U101) receives ASCII data from the controller board, decodes it into 14–segment display data, and then scans the display with the data. Once properly loaded into the driver, the displayed data is refreshed without any further processor action. The display driver is periodically reset by the actions of transistors Q118, Q119, and Q110 that watch the clock line from the processor to the display driver. When the clock line is held low for more than 600 mSec, the display driver resets and new display data follows.

2. 3 .3 Voltage Supply

The AC voltage present on Q23 of the controller board is used to obtain the –10 volts needed to run the display driver IC. This voltage is fed through L101 to limit the current and then rectified by CR107 and shunt regulated by CR108.

2. 3 .4 Status LEDs

These LEDs are driven by the display driver as though they were decimal points on the VF display. Level shifting transistors are required for this since the display driver uses 39 volts for control signals.

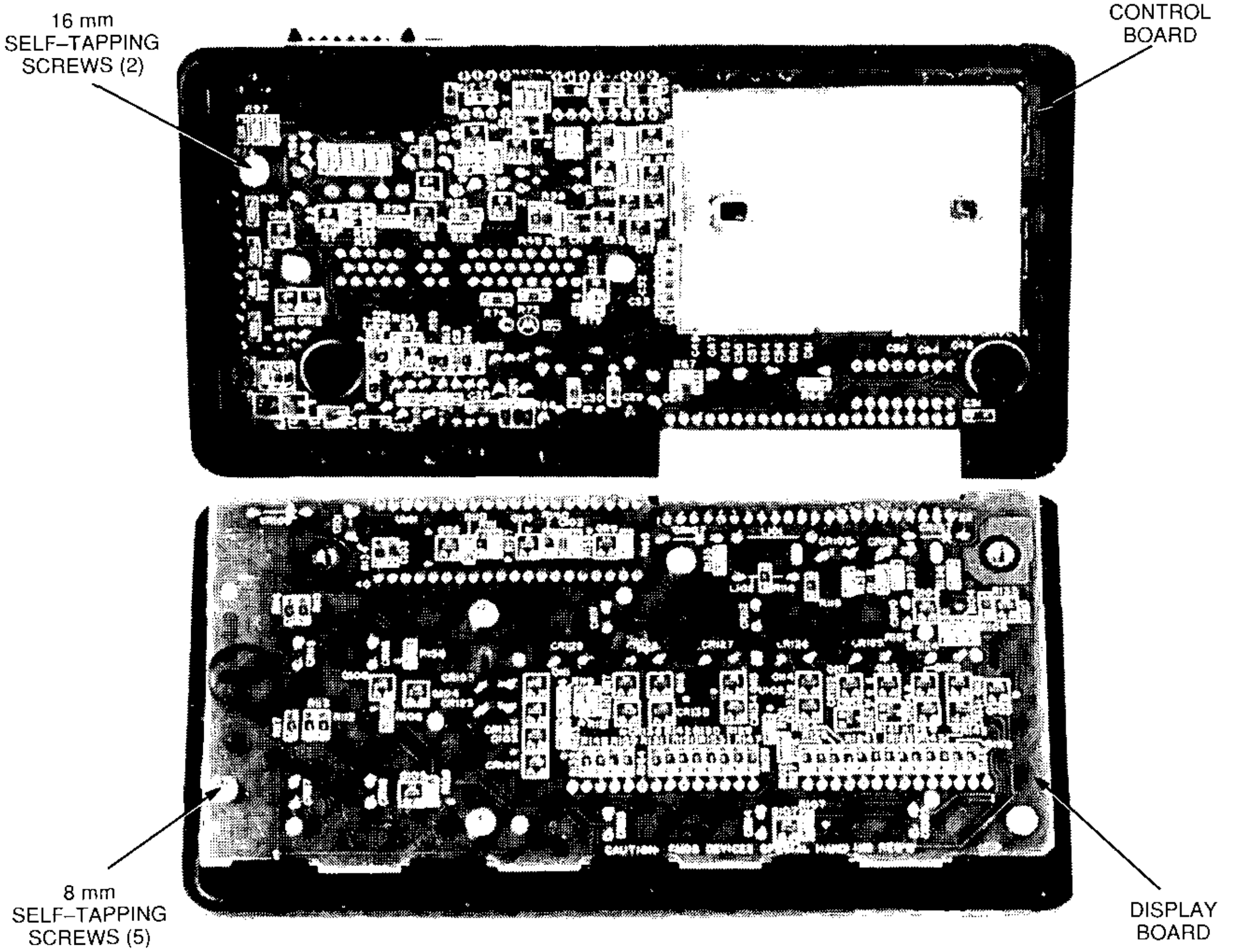


Figure 3. Disassembly of the Control Unit

2. 3 .5 Backlight LEDs

The same microprocessor signal that turns the VF power supply on and off also operates the backlight LEDs. Q120 supplies base current to the individual LED driver transistors. The driver transistors act as constant current sources to the LEDs. Backlight LEDs CR115, CR116, CR117, and CR118 are connected to thermistor R163 by way of Q108. This circuit allows more current to flow through these LEDs at room temperature and reduces current as the temperature rises.

3. Control Unit Maintenance

3. 1 DISASSEMBLY OF CONTROL UNIT
(See Figure 3)

Note
Before disassembling the control unit, note the location of the labeled buttons.

Remove the two 30mm slotted screws that hold the front and back of the control unit together. The two halves separate at the top; at the bottom, they are held together by the flex cable that interconnects the circuit boards. Place the unit so the PC boards are facing up.

Remove the five 8mm screws in the display board and carefully remove the front of the control unit housing. Keep the front housing parts as a complete unit (including the front housing, buttons, and display board light pipe). Always keep the front of the display housing face down when handling.

Remove the two 16mm self–tapping screws on the control board. Remove the back of the control unit housing. Remove the black gasket around the switch and set it aside. Remove the shields from the top and bottom of the control board. All components should be easily accessible.

Note
When working with chips and SOT parts, use extreme caution when heating. Never reuse a chip or SOT part; always replace with correct Motorola parts.

3. 2 RE–ASSEMBLY OF THE CONTROL UNIT

Be sure the orange gasket is still around the out side of the control cable "mini D" connector. If it was removed, replace it, ensuring a snug fit to the PC board. Replace the gasket around the power switch. Replace the shields on the top and bottom of the control board. Place the control board in the back housing, being careful to put the toggle switch arm in the proper position in the ON/OFF button actuator.

Screw in the two 16mm self–tapping screws to 6–8 inch lbs. Also, be sure the ON/OFF actuator still slides back and forth easily. Carefully check to see that all buttons are still in place, then place the display board in the front housing. Screw in the five 8mm self–tapping screws to 6–8 inch lbs. Be sure the black gasket is around the outside groove of the front housing. When mating the front and back housings, make sure the flex cable slides behind the control board and is not pinched. Screw in the two 30mm slotted screw to 9–10" lbs.

4. Vehicle Interface Ports

The Vehicle Interface Ports (VIP) allow the control unit to operate outside circuits and to receive inputs from outside the control unit. There are three VIP outputs that are used for relay control. There are also three VIP inputs that accept inputs from switches. See the cable kit section for typical connections of VIP input switches and VIP out put relays.

4. 1 VIP OUTPUT CONNECTIONS

The VIP output pins are located on the back of the control unit below the area labeled "VIP." These connections are used to control relays. One end of the re lay should be connected to switched B+, while the other side is connected to a software controlled ON/OFF switch inside the control unit.

The relay can be normally–on or normally–off depending on how the VIP outputs are configured. The control unit provides for three of these VIP output connections. See Table 3.

The function of these VIP outputs can be defined by field programming the control unit. Typical applications for VIP outputs are external horn/lights alarm and horn ring transfer relay control. For further information on VIP outputs, see the control unit programming manual.

4. 2 VIP INPUT CONNECTIONS

The VIP input pins are located on the back of the control unit below the area labeled "VIP." These connections are used to accept inputs from switches. One side of the switch is connected to ground while the other side is connected to a buffered input to the control unit. The switch can be normally–closed or normally–open depending on how the VIP inputs are configured. The control unit permits three of these VIP input connections. See Table 4.

The function of these VIP inputs is defined by field programming the control unit. Typical applications for the VIP inputs are for a foot switch or a horn ring switch. For further information on VIP inputs, see the control unit programming manual.

5. Power Connections

CAUTION
Use only *SYNTOR X 9000* cable kits. Connection to other cable kits or control panels may cause electrical damage.

Replace the fuse in the in–line fuseholder of the red power cable coming from the radio in the trunk. Also connect the green (and/or orange) fused wire(s) coming from the control unit to the ungrounded terminal (or source) of the battery.

Pull all excess cabling into the trunk. Clamp the cables to the vehicle body or chassis with the cable clamps supplied. Drill 1/8" mounting holes, then attach the clamps with four #8 by 3/8" tapping screws and four 1/4" lockwashers. Finally, be sure all in–line fuses are installed.

Table 3 . VIP Output Connections

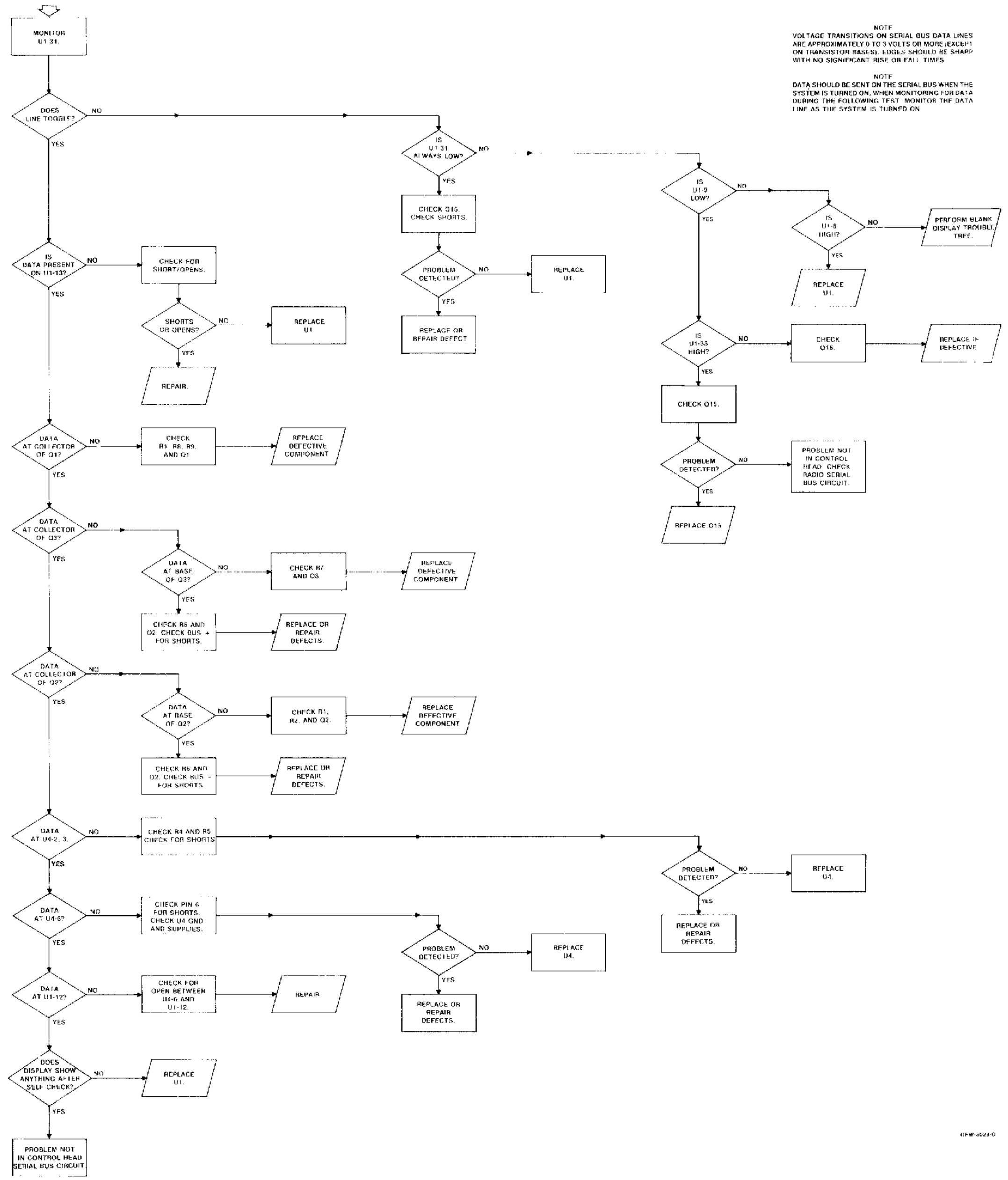
VIP OUTPUT NO.	SWITCHED B+ PIN NO.	ON/OFF SWITCH PIN NO.	DEFAULT FUNCTION IS CHANGED WITH FIELD PROGRAMMER
1	18	2	HORN RELAY (ALARM)
2	19	1	LIGHT RELAY (ALARM)
3	35	34	SIREN–HORN TRANSFER

Table 4. VIP Input Connections

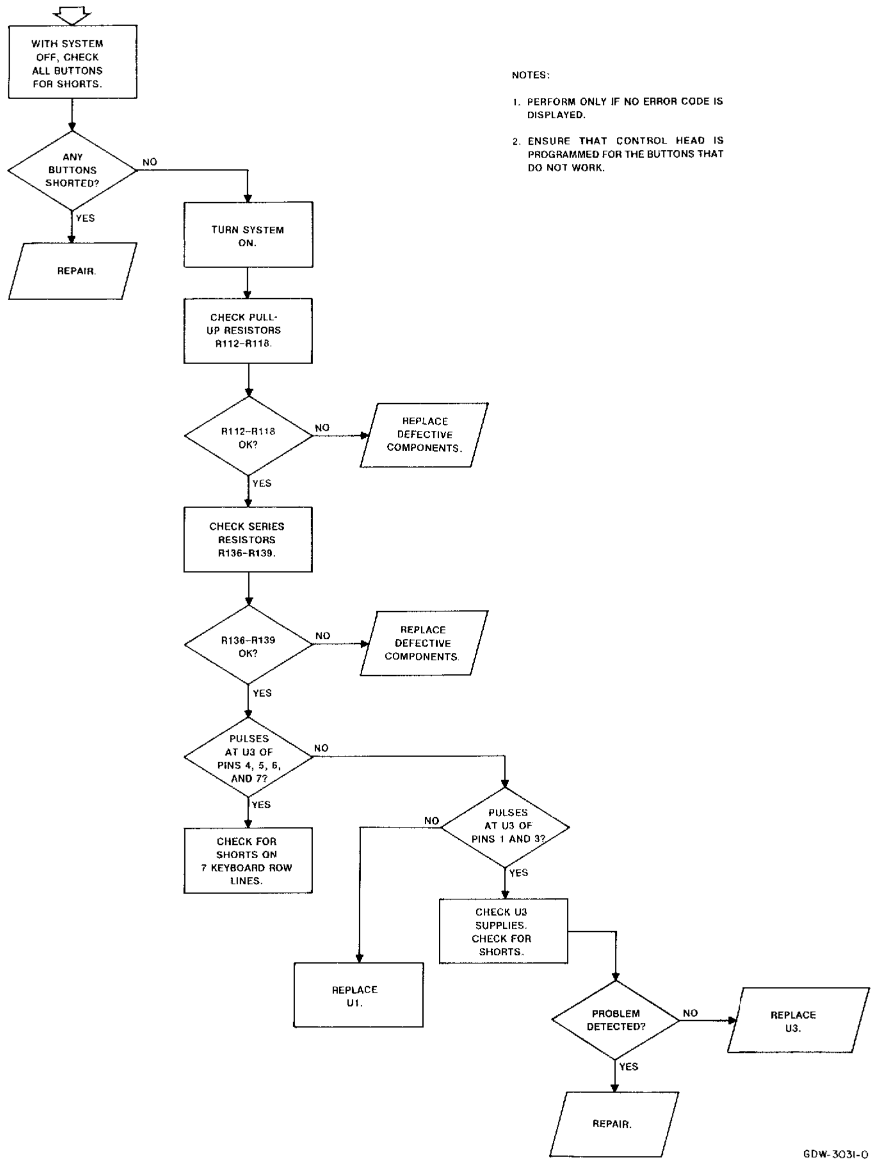
VIP INPUT NO.	GROUND PIN NO.	ON/OFF SWITCH PIN NO.	DEFAULT FUNCTION IS CHANGED WITH FIELD PROGRAMMER
1	20	4	SIREN; HORN RING
2	21	3	EMERGENCY (IF OPTION PRESENT)
3	36	37	NONE

NOTE
VOLTAGE TRANSITIONS ON SERIAL BUS DATA LINES ARE APPROXIMATELY 0 TO 3 VOLTS OR MORE (EXCEPT ON TRANSISTOR BASES). EDGES SHOULD BE SHARP WITH NO SIGNIFICANT RISE OR FALL TIMES.

NOTE
DATA SHOULD BE SENT ON THE SERIAL BUS WHEN THE SYSTEM IS TURNED ON. WHEN MONITORING FOR DATA DURING THE FOLLOWING TEST, MONITOR THE DATA LINE AS THE SYSTEM IS TURNED ON.



SELECTOR BUTTON FAILURE

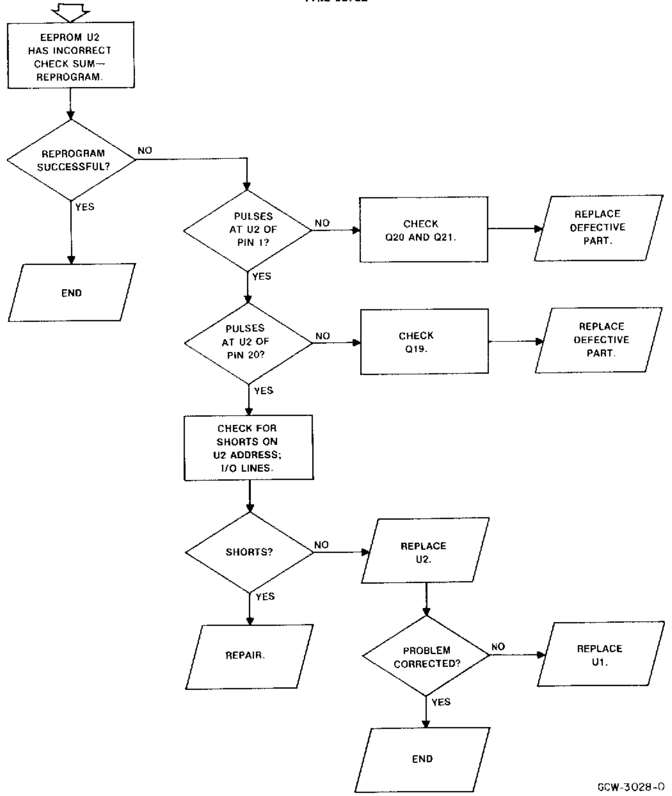


NOTES:

1. PERFORM ONLY IF NO ERROR CODE IS DISPLAYED.
2. ENSURE THAT CONTROL HEAD IS PROGRAMMED FOR THE BUTTONS THAT DO NOT WORK.

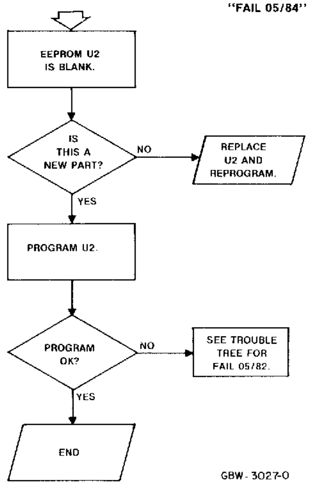
GDW-3031-0

ERROR CODE "FAIL 05/82"



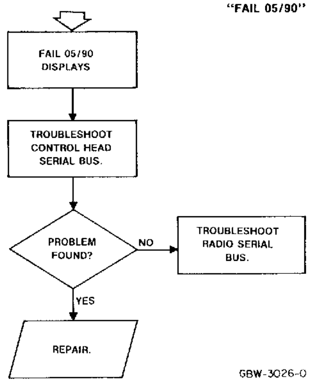
GDW-3028-0

ERROR CODE "FAIL 05/84"



GBW-3027-0

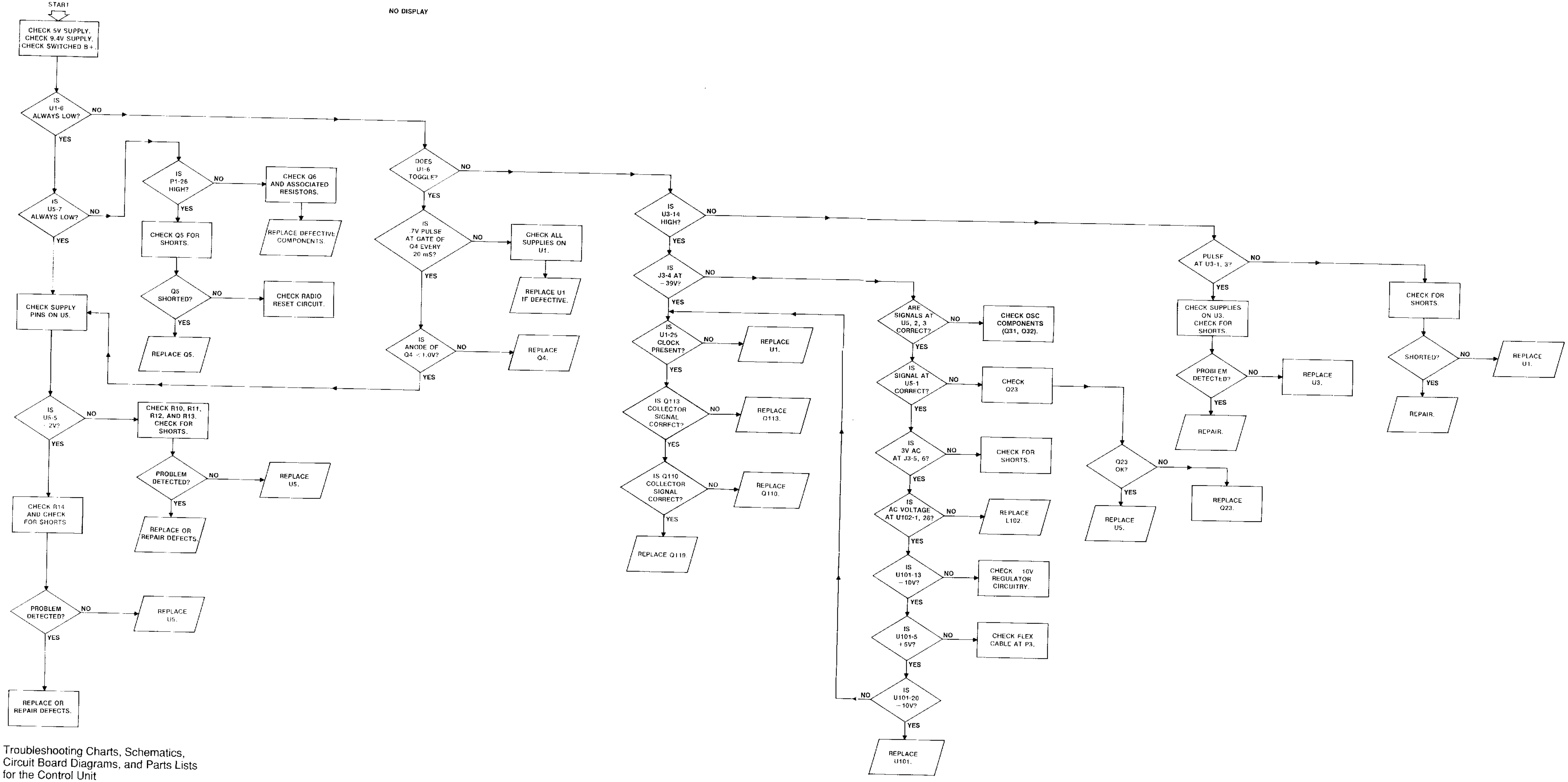
ERROR CODE "FAIL 05/90"



GBW-3026-0

Troubleshooting Charts, Schematics, Circuit Board Diagrams, and Parts Lists for the Control Unit
PW–4385–B
(Sheet 1 of 4)
8/30/88

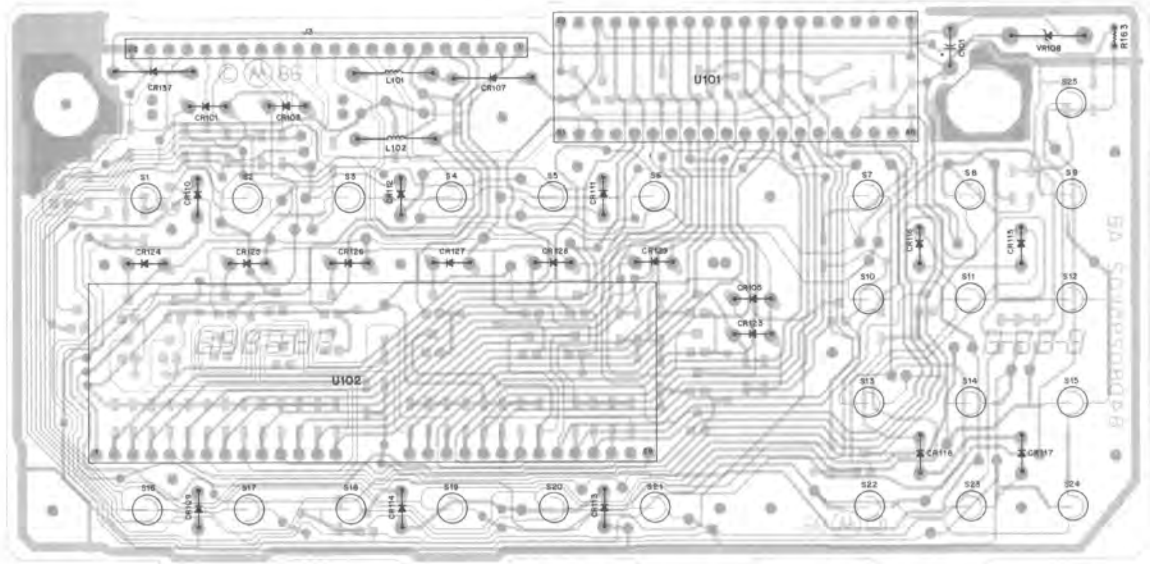
NO DISPLAY



GEW-3030-0

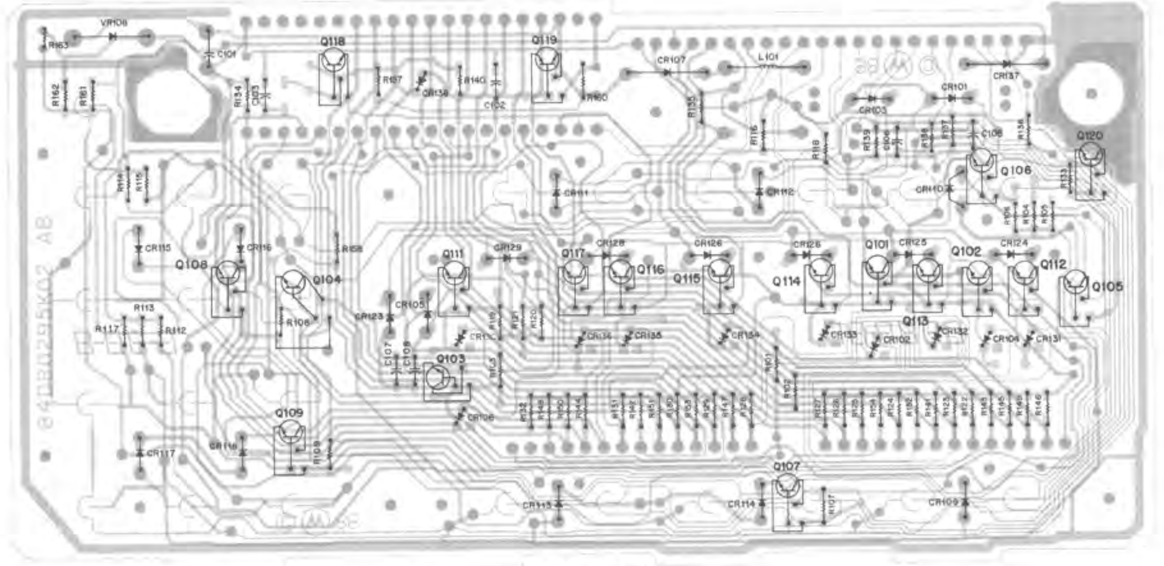
Troubleshooting Charts, Schematics, Circuit Board Diagrams, and Parts Lists for the Control Unit
PW–4385–B
(Sheet 2 of 4)
8/30/88

DISPLAY BOARD



SHOWN FROM COMPONENT SIDE

SOLDER SIDE GDW-2512-B
COMPONENT SIDE GDW-2513-B
OVERLAY — GDW-2515-0



SHOWN FROM SOLDER SIDE

SOLDER SIDE GDW-2512-B
COMPONENT SIDE GDW-2513-B
OVERLAY — GDW-2514-B

parts list

HLN5104D *Systems 9000* Display Board — MXW-4382-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±10%, 50V (unless otherwise stated)		
C101	23-11048C11	10, ±20%, 44V, electrolytic
C102	21-13741B21	.001
C103-108	21-13741B29	.1, +80, -20%
diode (see note)		
CR101	48-80246K01	red LED
CR102	48-80236E08	silicon
CR103	48-80246K02	yellow LED
CR104	48-80236E08	silicon
CR105	48-80246K01	red LED
CR106	48-80236E08	silicon
CR107	48-83654H01	silicon
CR109-118	48-80246K04	green LED
CR123	48-80246K02	yellow LED
CR124-129	48-80246K01	red LED
CR130-136	48-80236E08	silicon
CR137	48-84616A11	silicon
CR137	48-80012E01	hot carrier
CR138	48-80236E08	silicon
coil, RF		
L101	24-11047A44	390 uH
L102	24-80138G07	15.0 uH, ±5%
transistor (see note)		
Q101-103	48-80141L02	NPN
Q104	48-80141L04	NPN
Q105-120	48-80141L02	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R101-103	06-11077A50	100
R104	06-11077A90	4.7k
R105-107	06-11077A64	390
R108	06-11077A84	2.7k
R109	06-11077A36	27
R112-118	06-11077B23	100k
R119	06-11077A50	100
R120,121	06-11077A57	200
R122-132	06-11077B23	100k
R133,134	06-11077A98	10k
R135	06-11077A50	100
R136-139	06-11077A90	4.7k
R140-154	06-11077B23	100k
R157	06-11077B11	33k
R158	06-11077A70	680
R160	06-11077B11	33K
R161	06-11077A94	6.8k
R162	06-11077A92	5.6k
R163	06-83600K09	100k green thermistor
R164	06-11077A98	10k
R200	06-11077A74	1k
integrated circuit (see note)		
U101	51-80236C04	display driver
U102	72-80242J01	vacuum-florescent display
varactor		
VR108	48-82256C67	10V zener, 1W

8/15/88

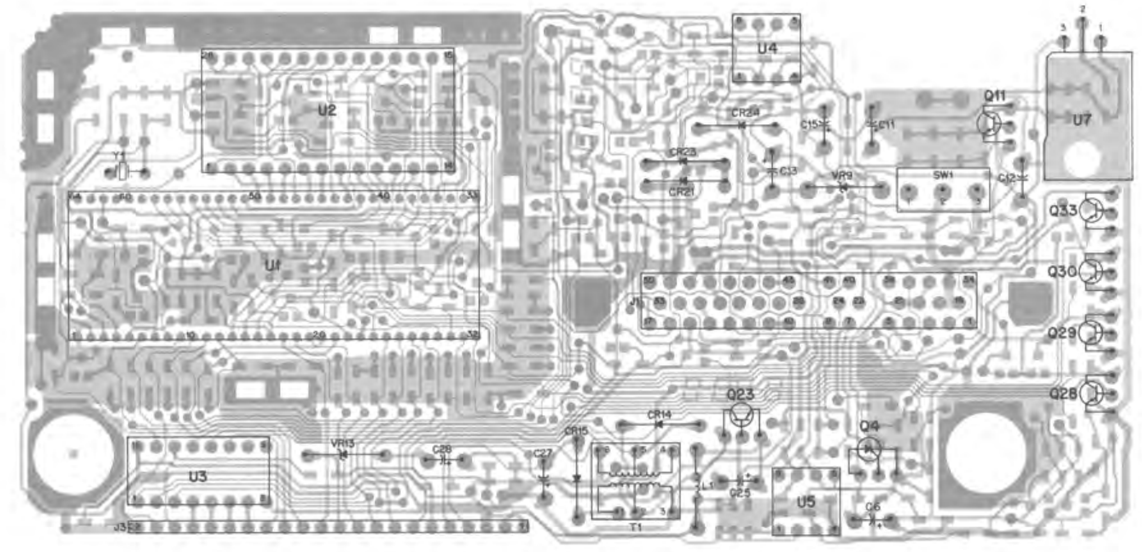
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

HKN4240A, HKN4241A and HKN4242A Cable Kits for *SYNTOR X 9000* — MXW-2529-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	non-referenced items	
	01-80739T53	22-foot cable
	01-80739T54	17-foot cable
	01-80739T55	10-foot cable
	01-80701T89	LD and lug, black, 66" high-power
	09-84151B03	contact receptacle
	09-84151B05	plated contact receptacle
	39-10184A44	contact receptacle
	15-10183A17	2-contact housing connector receptacle
	36-80220B06	connector knot
	03-00140079	tapping screw (6-19 × ½)
	42-80156B01	retainer ring
	09-80227B01	female contact
	15-80217K01	front cable housing
	15-80218B01	back housing connector
	32-83859M01	connector gasket

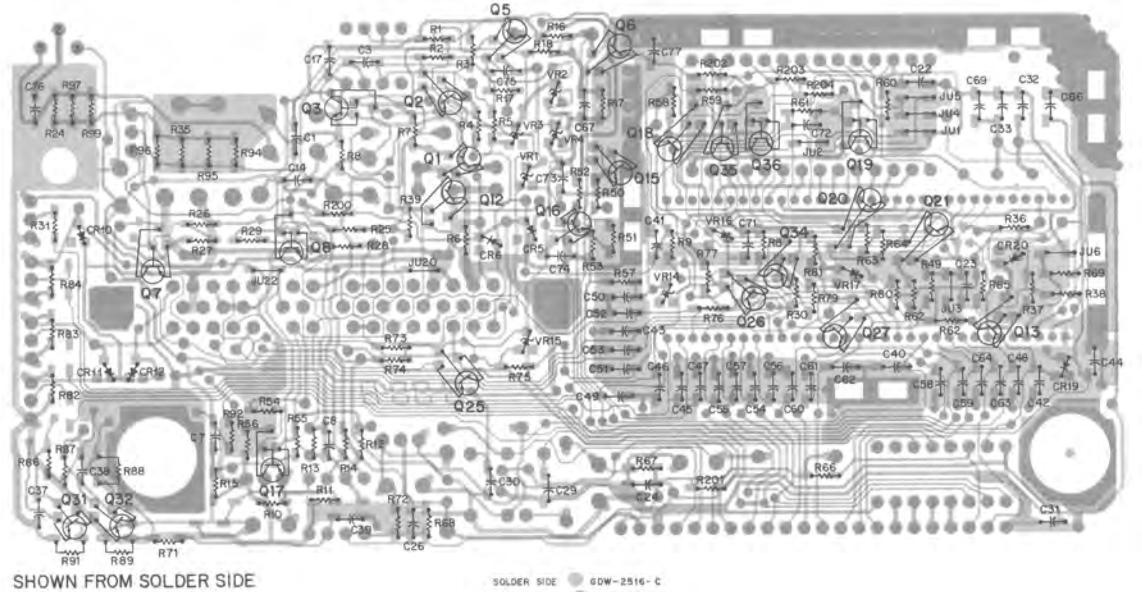
4/30/87

CONTROLLER BOARD



COMPONENT SIDE VIEW

SOLDER SIDE GDW-2516-C
COMPONENT SIDE GDW-2517-C
OVERLAY — GDW-2519-D



SHOWN FROM SOLDER SIDE

SOLDER SIDE GDW-2516-C
COMPONENT SIDE GDW-2517-C
OVERLAY — GDW-2518-D

HLN5104D *Systems 9000* Controller Board — MXW-4381-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C1	21-11032B13	.1, +80, -20%
C3	21-13740B60	300 pF
C6	23-11048C05	1, ±20%, 63V, electrolytic
C7	21-11032B01	.001, +80, -20%
C8	21-13740B57	220 pF
C11	23-11048C10	10, ±20%, 63V, electrolytic
C12,13	23-11048C05	1 ±20%, 63V, electrolytic
C14	21-13740B39	39 pF
C15	23-11048C06	2.2, ±20%, electrolytic
C17	21-11032B13	.1, +80, -20%
C22,23	21-11032B13	.1, +80, -20%
C24	21-11032B15	.22, +80, -20%
C25	23-11013E57	10, ±20%, 25V, tantalum
C26	21-11032B13	.1, +80, -20%
C27,28	23-11048C10	10, ±20%, 63V, electrolytic
C29,30	21-11032B01	.001, +80, -20%
C31	21-11032B13	.1, +80, -20%
C32	21-13740B34	24 pF
C33	21-13740B31	18 pF
C37,38	21-11031A60	820 pF
C39-64	21-13740B60	300 pF
C66	21-13740B60	300 pF
C67	21-13741B45	.01, ±10%
C69	21-13740B19	5.6 pF, ±.5 pF, 50V
C71	21-13741B45	.01, ±10%
C72	21-13740B39	39 pF
C73-76	21-13740B57	220 pF
C77	21-13740B60	300 pF
C78-80	21-13741B45	.01, ±10%
C81	21-13740B60	300 pF
diode (see note)		
CR5,6	48-80236E08	silicon
CR10-12	48-80236E08	silicon
CR14,15	48-83654H01	silicon
CR19,20	48-80236E08	silicon
CR21	48-82466H18	rectifier
CR23	48-84616A11	silicon
CR24	48-84616A11	silicon
jumper		
JU2	06-11077A01	0 ohm
JU5-7	06-11077A01	0 ohm
JU20	06-11077A01	0 ohm
JU22	06-11077A01	0 ohm
connector receptacle		
J1	28-80228J01	50 contact mini D connector
coil, RF		
L1	24-80138G04	5.6 uH, ±5%
transistor (see note)		
Q1	48-80141L01	PNP
Q2	48-80141L03	PNP
Q3	48-80141L04	NPN
Q4	48-80182D22	SCR
Q5	48-80141L03	PNP
Q6	48-80141L04	NPN
Q7	48-80141L03	PNP
Q8	48-80141L04	NPN
Q11	48-80182D11	NPN
Q12	48-80141L04	NPN
Q13	48-80141L01	PNP
Q15	48-80141L03	PNP
Q16	48-80141L04	NPN
Q17,18	48-80141L03	PNP
Q19	48-80141L02	NPN
Q20	48-80141L03	PNP
Q21	48-80141L02	NPN
Q23	48-00869732	PNP
Q25-27	48-80141L03	PNP
Q28-30	48-80182D28	NPN
Q31	48-80141L02	NPN
Q32	48-80141L02	NPN
Q33	48-80182D06	NPN
Q34	48-80141L04	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R1	06-11077A82	2.2k
R2	06-11077A98	10k
R3	06-11077A90	4.7k
R4	06-11077A50	100
R5	06-11077A50	100
R6	06-11077A90	4.7k
R7	06-11077A98	10k
R8	06-11077A82	2.2k
R9	06-11077B05	18k
R10,11	06-11077B31	220k
R12	06-11077A90	4.7k
R13	06-11077B23	100k
R14	06-11077B11	33k
R15	06-11077A98	10k
R16	06-11077A90	4.7k
R17	06-11077B15	47k
R18	06-11077B11	33k
R19	06-11077A98	10k
R24	06-11077A36	27

MXW-4381-B (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R25	06-11077A74	1k
R26	06-11077B07	22k
R27	06-11077A98	10k
R28	06-11077B15	47k
R29	06-11077A90	4.7k
R30,31	06-11077B11	33k
R35	06-11077A70	680
R36-38	06-11077A82	2.2k
R39	06-11077A98	10k
R49	06-11077B15	47k
R50	06-11077A90	4.7k
R51	06-11077A86	3.3k
R52	06-11077A90	4.7k
R53	06-11077A74	1k
R54	06-11077B07	22k
R55	06-11077A98	10k
R56	06-11077A90	4.7k
R57,58	06-11077A98	10k
R59	06-11077B15	47k
R60	06-11077A90	4.7k
R61-63	06-11077B15	47k
R63	06-11077A98	10k
R64	06-11077A66	470
R65	06-11077B15	47k
R66	06-11077A94	6.8k
R67	06-11077B06	20k
R68	06-11077A74	1k
R69,70	06-11077B15	47k
R71	06-11077A82	2.2k
R72	06-11077A74	1k
R73	06-11077B07	22k
R74	06-11077A98	10k
R75	06-11077B15	47k
R76	06-11077B07	22k
R77	06-11077A98	10k
R78	06-11077B15	47k
R79	06-11077B07	22k
R80	06-11077A98	10k
R81	06-11077B15	47k
R82-84	06-11077B11	33k
R86	06-11077A98	10k
R87	06-11077A84	2.7k
R88	06-11077A98	10k
R89	06-11077A84	2.7k
R91,92	06-11077A74	1k
R94-96	06-11077A70	680
R97	06-11077A36	27
R99	06-11077A36	27
switch		
S1	40-80033K01	toggle
transformer		
T1	25-80277J02	voltage conversion
integrated circuit (see note)		
U3	51-83627M42	bipolar
U4	51-80067C05	opamp
U5	51-80046K01	compartor
U7	51-80068C02	voltage regulator
varactor (see note)		
VR1-4	48-80140L11	7.5V zener
VR9	48-82256C67	10V zener, 1W
VR13	48-80236E14	43V zener
VR15-17	48-80140L11	7.5V zener
crystal (see note)		
Y1	48-80113K03	4.9152 MHz
	non-referenced items	
	01-80740T41	component side shield assembly
	26-80003K01	component side shield
	55-84300B02	handle
	05-80200K01	nylon rivet
	09-80002K01	IC socket
	09-80269B03	dual IC socket
	14-80076L01	insulator shield
	14-80269K01	insulator
	26-80220K01	solder side shield
	29-10134A68	connector lug, 12 used
	32-80179J01	D connector gasket
	32-80181J01	face connector gasket
	43-80011L01	8 position LED spacer
	43-80012L01	2 position LED spacer
	54-80111F01	PROM label
	75-05295B01	crystal base pad
	75-80098J01	keypad
	75-80184J01	VF shock pad
	75-80268K01	IC shock pad

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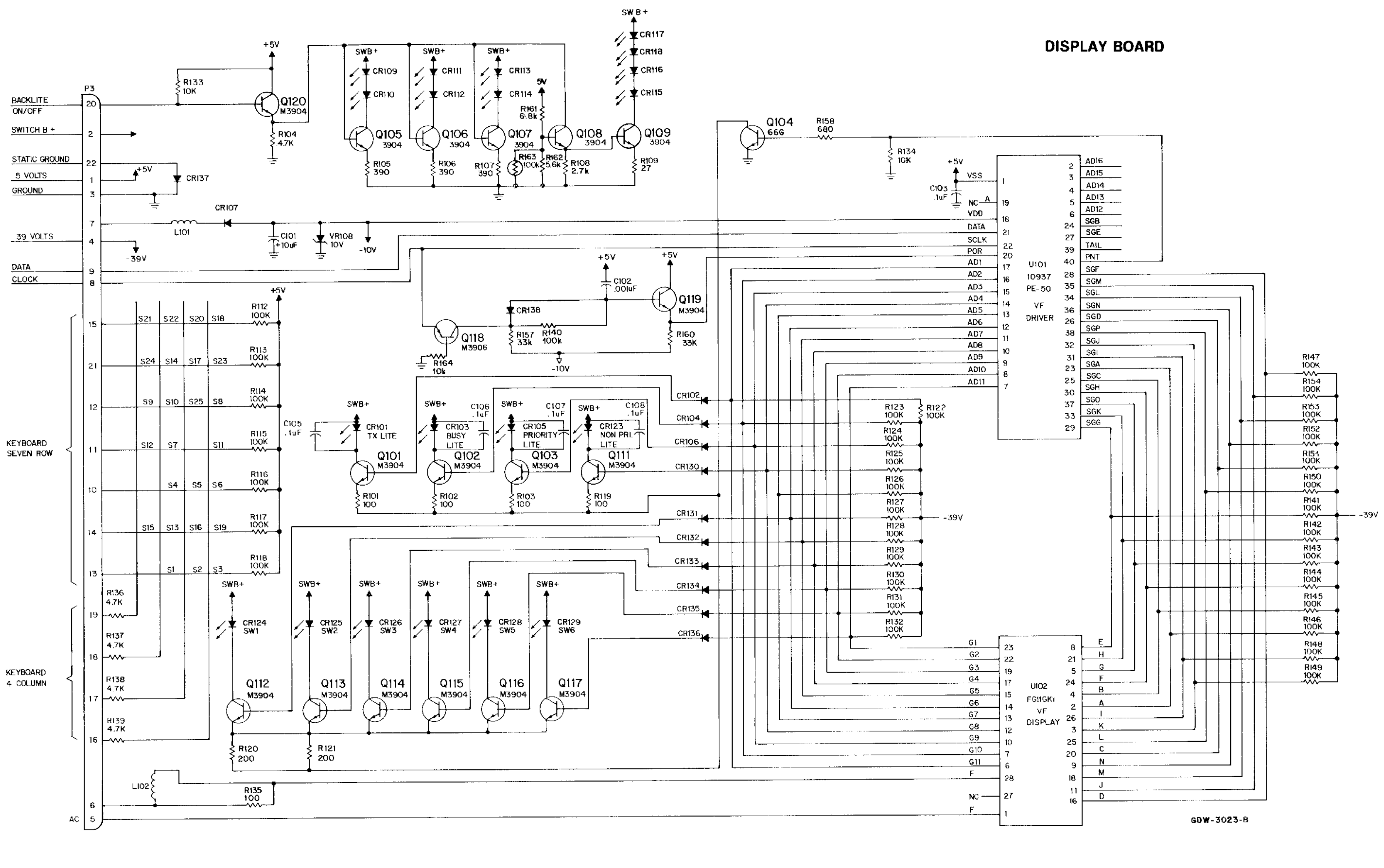
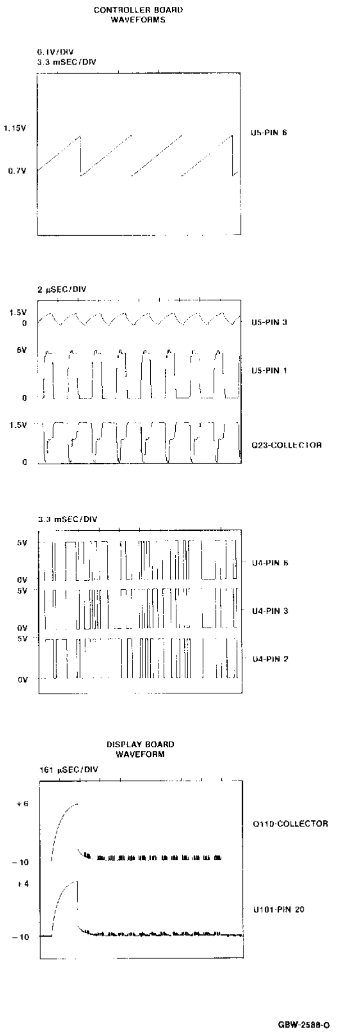
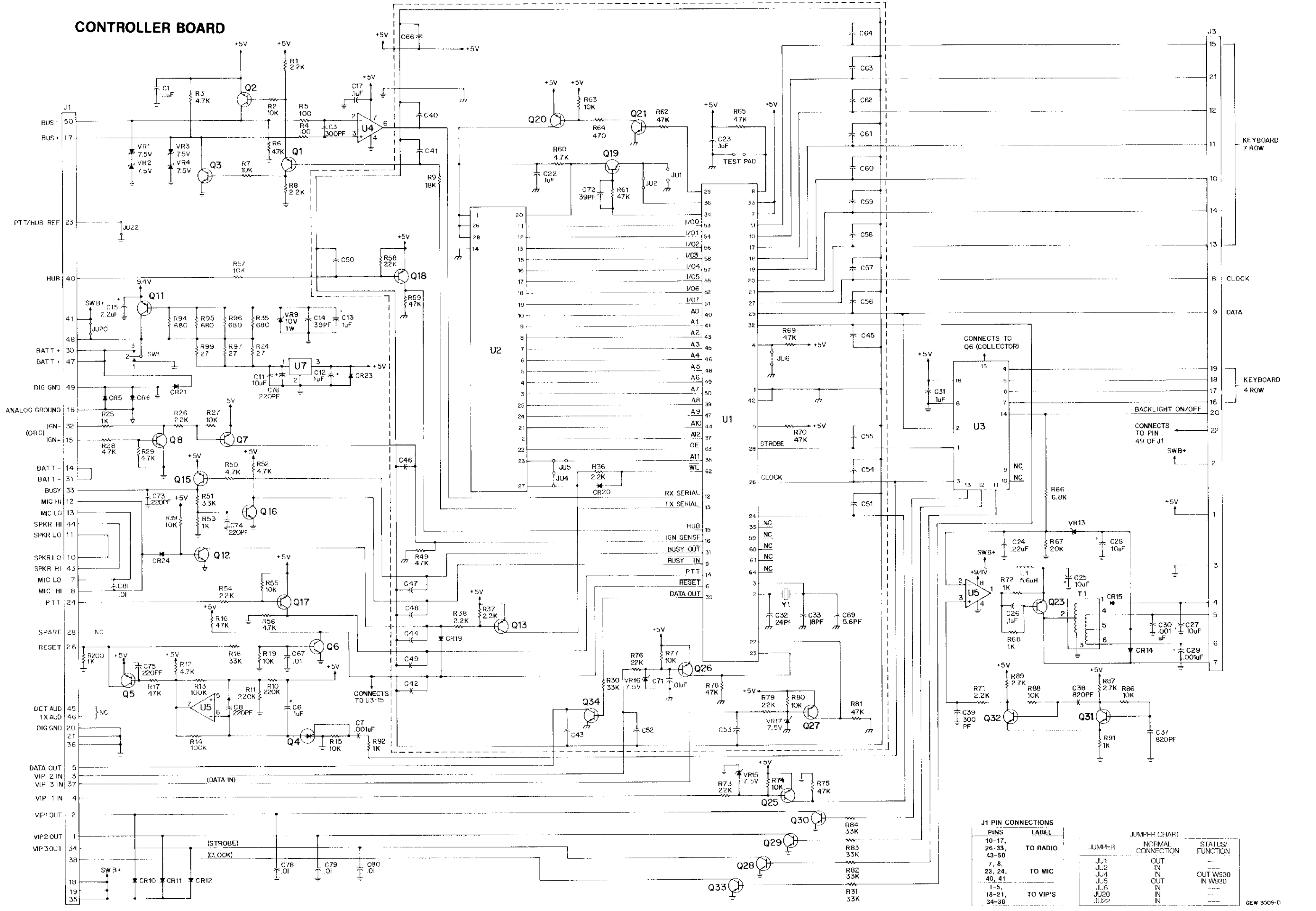
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

DISPLAY BOARD





CONTROLLER BOARD



Troubleshooting Charts, Schematics,
Circuit Board Diagrams, and Parts Lists
for the Control Unit
PW-4385-B
(Sheet 4 of 4)
8/30/88

parts list

HLN4384B Microphone Circuit Board — MXW-2051-C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed uF, ±5%, 50V (unless otherwise stated)		
C1301	21-11038H35	24 pF
C1302	21-11039B13	.001 ±10%
C1304	23-11019A20	10 ±20% 25V, electrolytic
C1305	08-11017A14	.047
C1306	21-11038P50	220 pF
C1307	21-11039B13	.001 ±10%
C1308	08-11051A14	.15 63V
diode (see note)		
CR1301	48082256C25	12V zener ±5% 400mW
connector receptacle		
JU1301,1302	06-11009B23	0 ohm jumper
microphone		
MK1301	50-80258E04	electret cartridge
transistor (see note)		
Q1302	48-80182D08	NPN
resistor, fixed ohm, ±5%, 1/4 watt (unless otherwise stated)		
R1302	06-11009C57	2.2k
R1303	06-11009C49	1k
R1305	06-11009C97	100k
R1306	06-11009C19	56
switch		
S1301	40-80652E02	momentary switch
mechanical part		
	14-80652E01	switch insulator

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note: For best performance, order diodes, transistors, and integrated circuits by Motorola part number.

HLN5389A Microphone Hardware — MXW-5475-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	15-80137D05	front housing
2	38-80144D03	mic button
3	30-80223J01	6 conductor cable
4	05-80221K01	PTT switch grommet
8	32-80058H03	housing gasket
10	15-80137D03	rear housing (p/o housing assembly)
11	03-80076E04	hi-lo metric screw, 3 used
14	35-80089D01	felt baffle
15	05-80148D01	mic cartridge grommet
16	39-10184A10	contact plug, 5 used
non referenced items		
	03-10943M09	tapping screw (3 x 0.5 x 6)
	54-84962K01	safety tag
	33-80016P01	nameplate
	04-80093E01	flat washer (p/o housing assembly)
	46-80297N01	hang-up stud (p/o housing assembly)
	46-80281G01	mic weight (p/l housing assembly

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HSN4018A Speaker — MXW-2053-C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	03-00136756	tapping screw (10-16x 5/8)
2	15-10183A18	connector housing plug, 2-contact
3	39-10184A45	contact plug, 2 used
4	42-82018H05	cable retainer
5	42-84081A03	wire clamp with S-hook
6	03-00140001	tapping screw (6-19 x 7/8), 4 used
7	03-84244C03	black shadow wing screw, 2 used
8	50-80135E01	speaker
9	07-80200E01	black speaker trunnion bracket
10	13-82671M04	bezel
11	15-84981B07	speaker base cover
12	32-84564B01	speaker gasket

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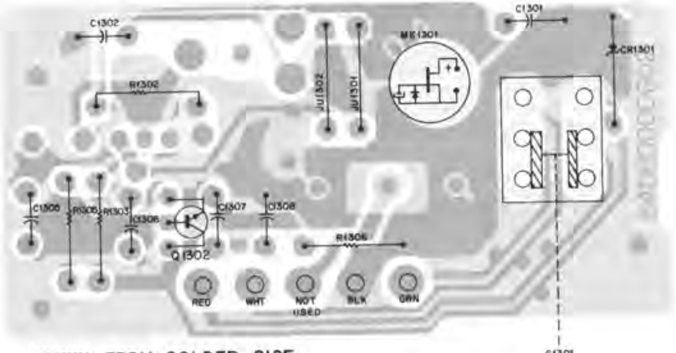
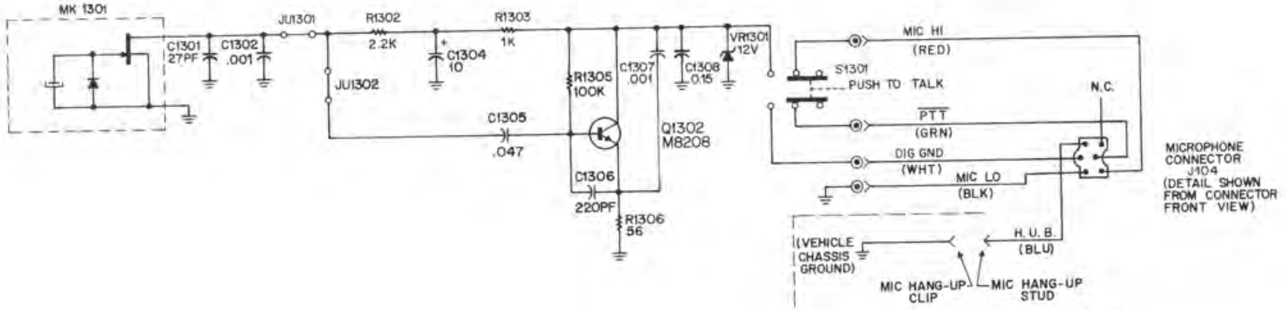
HLN4384B MICROPHONE BOARD



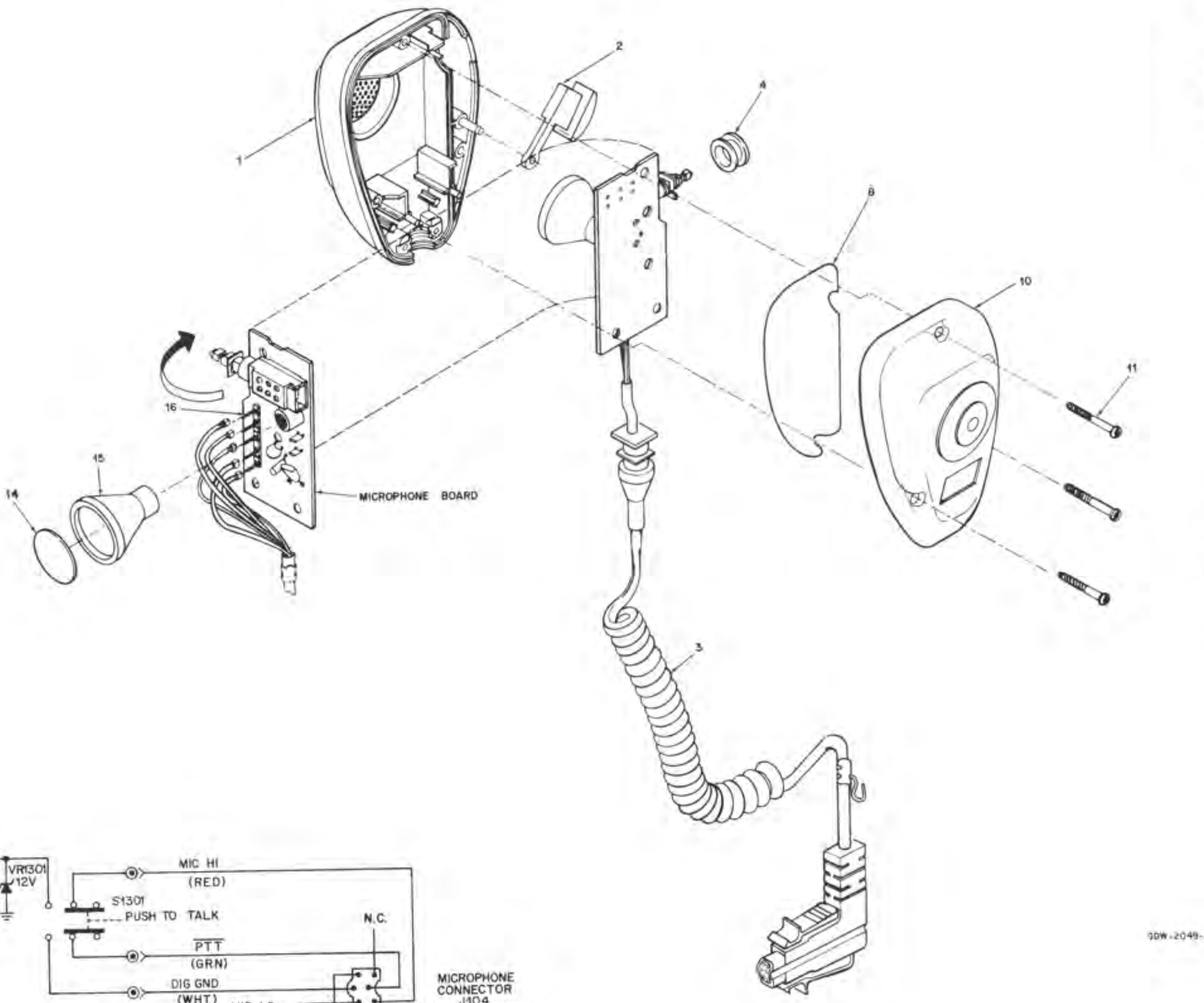
SHOWN FROM SOLDER SIDE

S1301 P.T.T.

COMPONENT SIDE - GBW-3447-A
SOLDER SIDE - GBW-3448-A
OVERLAY - GBW-3449-A



BCW-2050-A



GBW-2049-A

FUNCTION

The palm microphone contains an amplifier to provide the radio with a high-level, noise-free audio input. The microphone also provides push-to-talk transmit control for the radio as well as off-hook channel monitoring (PL/DPL squelch disable) capability.

GPW-3459-B