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MOTOROLA

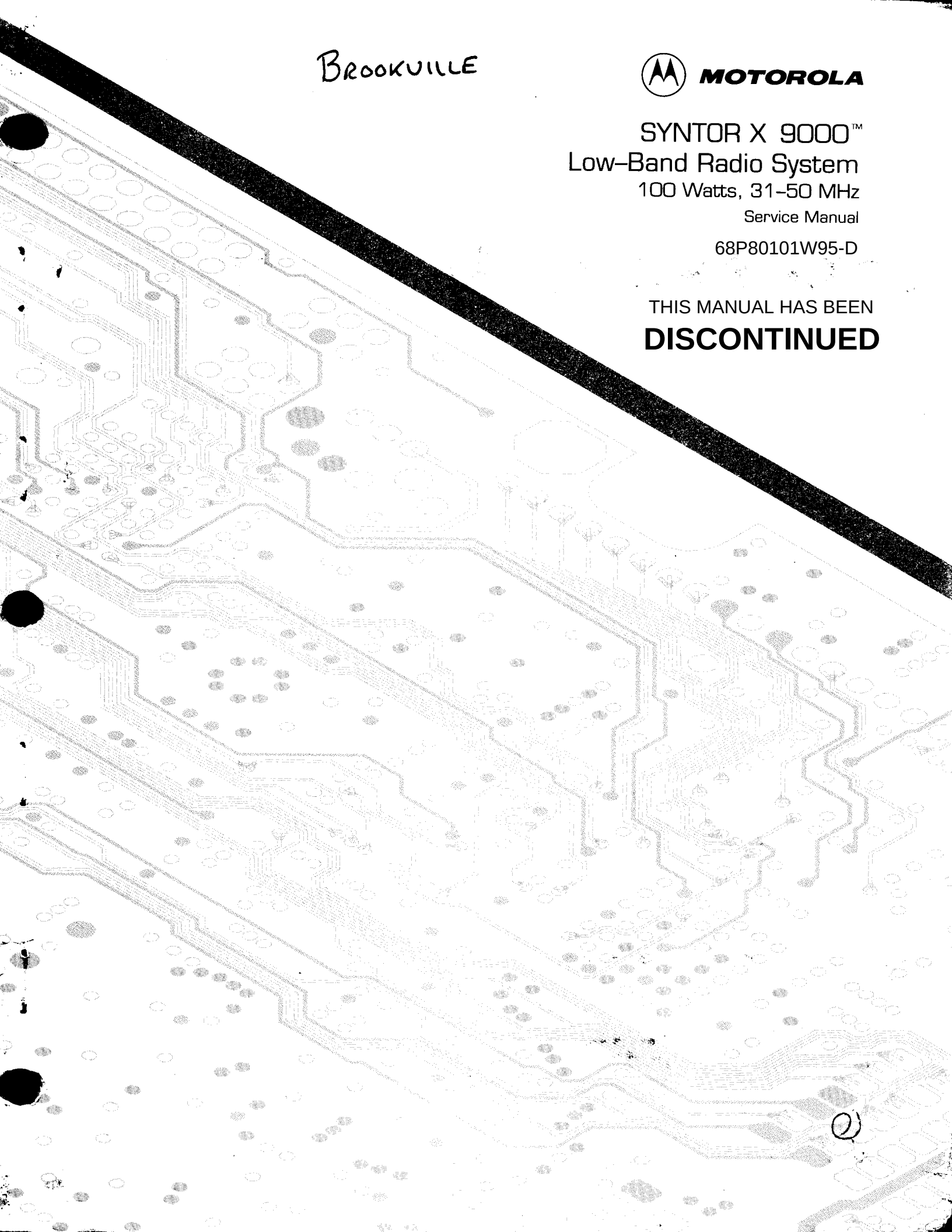
SYNTOR X 9000™
Low–Band Radio System
100 Watts, 31–50 MHz

Service Manual

68P80101W95-D

THIS MANUAL HAS BEEN

DISCONTINUED



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CONTENTS

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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.

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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.

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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
LOW-BAND RADIO 31–50 MHz
T71KXJ AND T71KEJ 100 WATT

		MODEL / ITEM	DESCRIPTION
		T71KEJ7J04AK	32-Mode, 100 Watt
		T71KXJ7J04AK	32-Mode, 100 Watt, SECURENET Capable
		ITEM	DESCRIPTION
◆	◆	HUB1105A	Unified Chassis
●	●	HCN1033D	Control Unit, 32-Mode (Early Version)
●	●	HBN4036A	Control Unit Packing Kit
●	●	HLN4907D	Control Unit Panel Kit
●	●	HLN4924B	Control Unit Hardware
●	●	HLN5210A	Control Unit Software and EEPROM
●	●	HCN1063	Systems 9000 Control Head (Later Version)
●	●	HBN4036A	Control Unit Packing
●	●	HLN5464A	Systems 9000 Control Head
●	●	HLN5562A	Standard Hardware
●	●	HVN4026A	Systems 9000 Control Head Firmware
●	●	HCN1073A	Systems 9000 Control Head (Latest Version)
●	●	HBN4036A	Control Unit Packing
●	●	HLN5562A	Standard Hardware
●	●	HLN6284A	Systems 9000 Control Head
●	●	HVN4026A	Systems 9000 Control Head Firmware
●	●	HKN4051A	Power Cable and Fuse Kit
●	●	HLN4111A	Installation Kit (Early Version)
●	●	HLN4022D	Installation Kit (Later Version)
●	●	HLN4243A	Bottom Cover
●	●	HLN4262A	Tuning Tool
●	●	HLN4263A	Top Cover
●	●	HLN4666A	Mounting Tray
●	●	HMN1061A	Microphone
●	●	HLN4384A	Microphone Board Kit (Early Version)
●	●	HLN5459A	Microphone Board Kit (Later Version)
●	●	HLN5389A	Microphone Hardware Kit
●	●	HLN5391A	Microphone Hang-Up Clip
●	●	HSN4018A	Speaker
●	●	TAB1002C	Antenna with Spring Base
●	●	HLN4457A	Antenna Base Kit
●	●	TKN6132A	Antenna Cable Kit
●	●	TLN6590A	Antenna Rod Kit
	●	HKN4256A	17 ft. Radio Power Cable (SECURENET)
●	●	HLN4921A	Trunnion
	●	HLN4980A	Nameplate
●		HLN4979A	Nameplate
●	●	HLN4952A	Fuse Kit for Green and Orange Leads
●	●	HLN4983A	Systems 9000 Basic Buttons
●	●	HLN5027A	Systems 9000 Radio Software
●	●	HLN5028A	Systems 9000 EEPROM
●	●	HLN5046A	Systems 9000 Tools
●	●	HLN5066A	Scan Button
	●	HLN5092A	SECURENET Button
●	●	HLN5095A	Blank Button (9 supplied)
●	●	HLN5096A	Blank Plug (5 supplied)
●	●	HLN5105A	Handle and Shield
●		HKN4241A	17 ft. Radio Power Cable
●	●	HBN4002A	Packing Kit

CODE: ● = ONE ITEM SUPPLIED, ◆ = BREAKDOWN IN SEPARATE CHART

MODEL CHART FOR SYNTOR X 9000
LOW-BAND RADIO UNIFIED CHASSIS

MODEL		DESCRIPTION
	HUB1105A	Unified Chassis, 31-50 MHz
	ITEM	**DESCRIPTION**
●	HLB1016A	Directional Coupler
●	HLN4837A	Directional Coupler Hardware
●	HLB4092A	Directional Coupler Board
●	HLB1025A	Internal Casting
●	HFB4001A	Receive Injection Filter
●	HLB1021A	Transmit Mixer
●	HLN4909B	Coax Cables
●	HLB4084A	Transmit Mixer
●	HLB4085A	Receive Mixer
●	HLB4086A	VCO
●	HLB4091A	Extender Back End Board
	or HLB4091B	Extender Back End Board
	or HLB4091C	Extender Back End Board
●	HLB4090A	Extender Front End Board
●	HLN4813A	Internal Casting Hardware
●	HLN4251A	VCO Interconnect
●	HLB4108A	High IF
●	HLB4109A	RF Board
●	HLN5222B	Common Circuits Board
●	HLB4093A	PA Transistors
●	HLN4814A	PA Hardware
●	HLN4913A	Feedthru Board, 7-pin
●	HLN4914A	Feedthru Board, 2-pin
●	HKN4202A	Interconnect Cable
●	HLN4461B	Bus Wire, Red/Black
●	HLN5299B	Personality Board
●	HLN4815A	Chassis Hardware
●	HLN4259A	Front Hardware
●	HFB4000B	Receive High-Pass Filter
●	HLB4083B	Transmit Buffer Board
●	HLB4094A	PA Board
●	HLN5349A	Self Q Hardware

CODE: ● = ONE ITEM SUPPLIED

Options Chart

Conventional

OPTION	DESCRIPTION
W20	Telephone Interconnect Microphone
W58	1/4 Wave Antenna (800 MHz)
W70	Omit Antenna
W71	Omit Microphone
W87	Omit Speaker
W90	Omit Standard Accessories
W90	Omit *SECURENET* Accessories
W101	Negative Ground cable, 22'
W109	Handset with Hang–up Box
W116	External Alarm (includes cable and 2 relays)
W239	Noise Cancelling Microphone
W269	Electronic Siren/Public Address
W290	Operator Select Multiple Coded Squelch
W370	*MDC–1200* Status/Message (8)
W412	*MDC–1200* Selective Call
W421	Dual Priority *Channel Scan*
W452	*MDC–600* Unit–ID and Emergency
W470	Hidden Footswitch
W496	Negative Ground cable, 10'
W589	Public Address
W591	Auxiliary Switch Panel
W681	*MDC–600* Selective Call Encode/Decode
W688	Hidden Emergency Pushbutton
W703	Talkback Scan
W712	*Mobile Voice Storage*
W800	Front and Rear Controls
W814	*MDC–1200* PTT/ID
W824	*MDC–600* Status
W825	*MDC–600* Message
W930	64 Mode Operation
W941	*MDC–1200* Status/Message (16)
W946	Conventional Telephone/DTMF
W983	Direct Entry *MDC–600* Status
W984	Direct Entry *MDC–600* Message
W988	Limited Control Unit Functions

SECURENET *Options*

W268	Code Storage Battery
W303	Dual Code Select
W304	Proper Code Detect
W391	Physical Security Housing
W794	Add *DVP* Encryption
W797	Add *DVP–XL* Encryption

SYNTOR X 9000 Low Band Performance Specifications

GENERAL

Number of Modes	Models available in 32– mode configuration standard. 64–mode 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 within 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 negative–ground vehicles. Optional cable kit permits operation with positive–ground vehicles.
Radio Unit Dimensions	2.65" H x 11.5" W x 16.0" L (76.5 mm x 292 mm x 406 mm).
Radio Unit Weight	Approximately 22 lb (10.2 kg). Shipping weight approximately 37 lb (17 kg).

			Maximum Battery Drain (inc. std. accessories)		
Model (Series)	**Frequency**	**Minimum RF Power Output**	**Standby @ 13.8V**	**Receive @ Rated Audio @ 13.8V**	**Transmit @ Rated Power**
T71KXJ, T71KEJ	31–50 MHz	100W	1.2 A	3.5 A	27A

TRANSMITTER

Output Impedance	50 ohms.
Spurious and Harmonic Emissions	More than 70 dB below carrier (for EIA spec. RS152B).
Frequency Stability	±.0005% of assigned center frequency from –30°C to +60°C ambient (+25°C reference).
Maximum Frequency Seperation	19 MHz without degradation.
Modulation	15F2 and 16F3, ±5 kHz for 100% at 1000 Hz.
Audio Sensitivity	0.080V ±3 dB for 60% maximum deviaiton at 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% at 1000 Hz, 60% maximum deviation.
FCC Designation	
T71KEJ:	ABZ89FT1610 – Licensable under FCC rules Parts 22, 74, and 90 for 15F2,16F3, and 16F9 emission.
T71KXJ:	ABZ89FT1612 – Licensable under FCC rules Parts 22, 74, and 90 for 15F2, 16F3, 16F9, and 20F3Y emission.

RECEIVER

Input Impedance	50 ohms.
EIA Modulaiton Acceptance	±6.5 kHz minimum.
Frequency Stability	±.0005% of assigned center frequency from –30°C to +60°C ambient (+25°C reference).
Maximum Frequency Separation	19 MHz without degradation.
Sensitivity	
20 dB quieting	0.35 uV.
EIA SINAD	0.25 uV.
Intermodulation (EIA SINAD)	75 dB.
Spurious & Image Rejection	90 dB except 80 dB at 37.85 MHz.

Selectivity (EIA SINAD)	**ADJACENT CHANNEL**	**ALTERNATE CHANNEL**	**4TH CHANNEL**	**±400 kHz**
20 kHz Channel	85 dB	89 dB	100 dB	100 dB

Squelch Sensitivity	Carrier squelch (at threshold setting), Tone–Coded Squelch (fixed), Digital–Coded Squelch (fixed), are all 8 dB SINAD (0.25 uV maximum without preamp; 0.13 uV with preamp). Audio 15 watts at less than 3% distortion into an 8–ohm load.
FCC Designation	ABZ89FT1610.

CONTROL HEAD

Dimensions: excluding mounting bracket	6.5" W x 3.375" H x 1.687" D (166mm x 87mm x 43mm)
Weight	1 lb (456 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)

1. Radio Features

1.1 GENERAL

The *SYNTOR X 9000* Low Band 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 MIL810D 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 *SYNTOR X 9000* Two–Way Radio Operator's Manual.

1.2 CONVENTIONAL FEATURES

SYNTOR X 9000 Low Band 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* radio operates over a broad band of frequencies. Since frequencies can be added or changed without retuning or realigning the radios, the units can operate in different systems on widely separated frequencies.

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

SYNTOR X 9000 Low Band transmitters provide audio distortion rated at less than 2% (at 1000 Hz, 60% maximum deviation) and a frequency stability of +0.0005% of assigned center frequency (over an ambient temperature range of –30°C to +60°C). Spurious and harmonic emissions are rated at greater than 70 dB below carrier. Sensitivity of the receiver is rated at 0.25 microvolts (EIA SINAD), and spurious and image rejections is –10 dB. Frequency stability is identical to that of the transmitter.

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 TALK–AROUND CAPABILITY

Repeater talk–around 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 talk–around 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.

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 low–band *SYNTOR X 9000* radio can be grouped into physical blocks: personality board, memory module, common circuits board, 100–watt power amplifier, radio frequency (RF) board, directional coupler board, and internal casting. The internal casting includes a voltage–controlled oscillator (VCO), RX injection filter, TX mixer, RX mixer, *Extender* front and back end, and high IF.

2.2 FUNCTIONAL DESCRIPTION

The radio can be functionally divided into five parts: (a) microcomputer, (b) control unit, (c) frequency synthesizer, (d) receiver/*Extender*, 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/*Extender* circuits are contained on the personality board, RF board, *Extender* 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 consisting of a reference oscillator, a voltage controlled oscillator (VCO), a multiplexed–input divider, a sample–and–hold phase detector, a phase modulator, and an adaptive loop filter. In addition to the phase–locked loop, the frequency synthesizer contains a receive injection doubler, transmit injection doubler, and a transmit injection mixer and buffer.

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) turn the receiver's *Extender* "on" or "off." 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.

In the receive mode, high side injection is supplied to the receiver's second mixer by the receive injection doubler. This signal is generated by doubling the third harmonic of the reference oscillator.

In the transmit mode, this signal is routed to the transmit injection doubler, which doubles and amplifies the signal to make it high–side injection for the transmit injection mixer. The transmit injection mixer then mixes this signal with that of the VCO to generate the transmit injection signal. The transmit injection signal is filtered and buffered before being applied to the transmitter's low level amplifier (LLA).

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 that 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 phase detector via the deviation and compensation circuits.

2.2.4 Receiver

Incoming RF signals go through the directional coupler, harmonic filter, antenna switch, high–pass filter, and pre–amp on their way to the first mixer stage. The combined selectivity of the harmonic filter and high–pass filter 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 injection frequency that is applied to the first mixer via an injection filter. The resulting 75.7–MHz high IF signal is amplified, filtered by a SAW (Surface Acoustic Wave) filter, and applied to the second mixer. The second mixer converts the signal to the 10.7–MHz low IF via an 86.4–MHz high–side injection from the synthesizer. The 10.7–MHz signal passes through the *Extender*'s blanking switches (unless blanked) and several stages of amplification and crystal filtering before being applied to the limiter/detector. The squelch circuit gives the microcomputer two signals (CHANNEL ACTIVITY and SQUELCH TAIL). In the absence of an RF carrier, both signals are low. When an RF carrier appears, both signals switch to high, and 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 *Extender*

The *Extender* is a noise–pulse blanking circuit, so named because it extends the operating range of the radio in high–noise environments (ignition noise, DC motor noise). It consists of three basic elements: a tuned– RF AM receiver with post–detection pulse shaping, a delay element in the high IF, and a low–IF blanking switch. The latter two elements are part of the main radio receiver. The *Extender* receiver's input is tapped off the main radio receiver's pre–amp output. The *Extender* receiver is field–tuned to a clear frequency about three MHz from the user's channel, where it listens for noise pulses. When it detects one, it generates an out put and routes it to the blanker switch. This switch shuts off the main receiver's low IF for the duration of the noise pulse, but since the blanking interval is short (6 mS), you do not hear an interruption in the audio. In order to allow time for the detection of the noise pulse and the generation of the blanking waveform, a SAW filter in the high IF ahead of the second mixer and blanking switches delays all signals (desired and undesired) in the main receiver signal path by 2.5 mS.

2.2.6 Transmitter

The RF output generated by the frequency synthesizer at the required transmit frequency goes to the low–level amplifier (LLA). A controlled stage on the PA circuit board, the LLA consists of Q801 and associated matching circuitry. It amplifies the synthesizer power from 75 milliwatts (typical) to 2.5 watts (typical). The power amplifier is driven by the LLA, and is supplied A+ through the red lead. The PA circuitry consists of Q802, 3, 4, and associated matching circuits.

Driver Q802 amplifies the drive from the LLA to approximately 20 watts, and Q803 and Q804, the final stage, amplify it further to approximately 140 watts. Losses in later passive circuits reduce this power to 105 watts (set level). The final stage also has current– sensing and temperature–sensing circuitry (R814, RT801, and R815) for power control functions. The PIN diode antenna switch is a solid–state circuit that uses the DC–excitable, variable–resistance properties of PIN diodes to make either low or high–impedance paths for RF signal flow. In the receive mode, receiver PIN diodes CR971 and CR972 are forward–biased, and PIN diode CR970 is reverse–biased by saturated transistor Q980.

This allows the incoming signal to pass from the low–pass filter to the high–pass filter and preamplifier.

During transmit, keyed 9.4V turns transistor Q980 off and concurrently forward–biases transmit PIN diode CR970, presenting a low–loss path from the PA to the low–pass filter. As the transmitter power in creases, a peak detector consisting of C970, CR973, CR974, CR975, and R972 detects the negative portion of the RF signal, converting it to a negative DC potential, which reverse–biases the receiver PINs and keeps the receiver isolated from the high–power transmitter signal.

The harmonic filter is an 11–pole, five–zero elliptic filter. It has the steep roll–off it needs to accommodate the large bandwidth of the transmitter. This circuit is in the receive path, as is the directional coupler. The directional coupler senses forward and reflected transmit power separately, and generates a detected DC voltage proportional to each. The forward detected voltage goes to the power–set circuitry on the common circuits board. The reflected detected voltage warns of a high (3>:1) VSWR and triggers the shut back circuitry, which is also on the common circuits board, along with temperature and over–current sense shutback circuits.

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.

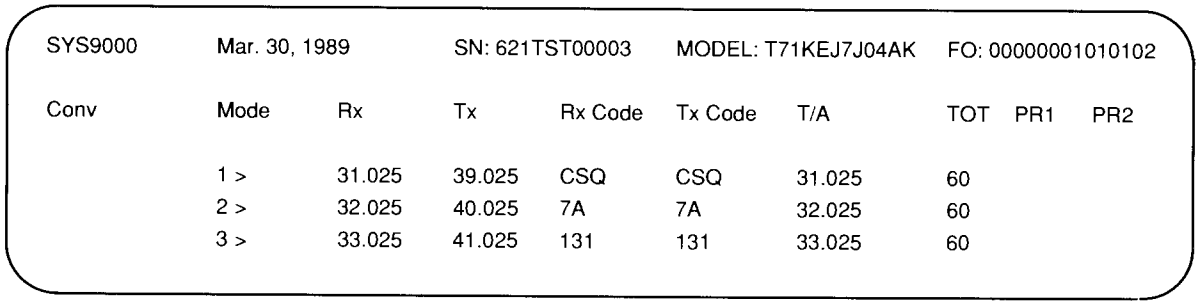
(13) PR1: this field identifies the first priority scan selection.

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

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

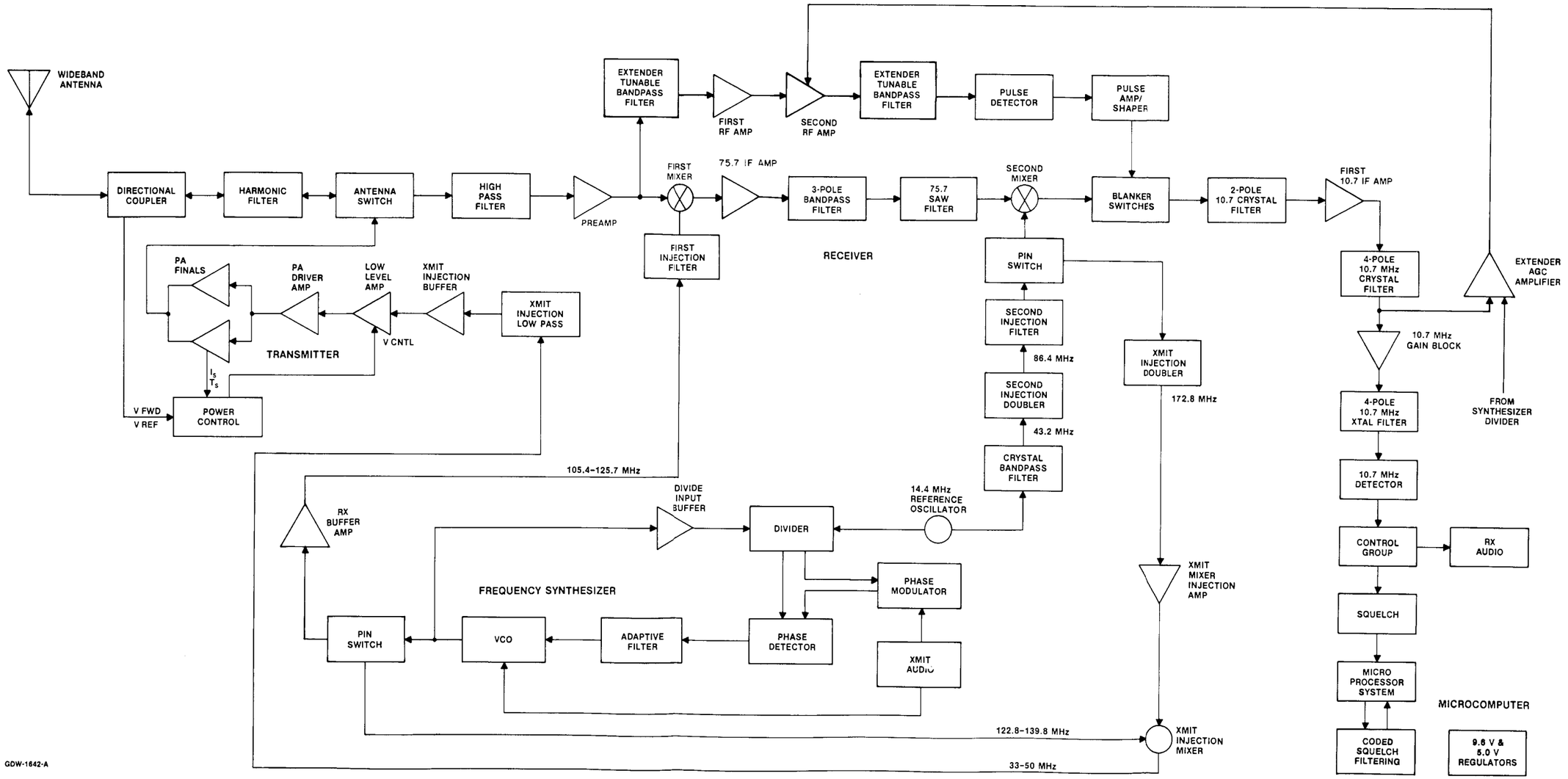
(16) RADIO NAME: this field identifies the radio name assigned at time of order processing.

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



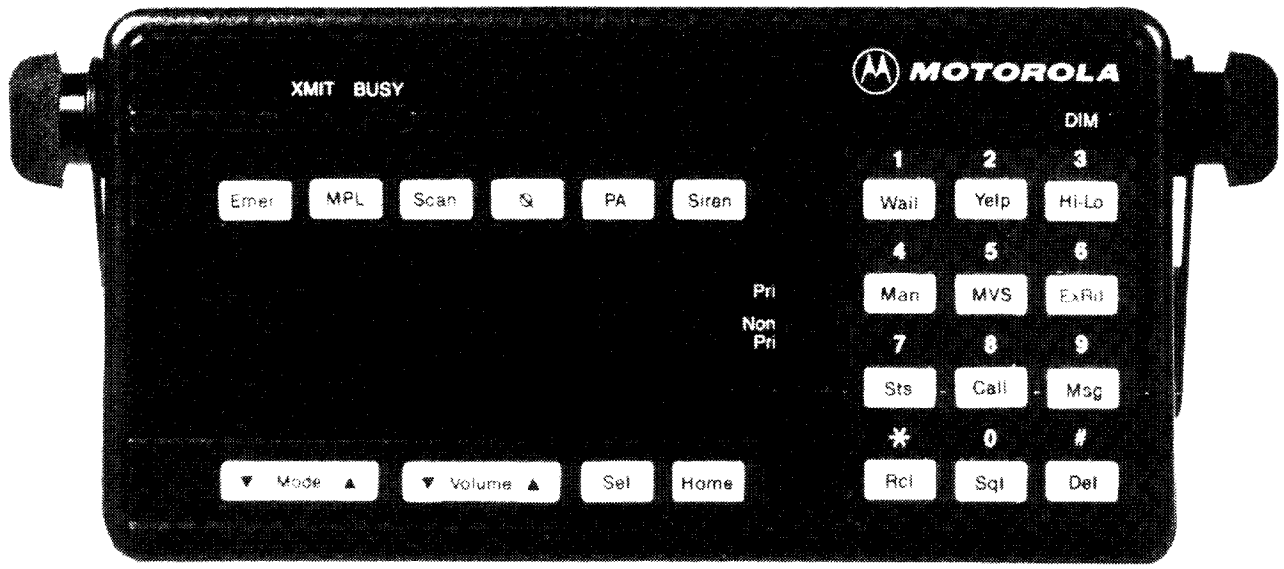
GPW–4544–A

Figure 1. SYNTOR X 9000 *Low Band Radio Identification Label*



GDW-1642-A

Block Diagram for
Low-Band *SYNTOR X/ SYNTOR X 9000* Radios
PW-2189-B
8/12/87



GPW–2538–A

Figure 1. Systems 9000 *Control Unit*

1. General

The *SYNTOR X 9000* mobile units consist of:

- Remote mountable radio.
- Dual operation control unit.
- Microphone.
- Speaker.
- Antenna.
- Interconnecting cable.

The mobile units are supplied with *Systems 9000* control units that meet the basic requirements for conventional operation.

The *Systems 9000* Control Unit has 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.
- Transmit indicator light.
- Priority channel indicator light.
- Non–priority 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 proceed 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 are allowed 11 characters, it is suggested however, to allow three digits for a mode number and eight digits for the mode name to provide both name and numeric mode association.

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 *Channel Scan* unmutes the radio.

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 TALK BACK SCAN

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

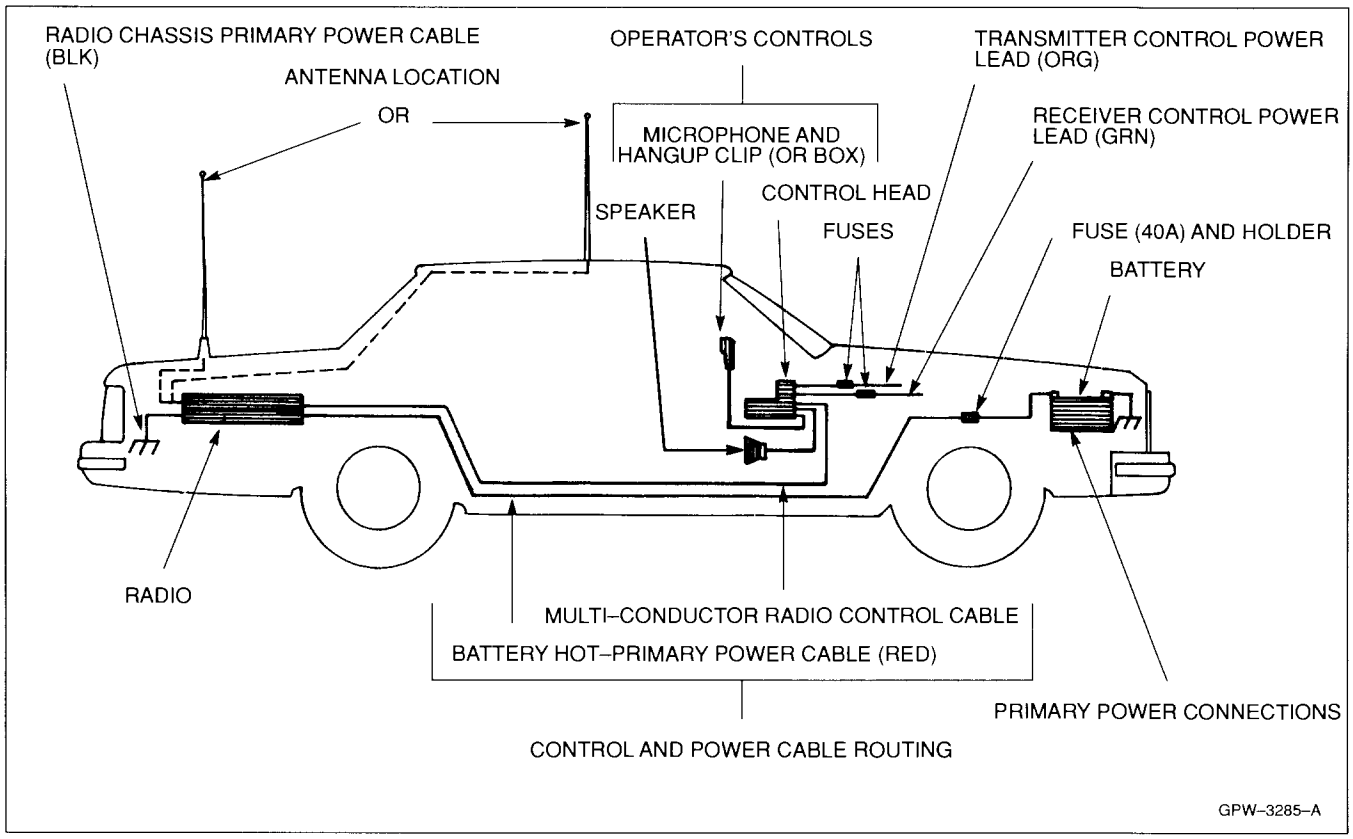


Figure 1. Installation Planning

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).

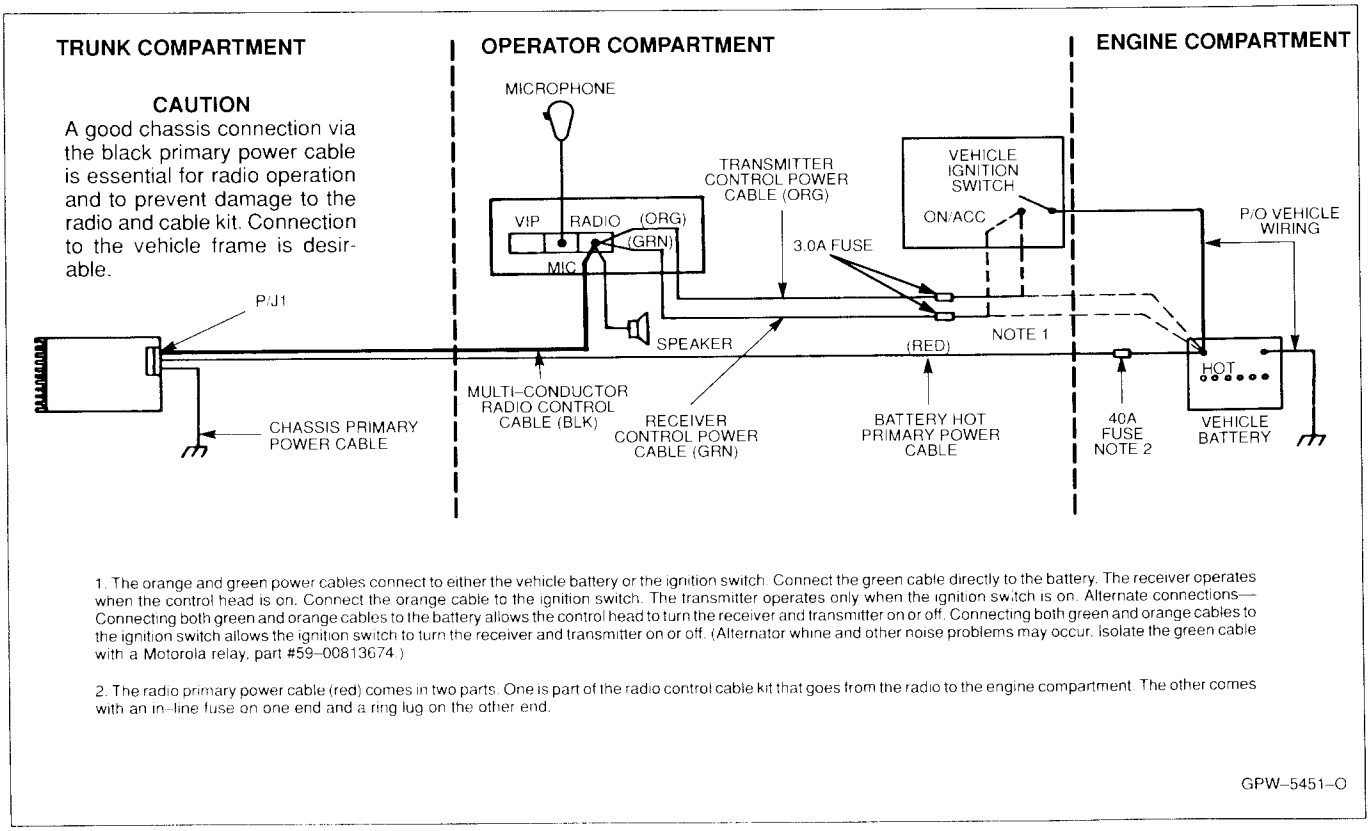


Figure 2. Cabling Interconnection Diagram

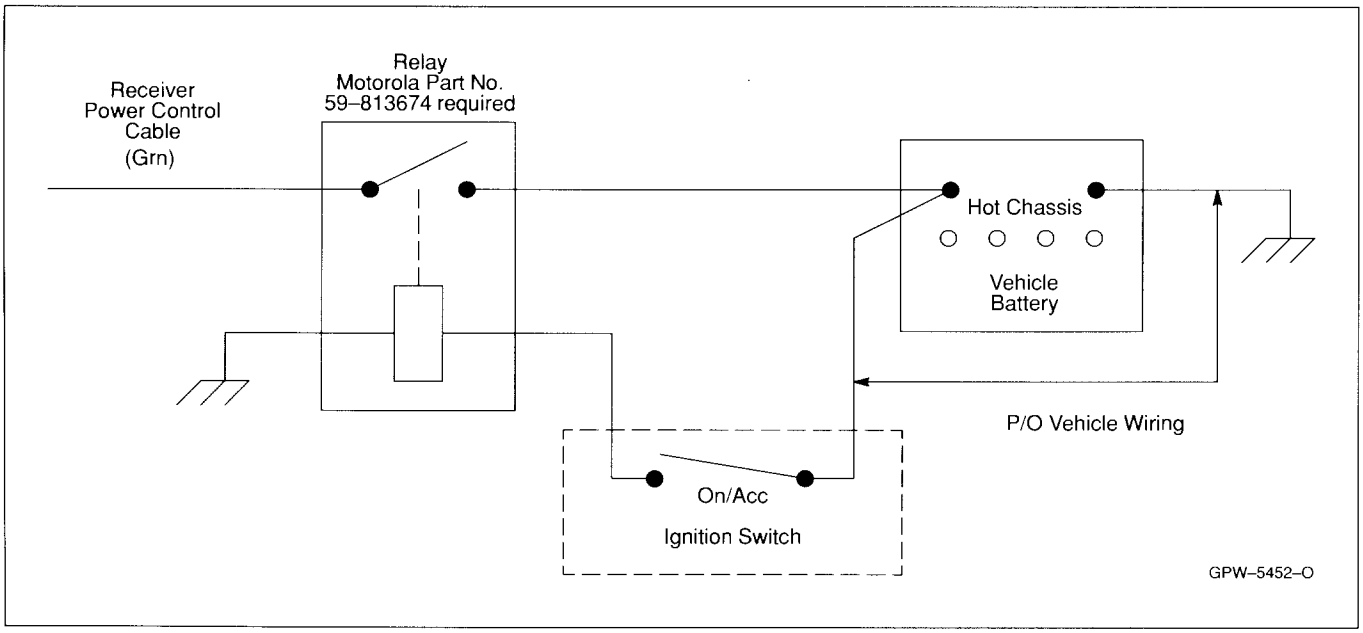


Figure 3. Power Control Isolation Detail

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.

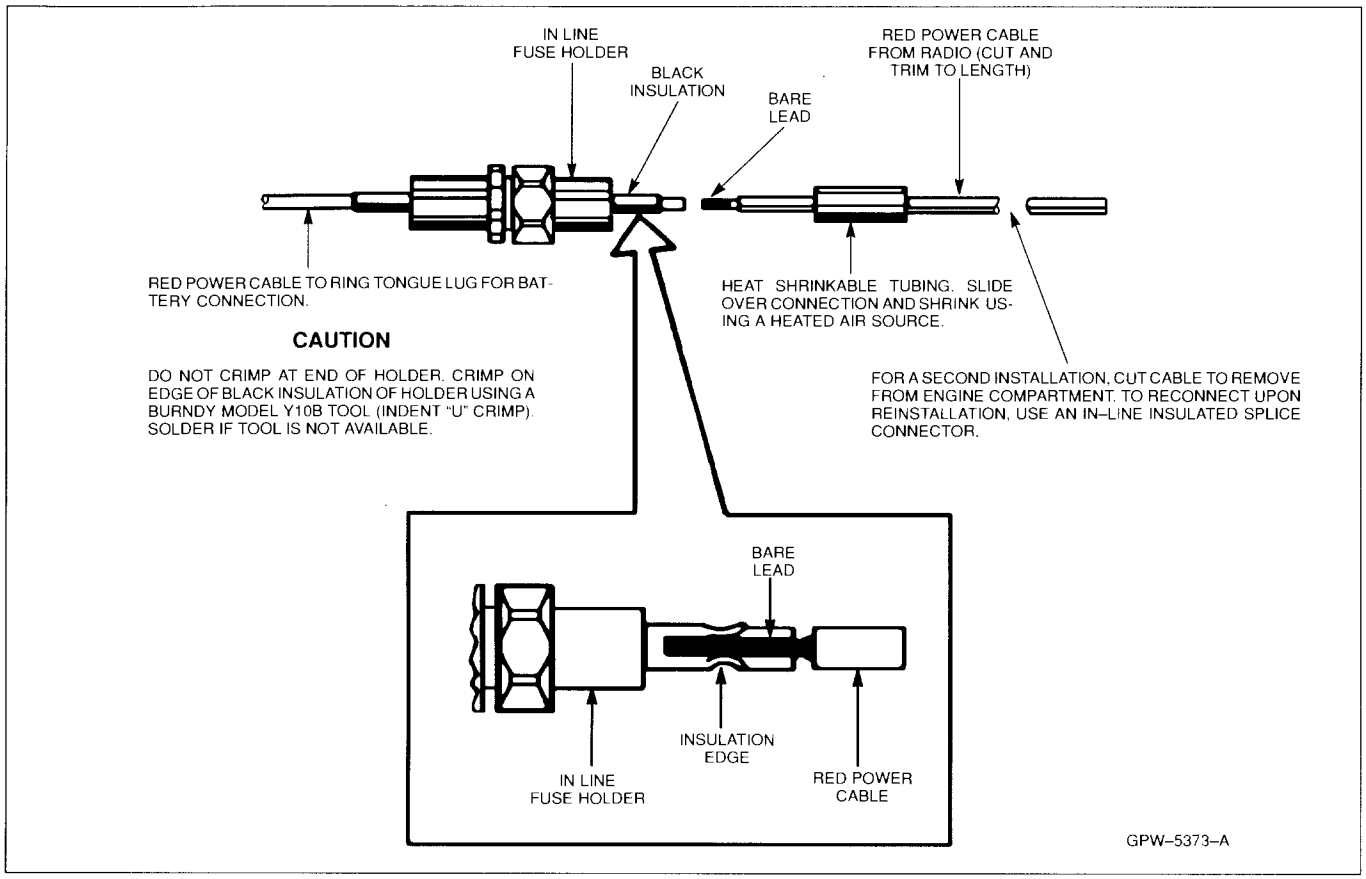
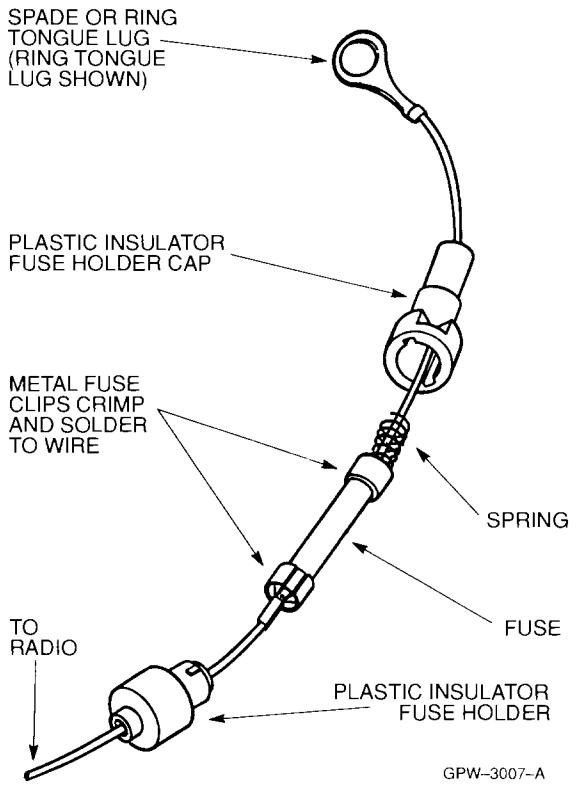


Figure 4. Fuse Installation



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)

05/23/88

HKN4051A Cable and Fuse — MXW-4224-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	01-80701T88	30" lead and lug assembly
	29-84528B05	ring lug
	30-00812505	8 strand wire, red
	03-00139931	tapping screw
	09-84277B02	fuse receptacle
	10-10043A02	red tie wrap
	37-00134371	heatshrink tubing
	38-84383D02	protective cap
	42-84275B01	fuse retainer
	65-84161B01	40 amp fuse (5AG)

7/15/89

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.

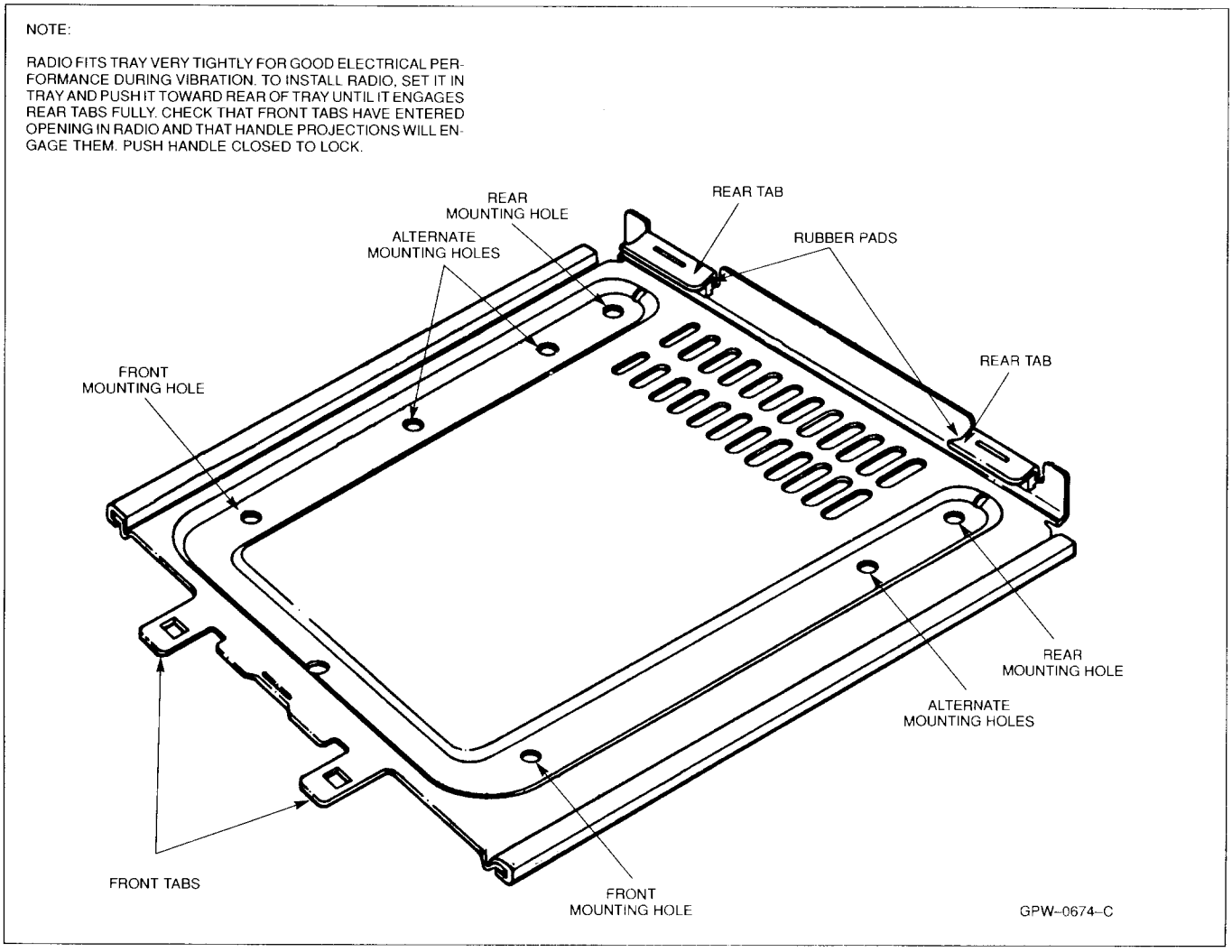


Figure 6. Radio Mounting Tray

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). 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 floor 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 a #14 x 3/4" self–tapping screw and the supplied 1/4" lockwasher to mount the cable lug. See Figure 8.

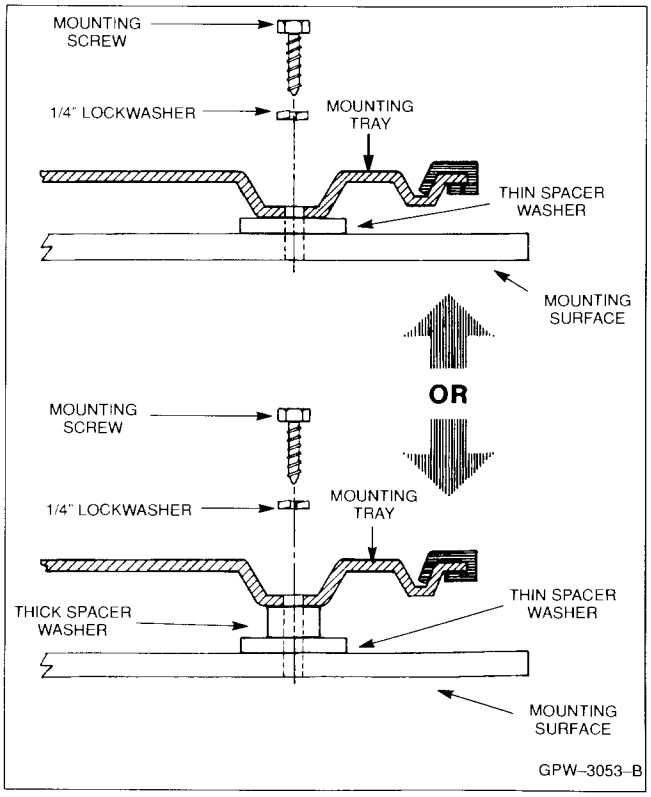


Figure 7. Radio Mounting Tray Installation Detail

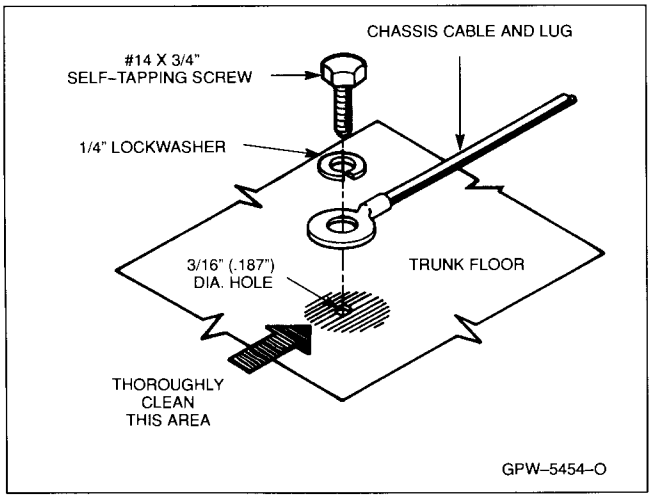


Figure 8. Radio Ground Connection

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

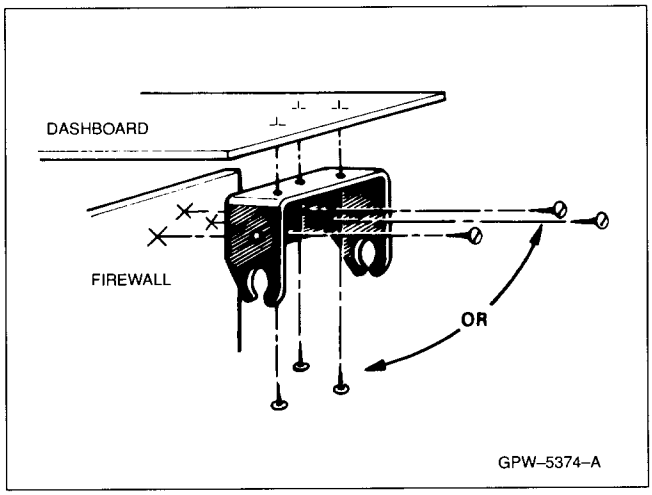


Figure 9. Standard Speaker Mounting

(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) Mount the trunnion bracket with the supplied self drilling screws.

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

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

(8) Tie up surplus lead cable.

Note

Using the self drilling screws eliminates the need for predrilled holes.

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

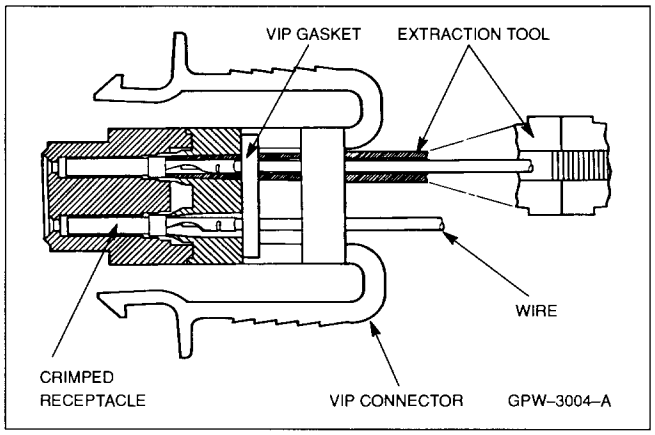


Figure 10. VIP Connector Detail

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.

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).

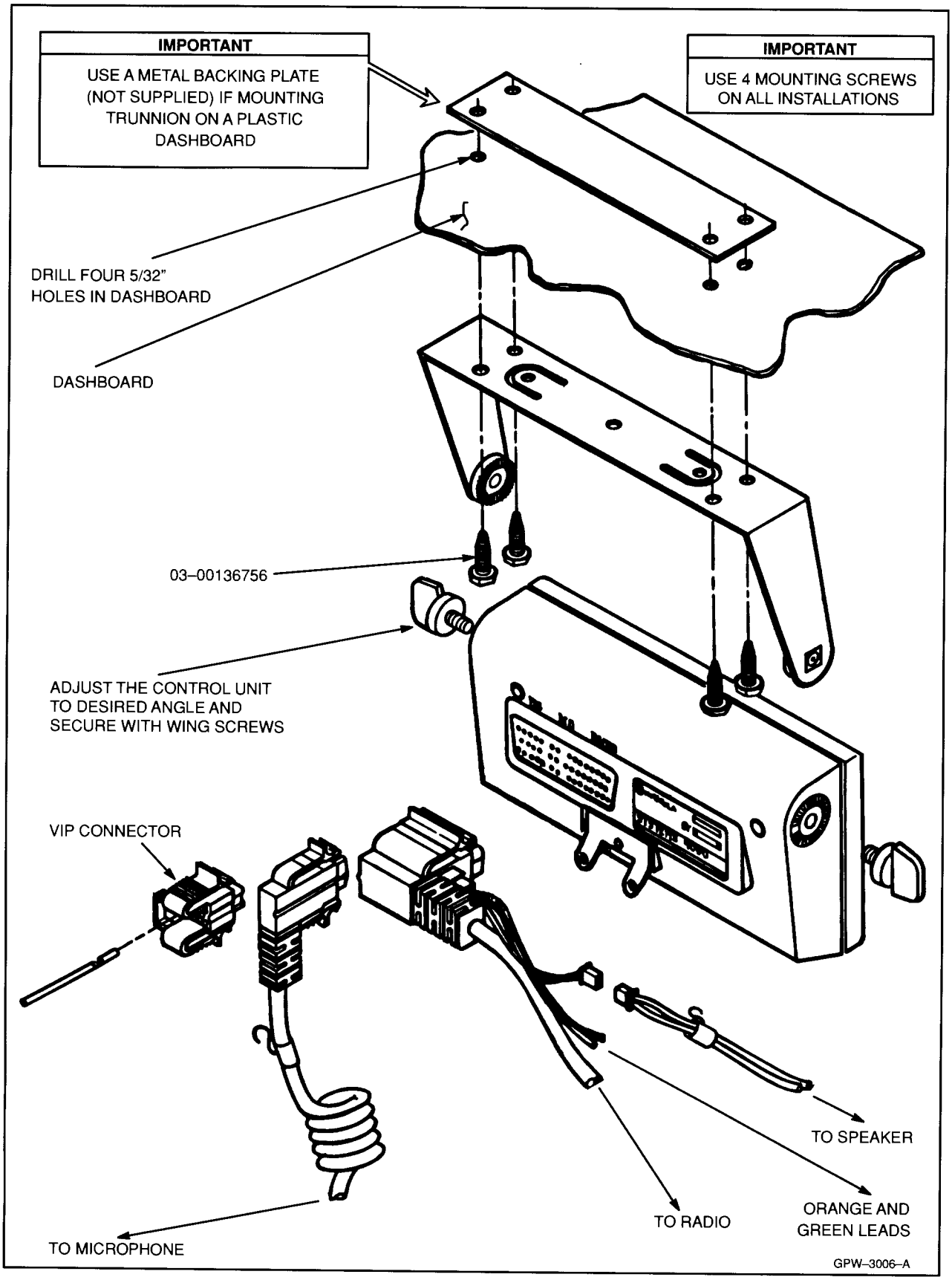


Figure 11. Control Unit Exploded View

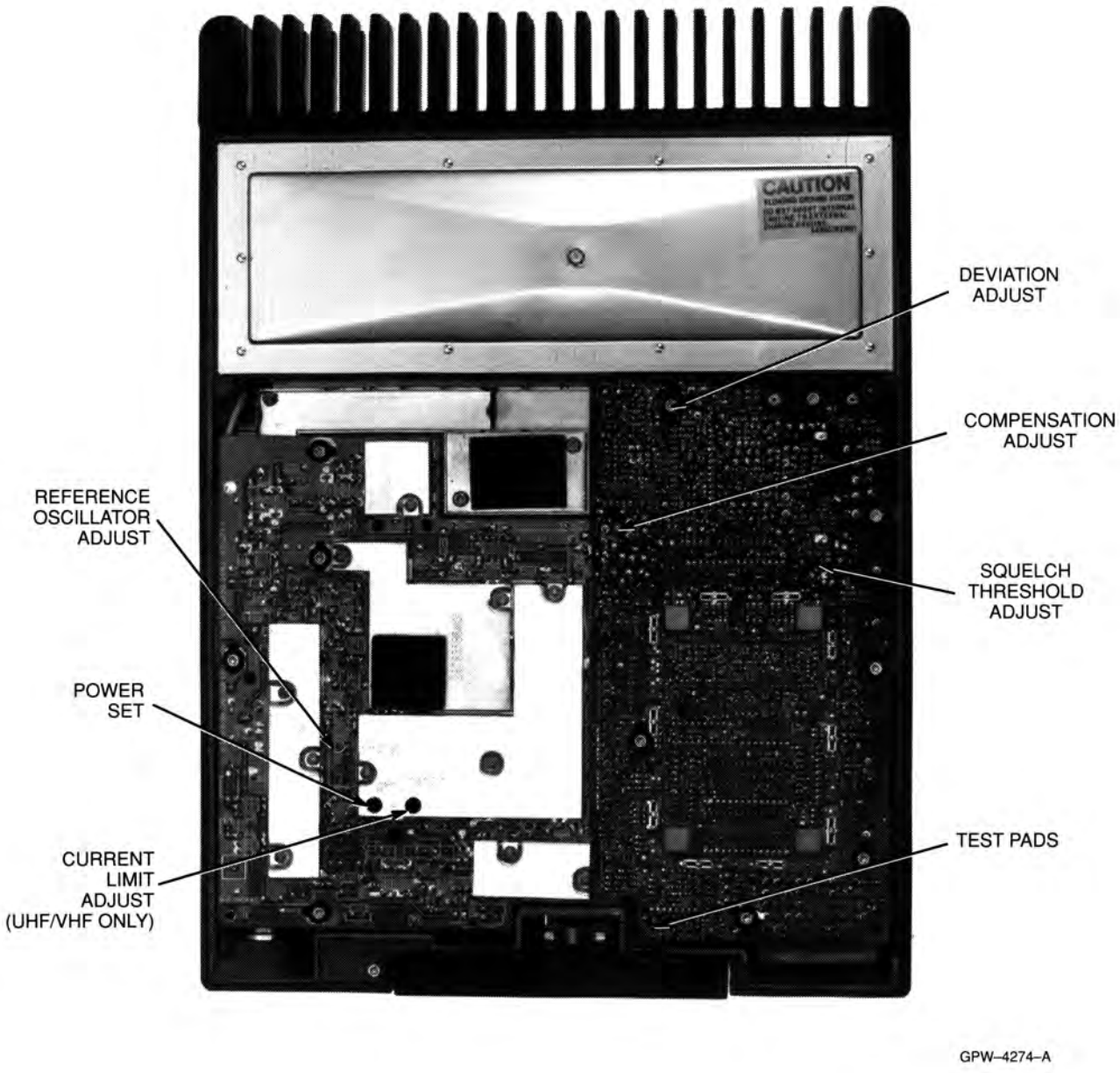


Figure 1. Typical SYNTOR X 9000/9000E *Radio (Top View)*

1. Recommended 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 a high–input–resistance meter	Motorola S1063B	Measurement range: 0–15V DC Input resistance: 11 megohms
AC Voltmeter	Audio voltage measurements	Motorola S1053C	Measurement range: 0–1 mV AC Input resistance: 1 megohm
RF Voltmeter	RF voltage measurements	Motorola S1339	Measurement range:100 µV–3V from 1 MHz to 50 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 S1350 with appropriate element and T1013 RF dummy load	Measurement range: 0–250 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. and SLN6381 Audio Frequency Synthesizer *(audio synthesizer required only for DPL radios)*	Measurement range: 1–10 KHz deviation Frequency range: 31–50 MHz
RF Signal Generator	Receiver alignment and troubleshooting	Motorola R1200 Service Monitor with attenuator.	Frequency range: 31–50 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
• Logic Probe	Checking of various digital devices	Motorola RTL–4014	
PL Tone Generator *	Tone–coded *Private–Line* decoder troubleshooting	Motorola S1333B	Frequency range: 10 Hz–9999 Hz Output level: 0–3 V rms
• DPL Test Set **	*Digital Private–Line* encoder–decoder troubleshooting	Motorola SLN6413A	
Radio Test set	Meter readings at circuit metering points for alignment and troubleshooting	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 HLN4262A	
• DC Power Supply	DC power for shop service	Motorola R1011AA	1–20V DC 0–40 A

* Required for tone–coded *Private–Line* models only
** Required for Digital Private–Line models only.

Note

The Motorola R2001 System Analyzer replaces all the test equipment listed above except that marked with (•).

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. Take precautions to prevent the test equipment from touching the vehicle chassis.

2. Radio Alignment and Adjustments

2.1 INTRODUCTION

You can adjust the following items on the Low Band *SYNTOR X 9000* radio:

- Oscillator frequency
- Deviation
- Compensation
- Transmitter output
- Transmitter power amplifier current limit
- *Extender* receive frequency

You can make all radio adjustments from the top of the radio. See Figure 1.

Important

Readjustment of the *SYNTOR X 9000* receiver is NOT recommended, since the receiver is preadjusted at the factory to have a wide passband for all frequencies between 31 and 50 MHz.

Note

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

2.2 OSCILLATOR FREQUENCY

Note

Adjust the oscillator frequency before checking or setting the deviation.

(1) Set the mode to Mode 1.

(2) Using the portable test set, key the transmitter without modulation. On *Private–Line* and *Digital Private–Line* radios, disable the encoder output.

(3) Adjust the reference oscillator (U608) warp control (Figure 1) until the proper indication shows on the frequency meter.

(4) Set the mode selector switch (for multiple–mode units only) to each of the remaining positions and check the transmitter frequency. No further oscillator frequency adjustments are required.

2.3 DEVIATION

Note

When setting deviation, be sure to check deviation on all transmit channels. This ensures the radio does not over–deviate.

(1) For PL or DPL radios only; Using deviation adjustment potentiometer R108, set the deviation on the highest PL or DPL customer transmit frequency, to ±4.7 kHz.

(2) For radios without PL or DPL; Using deviation potentiometer R108, set the deviation on the highest customer transmit frequency, to ±4.7 kHz.

(3) Check the deviation on each mode and reset it to ±4.7 kHz on the frequency with the highest deviation.

(4) Check the deviation on each transmit frequency to be sure that it does not exceed 5 kHz.

2.4 COMPENSATION

The compensation adjustment potentiometer (R111) is set at the factory and does not normally require readjustment. Nevertheless, you should use this compensation adjustment procedure whenever 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 adjusted.
- If the phase modulator is replaced.

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

(1) For PL or DPL radios only; Turn the deviation potentiometer (Figure 1) one–half turn clockwise.

(2) For radios without PL or DPL; Set the compensation potentiometer to the middle of its range. Go to step 7.

(3) For PL or DPL radios only; Set the mode selector to the highest PL/DPL customer transmit frequency (closest to 50 MHz).

(4) For PL or DPL radios only; Connect the center lead of the shielded cable of an AC voltmeter to the modulation compensation test point (Figure 1) and connect the shield to the radio ground (A–). Set the voltmeter to the 1–mV range.

(5) For PL or DPL radios only; Modulate the PL or DPL and adjust the compensation potentiometer until you see a null indication on the voltmeter. Cover the hole with tape to prevent accidental adjustment of this control.

(6) For PL or DPL radios only; Carry out step 1 of Section 2.3.

(7) For radios without PL or DPL; Carry out step 2 of Section 2.3.

2.4.1 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 TRANSMITTER POWER

Do not use coaxial cable adapters to connect different–sized cables. If you do, it may increase the output VSWR and cause protection circuitry to reduce output power. Use only cables that connect directly to the test equipment. See the Transmitter Section of this manual for information about the operation of the VSWR protection circuitry.

Note

There is a list of recommended test equipment earlier in this section of the manual. Use only the recommended equipment for making these adjustments to get the best results.

You can make all the transmitter adjustments described here through holes in the common circuits board. See Figure 1.

(1) Turn R917 clockwise to the stop.

(2) Select a mode with a middle customer frequency.

(3) Adjust R908 to get a power level of 105 watts.

(4) Verify that the power level on all customer frequencies is 105 ±5 watts.

2.6 RECEIVER TUNING

No field tuning of the receiver is required.

3. Radio Disassembly

3.1 GENERAL

To remove the radio from the vehicle, first release the handle, as described above. Now slide the radio for ward (about an inch) and lift it out. Disconnect the cables to remove the radio from the trunk.

You can reach the solder side of the RF board, personality board, and the power amplifier deck from the top of the radio after removing the top cover. Remove the top cover by turning the key to release the front handle and then pushing the button under the handle. This pops the top cover up, giving you access to the boards. For access to the PA deck, remove the five screws securing the PA shield and lift the shield out by its handle.

You can reach the rest of the radio by removing the four screws that secure the skid plate to the bottom of the radio. This gives you access to the metering socket of the common circuits board (J952). The common circuits board is hinged so you can open it to gain access to its component side and to the component side of the RF board. See Figures 1 and 2 in the Description Section of this manual. To turn the common circuits board on its hinge, remove two screws on the board as well as one additional screw on the regulator heat sink.

WARNING

When operating the radio with the regulator heat sink screw removed, avoid the exposed hot flange.

Note

All serviceable mounting screws have posi–drive heads that can be serviced with standard Phillips screwdrivers. To improve driver engagement, use posi–drive tools (available through National Parts, Motorola Part No. 66–80344A57 and 66–80344A58).

Note

Black plastic captivators identify the mounting screws for the common circuits board, personality board, and RF board.

3.2 COMMON CIRCUITS BOARD

To turn the common circuits board on its hinges, remove three screws. To remove the board from the radio, remove the two hinge screws also and unplug the ribbon cable between the common circuits board and the personality board, and the wires between the common circuits board and the PA deck. When putting the common circuits board back into the radio, pass the cable and the wires between the two board hinges.

3.3 PERSONALITY BOARD

To remove the personality board from the radio: (a) remove the seven screws that secure the board to the radio, (b) disconnect the cable from the front plug, (c) disconnect the ribbon cable from the common circuits board, (d) remove any connectors to the interface board, and (e) pull the board away from the radio to disconnect the connectors to the RF board. When putting the board back into the radio, insure that the front plug gasket is properly seated. (Silicone compound, Motorola Part No. 11–00834678, helps in this procedure.)

3.4 RF BOARD

To remove the RF board:(a) remove the personality board, as explained above, (b) remove the six retention screws, (c) disconnect the coaxial cables between the RF board and the internal casting, and (d) disconnect the wires near the antenna switch. To reach some segments of the solder side of the RF board, you must remove shields screwed to the board. Remove the two large cans on the component side of the board by simply pulling them off the board; other cans must be unsoldered to be removed.

Important

To reinstall the RF board, align the board guide posts and the internal casting carefully. Match the spring connectors on the board precisely with those in the internal casting.

3.5 INTERNAL CASTING

3.5.1 General

To remove the internal casting from the radio:

(1) Remove the radio covers.

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

(3) Remove the four casting mounting screws (bottom side of radio).

(4) Remove the input coax from the high–pass filter/preamp board.

(5) Unsolder the output coax from the RF board.

(6) Remove the TX buffer and disconnect the TX mixer output coax.

(7) Disconnect the remaining coax from the RF board.

(8) Disconnect P200 and P201 from the RF board.

(9) Remove three screws from the RF board (top side of radio).

Note

During reassembly, be sure that J650 is aligned correctly with the VCO assembly.

3.5.2 First Mixer

To remove the first mixer from the radio:

(1) Remove the cover and three gasket mounting screws.

(2) Unsolder the RF input wire coming from the *Extender* front end board.

(3) Unsolder the coax from the first injection filter board.

(4) Unsolder the output wire going to the high IF board.

(5) Remove the three mounting standoffs.

CAUTION

Do not use excessive heat. If you do, the tap leads will come off the filter.

3.5.3 First Injection Filter

To remove the first injection filter from the radio:

(1) Remove the cover mounting screw and cover.

(2) Unsolder the input wire from J125.

(3) Unsolder the output coax going to the RX first mixer board.

3.5.4 VCO

To remove the VCO from the radio:

(1) Remove the four screws from the VCO cover.

(2) Remove the cover.

(3) Remove the screw from the center of the VCO hybrid circuit module.

(4) Remove the coaxial cable from the VCO hybrid. Use a low–wattage iron.

(5) Pull J650 upward, removing it, the VCO, from the radio.

To install the VCO, reverse the procedure given above.

Note

If you replace the VCO assembly with a new one, readjust the compensation level, following the procedure given in the Maintenance and Troubleshooting Section of this manual.

3.5.5 *Extender* Front End Board

To remove the *Extender* front end board from the radio:

(1) Remove the two cover mounting screws and the cover.

(2) Unsolder the input wire from J300 (phono plug).

(3) Unsolder the output wire going to the first mixer board.

(4) Unsolder the DC feed wire from the high IF board.

(5) Unsolder the board from the three mounting tips.

(6) Unsolder the output coax leading to the *Extender* back end board.

3.5.6 *Extender* Back End Board

To remove the *Extender* back end board from the radio:

(1) Remove the cover mounting screws and the cover.

(2) Unsolder the board from the three feedthrus.

(3) Unplug connector J200 from the RF board.

(4) Unsolder the input coax from the *Extender* front end board.

(5) Remove the board mounting screws.

3.5.7 High IF Board

To remove the high IF board from the radio:

(1) Remove the cover and gasket mounting screw.

(2) Unsolder the output coax from the RF board.

(3) Unsolder the input wire from the first mixer.

(4) Unsolder the wire leading from the front end *Extender* board.

(5) Unsolder the board from the six mounting tips.

(6) Remove the board mounting screw (standoff).

3.5.8 TX Mixer

To remove the TX mixer from the radio:

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

(2) Remove the TX buffer and unfasten the TX mixer output coax from the TX buffer board.

(3) Remove the remaining two coax cables from the RF board.

(4) Unsolder the two DC voltage supply wires from the TX mixer hybrid.

(5) Remove the two TX mixer hybrid plate mounting screws.

(6) Remove the input coax from the VCO.

3.6 REPLACEMENT OF TRANSISTOR DEVICES

3.6.1 Driver Device (Q802)

To remove the driver device (Q802) from the PA board:

(1) Remove the hex nut from the stud of Q802. The hex nut is in a depression on the bottom of the radio.

(2) Unsolder the flanges of the device from the board. Use a four–pronged soldering iron if one is available. If not, heat up each flange with a soldering iron and use a sharp object such as a pick to pry up the flange from the board. When all the flanges are clear of the board, lift the device out of it.

To replace the driver device in the PA board:

(1) If you are reinstalling the old Q802, clean old thermal compound off the bottom of the device with a tissue or a rag. Also clean that part of the chassis exposed through the hole cut in the board for Q802 as well as possible. If you are installing a new Q802, just clean the chassis.

(2) Put a new, thin, even layer of thermal compound (Wakefield 120–8 or equivalent) on the bottom of Q802.

(3) Drop Q802 through the hole in the board, with the angled flange pointing towards L807. Screw the hex nut finger tight on the stud. (Be careful not to strip the threads on the stud.)

(4) Solder the flanges of Q802 to the board. Q802 will not operate properly unless these flanges are well soldered.

(5) Tighten the hex nut to 6–8 inch–pounds.

3.6.2 Final Devices (Q803, Q804)

To remove Q803 and Q804:

(1) Remove the flange screws (two per device) from Q803 and Q804.

(2) Lift up one end of R808 to make it easier to remove Q804.

(3) Unsolder the flanges, using the procedure given in Step 2 of Section 3.6.1, above.

To replace the final devices:

(1) If you are replacing old devices, clean off the old layer of thermal compound with a tissue or a rag. Also clean the chassis exposed through the hole in the board as well as possible.

(2) Apply a new, thin, even layer of thermal compound (Wakefield 120–8 or equivalent) to the bottoms of the devices and drop them into their holes, making sure that the angled flange of each is pointing towards T802.

(3) Install the flange screws. (Be sure to replace the thermistor bracket, Part No. 07–80078A01, on Q803.) Tighten the screws to 6–8 inch–pounds.

CAUTION

Tighten the flange screws before soldering the transistor tabs to the circuit board. Do not use more than six to seven inch–pounds of torque, or you may damage the transistor.

(4) Solder the flanges of Q803 and Q804 to the board. The flanges must be correctly soldered in place for Q803 and Q804 to operate properly.

3.7 RF POWER AMPLIFIER CIRCUIT BOARD

To remove the PA circuit board:

(1) Unsolder the coaxial cable from the output connector (MP801) on the PA board. Unsolder the coaxial cable from the output connector (MP802) on the high–pass filter preamp board.

(2) Disconnect the input cable (from the synthesizer) from input connector J801 on the PA board.

(3) Remove the hex nut from the stud of Q802 on the bottom of the radio.

(4) Remove the four flange screws from the final devices (Q803 and Q804).

(5) Remove the screw from the collar heatsink of Q801.

(6) Take the hex nut off the standoff on the PA board (next to T801).

(7) Remove the six remaining board screws.

(8) Unsolder all nine feedthrus, removing the solder with a solder sucker.

(9) Lift the board out.

To reinstall the PA board:

(1) Clean all old thermal compound off the bottoms of Q802, Q803, and Q804. Also clean the chassis, removing any thermal compound, dirt, grit, or other contamination.

(2) Apply a thin, even layer of thermal compound to Q802, Q803, and Q804.

(3) Resolder the coaxial cable to the output connector (MP801) on the PA board and to the output connector (MP802) on the high–pass filter preamp board.

(4) Put the board back in the chassis, making sure it is in properly.

(5) Install the flange screws in Q803 and Q804, making sure that the thermistor bracket (Part No. 07–80078A01) is on Q803. Tighten to 6–8 inch–pounds.

(6) Install the screw for the collar heatsink of Q801, making sure that the square plastic insulator (Part No. 14–80103B01) is under the heatsink. Also make sure that the plastic shoulder washer (Part No. 04–82345A01) is under the screw. Tighten the screw to 8–10 inch–pounds.

(7) Reinstall the hex nut on the standoff near T801. Tighten it to 6–8 inch–pounds.

(8) Install the remaining six board screws and tighten them to 8–10 inch–pounds.

(9) Resolder all feedthrus. Do not flow excessive solder.

(10) Reconnect the input cable (from the synthesizer) to input connector J801 on the PA board.

3.8 FRONT LATCH

To remove the front latch key mechanism, insert the key into the lock, turn the key about 45 degrees clockwise, and insert the special removal tool (Part No. 66–84909B01) with the point directed away from the lock. Twist the tool 180 degrees clockwise. This releases the key mechanism, which you can then remove. To remove the black plastic part, remove the single screw securing it.

3.9 DIRECTIONAL COUPLER

3.9.1 Directional Coupler Circuit Board

To remove the directional coupler circuit board:

(1) Remove the cover of the coupler casting and its gasket.

(2) Unsolder the three feedthrough capacitor leads.

(3) Unsolder the input and output coax leads.

(4) Remove the board.

To replace the directional coupler board, reverse the removal procedure.

3.9.2 Directional Coupler Casting

Note

You should be able to solve most board–related electrical problems without removing the directional coupler casting from the radio chassis.

To remove the directional coupler casting:

(1) Unsolder the output coax from the PA board output.

(2) Remove plug P953 from J953 on the common circuits board.

(3) Remove the retaining nut from the antenna connector.

(4) Remove the two screws securing the coupler casting to the chassis.

(5) Pull the coupler and antenna connector assembly out of the chassis.

To reinstall the directional coupler casting, reverse the removal procedure.

3.10 PREAMP CIRCUIT BOARD

To remove the high–pass filter circuit board:

(1) Remove the two screws holding the circuit board cover to the radio housing.

(2) Unsolder the input coax from the PA board and slide it through the HUB1077A radio housing.

(3) Disconnect the output coax from the internal casting.

(4) Remove the two remaining screws.

4. General System Troubleshooting Guide

4.1 GENERAL

A general system troubleshooting guide is provided in Tables 1 through 10. Table 1 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 while.

Table 1. General System Troubleshooting Guide

Symptom	Possible Source of Trouble	Chart or Diagram to be Referred to
No Receive Audio	Red or green lead fuse	None (Check the fuses.)
	Audio PA	Voltages and waveforms on audio schematic
	Audio enable switch	Squelch troubleshooting chart
	Squelch	Squelch troubleshooting chart
	Regulator	Regulator troubleshooting guide
	Synthesizer (not locking)	Synthesizer troubleshooting chart
	Microcomputer	Microcomputer troubleshooting chart
	Quad detector	Receiver section schematic
Distorted Receiver Audio	Audio PA	Audio schematic for voltages and waveforms
	Quad detector	Receiver section schematic
	IF	Receiver section schematic
Low Audio Power	Audio PA	Audio schematic
	Red lead fuse	None (Check fuse.)
	Quad detector	Receiver section schematic
	IF	Receiver section schematic
Failure to Squelch	Squelch	Squelch troubleshooting chart
	Microcomputer	Microcomputer troubleshooting chart
	Audio enable switch	Squelch troubleshooting chart
Failure to Unsquelch	Refer to *No Receive Audio* Symptom Above	
Improper Squelch Sensitivity	IF	Receiver section schematic
	Quad detector (low recovery)	Receiver section schematic
	Squelch	Squelch troubleshooting chart
Absence of PL/DPL Encode/Decode	Personality board	Personality board schematic
	Microcomputer	Microcomputer troubleshooting chart
	IDC	IDC portion of synthesizer troubleshooting chart
Absence of Regulated 9.6V or 5.0V	Short on printed circuit board	—
	Regulator	Regulator troubleshooting guide
Absence of RF Power Output	PA enable switch	Microcomputer schematic
	Keyed 9.4 switch	Microcomputer schematic
	Synthesizer (out of lock)	Synthesizer troubleshooting chart
	Red or orange lead fuse	None (Check fuses.)
	Power control	Power Control troubleshooting chart
	PA	PA troubleshooting chart
Absence of Power Control	Power control	Power control troubleshooting chart
Low RF Power Output	Power Control	Power control troubleshooting chart
	PA	PA troubleshooting chart
	Antenna switch	Antenna switch test procedure
Absence of Transmitter Modulation	IDC	IDC portion of synthesizer troubleshooting chart
	Power control	IDC portion of synthesizer troubleshooting chart
Distorted Transmitter Modulation	Misadjusted compensation	Compensation adjustment procedure (in radio alignment and adjustment)
	IDC (PL/DPL distortion only)	IDC portion of synthesizer troubleshooting chart
	Personality board	Personality board schematic
	Reference oscillator	IDC portion of synthesizer troubleshooting chart
	VCO	IDC portion of synthesizer troubleshooting chart
Improper Microphone Sensitivity	IDC	IDC portion of synthesizer troubleshooting chart
	VCO	
	Reference oscillator	
Transmitter Frequency Shift with High–Level Modulation	IDC	IDC portion of synthesizer troubleshooting chart
Failure of Synthesizer to Lock	Synthesizer	Synthesizer troubleshooting chart
	Microcomputer	Microcomputer troubleshooting chart
	Memory module	Programming section of synthesizer troubleshooting chart
Reference Frequency (6.25 kHz) in Speaker or on Transmitted Audio	Adaptive filter	Synthesizer troubleshooting procedure

Table 1. General System Troubleshooting Guide (continued)

Symptom	Possible Source of Trouble	Chart or Diagram to be Referred to
Synthesizer Locking on Wrong Frequency	Synthesizer	Synthesizer troubleshooting chart
	Microcomputer	
	Memory module	
	Adjustment of reference oscillator	
Long Synthesizer Lock Time	Synthesizer VCO	Synthesizer troubleshooting chart
Poor Receive Sensitivity	High IF	Receiver troubleshooting chart and receiver section schematic
	Low IF	
	Quad detector	
	Preamplifier	
	First mixer	
	Second mixer	
	Antenna switch	Antenna switch test procedure
Alternator Whine	Short, chassis to A–	None (Disconnect control cable and check for a short between chassis and A–.)
	Excessive whine in vehicle	Manual 68P81109E33

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 Common Circuits board 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. The first part, "WX," indicates the location of the error. The second part, "YZ," 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.

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 WX/YZ." WX/YZ 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 WX/YZ." WX/YZ specifies the type of error. 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 2. Radio Troubleshooting Display Codes

DISPLAY SHOWS	DESCRIPTION OF PROBLEM
FAIL 01/81 FAIL 01/84	Reprogram EEPROM or check J501/502. If "FAIL" shows after reprogram, replace U502.
FAIL 01/83 FAIL 01/85	Replace U501. Reprogram EEPROM or check J501/502. 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	If "FAIL" shows after reprogram, replace U502.
FAIL 01/8B FAIL 01/8D	Replace U500 and U501. Reprogram EEPROM or check 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 3. 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 4. 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 5. Trunking System Troubleshooting Display Codes

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

Table 6. 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 7. MDC–600 *PTT ID or* MVS *Troubleshooting Display Codes*

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

Table 8. MDC–600 *Full–Feature Troubleshooting Display Codes*

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

Table 9. MDC–1200 *Troubleshooting Display Codes*

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

Table 10. DTMF Troubleshooting Display Codes

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

5. Antenna Switch Test Procedure

5.1 INTRODUCTION

When the radio is in the receive mode, the antenna switch connects the antenna to the receiver via the directional coupler, harmonic filter, receive pin diodes and coax cable. It connects the antenna to the transmitter via the directional coupler, harmonic filter, and transmit pin diode.

5.2 TEST EQUIPMENT

Use a regular analog VOM for checking continuity paths, short circuits, and DC voltages. The list at the beginning of Section 1 recommends the Motorola T1009A AC–DC VOM.

5.3 PROCEDURE

This procedure consists of a receive signal path test and a transmit signal path test. Before conducting either, disconnect the coaxial cable from the PA deck input. This allows the antenna switch to change from one condition to the other (from receive to transmit or vice versa) without causing the PA to generate power output.

5.3.1 Receive Signal Path Test

(1) Use an ohmmeter to verify receive path continuity by checking between the antenna connector and the filter side of C824. Verify that CR941 and CR97 are turned on by measuring the resistance across both of the diodes. Verify that there are no shorts to chassis or B–.

(2) Verify that the DC voltage between R970 and the combination of L973 and L974 is approximately 1.1 V in the receive mode.

5.3.2 Transmit Signal Path Test

Important

Field servicing of the antenna switch assembly is NOT recommended. Replace the entire unit if it is defective.

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

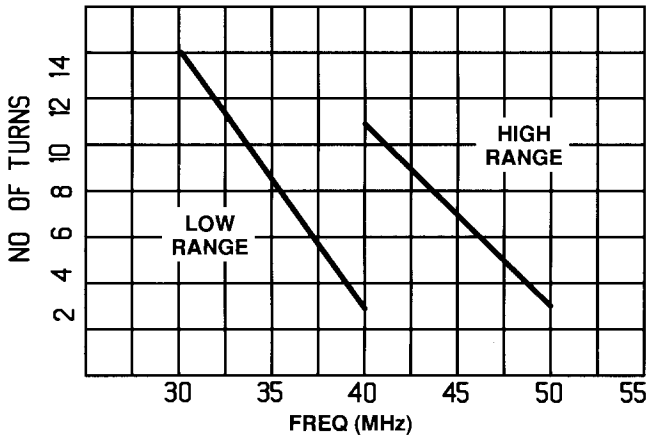
(2) Key–up the transmitter. Continuity through the harmonic filter to the antenna connector is verified in the receive signal path procedure. Measure the resistance across CR920. If the resistance is greater than 1 ohm with the radio keyed up, verify that voltages exist at the keyed 9.4 V and 9.6 V feedthru capacitors.

(3) Verify that there are no shorts between the transmit path, the chassis, or B–.

6. *Extender* Tuneup Procedure

(1) If the tuneup frequency is higher than 40 MHz, remove chip resistors (zero–ohm) R300, R301, and R302 from the *Extender* front–end board. They may be replaced with wire jumpers later if the *Extender* is returned to below 40 MHz.

(2) Preset L300, L301, and L302. See Figure 2.



Note: slug flush with top of form equals zero turns

GPW–2180–A

Figure 2. Preset Chart for L300–L302.

The #WX code stands for the option code number. Table 3 gives the number codes for each option.

(3) Set the frequency generator to the tuneup frequency and connect it to the radio. Set the generator 1/4 MHz below the tuneup frequency if you intend to use the metal–tipped tuning tool on C321.

(4) Set the trim capacitor on the back–end board (C321) for peak voltage at the *Extender*–tune test point. Use a hard plastic tuning tool, if possible. Do not use a screwdriver. During the tuneup process, adjust (and readjust as required) the generator RF level to maintain the voltage at the *Extender*–tune test point in its active region.

(5) After removing the tuning tool from the trim capacitor, adjust the generator frequency for peak out put at the *Extender*–tune test point. (Little or no adjustment should be required.)

(6) Adjust L300 and L302 for peak voltage at the *Extender*–tune test point.

(7) Adjust L301 for peak voltage at the *Extender*–tune test point.

(8) Repeak L300 and L302.

(9) Repeak L301.

After completing this procedure, you may be able to get 2 or 3 dB additional sensitivity by doing the following:

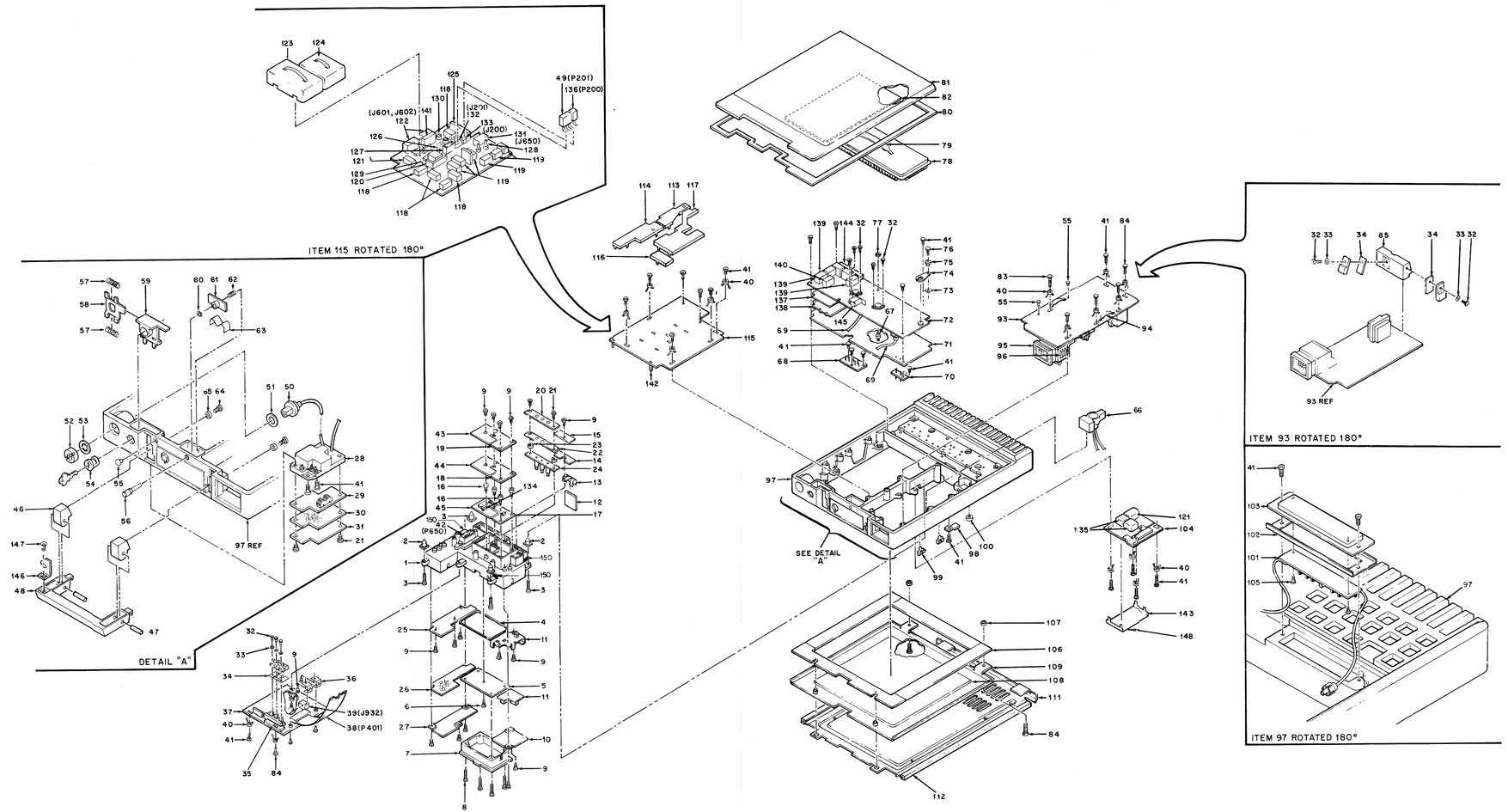
(1) Hook up a pulse generator to the radio connector.

(2) Monitor the pulse output at J200–1 with an oscilloscope with a 2 milliseconds–per–division sweep. Have it externally triggered by the pulse generator, if possible.

(3) Decrease the pulse generator amplitude until the J200–1 waveform starts to disappear.

(4) Tune L301, L302, L303, and C321 until the waveform is triggered solidly.

(5) Repeat steps 3 and 4 until the procedure gives no further improvement.



GEW-4547-B

parts list

SYNTOR X 9000 Low–Band Exploded View — MXW–4548–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	15–84776M11	internal casting housing
2	14–80212B01	expansion nut, 4 used
3	03–80157J01	tapping screw (4.55 X 1.59 X 19 mm), 4 used
4	32–82796H01	wire mesh gasket
5	HLB4086A	VCO substrate
6	03–10943M10	tapping screw (3 X .5 X 8 mm)
7	15–84817M01	VCO cover
8	03–80132J02	tapping screw (3.5 X .6 X 23 mm), 4 used
9	03–10943M14	tapping screw (3.5 X .6 X 6 mm), 19 used
10	15–84851M01	buffer cover
11	HLB1021A	transmit mixer, substrate and carrier
12	HFB4001A	injection filter board
13	42–80194H01	grounding clip
14	32–80207H01	injection filter gasket
15	15–80203H01	injection filter cover
16	43–80190A03	standoff (3.5 X .6 X 7 mm), 4 used
17	HLB4085A	receiver mixer board
18	32–80132K01	receiver mixer gasket
19	15–80126K01	receiver mixer cover
20	15–80204H01	RF extender cover
21	03–10943M16	tapping screw (3.5 X .6 X 10 mm), 4 used
22	32–80208H01	extender front end gasket
23	43–80294H01	board mounting spacer, 2 used
24	HLB4090A	extender front end board
25	HLB4091A	extender back end board
26	32–80043D01	pre–amp gasket
27	15–84853M01	pre–amp cover
28	15–80107H01	directional coupler housing
29	HLB4092A	directional coupler board
30	32–80284H01	directional coupler gasket
31	15–80108H01	directional coupler cover
32	03–10911A11	machine screw (3 X .5 X 8 mm), 9 used
33	04–84180C01	shoulder washer, 5 used
34	48–83208M02	transistor insulator, 5 used
35	26–84835M01	regulator heatsink
36	55–83493M01	hinge, 2 used
37	HLN4817A	common circuits board
38	30–83602M01	cable (includes P401)
39	28–80052D01	10–contact right–angle connector
40	42–83503M01	screw retainer, 19 used
41	03–10943M15	tapping screw (3.5 X .6 X 8 mm), 33 used
42	HLN4251A	VCO feedthrough plate
43	15–80125K01	high IF cover
44	32–80131K01	high IF gasket
45	HLB4098A	high IF board
46	07–80152B01	handle pivot bracket, 2 used
47	22–83491M01	spring pin, 2 used
48	55–80242D01	handle
49	01–80739T21	interconnect cable assembly
50	01–80739T01	antenna connector and cable
51	32–80080A01	antenna connector gasket
52	02–80206A01	spanner nut
53	04–00114522	5/8" internal lock washer
54	55–84101B01	lock with key
55	75–00838826	rubber bumper, 2 used
56	38–80154B02	cover release button
57	41–80160B01	lock spring, 2 used
58	55–80161B01	lock catch
59	15–80159B02	lock housing
60	42–81056B01	retainer ring
61	55–80157B02	cover release catch
62	41–80155B01	cover release spring
63	41–80206F01	cover lift spring
64	03–10908A46	machine screw (M5 X .8 X 16 mm), 2 used
65	04–00007652	5/16" lock washer, 2 used
66	HLN4461B	PA wiring bus
67	43–80013B01	PA board standoff
68	HLN4913A	power amplifier feedthrough board
69	29–83897M01	wire receptacle terminal, 2 used
70	HLN4914A	IPA feedthrough board
71	14–80287H01	PA insulator
72	HLN4094A	power amplifier circuit board
73	14–80103B01	IPA heatsink insulator
74	26–80016B01	IPA heatsink
75	04–84152B01	shoulder washer
76	03–10943M17	tapping screw (3.5 X .6 X 13 mm)
77	02–10971A63	machine nut (M3.5 X .6 mm)
78	01–80244H02	PA shield
79	55–84300B04	PA shield handle
80	32–80226D01	top cover gasket
81	15–84075N02	top cover
82	14–84691M01	top cover insulator
83	03–80132J01	tapping screw (3.5 X .6 X 28 mm), 2 used
84	03–10943M18	tapping screw (3.5 X .6 X 16 mm), 6 used
85	26–83498M01	audio PA heatsink
93	HLN4915A	personality board
94	55–84300B03	short handle, 2 used
95	32–80219B01	front connector gasket
96	01–80746T79	37–contact male front connector assembly
97	15–84763M02	radio housing
98	42–80231B01	bus wire clip
99	42–84367M01	wire hold–down clip, 2 used
100	02–00119913	nut (8–32 X 11/32 X 1/8)
101	HLB4000A	high–pass filter preamp board
102	32–80283H01	high–pass filter preamp gasket
103	15–80192H01	high–pass filter preamp cover
104	HLB4083B	transmitter buffer board
105	03–10943M09	tapping screw (3.5 X .5 X 6 mm), 2 used
106	32–80225D01	bottom cover gasket
107	04–80149A01	captive washer, 4 used

MXW–4548–B (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
108	14–84691M02	bottom cover insulator
109	15–80174B01	bottom cover
111	07–80208G03	mounting tray
112	07–80173B02	guide rail, 2 used
113	26–80199K01	second mixer shield, solder side
114	26–80198K01	low IF shield, solder side
115	HLB4087B	RF board
116	26–80289H01	RF board detector shield
117	26–80137K01	synthesizer divider shield
118	26–80055K01	RF board shield, component side, 6 used
119	26–84898M01	RF board shield, component side, 6 used
120	26–80288H02	fence shield, component side
121	26–83595M01	quad detector shield, component side, 2 used
122	09–83445L09	10–contact female connector, 2 used
123	26–80127K01	RF synthesizer shield
124	26–80292H01	RF adaptive filter shield
125	26–80296H01	transmit doubler hybrid shield
126	26–80293H01	receive injection double hybrid shield
127	26–80299H01	AGC extender fence shield
128	48–83948M01	guide post, 2 used
129	42–82160N02	speed clip, 7 used
130	09–80001F01	female phono connector, 2 used
131	09–83730M01	7–contact socket
132	28–84324M03	5–contact connector
133	28–84324M01	2–contact connector
134	26–80238K01	RF board high IF coil shield
135	26–80121A01	transmitter buffer board shield, 2 used
136	HKN4202A	2–contact interconnect cable assembly
137	14–80165K01	harmonic filter shield insulator
138	26–80287H02	harmonic filter shield
139	26–80298H01	harmonic filter coil shield, 5 used
140	26–80149J01	PA board capacitor shield
141	26–80237K01	synthesizer divider hybrid shield
142	29–80146B01	amp mod terminal, 23 used
143	26–80189M01	transmit buffer shield
144	26–80129K01	harmonic filter shield
145	25–80229J02	power transformer
146	55–80244C02	handle latch
147	03–10943R21	tapping screw (4 X .7 X 8 mm)
148	29–00005292	solder lug
150	14–80175M02	insulator shield, 3 used

6/30/89

Exploded View and Mechanical Parts List for
SYNTOR X 9000 Low–Band Radio
PW–4546–B
6/30/89

Functional Block Diagram for
SYNTOR X 9000 Low-Band Radio
PW-4549-O
8/03/87

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.

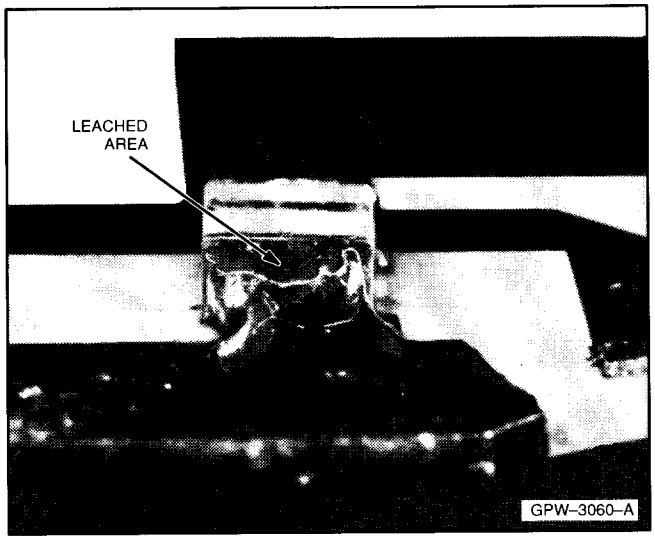


Figure 1. "Leached" Chip Capacitor

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.

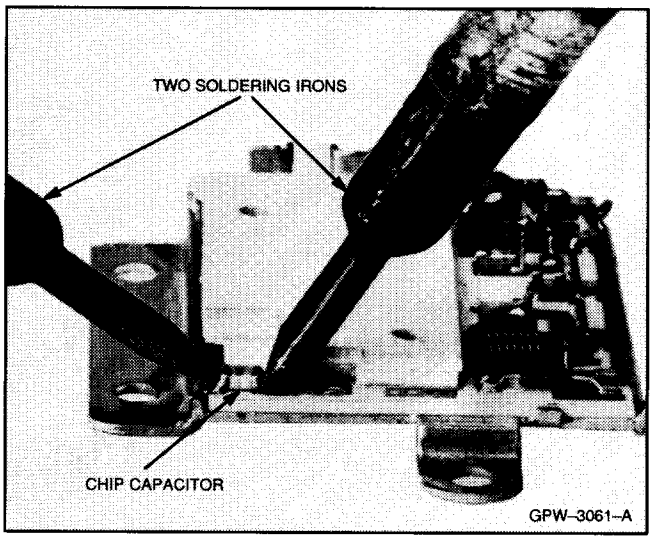


Figure 2. Capacitor Removal with Two Soldering Irons

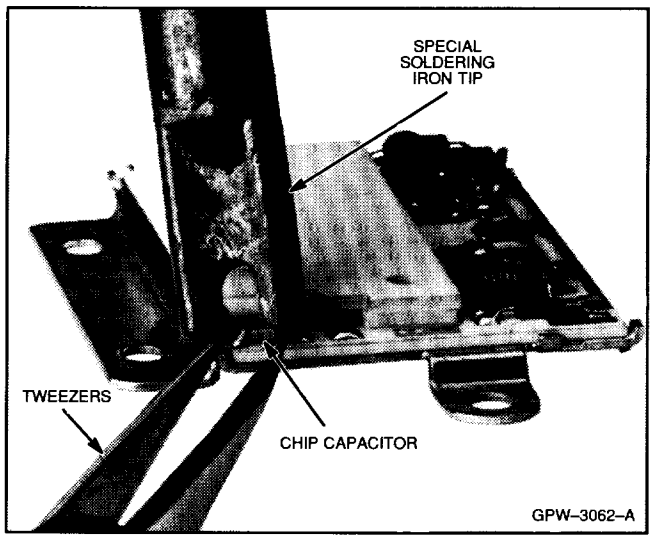


Figure 3. Capacitor Removal with Special Soldering Tip

MOTOROLA

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 input. 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 JU500, 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 JU503 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 JU500, 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 hardware 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 generate 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 above, the D/A is summed with the TX flat path.

PL and DPL are used only when the microphone 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 output 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 pre–amplifier 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.

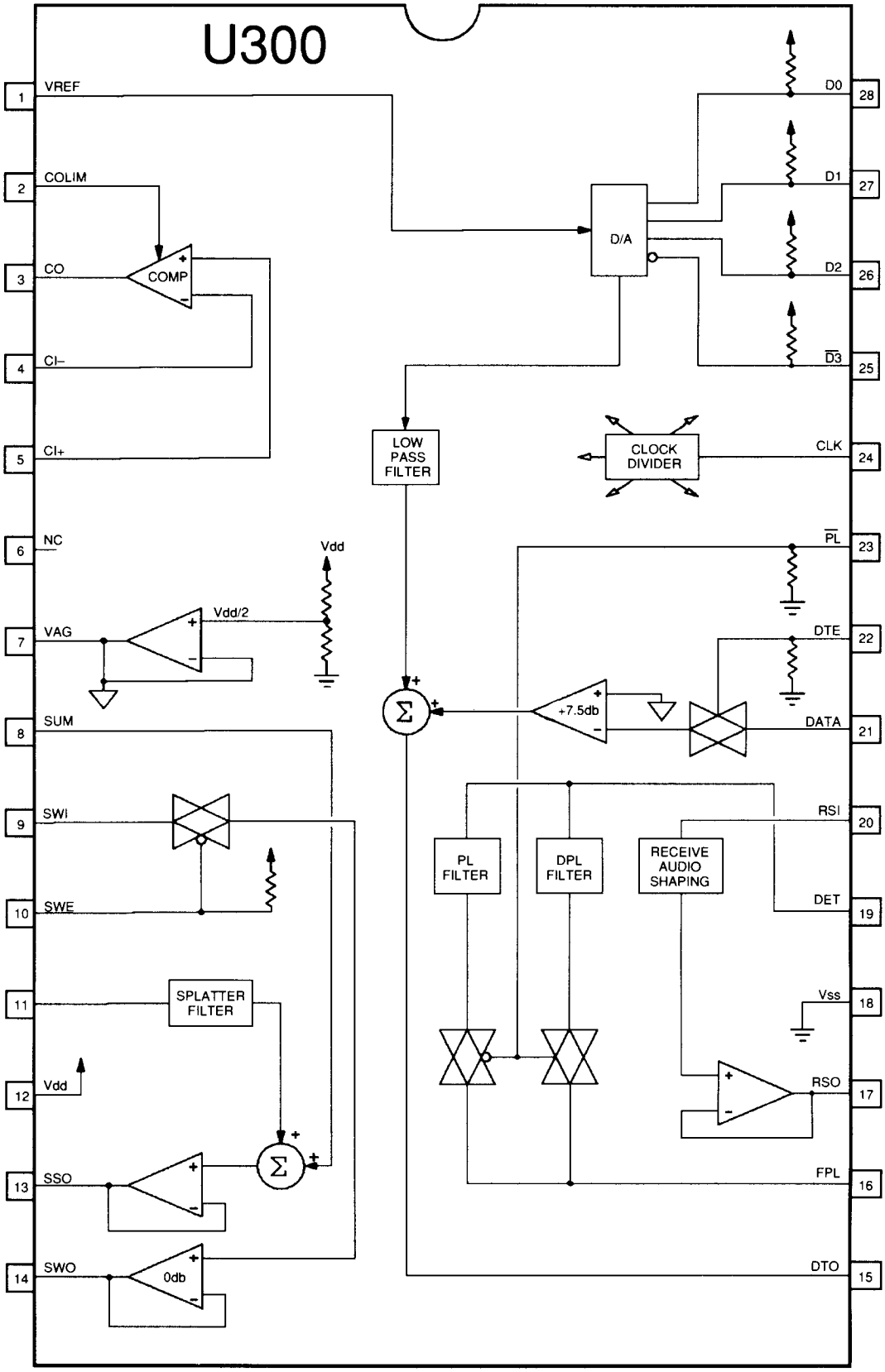
3.3.1 Oscillator (4–MHz)

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.

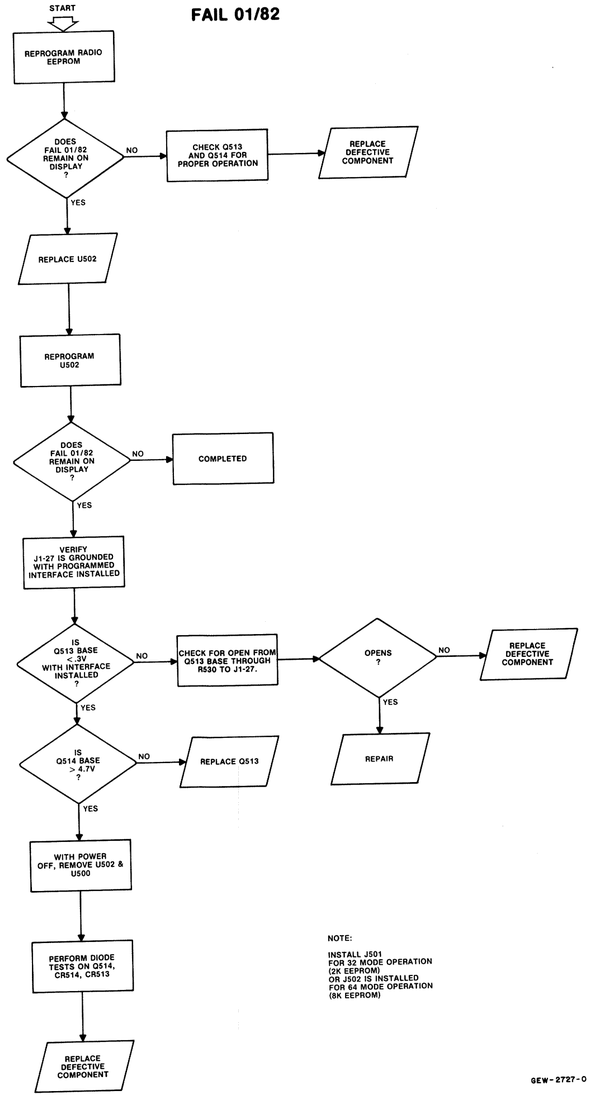
U300 BLOCK DIAGRAM



GPW–2585–A

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

FAIL 01/82

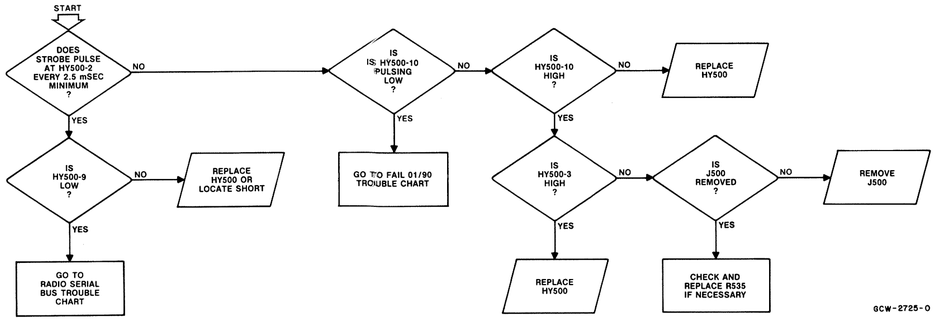


NOTE:

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

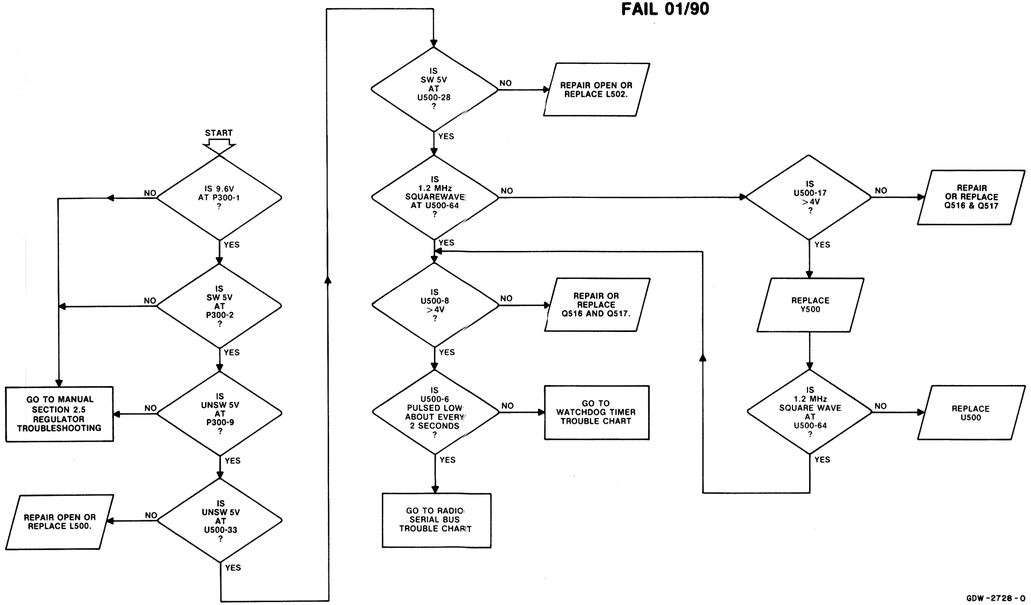
GEW-2727-0

WATCHDOG TIMER FAILURE



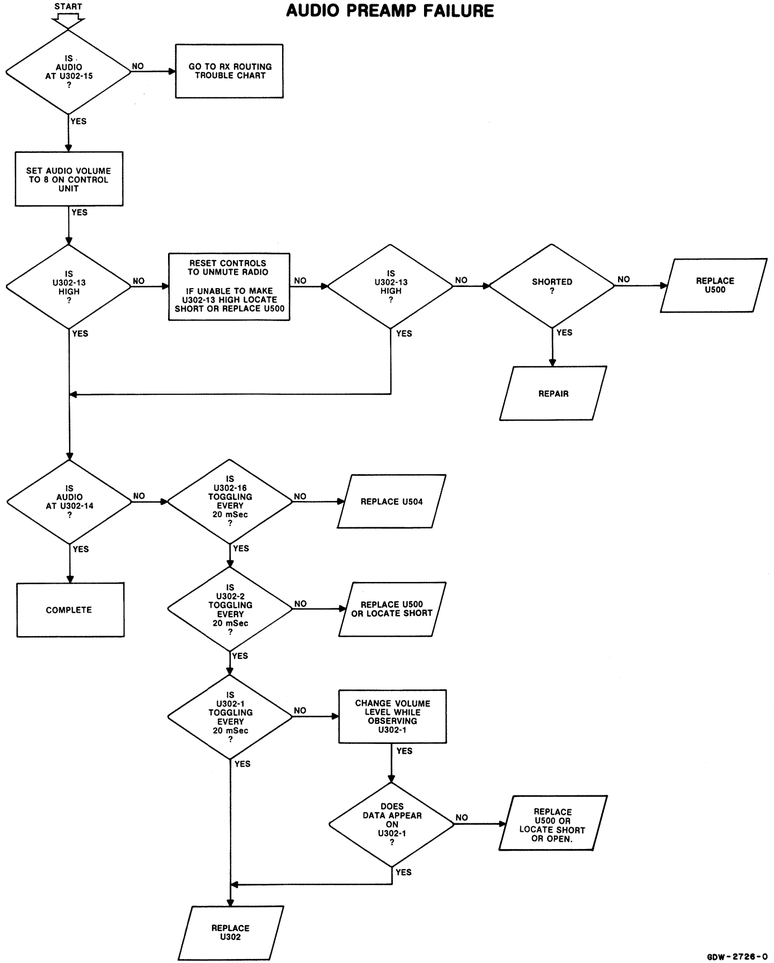
GCW-2725-0

FAIL 01/90



GDW-2728-0

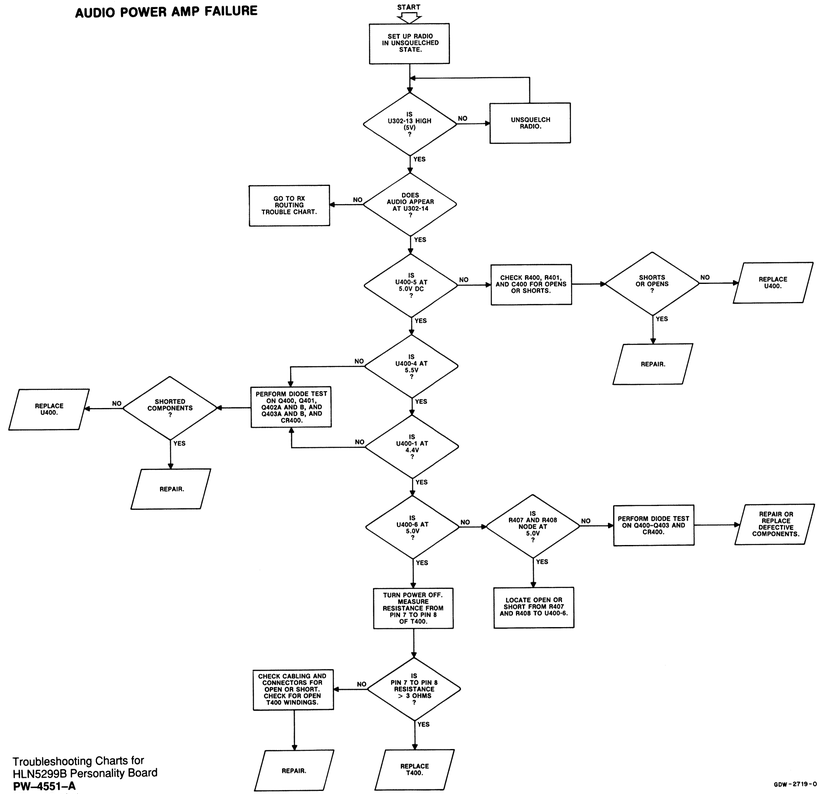
AUDIO PREAMP FAILURE



GDW-2726-0

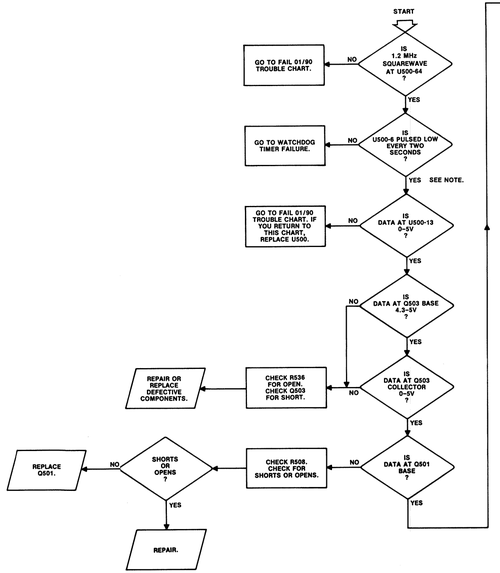
Troubleshooting Charts for
HLN5299B Personality Board
PW-4551-A
(Sheet 1 of 4)
5/10/88

AUDIO POWER AMP FAILURE

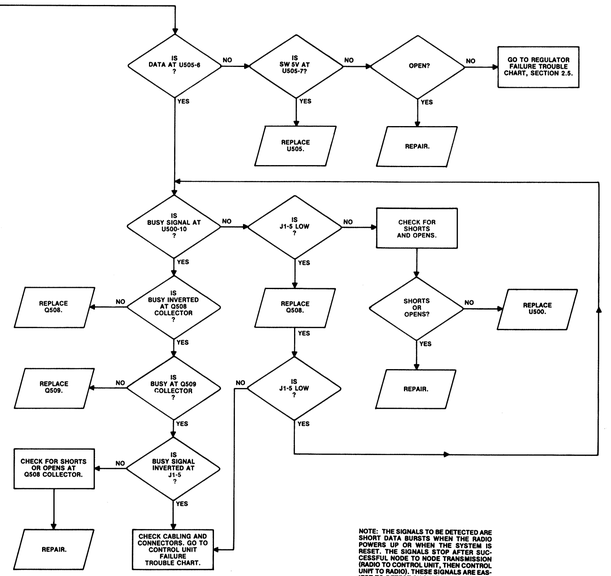


GDW-2719-0

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



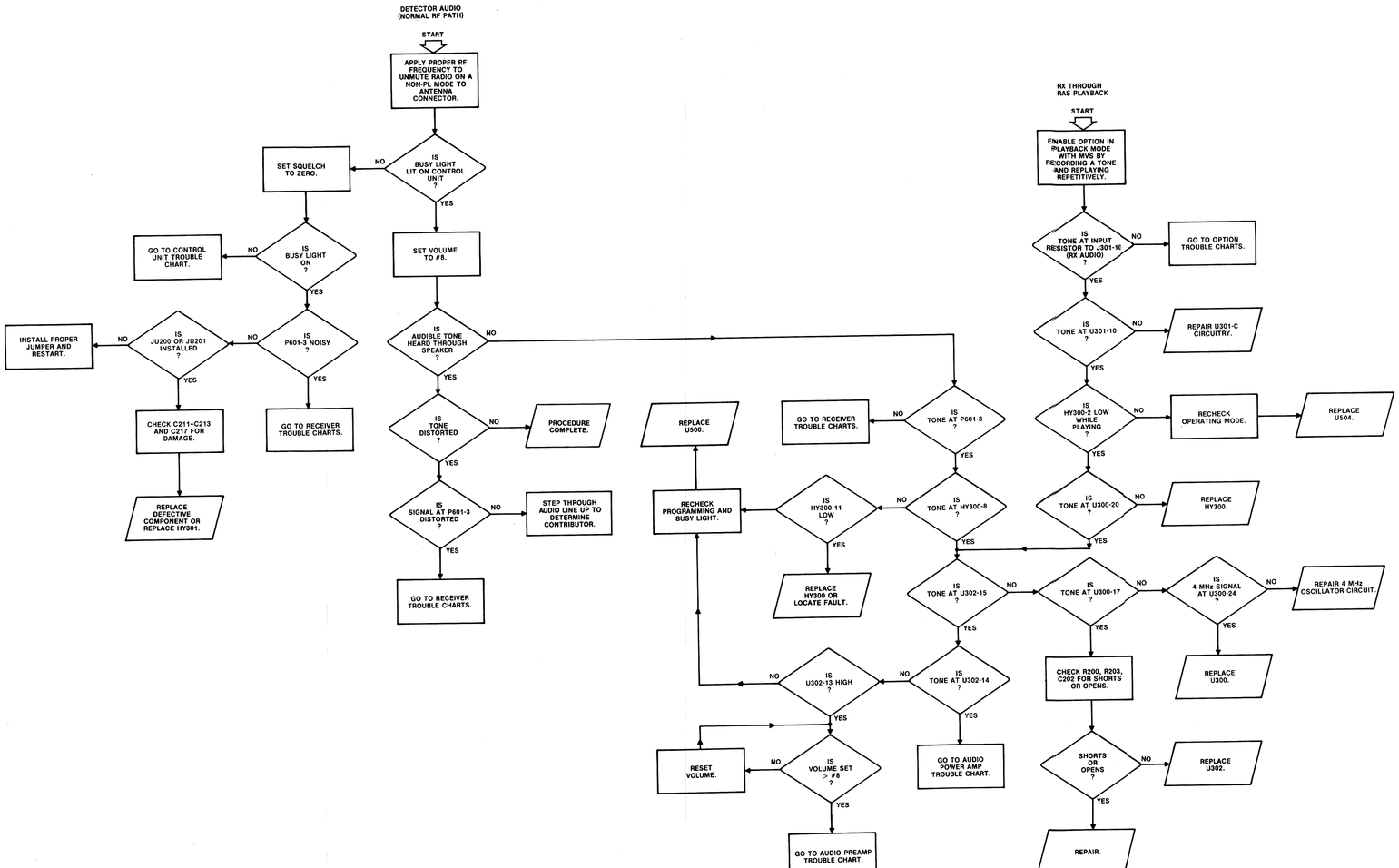
SERIAL BUS FAILURE



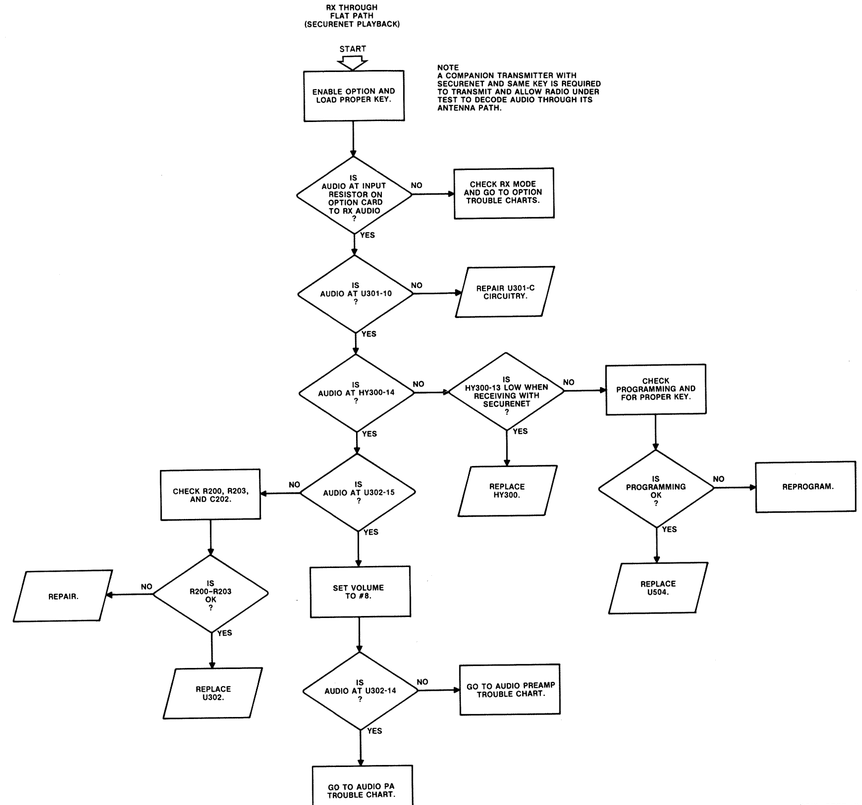
NOTE: THE SIGNALS TO BE DETECTED ARE SHORT DATA BURSTS WHEN THE RADIO POWERS UP OR WHEN THE SYSTEM IS RESET. THE SIGNALS START WHEN SUCCESSFUL HOOK TO HOOK TRANSMISSION (RADIO TO CONTROL UNIT, THEN CONTROL UNIT TO RADIO). THESE SIGNALS ARE EASIEST TO DETECT BY SWITCHING THE SYSTEM ON AND OFF AT THE CONTROL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

GEW-2710-0

RX ROUTING



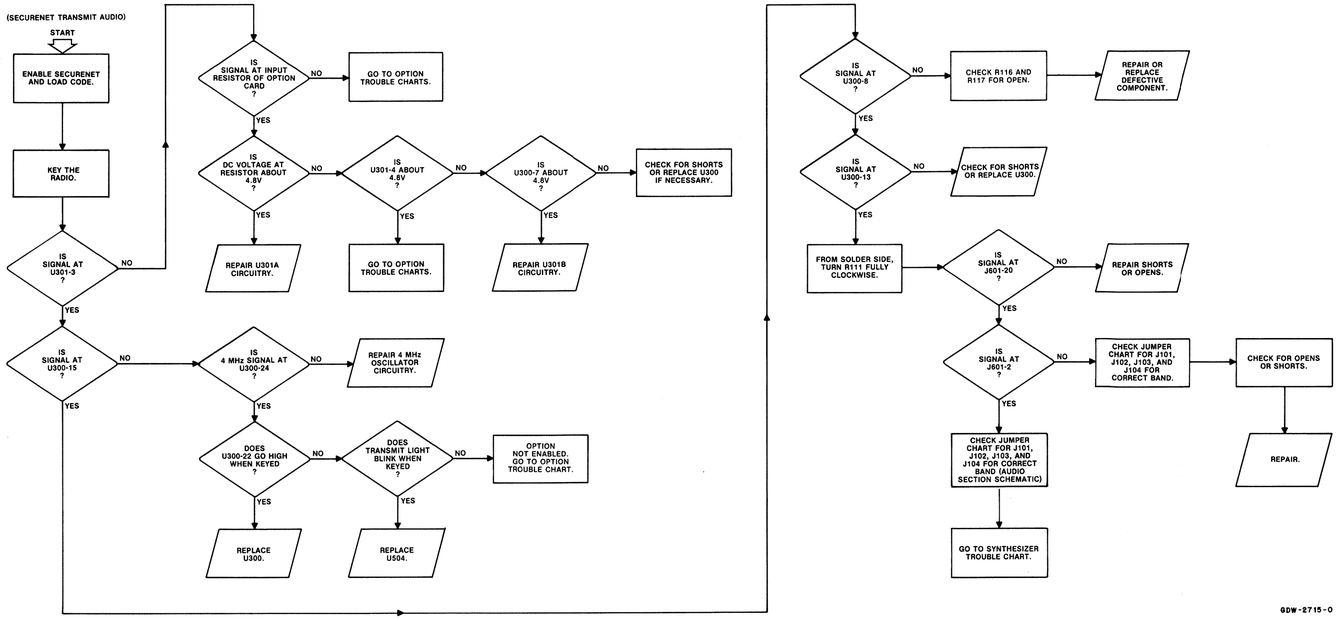
GEW-2718-0



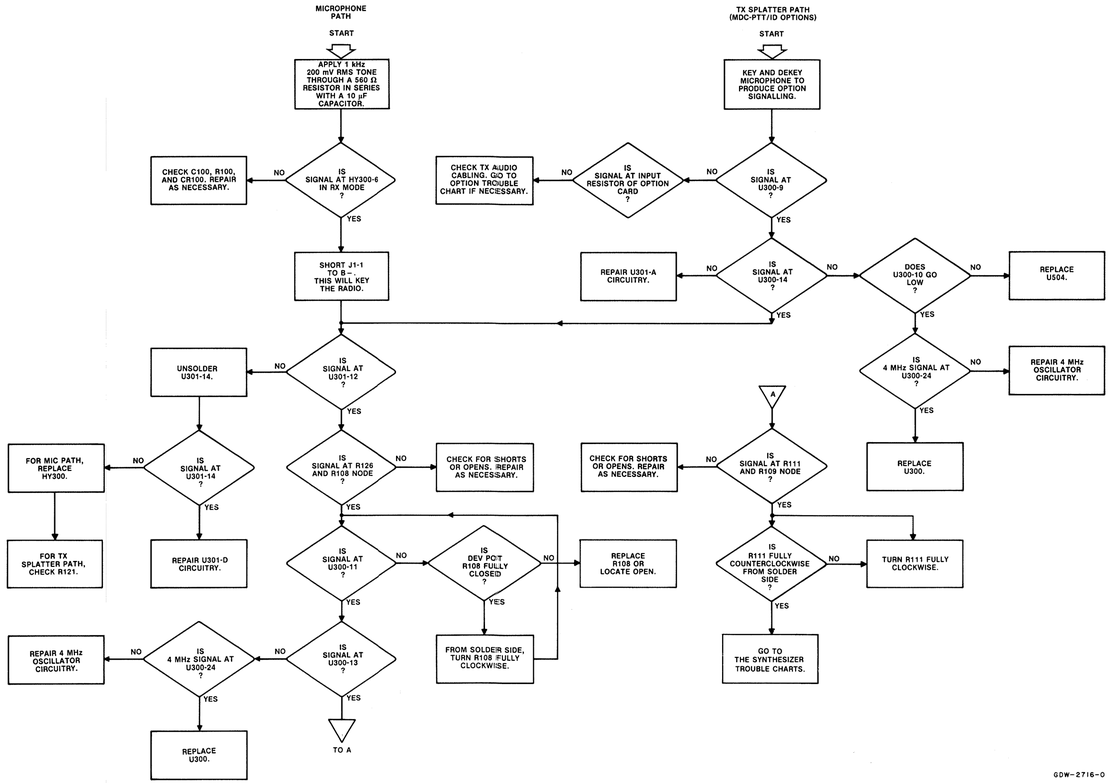
GDW-2723-0

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

TX ROUTING



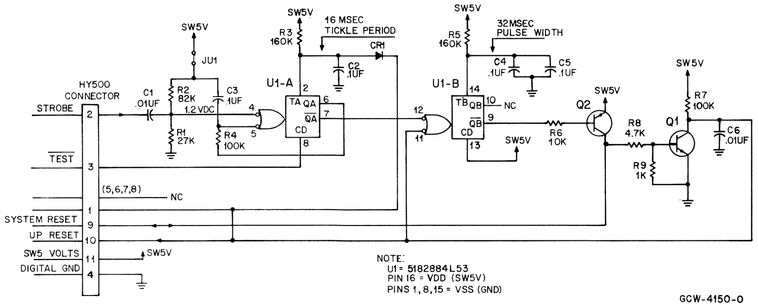
GDW-2715-O



GDW-2716-O

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

WATCHDOG TIMER



NOTE:
U1 = 5182884L53
PIN 16 = VDD (SW5V)
PINS 1, 8, 15 = VSS (GND)

GCW-4150-0

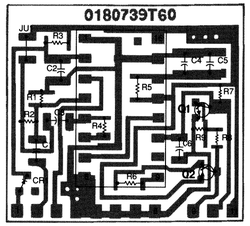
parts list

Watchdog Timer (p/o HLN5299B Personality Board) MXW–4564–C

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

1/03/89

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



SUBSTRATE ● GPW–4358–A
OVERLAY — GPW–4359–A

SQUELCH HYBRID

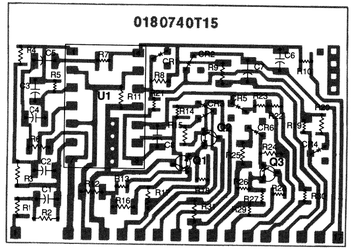
parts list

Squelch Hybrid (p/o HLN5299B Personality Board) MXW–4563–C

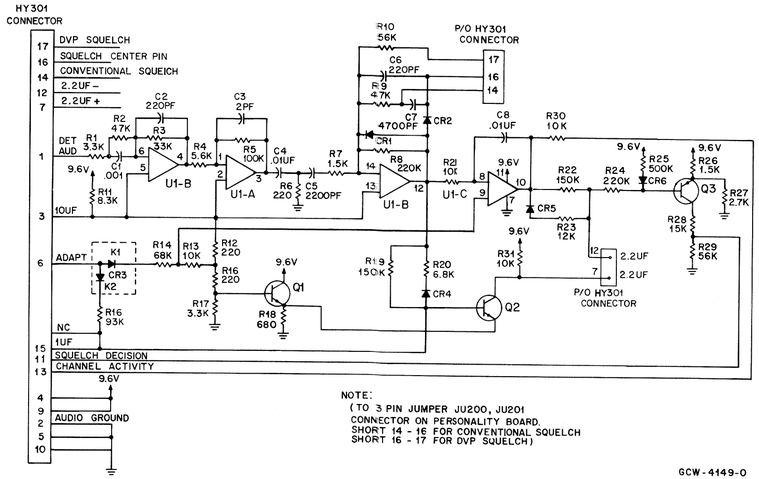
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
HY301	01–80740T15	includes the following
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C1	21–13740B73	.001
C2	21–13740B57	220 pF
C3	21–13740B47	82 pF
C4	21–13741N45	.01
C5	21–13741N29	.0022
C6	21–13740B57	220 pF
C7	21–13741N37	.0047, ±10%
C8	21–13741N45	.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	48–30141L04	NPN
Q3	48–80141L01	PNP
integrated circuit (see note)		
U1	51–80067C06	quad opamp

1/03/89

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



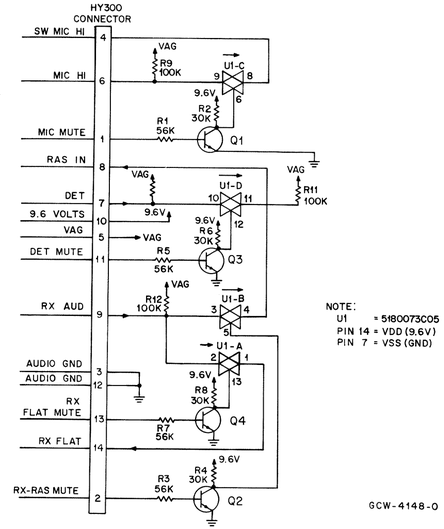
SUBSTRATE ● GPW–4356–A
OVERLAY — GPW–4357–A



NOTE:
(TO 3 PIN JUMPER JU200, JU201
CONNECTOR ON PERSONALITY BOARD.
SHORT 14 - 16 FOR CONVENTIONAL SQUELCH
SHORT 16 - 17 FOR DVP SQUELCH)

GCW-4149-0

TRANSMISSION GATE HYBRID



NOTE:
U1 = 5180073C05
PIN 14 = VDD (9.6V)
PIN 7 = VSS (GND)

GCW-4148-0

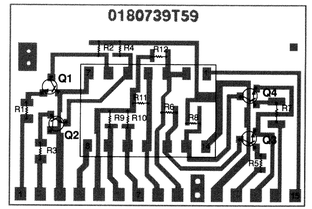
parts list

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 1-gate

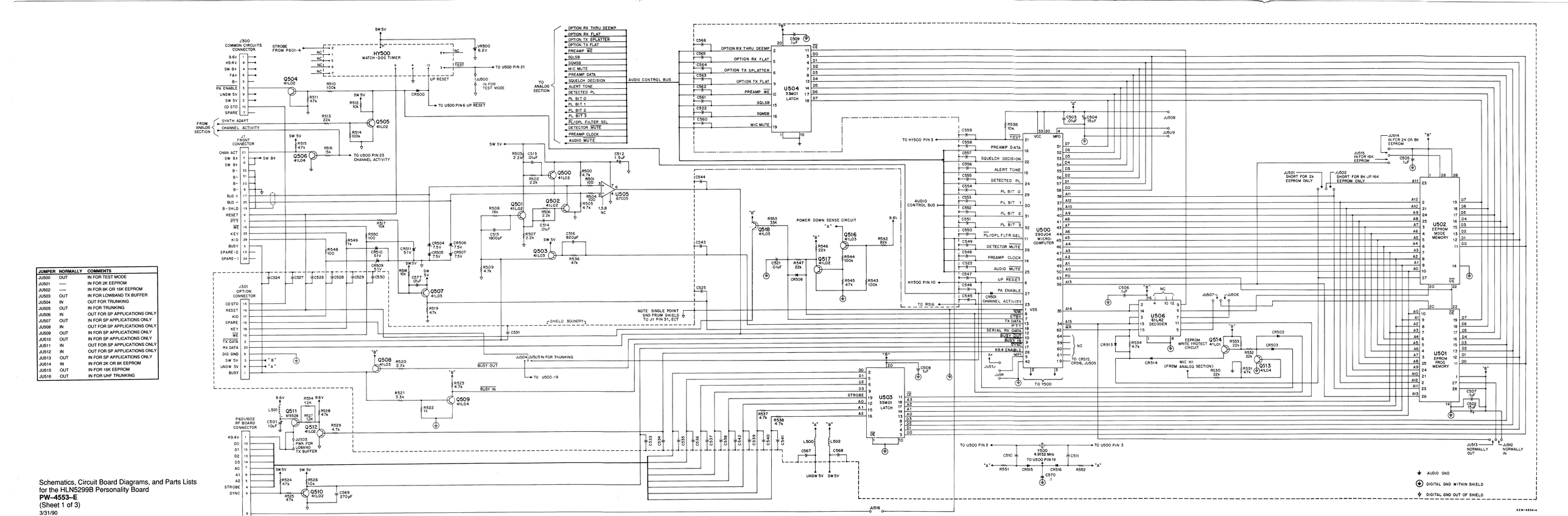
5/4/88

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



SUBSTRATE ● GPW–4354–A
OVERLAY — GPW–4355–B

Schematics, Circuit Board Diagrams, and Parts Lists for the Transmission Gate, Squelch, and Watchdog Timer Hybrids
PW–4561–E
4/15/90



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

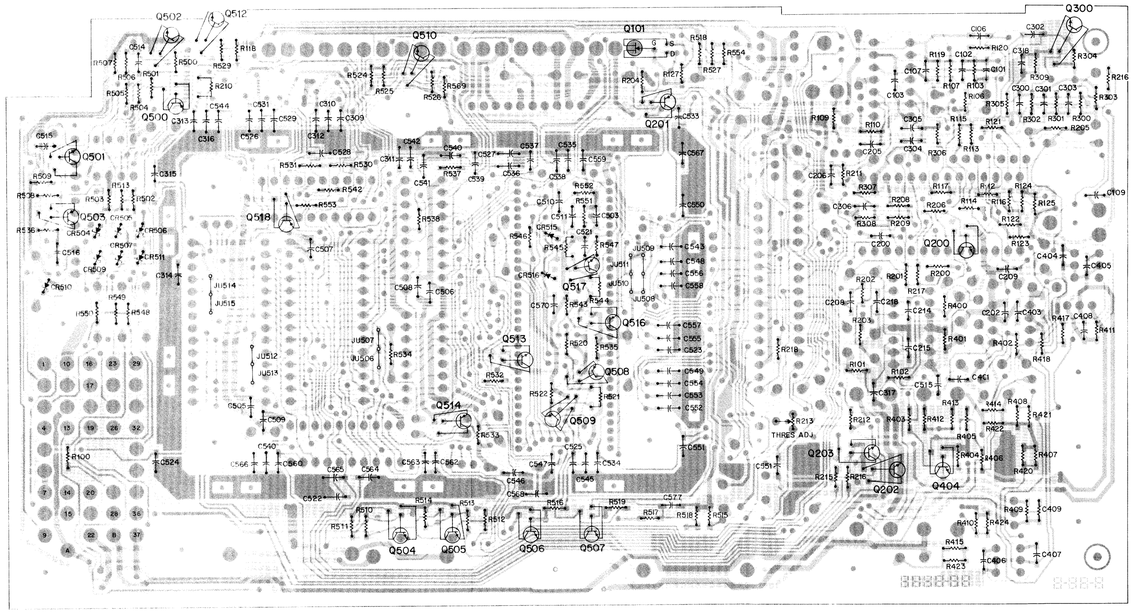
Schematics, Circuit Board Diagrams, and Parts Lists for the HLN5299B Personality Board

PW–4553–E

(Sheet 1 of 3)

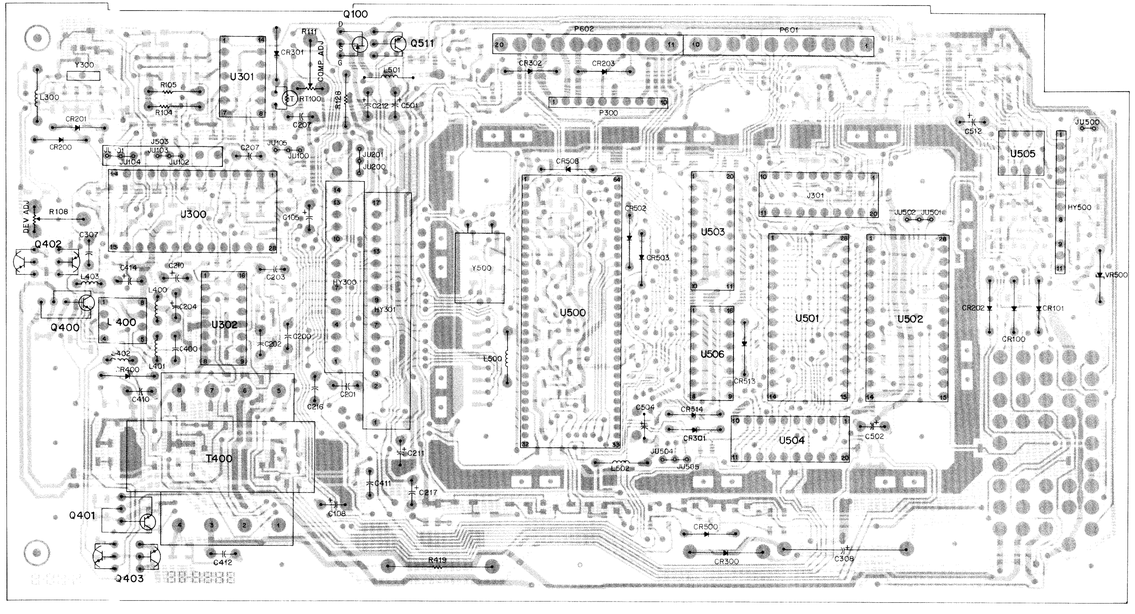
3/31/90

HLN5299B PERSONALITY BOARD



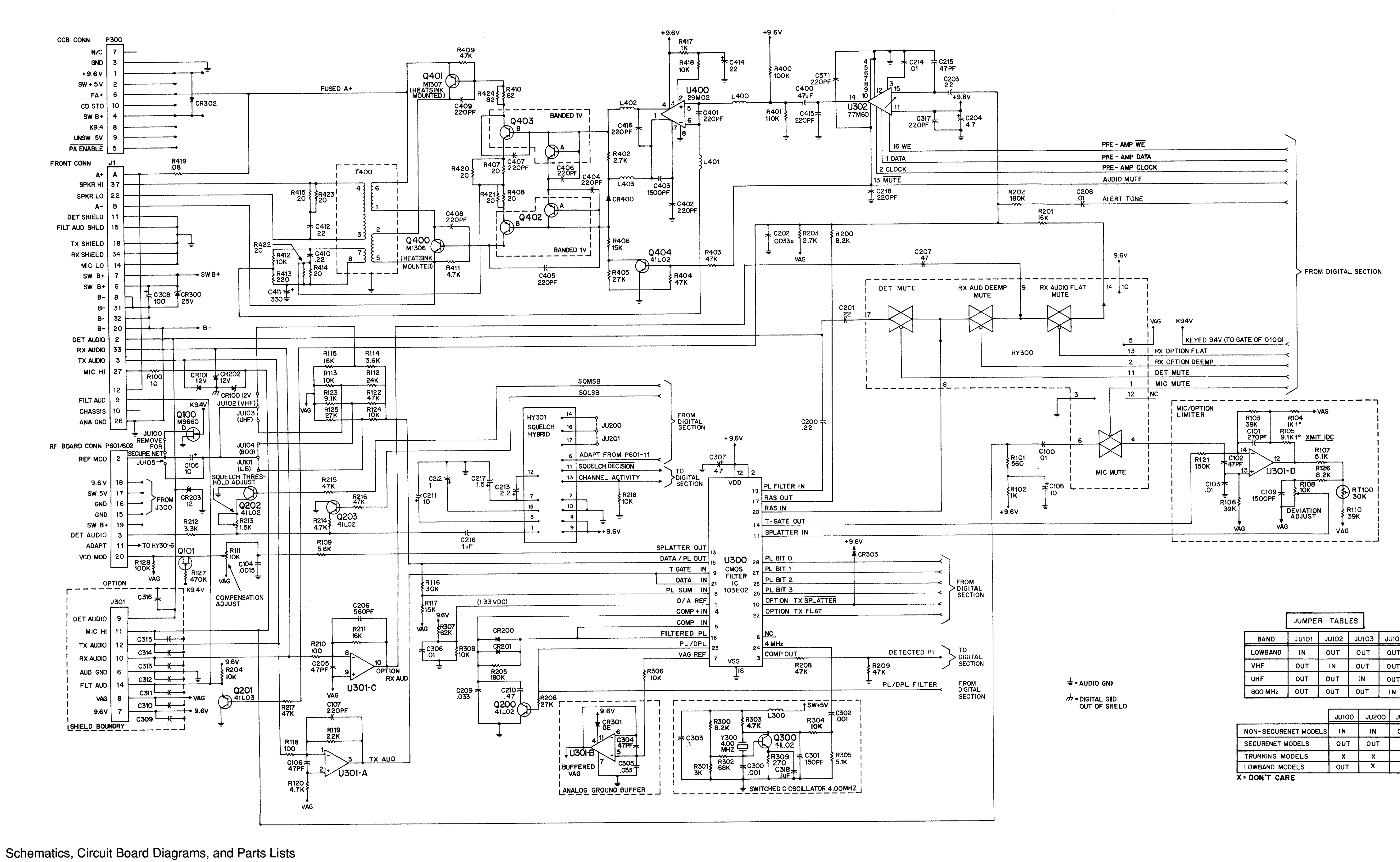
SHOWN FROM SOLDER SIDE

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



SHOWN FROM COMPONENT SIDE

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



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

GEW-4560-B

Schematics, Circuit Board Diagrams, and Parts Lists
for the HLN5299B Personality Board
PW–4553–E
(Sheet 3 of 3)
3/31/90

parts list

HLN5299B Personality Board — MXW–4559–F

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C100	08–11051A07	.01, 63V
C101	21–13740B59	270 pF
C102	21–13740B41	47 pF
C103	21–13741N45	.01, ±10%
C104	08–11051A02	.0015, 63V
C105	23–11048C11	10, ±20%, 35V, electrolytic
C106	21–13740B41	47 pF
C107	21–13740B57	220 pF
C108	23–11048C11	10, ±20%, 35V, electrolytic
C109	21–13740B76	1500 pF, ±5 pF
C200	21–11032B15	.22, +80, –20%
C201	08–11051A15	.22, 63V
C202	08–11051A04	.0033, 63V
C203	08–11051A15	.22, 63V
C204	23–11013D55	4.7, ±20%, 20V, tantalum
C204	23–11054N08	4.7, ±10%, 35V, tantalum
C205	21–13740B41	47 pF
C206	21–13740B67	560 pF
C207	08–11051A17	.47, 63V
C208	21–13741N45	.01, ±10%
C209	21–13741N57	.033 uF, ±10%
C210	08–11051A17	.47, 63V
C211	23–11048C11	10, ±20%, 35V, electrolytic
C212	23–11048C05	1, ±20%, electrolytic
C213	23–11048C06	2.2, ±20%, electrolytic
C214	21–13741N45	.01, ±10%
C215	21–13740B41	47 pF
C216	08–11051A13	.1, 63V
C217	23–11054N02	1.5, ±10%, 35V, tantalum
C218	21–13740B57	220 pF
C300	21–13741N21	.001, ±10%
C301	21–13740B53	150 pF
C302	21–13741N21	.001, ±10%
C303	21–11032B13	.10, +80, –20%
C304	21–13740B41	47 pF
C305	21–11032B15	.22, +80, –20%
C306	21–13741N45	.01, ±10%
C307	23–84538G06	47, ±20%, 20V, tantalum
C308	23–84669A08	100, –10, +150%, 25V, electrolytic
C309–316	21–13740B49	12 pF
C317	21–13740B57	220 pF
C400	08–11051A17	.47, 63V
C401,402	21–13740B57	220 pF
C403	21–13740B76	.0015 uF, ±5 pF
C404,409	21–13740B57	220 pF
C410	08–11051A15	.22, 63V
C411	23–82747L01	330, –10, +100%, 20V, electrolytic
C412	08–11051A15	.22, 63V
C414	23–11054F10	22, ±10%, 15V, tantalum
C415,416	21–13740B57	220 pF
C501	23–11048C11	10, ±20%, 35V, electrolytic
C502	23–11054H10	15, ±10%, 25V, tantalum
C503	21–13741N45	.01, ±10%
C504	23–11054H10	15, ±10%, 25V, tantalum
C505–509	21–11032B13	.1, +80, –20%
C510,511	21–13740B25	12 pF
C512	23–11054N02	1.5, ±10%, 35V, tantalum
C513,514	21–13741N45	.01, ±10%
C515	21–13740B78	.0018 uF
C516	21–11031G61	820 pF
C521	21–11032B13	.1, +80, –20%
C522–569	21–13741N07	270 pF, ±10%
C570	21–13741N45	.1, +80, –20%
C571–576	21–13740B57	220 pF
C577	21–13741N45	.01, ±10%
diode (see note)		
CR100,101	48–80007E02	12V zener
CR200,201	48–83654H01	silicon
CR202,203	48–80007E02	12V zener
CR300	48–80236E07	28V zener
CR301	48–82178A01	germanium
CR302	48–80008E01	rectifier silicon
CR303	48–82178A01	germanium
CR400	48–83654H01	silicon
CR500–503	48–83654H01	silicon
CR504–507	48–80140L11	5V zener
CR508	48–83654H01	silicon
CR509–511	48–80140L06	1V zener
CR513,514	48–83654H01	silicon
CR515,516	48–80013E02	silicon pin
hybrid (see note)		
HY300	01–80739T59	transmission gate, see parts list MXW–4562
HY301	01–80740T15	squelch, see parts list MXW–4563
HY500	01–80739T60	watchdog timer, see parts list MXW–4564
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	0 ohm
JU200	09–80080L01	0 ohm

MXW–4559–F (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
JU501	09–80080L01	0 ohm
JU504	09–80080L01	0 ohm
JU506	06–11077A01	0 ohm resistor
JU508	06–11077A01	0 ohm resistor
JU511,512	06–11077A01	0 ohm resistor
JU514	06–11077A01	0 ohm resistor
coil, RF		
L300	24–80293D02	ferrite
L400–403	24–80036A01	ferrite, 1/2 turn
L500	24–80138G04	5.6 uH, ±5%
L501	24–80036A01	ferrite, 1/2 turn
L502	24–80138G04	5.6 uH, ±5%
connector plug		
P300	28–80264K01	top entry
P601,602	28–80085E37	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 transistor & clip assembly
Q403	01–80734T96	NPN transistor & clip assembly
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
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
R208,209	06–11077B15	47k
R210	06–11077A50	100
R211	06–11077B04	16k
R212	06–11077A86	3.3k
R213	18–05500L17	1.5k, ±20%, 100V, 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
R307	06–11077B18	62k
R308	06–11077A98	10k

MXW–4559–F (3)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
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	06–11077A90	4.7k
R548	06–11077A50	100
R549	06–11077A74	1k
R550	06–11077A50	100
R551,552	06–11077A98	10k
R553	06–11077B07	22k
R554	06–11077A76	1.2k
transformer		
T400	25–84083B03	audio
integrated circuit (see note)		
U300	51–80103E02	switch filter
U301	51–80067C04	opamp
U301	51–80067C06	opamp
U302	51–83977M60	digital volume control
U400	51–84621K14	driver
U500	51–80290J04	1.5 MHz microprocessor
U501	—	radio software (see model chart)
U502	—	EEPROM software (see model chart)
U503	51–05133M01	octal latch
U504	51–05133M01	octal latch
U505	51–80067C05	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		
	03–10943M10	tapping screw (3 x 0.5 x 8)
	03–10911A11	machine screw (3 x 0.5 x 8)
	04–84180C01	nylon shoulder washer
	07–05375P09	plated lead
	07–80042L01	hybrid support
	09–80269B03	dual socket
	09–82808R10	28 contact
	09–80269B01	dual socket
	09–82808R04	16 contact
	09–80002K01	socket
	14–80175M01	insulator shield
	14–80175M03	insulator shield
	14–80179N01	crystal pad
	14–80206M01	heat sink insulator

MXW–4559–F (4)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	14–83820M02	heat conductive insulator
	26–80033M01	RFI shield
	26–80051K01	solder side option shield
	26–83498M01	heat sink
	28–80264K01	top entry
	28–82647K02	10 pin
	28–83485M05	male plug assembly
	29–10134A68	lug connector
	29–10134A70	lug connector
	32–80219B01	housing gasket
	37–00132026	tubing
	37–00132026	3/16 clear heatshrink tubing
	37–00132526	1/16 heatshrink tubing
	42–82891K01	transistor clip, 2 used
	43–80054K02	support spacer
	54–80072G01	circuit board label
	55–84300B04	handle
	75–80051P01	crystal pad
	75–80129N01	crystal mounting pad
	75–80144H01	vibration pads
	84–80036N02	circuit board

3/31/90

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

1. General

The *SYNTOR X* frequency synthesizer generates injection frequencies for both first and second receive mixers as well as generating the transmitter carrier. It is composed of the receive injection doubler, the transmit injection doubler, the transmit mixer and buffer, and a phase–locked loop (PLL) consisting of a 14.4 MHz reference oscillator, a phase modulator, a low–noise voltage–controlled oscillator (VCO), a programmable divider, a sample–and–hold phase detector, and an adaptive loop filter. In the receive mode, the PLL locks on a frequency 75.7 MHz (first IF) above the receive frequency for injection into the first mixer. The receive injection doubler doubles the third harmonic of the 14.4 MHz reference oscillator, and the result is the second mixer injection frequency.

In the transmit mode, the the transmit injection doubler redoubles the signal from the receive injection coupler and amplifies it, and the result is high–side injection to the transmit mixer. The PLL generates the frequency which, when mixed with the transmit injection, yields the transmitter carrier. The VCO and phase modulator modulate the transmitter carrier.

The synthesizer circuits are on the RF board, in the internal casting, and on a small board above the personality board.

2. Theory of Operation

2.1 INTRODUCTION

The PLL synthesizer is a single negative–feedback loop that uses the phase of the input signals to the phase detector as the controlling variable. The out put 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 5.00 kHz (6.25 kHz for some customer frequencies) squarewave signal that is routed from the reference divider through the phase modulator 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, the output frequency of which is proportional to the voltage on the VCO's steering line (P650–2).

The VCO is a FET RF oscillator (Q1401) that covers the frequency range from 105.4 MHz to 139.8 MHz. A programmable N divider divides the VCO frequency down to the loop frequencies 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 DC output voltage of the phase detector (PHASE DET OUT at U603–15) is applied via the loop adaptive filter to the VCO steering line, thus completing the feed back 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 at the out put 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 informa tion from the personality board memory module, com bines 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 microcom puter is sending on the data lines.

Of the bits sent to the divider, two determine the frequency range of the VCO. These bits are transferred from the divider (U602–19 and U602–20) to the synthesizer switching hybrids (HY604–5 and HY605–5, respectively), which supply 9.6V to the VCO pin switch circuitry via P650–5 and P650–6. These switching hybrids also load the modulation circuitry of the VCO via P650–4 to maintain level modulation across the frequency range. Sixteen bits program the A and B counters, which are inside the programmable divider. Two bits program a reference divider. One latched bit goes from the divider (U602–15) to the extender circuitry (Q241) to enable or disable the extender. The sample–and–hold phase detector uses two other latched outputs (U603–3 and U603–5) from the divider to con trol the adaptive loop filter. When set high, U603–5 in dicates a change in frequency. In this case, the seventh word clears the frequency change indication by setting U602–18 (same as U603–5) low, thus generating a con trol pulse. U602–17 switches between the transmit and receive loop filters (high for transmit filter). One bit is not used.

The six four–bit words on the data lines remain the same once the condition of synthesizer oper ation and the frequency have been selected. Any change in radio mode makes the microcomputer address differ ent memory locations in the memory module. Conse quently, 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 ad dress 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," using 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 input 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 and B.

Each PLL 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–63–or–64 starts dividing by 64 for the number of times programmed by 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 VCO1 and VCO2 which, through synthesizer switching hybrids HY604 and HY605, select the operating range of the VCO. When the VCO bits are latched into the divider, VCO1 and VCO2 go from U602–19 and U602–20 to HY604–5 and HY605–5. Each hybrid inverts its bit and then sends it out through Pin 9 to the VCO via P650–5 and P650–6, respectively. Also, when either VCO bit goes high, an NPN transistor on its hybrid turns on, adding in a shunt resistance on the VCO modulation line, which has the effect of reducing the level of the audio signal to the VCO. This maintains a constant level of deviation across the entire frequency band.

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 (U602–18) and the LOW BANDWIDTH SELECT line (U602–17) and uses this information to generate control signals for the adaptive filter.

The phase detector output signal level is con–trolled 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 Q600 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 Q600 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 hold capacitor (C632) is 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 OUT PUT 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 BANDWIDTH SELECT signal at U603–3 to generate four control signals that are coupled to the adaptive filter. These four control signals are: ADAPT, $\overline{\text{ADAPT}}$, RX, and TX (appearing at U603–10, –7, –12, and –6, 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 RX line is driven high, the TX 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 3.0 milliseconds under phase detector control, forcing the adaptive filter to enter into the normal receive mode.

When the PTT button is pushed, 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 TX line is driven high, the RX 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 is connected 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 J601–9, 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 of the RX, TX, and ADAPT lines. These lines are coupled from the phase detector (U603–12, –6, and –10, respectively) to transmission gates U605A–D and U606A–D. 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 TX line high and the RX and ADAPT lines low. The high on the TX line turns on transmission gates U605A, U606A, and U606D. The natural loop frequency 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 R653 in parallel with C649 and C641, and C637 and C654. This signal passes through 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 RX line high and the TX and ADAPT lines low. With the RX line high, transmission gates U605C and U606C are turned on. The natural loop frequency in this mode is 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 R637, C641, C654, C637 and of R636 in parallel with C540. (The ON impedance of the transmission gates is neglected.) The signal passes through the test jumper (J600) to the VCO via J650–2.

2.5.5 Transmit–Adapt Mode

When the synthesizer is in the transmit–adapt mode, the TX and ADAPT lines are driven high by the phase detector, and their respective complements, RX 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 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. 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 RX and ADAPT lines are driven high by the phase detector, and their respective complements, TX 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 2.4 milliseconds while the radio changes from the transmit mode to the receive mode or from one receive frequency to another (as when changing the operating channel).

In this mode, the greater part of the adaptive filter is shorted by transmission gate U606B, and the steering line is connected to C641. When the filter is in the receive–adapt mode, C641 and C654 are being charged. The accumulated charge on C654 pre vents 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, which turns on the LED indicating out–of–lock. Therefore, in normal operation of the frequency synthesizer, the out–of–lock LED flashes briefly whenever the frequency is being changed. During Channel Scan operation, the radio can be changing frequencies continuously and fast, making the out–of–lock LED glow dimly. A brightly lighted LED points to the presence of an out–of–lock fault in the frequency synthesizer, making this LED 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 +8.6V out put voltage. The filter removes any ripple or noise present on the +9.6V supply line, thus preventing unwanted modulation of the VCO. It also lowers the 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 (Q603). The +9.6V supply is connected to U600–1 as well as to the emitter of Q603. 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 Q603 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 Q603 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 VCO via P650–1 and P650–3. It is also applied to synthesizer switching hybrids HY604–4 and HY605–4.

2.5.8 Divider Buffer

A feedback signal from the VCO is routed back into the PLL (to J600 on the RF board) through a coaxial cable from the TX mixer compartment of the internal casting to the divider buffer hybrid (HY600–4). Here the VCO signal is attenuated to a level acceptable to the programmable divider. Signal is then routed out of HY600–8 through a coaxial cable to the divider's prescaler input (U602–25).

2.6 VOLTAGE–CONTROLLED OSCILLATOR (VCO)

2.6.1 General

Voltage from the phase detector controls the output of the HLB4086A VCO. Its pin switch circuitry allows it to generate frequencies from 105.4 to 139.8 MHz, which covers the receive first injection as well as a frequency modulated transmit injection. The oscillator, buffer, pin switch, and associated circuitry are constructed on an 0.1–inch alumina substrate in the internal casting.

2.6.2 Oscillator Circuit

The VCO is a Colpitts oscillator that uses a low–noise JFET (Q1401) as the amplifying element. Pin diode switching circuitry gives the VCO a relatively large tuning bandwidth by adding additional lengths of transmission line to the tank's main transmission line resonator. The amount of transmission line added depends on four pin states, which are dictated by the switching hybrids (HY604 and HY605).

With PS1 (J650–5) and PS2 (J650–6) both high, only the main resonator is present in the oscillator tank. In this mode, the oscillator's output frequency ranges from 105.4 to 113.8 MHz over a steering line range from three to eight volts. With PS1 high and PS2 low, pin diode CR1415 is turned on, adding the pinshift 2 transmission line in parallel with a portion of the main resonator. In this mode, the oscillator can be tuned from 113.8 to 122.8 MHz over the range of steering line voltages. With PS1 low and PS2 high, CR1413 is turned on, adding the pinshift 1 T–line in parallel with a portion of the main resonator. In this mode, the oscillator tunes from 122.8 to 132.6 MHz. In the fourth state, both PS1 and PS2 are low. In this state, all PIN diodes are on, so the pinshift 1 T–line is added in as well as a portion of the pinshift 2 T–line. In this mode, the VCO tunes from 132.6 to 139.8 MHz. If actually given an independent steering line supply, the VCO would tune over a

wider frequency range, but PROM programming dictates that steering line voltages stay between three and eight volts.

2.6.3 VCO Buffer

The VCO buffer uses a saturated NPN transistor (Q1402) to maintain a constant level of VCO out put power across the frequency range. The output of the buffer amplifier goes through a low–pass filter to attenuate higher–order harmonics before going out of the VCO compartment of the internal casting to the TX mixer compartment through a short coaxial cable.

2.6.4 Steering Line Circuit

The steering line, in conjunction with the pinshift 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 voltage 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.

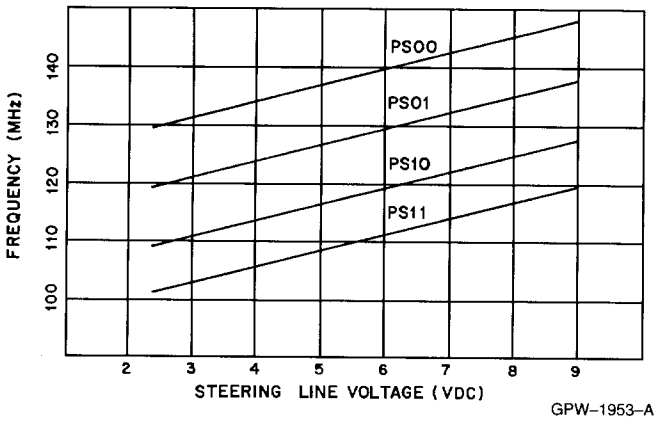


Figure 1. VCO Response to Steering Line Voltage

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 CR1401 through CR1410. An in crease 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 CR1411. The transmit audio signal is coupled, via Pin 4 of the VCO interconnect plate, to CR1411, 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 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 U501A, 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 combiner U502B, the gain of which is set by 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 in puts, 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.

The output of combiner U502B is routed to the phase modulator (HY601) via P401–17, and also to the compensation adjust potentiometer (R516). The wiper arm of the compensation adjust potentiometer is routed to the VCO via P401–14. PL and DPL signals at HY601 phase–modulate the reference input to the phase detector, thus preventing the phase detector out put from defeating the direct low–frequency modulation of the VCO generated by the PL/DPL signal. (The phase modulator and phase detector form part of the synthesizer schematic.) The compensation adjustment potentiometer, R516, is adjusted at the factory and should be readjusted only if the common circuits board, phase modulator, or VCO is changed. R516 can be readjusted by the

procedure presented in the Radio Alignment and Adjustments part of the Maintenance and Troubleshooting Section of this manual.

VCO modulation inhibit switch Q502 is allowed to conduct while the radio is in the receive mode, effectively shorting the VCO modulation signal line to ground. This prevents any noise induced on the line in receive mode from affecting the receive injection frequency. During initial turn–on, C600 is charged through Q602. This action allows a stable receive frequency to be attained almost immediately. Q602 is turned off by TX +9.4V during transmit, enabling the VCO modulation signal line.

2.8 RECEIVE INJECTION DOUBLER

The receive injection doubler, HY602, supplies 9.6 VDC to the reference oscillator, U608. It also has diplexing circuitry which, along with that on the RF board, presents to the reference oscillator terminating impedances that accent its fundamental (14.4 MHz) and third harmonic (43.2 MHz) outputs. The 43.2 MHz signal from the reference oscillator goes to the receive injection doubler at HY602–2, where a two–pole monolithic crystal filter (Y1300) filters it to reduce adjacent channel noise levels and 14.4 MHz harmonics. Class C NPN transistor Q1300 doubles and amplifies the signal, and a three–pole tuneable bandpass filter reduces the level of any remaining and undesired harmonics. This filter is factory tuned and does not require readjustment. The 86.4 MHz signal goes to pinswitch circuitry via C1318. In the receive mode, 9.4V is present at HY602–19, forward biasing CR1300. This opens up an RF signal path to the receiver's second mixer via C1319, HY602–21, and a short coaxial cable. In the transmit mode, 9.4V is present at HY602–26, forward biasing CR1301. Resistive padding is present in this path to get the proper drive level to the transmit injection doubler, HY603. Transmit 86.4 MHz output is routed from HY602–24 through JU604 to HY603–3.

2.9 TRANSMIT INJECTION DOUBLER

The transmit injection doubler, HY603, works like the receive doubler, but it runs entirely off of keyed 9.4V and therefore only operates in the transmit mode. It takes the 86.4 MHz signal from the receive doubler and doubles and amplifies it in Class C NPN transistor Q1351. A two–pole filter now reduces unwanted harmonic levels and passes only 172.8 MHz. The resulting signal now goes through a saturated amplifier, Q1352, to hold a constant power output level. Additional filtering at the output and on the RF board reduces the levels of undesired signals. You can measure power conveniently at J603, where it should measure 21.0 +1 dBm.

2.10 TRANSMIT MIXER AND RECEIVE BUFFER

The transmit mixer and the receiver's first injection buffer amplifier are in the internal casting adjacent to the VCO compartment. Signal from the VCO goes to the transmit mixer compartment via a short coaxial cable. Here part of the signal is tapped off to become synthesizer feedback, going via a coaxial cable to the RF board (P600). The rest of the signal goes through a lowpass filter to reduce the levels of VCO harmonics.

The transmit mode forward–biases CR1451, opening an RF path to diode quad CR1452 via a resistive pad and transformer T1450. Transmit mixer injection to CR1425 is supplied by the transmit injection doubler, HY603, through a coaxial cable to the RF board (P603). The resulting frequency spectrum is coupled out through transformer T1451 to the transmitter buffer board through a coaxial cable (P1501). Among the various signals that can be seen at this point is the transmit frequency (172.8 MHz – f_{VCO})

In the receive mode, CR1451 is off and CR1450 is on, opening an RF path for the VCO signal to amplifier Q1451. This saturated amplifier sends a minimum 20–dBm injection to the receiver's first mixer via J125.

2.11 TRANSMIT BUFFER

The transmit buffer board is above the audio transformer on the personality board. The transmit mixer output is injected at J1501 and filtered by a seven–pole lowpass filter to reduce the levels of 172.8 MHz, VCO signal, and other mixing products present at the TX mixer output. The transmit frequency then goes through a two–stage amplifier consisting of Q1501 and Q1502 to become a minimum +17–dBm output to the radio's PA. The signal goes to the PA compartment via a short coaxial cable (P801).

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 2. Problems in Synthesizer and Their Possible Causes

Problems	Possible Source of Trouble
Synthesizer does not lock.	(See synthesizer troubleshooting chart.)
Synthesizer locks on wrong frequency.	reference oscillator (U608) frequency off (should be 14.4 MHz +2 72 Hz)
	erroneous divider programming from microcomputer (possible defective memory module, or code plug, or microcomputer)
	defective divider U602
Excessive reference frequency feeds through (spurs).	defective hold capacitor C632 (open or leaky)
	defective ramp capacitor C630
	defective phase detector U603
	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.	marginal input level to loop divider (U602–25) or reference divider (U602–2)
	loose connection, cold solder joint, or faulty component
	noisy Q600
	defective phase detector U603
	defective divider U602 (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, and U606.)
	phase detector U603 gain too low (overdamped response) or too high (underdamped response) (Check R625, R626, RT600, C630, and Q600.)
	leaky adaptive filter capacitors or transmission gates (U605, U606, and C641)
	leaky VCO varactor diodes

Table 2 summarizes these problems and their possible causes. Other tables show pin connections and voltages for the phase detector, divider, 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 JU603 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 JU603 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 VCO feedback from the internal casting (P600). Check the pinshift lines to determine the expected VCO operating range. Verify that the lines are either high ($\geq$ 9V) or low ($\leq$ 0.5V). Slowly vary the steering line voltage from 3V to 8V. Verify that the VCO covers its intended frequency range (see 2.6.2.2 and Figure 1). Also check the power level and verify that it is greater than –4 dBm. Check for proper operation in all pin states. If the pinshift lines are all right and the output level to the divider port is adequate but the VCO cannot be tuned over the desired frequency range with the steering line voltage, then 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.

(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 yields exactly this period on the loop divider output. (The period de pends on the customer's programming requirements. In most cases, it is 200 microseconds for a 5 kHz reference.)

(4) If the conditions specified in Steps 2 and 3 are met, then check the divider buffer (HY600), the divider (U602), the reference oscillator (U608), and the divider programming.

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 phase 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 (CR1400–1410). To determine which is defective, remove the VCO from the RF internal casting and perform 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 and a test memory module (Motorola Kit No. HLN1127A). The Maintenance and Troubleshooting Section of this manual recommends specific models. Table 4 gives the pin numbers and functions of the divider (U602). The timing diagram on the synthesizer troubleshooting chart shows the waveforms generated under Mode 4 of the test memory module.

(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) Compare the waveforms on the oscilloscope with those in the timing diagram, and verify that the relationship between the STROBE and A0 signals is the same.

(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 for A2 (U602–26), D0 (U602–11), D1 (U602–12), D2 (U602–13), and D3 (U602–14).

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.

3.4 INJECTION STRING TESTS

Problems likely to occur because of improper injection string operation are:

- Failure of synthesizer to lock
- Low or no transmitter power output
- Poor receiver sensitivity

The best way to find injection string problems is to operate the radio in the transmit mode and working back from the transmit buffer toward the reference oscillator. See also the synthesizer troubleshooting chart at the end of this section, which gives a comprehensive procedure for troubleshooting the injection string.

Table 3. Phase Detector (U603) Pin Connections and Voltages

Pin No.	Function	To/From	Nominal Voltage
1	high current ground	—	0 VDC
2	REFERENCE IN	from HY601–8	0V to 4.3V square wave (200 ms period for 5 kHz reference frequency)
3	LOW BANDWIDTH	from U602–17	0 VDC receive; 5 VDC transmit
4	SYNTHESIZER SYNC	to microcomputer	60 ms positive pulse 0 5V at loop pulse rate; equal to Pin 2 if Pin 11 is low
5	FREQUENCY CHANGE	from U602–18	0.5V, 11.1 ms when frequency changes
6	TX	to adaptive filter	0 VDC receive, 9.6 VDC transmit
7	ADAPT	to adaptive filter	9.6 to 0.6V single pulse, 3.0 ms (RX) dekey; 15 ms (TX) key
8	no connection	—	—
9	no connection	—	—
10	ADAPT	to adaptive filter	0 9.0V single pulse, 3.0 ms (RX) dekey; 15 ms (TX) key
11	no connection	—	—
12	RX	to adaptive filter	9.6 VDC receive, 0 VDC transmit
13	HOLD 2	C632	1.4 to 8 VDC (use high–input–impedance voltmeter)
14	Guard Band	—	—
15	PHASE DET OUTPUT	to adaptive filter	1.2 to 9.5 VDC (depending on loop output frequency)
16	low current ground		0 VDC
17	EXT PNP BASE	to PNP Q604 base	8.9 VDC
18	VCC	from regulator	9.6 VDC
19	RAMP BASE	to PNP Q603 base (ramp generator)	9.1 VDC
20	FILTERED 9.1V	to R624, R625, RT600, C629	9.1 VDC
21	RAMP RES	to R626, PNP Q603 emitter	8.0 to 8.7 VDC 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 1.6 VDC (200 ms, 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 4. Divider (U602) Pin Connections and Voltages

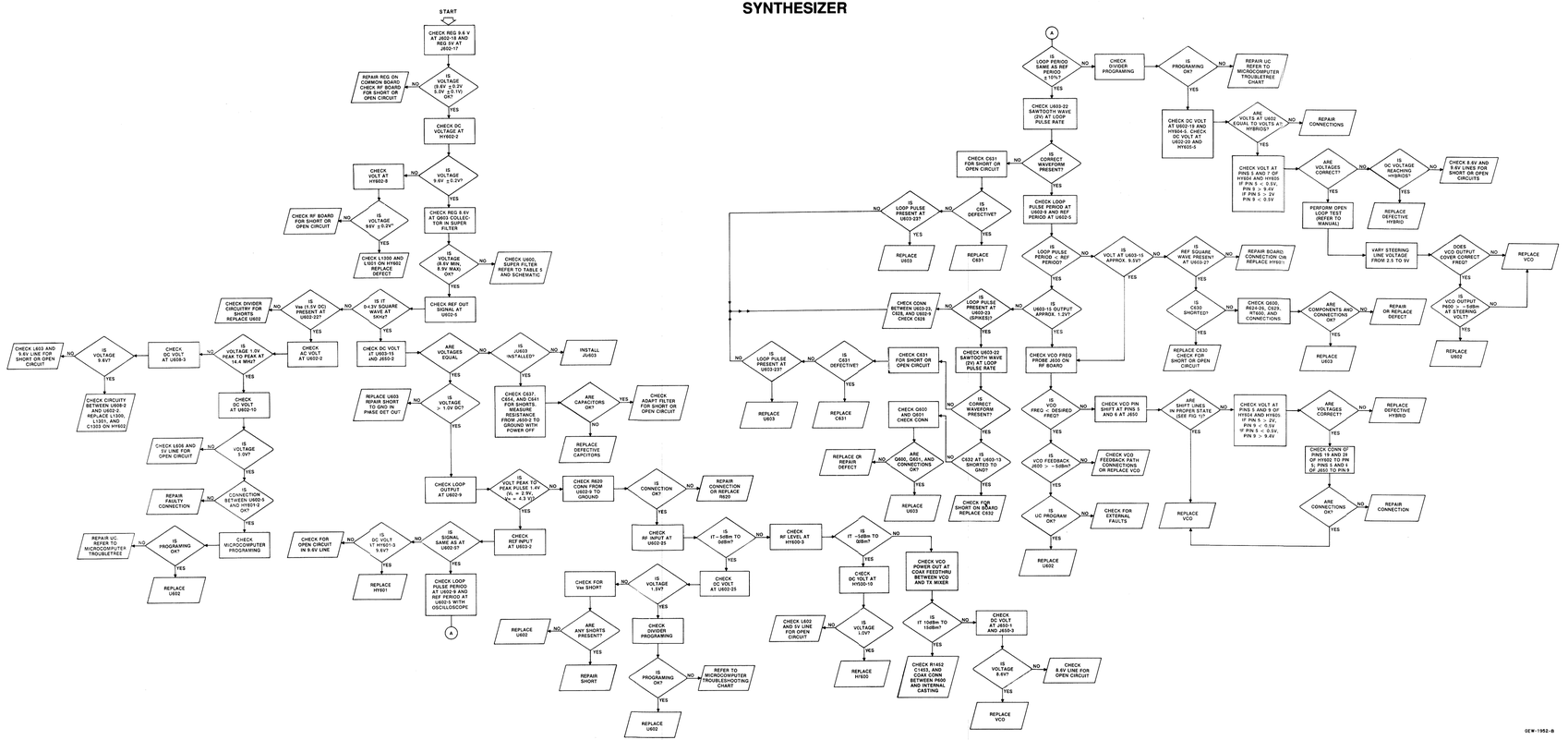
Pin No.	Function	To/From	Nominal Voltages
1*	GND	—	0 VDC
2	REF IN	from U608 (reference oscillator)	1.5 VDC +0.6V pp AC (14.4 MHz)
3	3.6 MHz OUT	NC	—
4	GND	—	0 VDC
5*	REFERENCE OUT	to HY601 (phase modulator)	0 to 4.3V square wave (5.0 or 6.25 kHz)
6	NC	—	—
7	NC	—	—
8	NC	—	—
9*	LOOP OUT	to phase detector	2.9V to 4.3V narrow pulse (1.4V pp) (200 ms nominal period)
10*	VCC	from regulator	5 VDC
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 Q241 (extender)	0 to 5 VDC
16	NC	—	—
17	LOW BANDWIDTH	to phase detector	0 to 5 VDC
18	FREQ CHANGE	to phase detector	0 to 5 VDC
19	VCO1	to HY604–5	0 to 0.7 VDC
20	VCO2	to HY605–5	0 to 0.7 VDC
21	NC	—	—
22	VBB	to divider	1.5 VDC
23	A0	from microcomputer	0 to 5V pulse train
24	A1	from microcomputer	0 to 5V pulse train
25	PRESCALE IN	from HY601–8 via coaxial cable	1.5 VDC +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

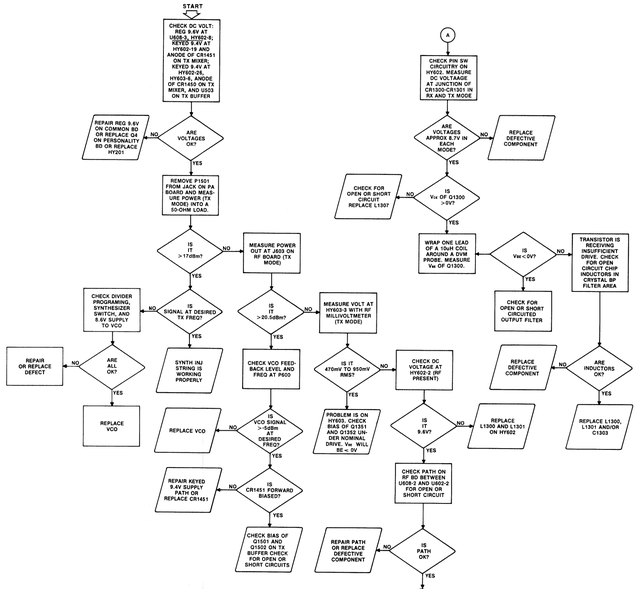
Table 5. Superfilter Pin Connections and Voltages

Pin No.	Function	To/From	Nominal Voltage
1	VCC	from 9.6V regulator	9.6 VDC
2	FILTER CAP	C603	7.1 VDC
3	EXT DRIVER CONTROL	Q601 base	8.9 VDC
4	8.6V OUT	to VCO switching	8.6 VDC
5	Ground (internal NPN emitter)	from regulator	0 VDC
6	no connection	—	—
7	no connection	—	—
8	no connection	—	—

SYNTHESIZER



INJECTION



Troubleshooting Diagrams
for Synthesizer
PW–1949–B
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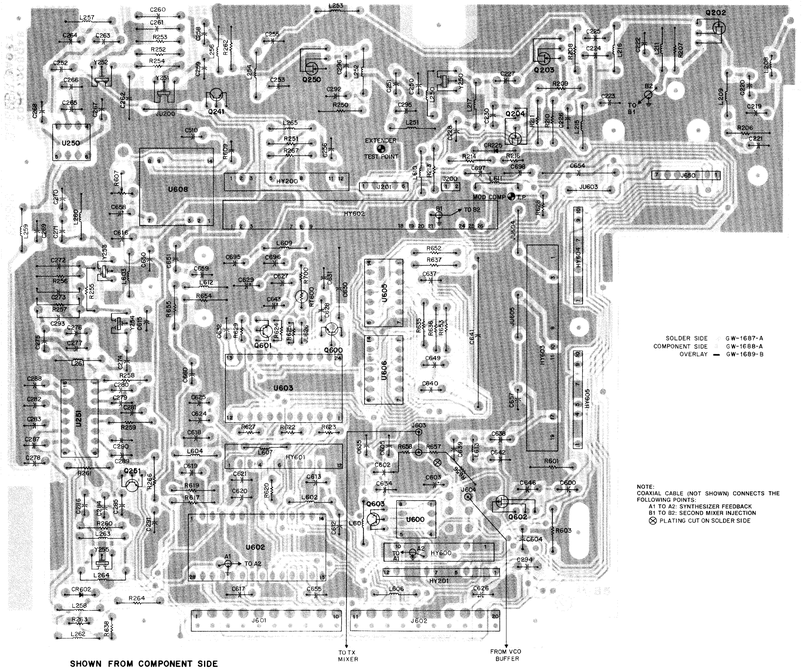
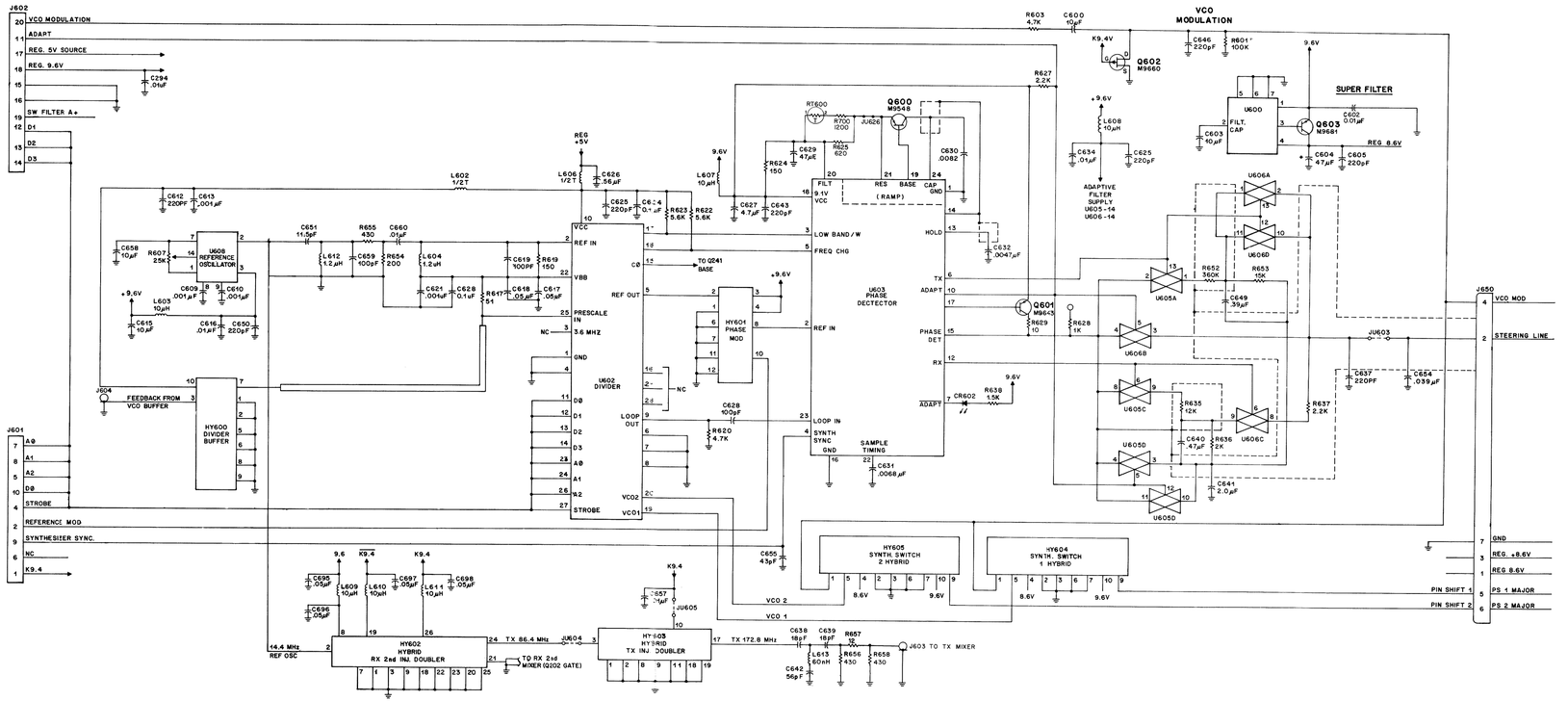
RF BOARD





Schematics, Circuit Board Diagrams, and
Parts Lists for RF Board and Transmitter Mixer
PW–1684–F
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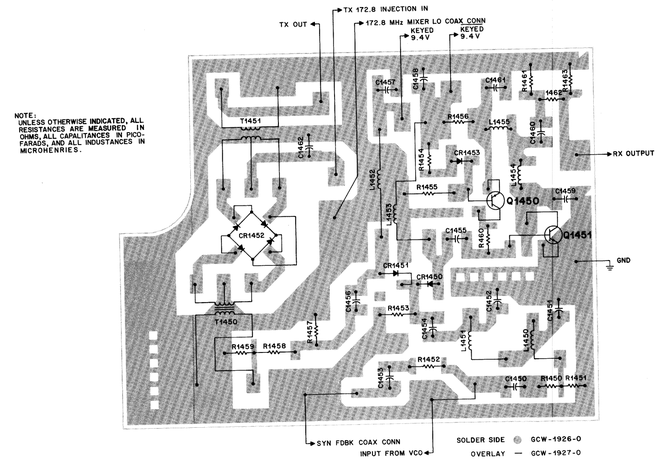
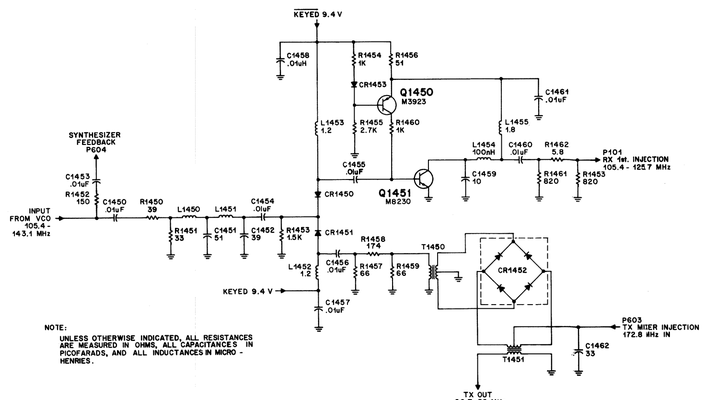
TX MIXER



NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICOFARADS, AND ALL INDUCTANCES IN MICROHENRIES.



NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICOFARADS, AND ALL INDUCTANCES IN MICRO-HENRIES.

parts list

HLB4109A RF Board (Synthesizer section) MXW–5115–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed (unless otherwise stated)		
C600	23–13749D79	10 uF, ±10%, tantalum
C602	08–11051A07	.01 uF, ±5%, 63V
C603	23–13749D79	10 uF, ±10%, tantalum
C604	23–84538G06	47 uF, ±20%, 20V, tantalum
C605	21–11015B05	220 pF, ±10%, 100V
C609,610	08–11051A01	.001 uF, ±5%, 63V
C612	21–11015B05	220 pF, ±10%, 100V
C613	08–11051A01	.001 uF, ±5%, 63V
C615	23–13749D79	10 uF, ±20%, 25V, tantalum
C616	08–11051A07	.01 uF, ±5%, 63V
C617,618	21–82372C10	.05 uF, +80, –20%, 25V
C619	21–11014H49	100 pF, ±5%, 100V
C620	08–11051A13	.1 uF, ±5%, 63V
C621	08–11051A01	.001 uF, ±5%, 63V
C624	08–11051A13	.1 uF, ±5%, 63V
C625	21–11015B05	220 pF, ±10%, 100V
C626	23–13749D39	.56 uF, ±10%, tantalum
C627	23–13749D71	4.7 uF, ±20%, 35V, tantalum
C628	21–11015B01	100 pF, ±10%, 100V
C629	23–84538G06	47 uF, ±20%, 20V, tantalum
C630	08–80027B03	.0082 uF, ±5%, 100V
C631	08–11051A06	.0068 uF, ±5%, 63V
C632	08–11051A05	.0047 uF, ±5%, 63V
C634	08–11051A07	.01 uF, ±5%, 63V
C635	21–11015B05	220 pF, ±10%, 100V
C637	21–11015B05	220 pF, ±10%, 100V
C638,639	21–11014H31	18 pF, ±5%, 100V
C640	08–11051A17	.47 uF, ±5%, 63V
C641	08–80206H01	2 uF, ±20%, 100V
C642	21–11014H43	56 pF, ±5%, 100V
C643	21–11015B05	220 pF, ±10%, 100V
C646	21–11015B05	220 pF, ±10%, 100V
C649	23–13749D31	.39 uF, ±10%, 50V, tantalum
C650	21–11015B05	220 pF, ±10%, 100V
C651	21–80067A30	11.5 pF, ±.25 pF, 500V
C654	08–80027B04	.039 uF, ±5%, 100V
C657	08–11051A07	.01 uF, ±5%, 63V
C658	23–13749D79	10 uF, ±10%, tantalum
C659	21–11014H49	100 pF, ±5%, 100V
C660	08–11051A07	.01 uF, ±5%, 63V
C680–682	21–84547A01	.001 uF, ±20%, 50V
C691	21–13740A55	100 pF, ±5%, 50V
C692	23–84677D13	10 uF, ±10%, 35V, tantalum
C693	21–13740B76	.0015 uF, ±5%, 50V
C694	23–84677D14	22 uF, ±10%, 20V, tantalum
C695–698	21–82372C10	.05 uF, +80, –20%, 25V
C1300	21–13741M45	.01 uF, ±10%, 50V
C1301	21–11032B13	1 uF, +80, –20%, 50V
C1302	21–13740A71	470 pF, ±5%, 50V
C1303	21–13740A49	56 pF, ±5%, 50V
C1304	21–13740B26	11 pF, ±5%, 50V
C1305	21–11078A09	1.8 pF, ±.25 100V
C1306	21–13740B17	4.7 pF, ±5%, 50V
C1307	21–13740B13	3.3 pF, ±5%, 50V
C1308	21–13740B37	33 pF, ±5%, 50V
C1309	21–13740B39	39 pF, ±5%, 50V
C1312	21–13740A60	160 pF, ±5%, 50V
C1313	21–05157A87	47 pF, ±2%, 50V
C1314	21–13740B13	3.3 pF, ±5%, 50V
C1315	21–13740A39	27 pF, ±5%, 50V
C1316	21–13740B11	2.7 pF, ±5%, 50V
C1317	21–13740A40	30 pF, ±5%, 50V
C1318	21–13741M45	.01 uF, ±10%, 50V
C1319	21–13740A27	8.2 pF, ±5%, 50V
C1320–1322	21–13741M45	.01 uF, ±10%, 50V
C1351	21–13740A41	33 pF, ±5%, 50V
C1352	21–05157A83	22 pF, ±2%, 50V
C1353	21–05157A71	6 pF, ±.25 pF, 25V
C1354	21–84873H75	7 pF, ±.25 50V
C1355	21–05157A86	43 pF, ±2%, 50V
C1356	21–82450B47	1, ±5%, 500V
C1357	21–13740B26	11 pF, ±5%, 50V
C1358	21–05157A87	47 pF, ±2%, 50V
C1359	21–13740B26	11 pF, ±5%, 50V
C1360,1361	21–13740A71	470 pF, ±5%, 50V
C1362	21–13740A31	12 pF, ±5%, 50V
C1363	21–13740A40	30 pF, ±5%, 50V
C1364	21–13740A36	20 pF, ±5%, 50V
C1365	21–13741M45	.01 uF, ±10%, 50V
C1368	21–13740A71	470 pF, ±5%, 50V
C1369	21–13741M45	.01 uF, ±10%, 50V
C1370	21–13741C17	.001 uF, ±10%, 50V
C1371	21–84547A13	.1 uF, ±10%, 50V
diode (see note)		
CR602	48–84404E01	LED
CR1300	48–80010E02	pin
CR1301	48–80010E02	pin
hybrid (see note)		
HY600	01–80739T79	buffer/divider assembly
HY601	01–80736T10	phase modulator assembly
HY603	01–80736T08	TX injection doubler assembly
HY604	01–80737T91	synthesizer switch 1 assembly
HY605	01–80737T92	synthesizer switch 2 assembly
connector receptacle		
J601,602	09–83445L09	10 contact
J603,604	09–80001P01	phono jack
J610–618	29–10134A70	lug connector
J650	09–83730M01	7 contact

MXW–5115–B (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
jumper		
JU603–605	06–11009B23	0 ohm
JU626	06–11009F23	0 ohm
coil, RF		
L602	24–80293D02	ferrite
L603	24–80138G05	10 uH
L604	24–83397L12	1.2 uH, white
L606	24–80293D02	ferrite
L607–611	24–80138G05	10 uH
L612	24–83397L12	1.2 uH, white
L613	24–11030D05	blue
L1300	24–80140E13	820 nH inductor
L1301	24–80140E01	1.2 uH inductor
L1302	24–80140E08	1.5 uH inductor
L1303	24–80140E01	1.2 uH inductor
L1304	24–80140E15	275 nH inductor
L1305	24–80091G36	airwound
L1307	24–82723H27	1.2 uH, green
L1308–1310	24–80091G36	airwound
L1311,1312	24–80140E16	10 uH inductor
L1351	24–80140E11	360 nH inductor
L1352	24–80140E06	130 nH inductor
L1353	24–80140E01	1.2 uH inductor
L1354,1355	24–80091G07	airwound
L1356	24–80140E15	275 nH inductor
L1357	24–80091G36	airwound
L1358	24–80091G21	airwound
L1359,1360	24–80091G07	airwound
L1361	24–80140E01	1.2 uH inductor
connector plug		
P1300	29–80215H01	terminal
P1701	29–80215H01	terminal
transistor (see note)		
Q600	48–11043C28	PNP
Q601	48–00869643	PNP
Q602	48–00869660	JFET
Q603	48–00869681	PNP
Q660	48–84939C24	NPN
Q661,662	48–84939C25	NPN
Q670	48–84939C24	NPN
Q671,672	48–84939C25	NPN
Q680	48–84939C25	NPN
Q691,692	48–84939C24	NPN
Q693,694	48–84939C26	PNP
Q1300	48–84939C31	NPN
Q1351	48–84939C31	NPN
Q1352	48–80182D30	NPN
Q1353,1354	48–84939C26	PNP
thermistor		
RT600	06–80275N01	rod type
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R601	06–11009A97	100k
R603	06–11009A65	4.7k
R607	18–80087E01	25k, potentiometer
R617	06–11009A18	51
R619	06–11009A29	150
R620	06–11009E65	4.7k
R622,623	06–11009E67	5.6k
R624	06–11009E29	150
R625	06–11009E44	620
R627	06–11009E57	2.2k
R628	06–11009E49	1k
R629	06–11009E01	10
R635	06–11009A75	12k
R636	06–11009A56	2k
R637	06–11009A57	2.2k
R638	06–11009E53	1.5k
R652	06–11009B11	360k
R653	06–11009A77	15k
R654	06–11009A32	200
R655,656	06–11009A40	430
R657	06–11009E03	12
R658	06–11009E40	430
R660	06–11077B15	47k, 1/8W
R670	06–11077B19	68k, 1/8W
R700	06–11009C51	1.2k
R1301	06–11077B05	18k, 1/8W
R1351	06–11009C34	240
R1352	06–11077B09	27k, 1/8W
integrated circuit (see note)		
U600	51–84768F65	lowpass filter
U602	51–84768F63	synthesizer
U603	51–83977M36	phase detector
U605	51–80073C02	quad switch
U606	51–80073C03	quad switch
U608	51–80291B05	reference oscillator
crystal (see note)		
Y1300	91–80160J01	filter crystal

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

HLB4084A Transmit Mixer MXW–1954–C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C1450	21–13741M45	.01 uF, ±10%
C1451	21–13740A48	51
C1452	21–13740A43	39
C1453–1458	21–13741M45	.01 uF, ±10%
C1459	21–13740A29	10
C1460,1461	21–13741M45	.01 uF, ±10%
C1462	21–13740A41	33
diode (see note)		
CR1450,1451	48–84622E02	silicon
CR1452	48–80236E09	silicon, quad (early version)
CR1452	48–80236E17	silicon, quad (later version)
CR1453	48–05129M17	silicon rectifier
coil, RF		
L1450	24–80091G23	airwound
L1451	24–80091G32	airwound
L1452,1453	24–82723H27	1.2 uH, green
L1454	24–80140E10	100 nH
L1455	24–80140E02	1.8 uH
connector plug		
P101	28–84227B04	power connector
transistor (see note)		
Q1450	48–84939C23	PNP
Q1451	48–80182D30	NPN
transformer		
T1450,1451	25–80125J01	toroid
mechanical parts		
	29–84407M01	connector lug
	64–80190H01	carrier

9/29/89

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

HLN4909B Transmit Mixer Coax Cables MXW–1957–A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
connector plug		
PJ3	28–82365D02	coax jack
P604	28–82365D02	coax jack
P1500	28–82365D02	coax jack
mechanical parts		
	01–80750T27	coax cable assembly
	01–80750T28	coax cable assembly
	01–80750T29	coax cable assembly
	37–00134165	3/8" heatshrink
	37–00135566	1/4" heatshrink tubing
	76–83466K01	ferrite

12/15/88

Schematics, Circuit Board Diagrams, and Parts Lists for RF Board and Transmitter Mixer

PW–1684–F

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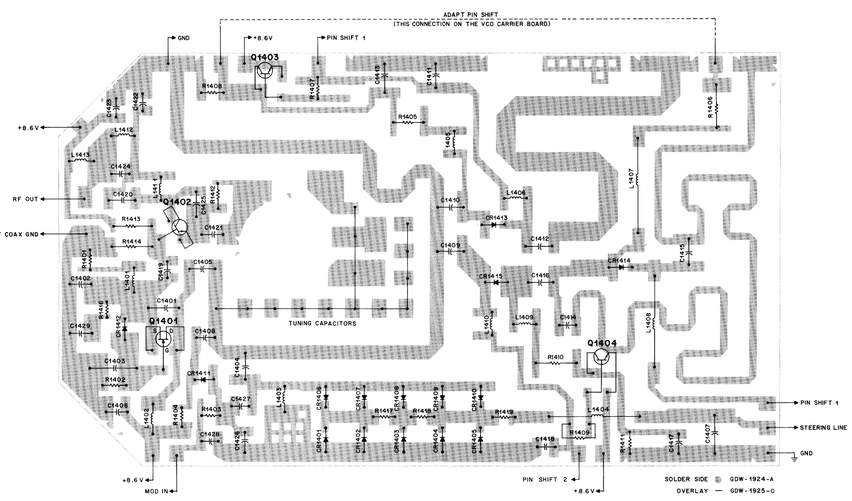
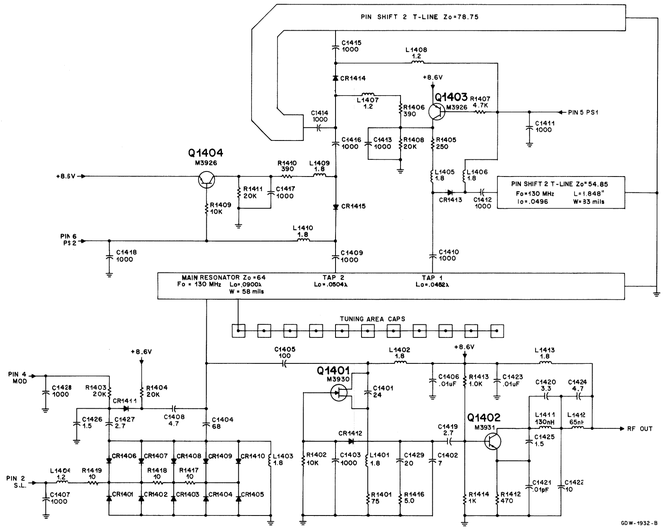
VCO

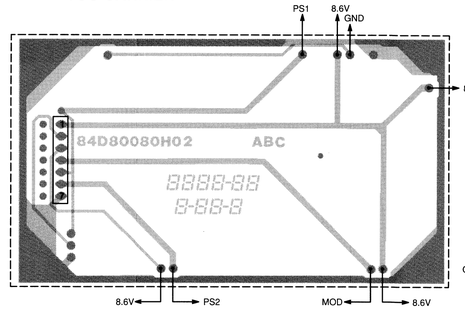




NOTES:

1. UNLESS OTHERWISE NOTED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICO FARADS, AND ALL INDUCTANCES IN MICRONENRIES.
2. ALL RESISTORS ARE SCREENED DIRECTLY UPON THE SUBSTRATE.

VCO CARRIER



SOLDER SIDE VIEW

SOLDER SIDE — GPW–6278–O
COMPONENT SIDE — GPW–6279–O
OVERLAY — GPW–6280–O

parts list

HLB4086A VCO — MXW–1690–C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C1401	21–11078B23	24
C1402	21–84673H75	7, ±.25 pF, 50V
C1403	21–84673H13	.001 uF
C1404	21–11078B38	68
C1405	21–11078B42	100
C1406	21–13741M45	.01 uF, ±10%, 50V
C1407	21–84673H13	.001 uF
C1408	21–11078A21	4.7, ±.25 pF
C1409–1413	21–84547A01	.001 uF, ±20%, 50V
C1415,1416	21–84547A01	.001 uF, ±20%, 50V
C1419	21–13740A13	2.7, 50V
C1420	21–13740B13	3.3, 50V
C1421	21–13741M45	.01 uF, ±10%, 50V
C1422	21–13740A29	12, 50V
C1423	21–13741M45	.01 uF, ±10%, 50V
C1424	21–11078A21	4.7, ±.25 pF
C1425	21–11078A06	1.5, ±.25 pF
C1426	21–11078A06	1.5, ±.25 pF
C1427	21–11078A15	2.7, ±.25 pF
C1428	21–13741M21	.001 uF, ±10%, 50V
C1429	21–13740A36	20, 50V
diode (see note)		
CR1401–1411	48–80006E10	varactor
CR1412	48–80236E05	hot carrier
CR1413	48–84622E03	silicon
CR1414,1415	48–84622E02	silicon
connector receptacle		
J1400	09–83729M01	7 contact
coil, RF		
L1401–1403	24–80140E02	1.8 uH
L1404	24–82723H27	1.2 uH, green
L1405,1406	24–80140E02	1.8 uH
L1407,1408	24–82723H27	1.2 uH, green
L1409,1410	24–80140E02	1.8 uH
L1411	24–80140E06	130 nH
L1412	24–80140E04	65 nH
L1413	24–80140E02	1.8 uH
connector plug		
P1400	07–80162D01	formed lead
transistor (see note)		
Q1401	48–84939C30	FET, N–channel
Q1402	48–84939C31	NPN
Q1403,1404	48–84939C26	PNP

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

HLN4813A Internal Casting Hardware — MXW–1697–C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, +20%, 250V (unless otherwise stated)		
C1403	23–13740D79	10 uF, 35V, ±10%, tantalum
C1900	21–84874K01	470, feedthru
C1902	21–84874K01	470, feedthru
C1903–1905	21–82812H04	.001 uF, +100, –0%, feedthru
C1906	21–84874K01	470, feedthru
coil, RF		
L200,201	76–83960B01	ferrite core
L1400,1401	76–83960B01	ferrite core
connector plug		
P204–208	39–82717M01	receptacle contact
P320	15–84301K16	3 contact housing
P1900,1901	09–84135B02	connector
mechanical parts		
	03–10943M15	tapping screw (3.5 x 0.6 x 8)
	03–10943M16	tapping screw (3.5 x 0.6 x 10), 2 used
	03–10943M17	tapping screw (3.5 x 0.6 x 13), 2 used
	03–10943M13	tapping screw (3 x 0.5 x 8)
	03–10943M14	tapping screw (3.5 x 0.6 x 6), 18 used
	03–80132J02	pan head screw, 6 used
	04–83755H01	shoulder washer
	14–80175M02	insulator shield
	14–80191C01	preamp feedthru plate
	15–84301K03	5 contact connector housing
	15–80203H01	injection filter cover
	15–80204H01	EXTENDER cover
	15–83214M01	plug cover
	15–84778M11	plated internal casting
	15–84817M01	VCO cover
	15–84851M01	buffer cover
	15–80126K01	mixer cover
	15–84853M01	preamp cover
	15–80125K01	high–IF cover
	29–00005227	lug
	32–80131K01	high–IF gasket
	32–80132K01	mixer cover gasket
	32–82796H01	gasket
	32–80207H01	injection filter gasket
	39–82717M01	contact receptacle, 2 used
	43–80294H01	PCB mounting speaker
	43–80294H01	PCB mounting spacer
	32–80007L01	transmit mixer gasket
	32–82796H01	gasket
	37–00132562	1/8" heatshrink tubing
	42–10217A02	nylon tie strap
	42–80184H01	ground clip
	43–80190A04	standoff, 4 used
	54–84697B01	label

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

Schematic, Circuit Board Diagrams, and Parts Lists for the VCO and VCO Carrier
PW–3468–D
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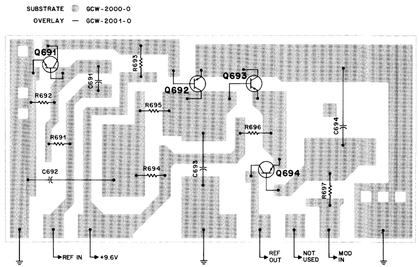
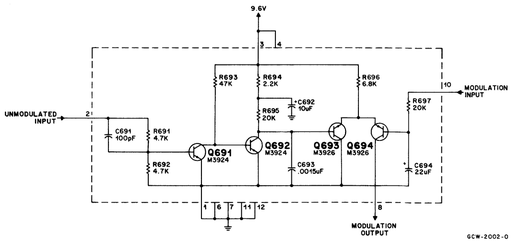
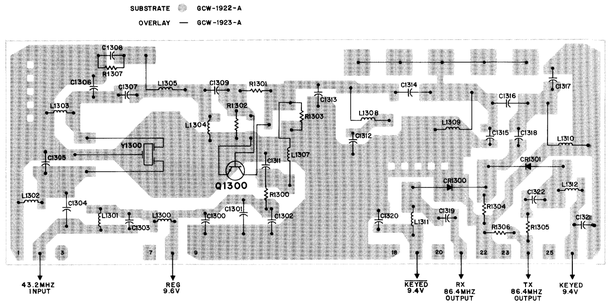
PHASE MODULATOR

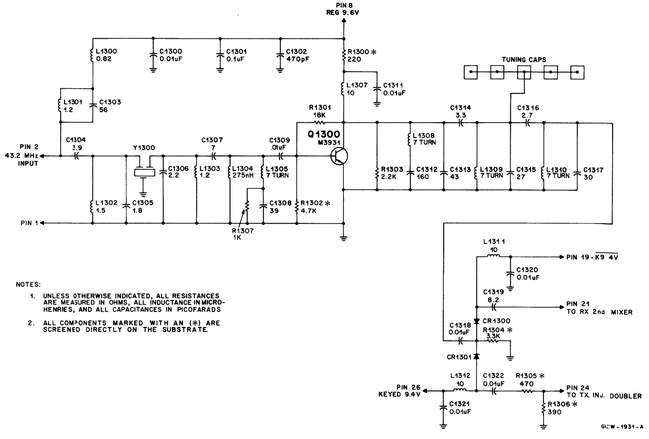




RX INJECTION DOUBLER

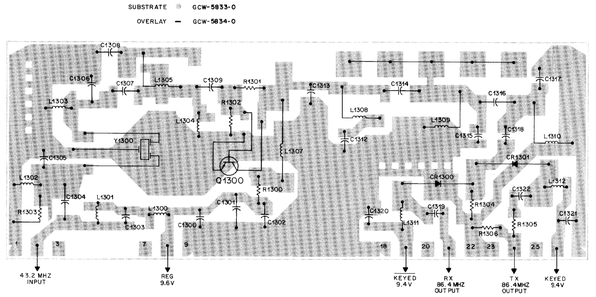
EARLY VERSION

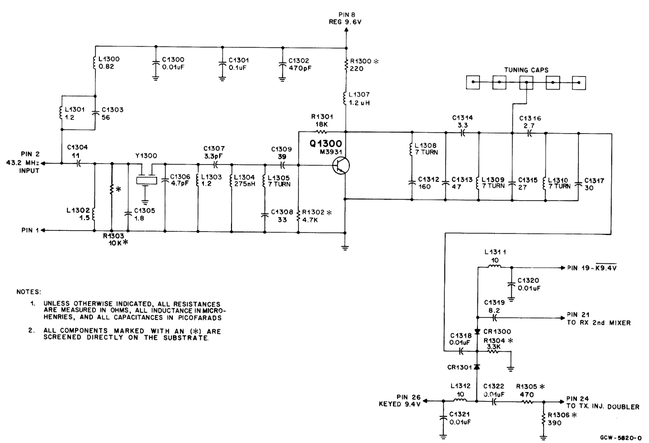




NOTES:
1. UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCE IN MICRO-HENRIES, AND ALL CAPACITANCES IN PICOFARADS
2. ALL COMPONENTS MARKED WITH AN (*) ARE SCREENED DIRECTLY ON THE SUBSTRATE.

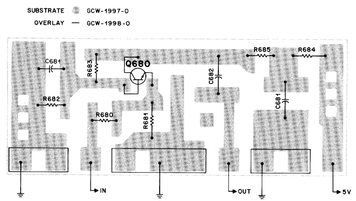
LATER VERSION

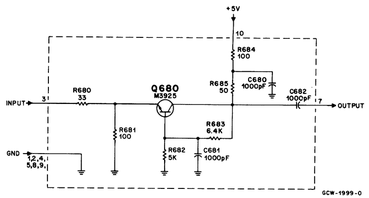




NOTES:
1. UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCE IN MICRO-HENRIES, AND ALL CAPACITANCES IN PICOFARADS
2. ALL COMPONENTS MARKED WITH AN (*) ARE SCREENED DIRECTLY ON THE SUBSTRATE.

DIVIDER/BUFFER





Schematics and Circuit Board Diagrams
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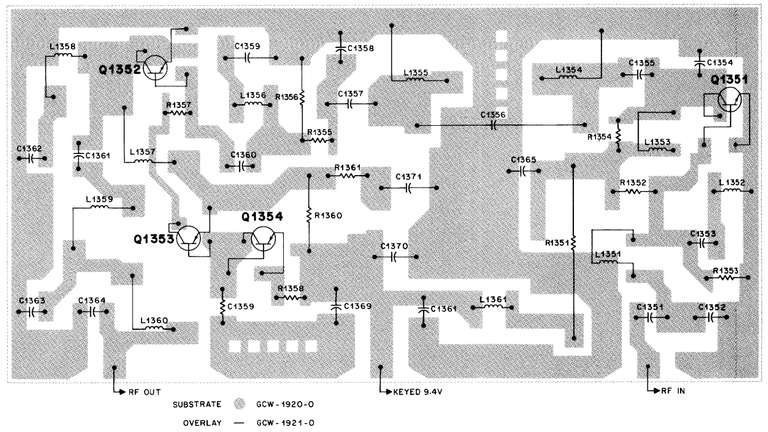
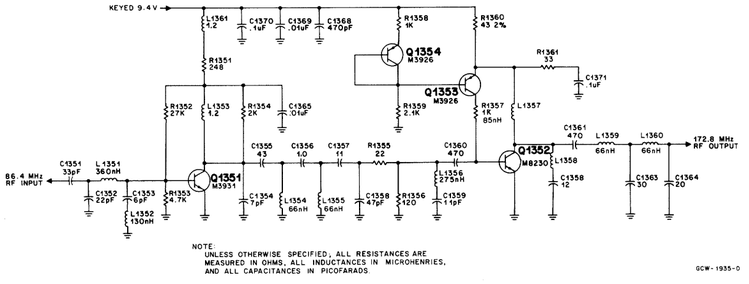
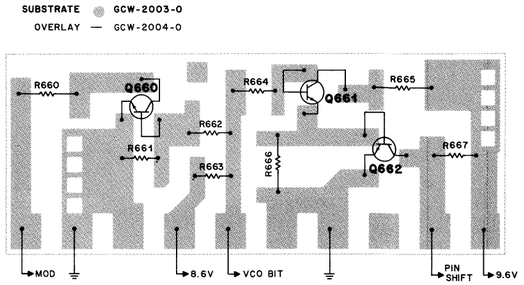
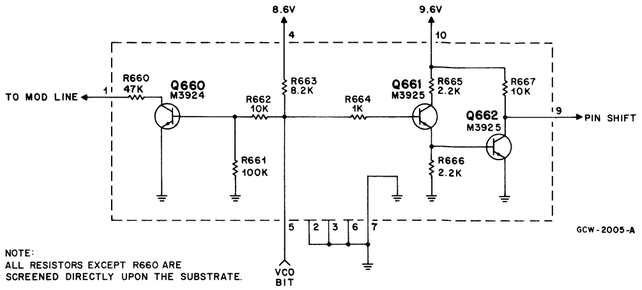
TX INJECTION DOUBLER





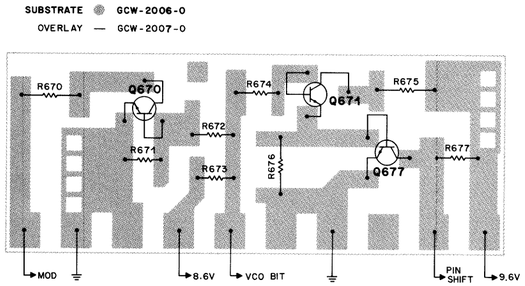
SYNTHESIZER SWITCH ONE

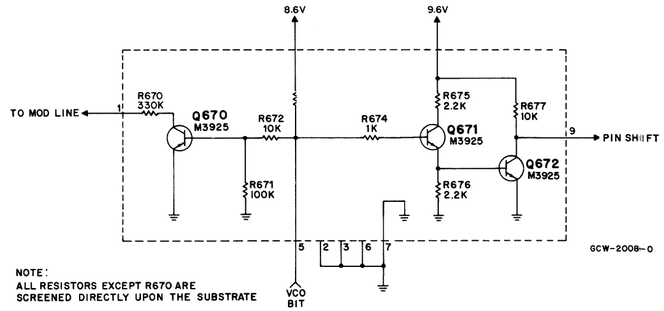




NOTE:
ALL RESISTORS EXCEPT R660 ARE SCREENED DIRECTLY UPON THE SUBSTRATE.

SYNTHESIZER SWITCH TWO





NOTE:
ALL RESISTORS EXCEPT R670 ARE SCREENED DIRECTLY UPON THE SUBSTRATE

Schematics and Circuit Board Diagrams
for Synthesizer Hybrids
PW–3469–C
(Sheet 2 of 2)
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Section Contents

1. Receiver

1.1 DESCRIPTION

The low band *SYNTOR X* radio has a dual conversion receiver with intermediate frequencies of 75.7 MHz and 10.7 MHz. The cascade of PA lowpass harmonic filter, antenna switch, and receive high–pass filter is wide enough to accommodate all frequencies in the receive bandwidth without tuning. However, the high IF board does get three tuning adjustments at the factory. Because proper tuning of these adjustments is critical for *Extender* and IF operation, field tuning of the high IF filter is not recommended. The receiver circuits are in the RF internal casting and on the PA board, the RF board, the Personality board, and the Common Circuits board.

1.2 THEORY OF OPERATION

1.2.1 Front End and High IF

The low band preselector is a cascade of two filters separated by the antenna switch. The receive signal goes first to a lowpass filter with a cutoff frequency of approximately 54 MHz. (This filter also serves as the transmitter harmonic filter.) If the radio is in the receive mode, the antenna switch passes the receive signal and applies it to the high–pass portion of the preselector, a seventh–order elliptical filter with a cutoff frequency of approximately 29 MHz. The signal then goes to a standard NPN BJT preamplifier in a common emitter configuration.

The signal leaving the preamp goes to the *Extender* front–end board, where it divides into two parts. One goes to the *Extender* and the other to the RX first mixer. The synthesizer injection output of 105.4–125.7 MHz also goes to the first mixer via a three–pole injection filter. The first mixer is a double–balanced diode design that uses an up–conversion scheme to generate the 75.7 MHz first IF.

The 75.7 MHz IF signal leaving the first mixer goes to the high IF board, where it goes through the first IF amplifier, an NPN BJT operating in a common–emitter configuration. The amplified output signal goes on to a tunable three–pole bandpass filter with a 4 MHz bandwidth and then to a surface acoustical wave (SAW) filter. The SAW device gives the radio IF selectivity, and also generates a 2.5 microsecond delay that gives the Extender circuitry time to shut off the blanker switches if noise pulses are present.

The 75.7 MHz IF signal leaving the high–IF board and RF internal casting goes to the RF board and the second mixer. The third harmonic of the frequency synthesizer's 14.4 MHz reference oscillator is picked off and applied to the RX doubler hybrid, which generates the injection frequency of 86.4 MHz for the second mixer. The second mixer, a JFET device in a common–gate configuration, uses these two input signals (86.4 MHz and 75.7 MHz) to produce the second intermediate frequency, 10.7 MHz.

1.2.2 Second IF

The second IF circuitry uses several stages of filtering and amplification, performing selective IF filtering with dual–resonator, mode–coupled monolithic crystals cut to a fundamental frequency of 10.7 MHz. This circuitry requires no tuning.

The second mixer's output goes to two blanking switches (Q203 and Q204) which, in conjunction with the *Extender* circuitry, shunt ignition noise in the IF to ground. Following the blanking switches are a two–pole crystal filter (Y250) and the first 10.7 MHz IF amplifier (Q250), a FET device used in a common gate configuration. The output of the first 10.7 MHz IF amplifier goes to an additional four poles of crystal filtering (Y251 and Y252). At this point in the IF, the receive signal strength is monitored by the circuitry on the AGC hybrid (HY200) and used to control the *Extender*'s noise blanking circuitry. Also following Y251 and Y252 is the high–gain (approximately 50 dB) second 10.7 MHz IF amplifier (U250), the output of which goes to the final four poles of crystal filtering (Y253 and Y254) and then to the limiter/detector (U251).

1.2.3 DC Supply Hybrids

The receive switch hybrid (HY201) is supplied with switched B+ (13.6V), regulated 9.6V, and keyed 9.4V from the personality board. Using these voltages, the circuitry on the hybrid generates: (1) switched filtered B+ to be used on the front–end bias hybrid, the first 10.7 MHz IF amplifier,

and the second mixer; and (2) not keyed 9.4V (RX 9.4) to be used on the *Extender* back end and *Extender* front end, and on the TX mixer. The front–end bias hybrid (HY160), which receives switched filtered B+ from the RX switch hybrid, serves as a current source for the 75.7 MHz IF amplifier and the preamplifier.

1.2.4 Limiter/Detector

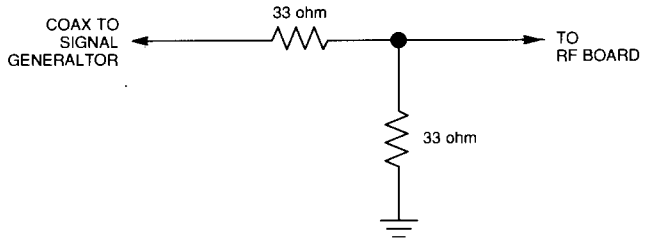
The limiter/detector (U251) generates a limiting function. It also has a quadrature detector which, with an external two–pole dual–resonator crystal, recovers the audio from the second IF signal. The recovered audio then passes through an emitter–follower buffer (Q250) and goes to the audio stages on the personality board (via the personality board and the control head). The detector buffer supplies approximately 650 millivolts RMS to the control head. No tuning is required in the detector circuitry.

1.3 RECEIVER TROUBLESHOOTING

If the receiver does not receive any signal, check power supplies 9.6V, 5.0V, A+, RX 9.4, and switched filtered A+. Check the audio power out (15 watts with no input signal), and check for proper injection frequencies at the first and second mixers. Also, determine the injection level at the first mixer by measuring the resistance across R153. Use an ohmmeter probe with a 10–uH choke in series with the + lead. A resistance of less than 10 ohms (in the receive mode) indicates adequate injection power. Determine the injection level in the second mixer by measuring the DC voltage at the source of Q202. A voltage reading of 3.5–4.0V indicates a proper injection level. A reading of approximately 2.5V indicates no injection signal is present. The receiver sensitivity (12 dB SINAD) can be measured at several points to help isolate a receiver malfunction.

If the sensitivity has degraded by 20 to 40 dB, one of the first RF stages is probably defective. Check the bias to the preamp by unplugging P300 and measuring the current from J300 center conductor to ground. It should be 30 to 38 mA. This indicates that the biasing circuitry is working correctly. If the DC voltages do not agree with the schematic, the problem is with the preamp.

Measure the sensitivity at J300 through an attenuator (preferably 10 dB) to insure a DC path from J300 to ground. The sensitivity should be better than –103 dBm (1.5 uV). Measure sensitivity at the high–IF in put by removing the lead from the first mixer, and soldering in a coax at this point. The sensitivity should be better than –119 dBm (.25 uV). To measure sensitivity at the RF board, remove the coax that comes out of the internal casting and goes to the RF board. Insert the resistor network shown below. The sensitivity should be better than –110 dBm (1.2 uVr).



When the problem is isolated to a circuit board, restore the receiver's normal wiring configuration. See the voltages listed on the schematic to find what component is defective. Test the blanker switches by first unplugging J200. The sensitivity should be unchanged. Now, short J200–1 to 9.6V. If the sensitivity degrades by 55 to 60 dB, the blanker switches are operating properly.

2. *Extender*

2.1 DESCRIPTION

The *Extender* receives, detects, and blanks wide band noise pulses from ignition systems and other man–made sources. It can be tuned through the entire receive bandwidth (29.7–50 MHz) in two ranges.

Extender circuits are in the RF internal casting (*Extender* front–end and back–end boards and the SAW filter on the high IF board) and on the RF board (blanking switches Q203 and Q204 and the *Extender* AGC hybrid HY200).

2.2 THEORY OF OPERATION

2.2.1 RF and Detector Circuitry

The *Extender* front–end board splits the receive input signal into two equal signals. One signal goes to the first receive mixer and the other goes to the three–pole bandpass filter on the *Extender* front end. The three–pole filter, which limits the input signal, is tunable (L300, L301, L302) over the entire receive bandwidth in two ranges. (The first range, 29.7 to 40 MHz, requires chip resistors R300, R301, and R302 to be in place. The second range, 39.0 to 50 MHz, requires the same chip resistors to be removed.) The division of the *Extender* into two ranges and the proper selection of tuning coil polarity have made it possible to maintain a constant *Extender* front–end bandwidth of approximately one MHz over the *Extender*'s entire bandwidth.

The signal leaving the bandpass filter goes to the first *Extender* RF amplifier (Q300), an NPN BJT device in a common–base configuration. At this point, the signal leaves the *Extender* front–end board and goes via a small coax to the high–gain (approximately 50 dB) second RF amplifier (U318) on the *Extender* back–end board. The gain of this amplifier is controlled by the *Extender* AGC hybrid (HY200) on the RF board, which greatly reduces this gain when it senses relatively high RF levels in the second IF.

When it leaves the second RF amplifier, the signal goes to a one–pole capacitively–tuned resonant circuit. (To tune the *Extender*, insert the tuning tool through the hole in the

internal casting and the hole in the RF board and adjust C321. These holes are aligned, so that you need not remove the internal casting to make this adjustment.) The output of the resonant circuit goes to a balanced AM detector that detects noise pulses. The output of the detector is monitored via the *Extender* test point (P201–4) that is used in conjunction with L300, L301, L302, and C321 to tune the *Extender* channel. Q330 follows the *Extender* detector and serves as an impedance buffer between the detector and the pulse shaping circuitry.

2.2.2 Pulse–Shaping Circuitry

The pulse–shaping section has circuits that generate, amplify, shape, and filter pulses, and limit the maximum pulse rate. When the detector circuitry detects a pulse greater than approximately 0.65 volt in amplitude and 1.5 microseconds in period, the detector buffer, Q330, applies a pulse to amplifier Q331, an NPN BJT device in a common–emitter configuration. Q331 drives a retriggerable monostable multivibrator. The multivibrator sends a rectangular pulse to transistor Q350, which acts as an integrator to convert it to a triangular pulse with its time constants governed by R350, R351, and C351. This triangular output goes to transistor Q360. Q360 is biased near saturation so that when the output of the preceding integrator circuit begins to go negative, the leading edge of the trapezoidal blanker pulse follows immediately. Q360 (collector) continues to rise until it reaches cutoff, effectively clipping the triangular drive waveform and turning it into a trapezoidal waveform. This waveform goes through a one MHz cutoff lowpass filter (R363 and C361) that removes excessive noise, and then to the blanker switches.

The pulse–shaping circuitry of the *Extender* also includes a Schmitt trigger formed by Q370 and Q371. It senses the duty cycle of the monostable multivibrator, and disables the integrator at pulse rates greater than 110 kHz. The monostable multivibrator continues to run, and when the pulse rate drops to below 110 kHz, the integrator is again enabled.

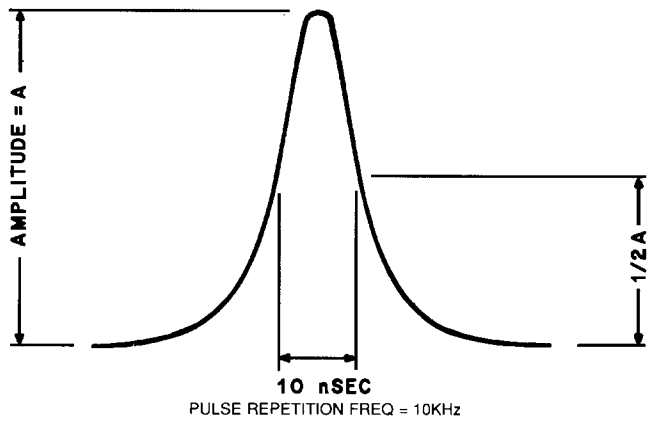
2.2.3 Programming

The low band *SYNTOR X Extender* can be programmed on or off for any mode, because the C0 receive frequency bit in the EEPROM has been defined as the *Extender* ON/OFF bit. (The low band radio does not use a prescaler, and that leaves C0 available for this purpose.) The divider latches "C0" to Q241 (RF board) for *Extender* ON/OFF control, rather than to the prescaler.

2.3 TROUBLESHOOTING

2.3.1 General

If the radio has problems that could originate in the *Extender*, first measure receiver sensitivity and distortion. Correct any receiver problems before troubleshooting the *Extender*. When testing the *Extender* in the shop, add pulses from the Pulse Generator resembling the one shown below, with the selected carrier.



GPW–2184–A

You can switch off the *Extender* (for comparison) (a) from the control head if the EEPROM is so programmed, (b) by forcing the AGC voltage to 9.5V, or (c) by disconnecting J200 from the RF board.

2.3.2 Troubleshooting Diagram

Use the troubleshooting diagram at the end of this section for identifying and correcting faults in the *Extender*.

2.3.3 Troubleshooting the *Extender* AGC

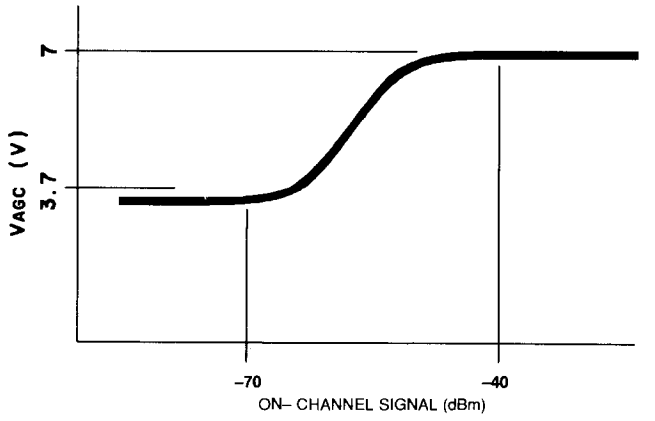
(1) Check receiver performance. Low gain or oscillation affects AGC operation.

(2) Disconnect J201 (5–pin molex connector to internal casting), isolating the AGC circuit on RF board from the *Extender* back–end board.

(3) Measure the AGC voltage at pin 3 (red wire) with:

a. *Extender* "OFF," no on–channel signal; VAGC should be approximately 9V (Vc Q241 ≈ 9V).

b. *Extender* "ON," vary the on–channel signal level and verify performance per the graph below (Vc Q241 ≈ 0.2V).



GPW–2183–A

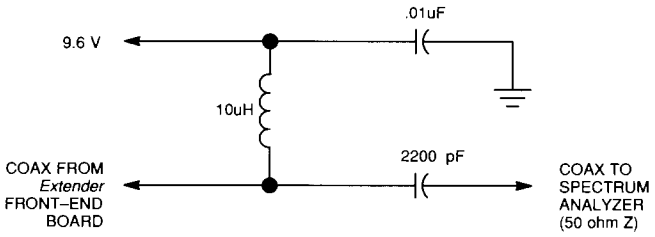
If the above is not the case, check DC inputs to the AGC amplifier hybrid on the RF board (HY200). Troubleshoot or replace the hybrid if the problem still persists.

2.3.4 Troubleshooting the *Extender* RF Circuits

When troubleshooting an *Extender* sensitivity problem (after checking receive performance, AGC voltage, supply voltages, and detector biasing), it may be necessary to RF troubleshoot the *Extender*. The first step is to isolate the problem to the correct board. The impedance at the front–end/back–end interface is approximately 400 ohms. For ease of measurement, use the following procedure, which tests the *Extender* front–end board with a 50–ohm load.

(1) Lift the center conductor of the coax from the back–end board.

(2) Connect the signal generator to the phono connector where the preamp/high–pass–filter board was previously connected.



GPW–2181–A

(3) Set the frequency of the generator to the *Extender* tune–up frequency.

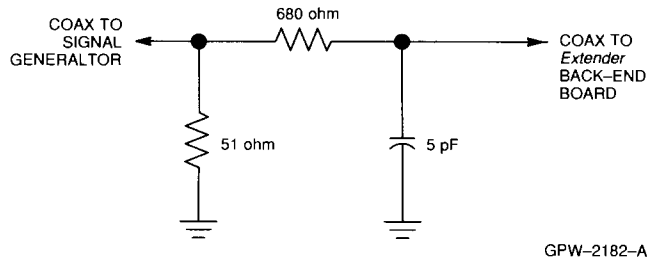
(4) Set the generator level to –30 dBm.

(5) Check that the level is approximately –33 dBm at 30–40 MHz and –35 dBm at 50 MHz.

2.3.5 Checking the *Extender* Front–End Board

To check the *Extender* front–end board separately:

(1) Supply 9.6V to the input, ground the AGC input, and connect the following network to the input of the *Extender* back–end board.



GPW–2182–A

(2) Tune the signal generator to the center frequency of the *Extender*, as determined by peaking the meter–out voltage.

(3) With the signal generator set for –25 dBm, 100% AM, and 1 kHz modulation frequency, check that the *Extender* puts out a pulse that is somewhat longer than shown on the schematic.

When troubleshooting the front–end board, check for tuning slugs out of place, possibly indicating a bad capacitor or shorted coil. Check the R–pad resistors with an ohmmeter. When changing L300, L301, or L302, be sure the coils are properly oriented. (See schematic for details.)

2.3.6 Checking the *Extender* Back–End Board

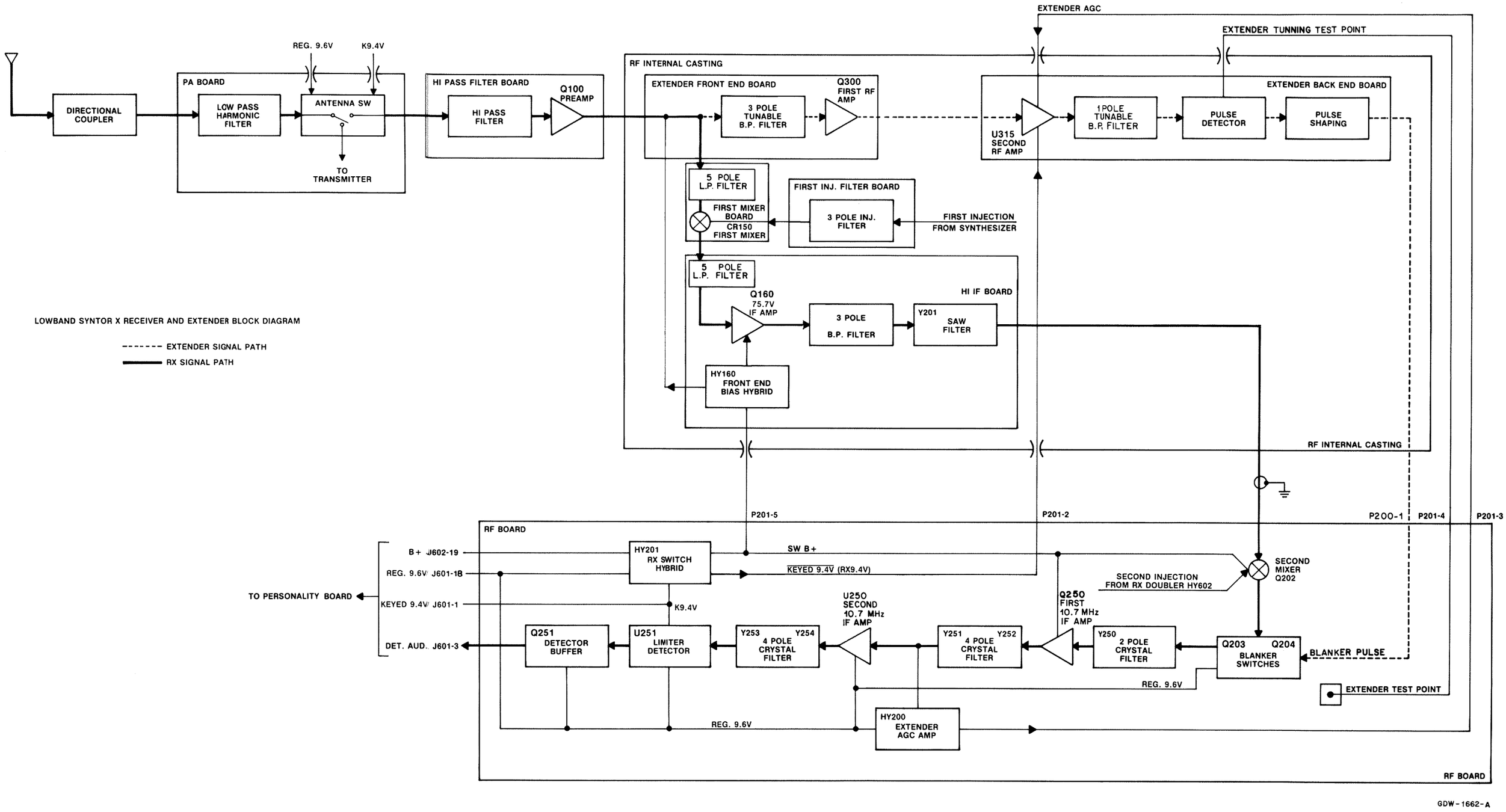
When troubleshooting the back–end board, watch for shorted/open chip inductors. A defective L316 can make front–end board gain appear low. L321 and L322 feed DC to the gain block and partially resonate C321. DC voltage measurements cannot identify a single defective coil. If a high–impedance probe is available, balance can be checked at the junction of L321, L322, and R324. The RF level should be near zero because of symmetry (compared to pins 5 and 6 of U315). Balance can also be degraded by defective U315, C321, or C322, or a defective detector circuit (Q320 and Q321).

2.3.7 Troubleshooting the Rate Shut–Off Circuitry

This circuit consists of a rectifier and integrator that generate a DC level proportional to the pulse repetition frequency (CR370, R370, R371, and C370), a Schmitt trigger (Q370 and Q371), and a buffer amplifier (Q372).

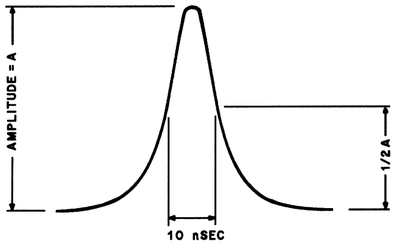
Rate shut–off can be measured with a pulse of any amplitude that triggers the *Extender*. When the repetition frequency approaches 120 kHz, Q370 should snap "ON" and Q371 should snap "OFF," switching Q372 "ON." Note that a shorted or permanently "ON" Q372 causes all *Extender* operation to cease. An open Q372 causes rate shut–off operation to cease.

Measurement of DC voltages should identify defective components in this circuit. (See schematic.)



Functional Block Diagram
for Extender
PW-1699-A
8/15/86

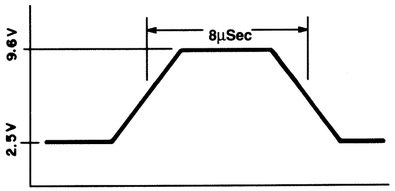
DETAIL 1



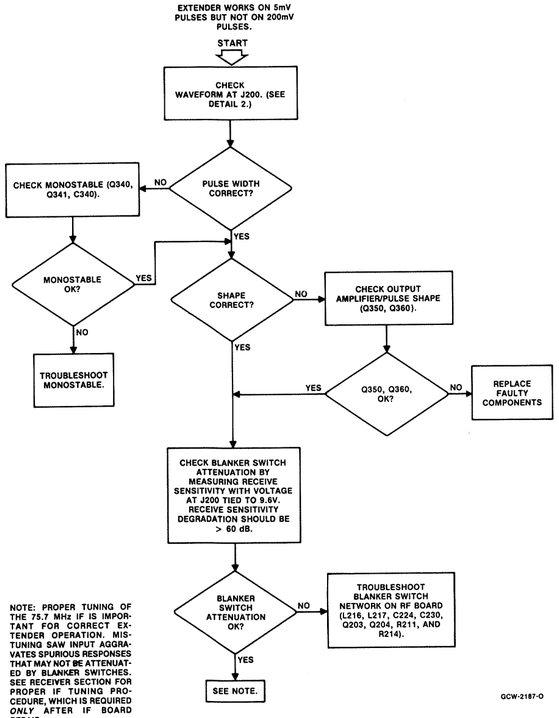
PULSE REPETITION FREQ = 10KHz

GPW–2184–A

DETAIL 2

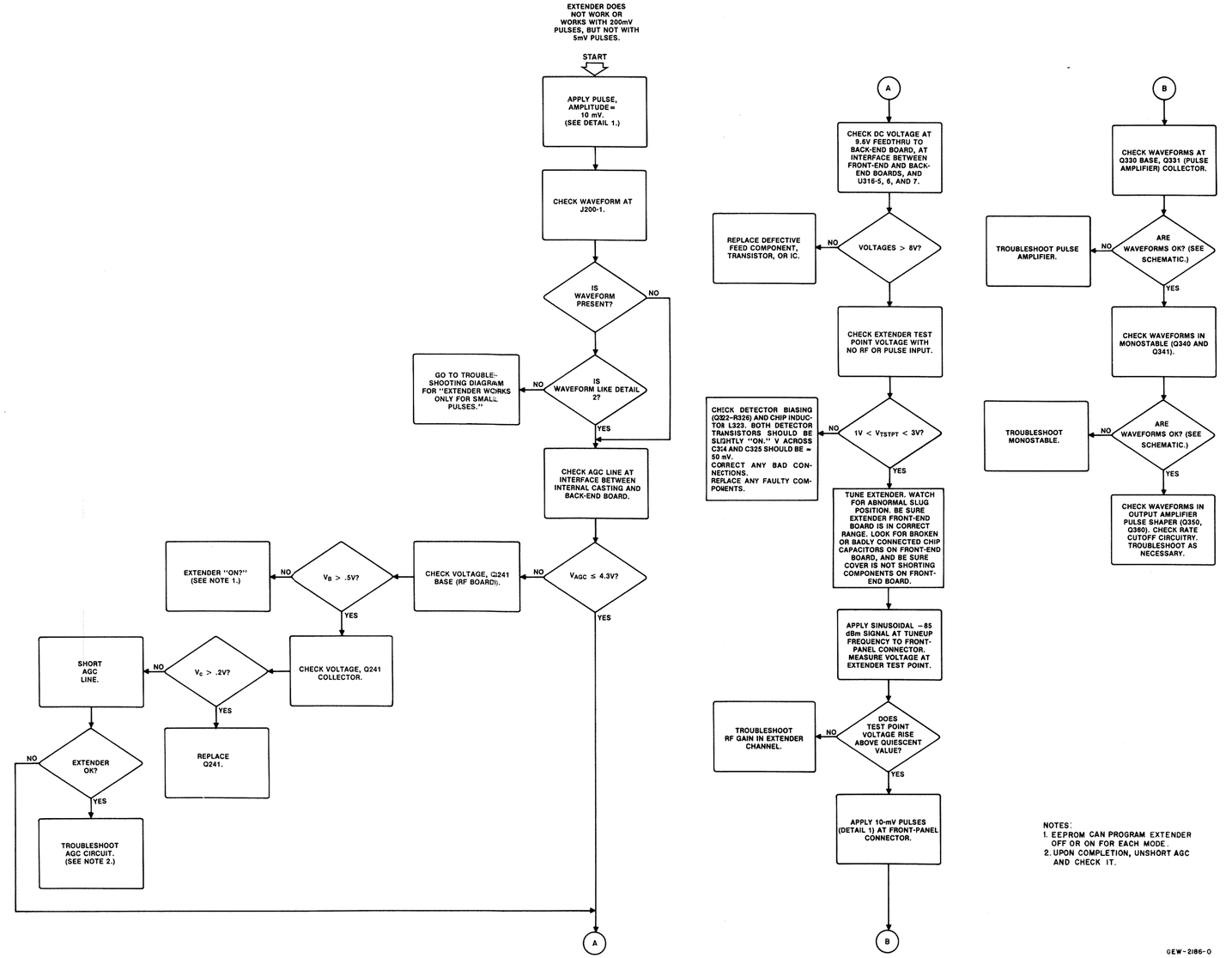


GPW–2188–B



NOTE: PROPER TUNING OF THE 75.7 MHz IF IS IMPORTANT FOR CORRECT EXTENDER OPERATION. MISTUNING SAW INPUT AGGRAVATES SPURIOUS RESPONSES THAT MAY NOT BE ATTENUATED BY BLANKER SWITCHES. SEE RECEIVER SECTION FOR PROPER IF TUNING PROCEDURE, WHICH IS REQUIRED *ONLY* AFTER IF BOARD REPAIR.

GCW-2187-O

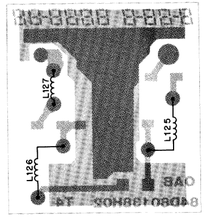


NOTES:
1. EEPROM CAN PROGRAM EXTENDER OFF OR ON FOR EACH MODE.
2. UPON COMPLETION, UNSHORT AGC AND CHECK IT.

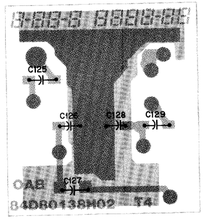
GEW-2186-O

RX INJECTION FILTER

SOLDER SIDE — GBW-1904-O
COMPONENT SIDE — GBW-1905-O
OVERLAY — GBW-1907-O

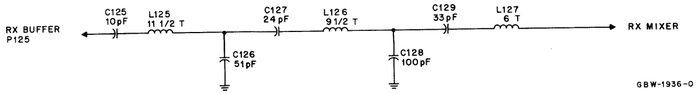


COMPONENT SIDE VIEW



SOLDER SIDE VIEW

SOLDER SIDE — GBW-1904-O
COMPONENT SIDE — GBW-1905-O
OVERLAY — GBW-1906-O



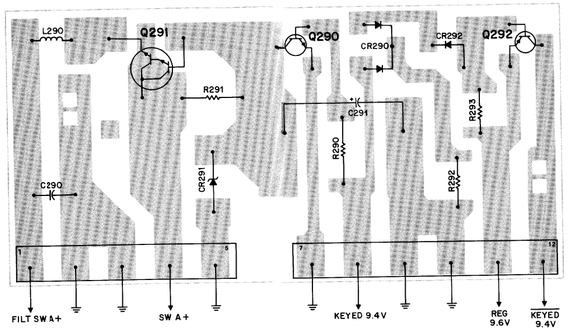
parts list

HFB4001A Receive Injection Filter — MXW-1958-A

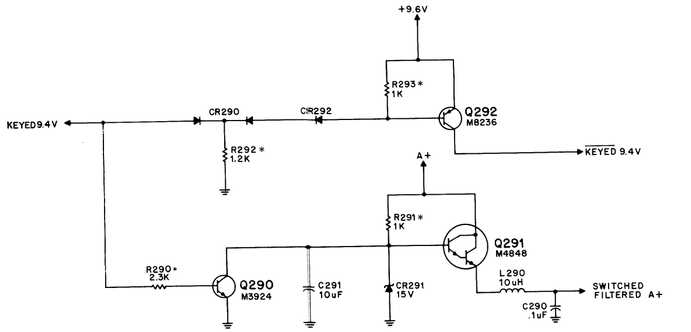
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C125	21-13740B25	10
C126	21-13740B42	51
C127	21-11078B23	24, 100V
C128	21-13740B49	100
C129	21-13740B37	33
coil, RF		
L125	24-84411B03	airwound, brown
L126	24-83884G05	150.2 uH, white
L127	24-11030D05	65.7 nH, blue

12/30/88

RX SWITCH HYBRID



SUBSTRATE — GCW-2015-O
OVERLAY — GCW-2016-A



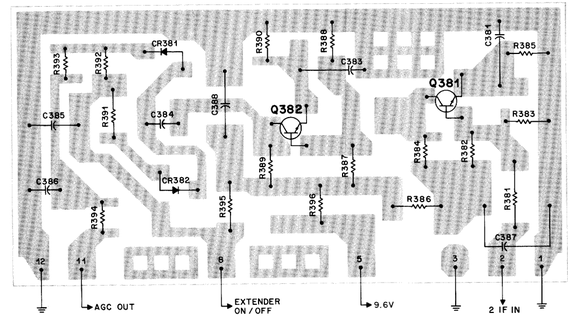
GCW-2017-O

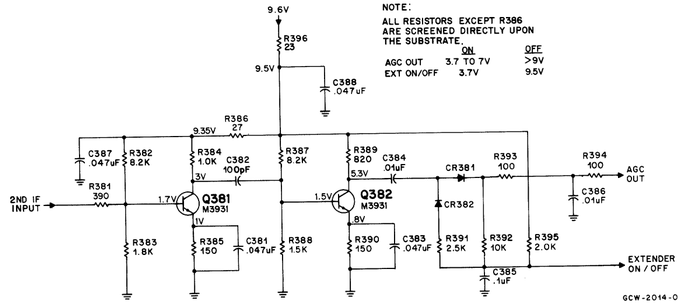
NOTE:
1. COMPONENTS MARKED WITH ASTERISK (*) ARE SCREENED DIRECTLY ON THE SUBSTRATE.

Note:
Component part numbers are identified are in the RF Circuit Board Parts List.

EXTERNAL AGC AMPLIFIER

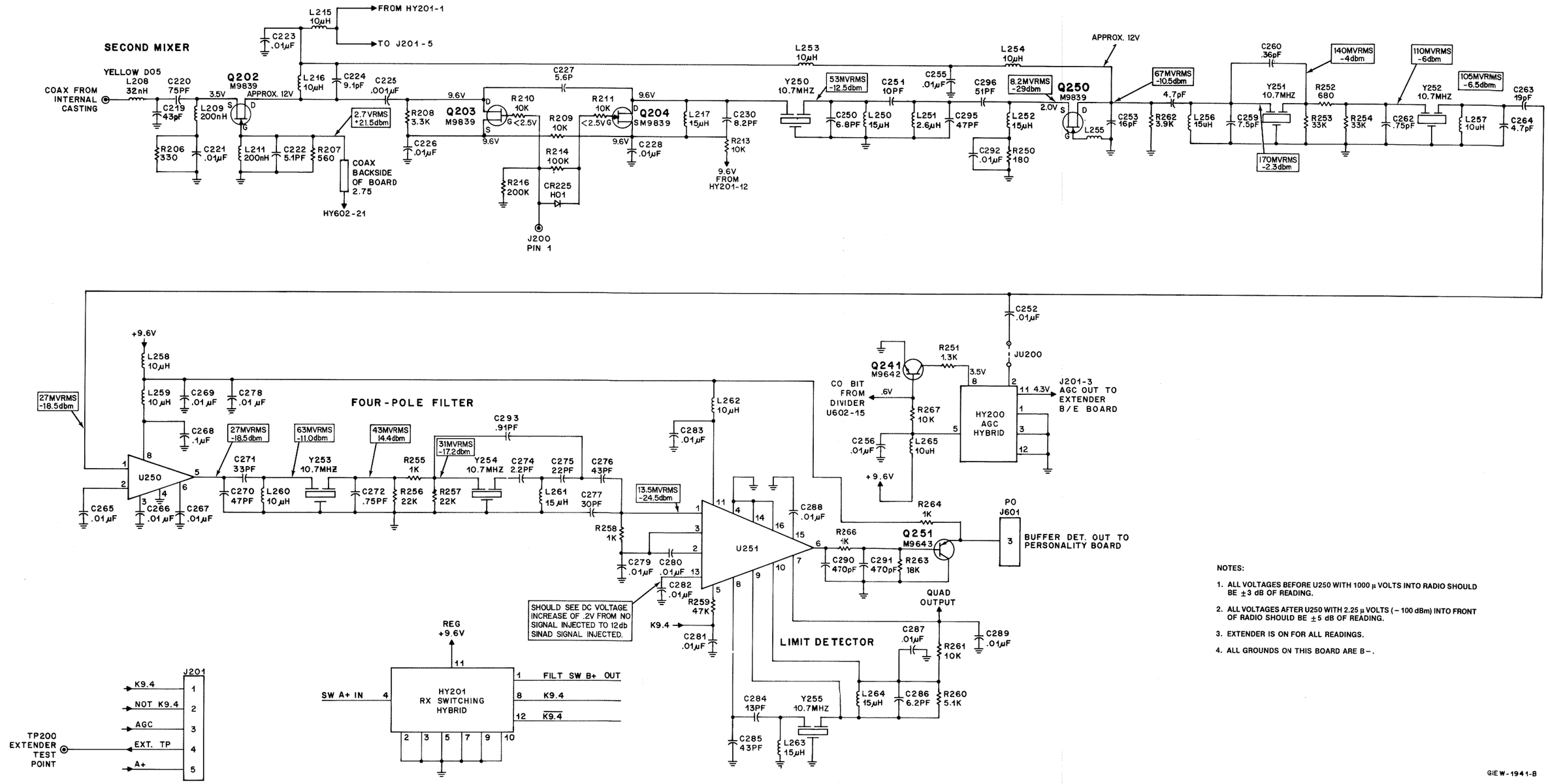
SUBSTRATE — GCW-2012-O
OVERLAY — GCW-2013-O





Note:
Component part numbers are identified are in the RF Circuit Board Parts List.

RF BOARD SCHEMATIC



NOTES:

1. ALL VOLTAGES BEFORE U250 WITH 1000 µ VOLTS INTO RADIO SHOULD BE ±3 dB OF READING.
2. ALL VOLTAGES AFTER U250 WITH 2.25 µ VOLTS (– 100 dBm) INTO FRONT OF RADIO SHOULD BE ±5 dB OF READING.
3. EXTENDER IS ON FOR ALL READINGS.
4. ALL GROUNDS ON THIS BOARD ARE B–.

GIEW-1941-B

Schematic, Circuit Board Diagram, and
Parts List for RF Board
PW–1692–F
(Sheet 1 of 2)
9/29/89

parts list

HLB4109A RF Board (Receiver Section) — MXW–4100–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C219	21–11014H40	43, 100V
C220	21–11014H46	75, 100V
C221	08–11051A07	.01 uF, 63V
C222	21–11014H18	5.1, ±.5 pF, 100V
C223	08–11051A07	.01 uF, 63V
C224	21–83406D94	9, ±.5 pF, 500V
C225	08–11051A01	.001 uF, 63V
C226	08–11051A07	.01 uF, 63V
C227	21–11014H19	5.6, ±.5 pF, 100V
C228	08–11051A07	.01 uF, 63V
C230	21–11014H23	8.2, ±.5 pF, 100V
C250	21–11014H21	6.8, ±.5 pF, 100V
C251	21–11014H25	10, ±.5 pF, 100V
C252	08–11051A07	.01 uF, 63V
C253	21–11014H30	16, 100V
C255,256	08–11051A07	.01 uF, 63V
C258	21–11014H17	4.7, ±.25 pF, 100V
C259	21–11014H22	7.5, ±.5 pF, 100V
C260	21–00842041	.36, 500V
C262	21–82450B48	.75, 500V
C263	21–84493B35	19, 500V
C264	21–11014H17	4.7, ±.25 pF, 100V
C265–267	08–11051A07	.01 uF, 63V
C268	08–11051A13	.1 uF, 63V
C269	08–11051A07	.01 uF, 63V
C270	21–11014H41	47, 100V
C271	21–11014H37	33, 100V
C272	21–82450B48	.75, 500V
C274	21–11014H09	2.2, ±.25 pF, 100V
C275	21–11014H33	22, 100V
C276	21–11014H40	43, 100V
C277	21–11014H36	30, 100V
C278–283	08–11051A07	.01 uF, 63V
C284	21–11014H28	13, 100V
C285	21–11014H40	43, 100V
C286	21–11014H20	6.2, ±.5 pF, 100V
C287–289	08–11051A07	.01 uF, 63V
C290	21–13741C17	.001 uF, ±10%
C290	21–11015B09	470, ±10%, 100V
C291	23–84677D13	10 uF, ±10%, 35V, tantalum
C291	21–11015B09	470, ±10%, 100V
C292	08–11051A07	.01 uF, 63V
C293	21–82450B39	.91, 500V
C294	08–11051A07	.01 uF, 63V
C295	21–11014H41	47, 100V
C296	21–11014H42	51, 100V
C381	21–84547A22	470, ±10%, 25V
C382	21–13740A55	12
C383	21–84547A22	470, ±10%, 25V
C384	21–13741M45	.01 uF, ±10%
C386	21–13741C17	.001 uF, ±10%
C387,388	21–84547A22	470, ±10%, 25V
diode (see note)		
CR225	48–83654H01	silicon
CR290	48–05129M12	silicon rectifier
CR291	48–82958R01	0.5 Watt, 2.4 V
CR292	48–84939C29	selecon rectifier
CR381	48–84939C35	hot carrier
CR382	48–84939C35	hot carrier
hybrid (see note)		
HY200	01–80736T09	*Extender* hybrid
HY201	01–80737T82	RX swtch hybrid
connector receptacle		
J200	28–84324M01	2 contact
J201	28–84324M03	connector
J210–220	29–10134A70	lug connector
jumper		
JU200	06–11009B23	0 ohm
coil, RF		
L208	24–11030D03	yellow
L209	24–82723H11	.2 uH, brown brown
L211	24–82723H11	.2 uH, brown brown
L215	24–80138G05	10 uH ±5%
L216	24–83397L07	10 uH blue blue
L217	24–83397L08	15 uH gray gray
L250	24–83397L08	15 uH gray gray
L251	24–82723H19	2.6 uH, red gold blue
L252	24–83397L08	15 uH gray gray
L253	24–80138G05	10 uH ±5%
L254	01–80725T04	assembly
L255	76–83960B01	ferrite core
L256	24–83397L08	15 uH, gray gray
L257	24–83397L07	10 uH, blue blue
L258,259	24–80138G05	10 uH, ±5%
L260	24–83397L07	10 uH, blue blue
L261	24–83397L08	15 uH, gray gray
L262	01–80746T71	choke & sleeve assembly
L263,264	24–82549D24	15 uH
L265	24–80138G05	10 uH, ±5%
L290	24–80140E16	10.uH
transistor (see note)		
Q202–204	48–00869839	N–channel
Q241	48–00869642	NPN
Q250	48–00869839	FET, N–channel
Q251	48–00869643	PNP
Q290	48–84939C24	NPN

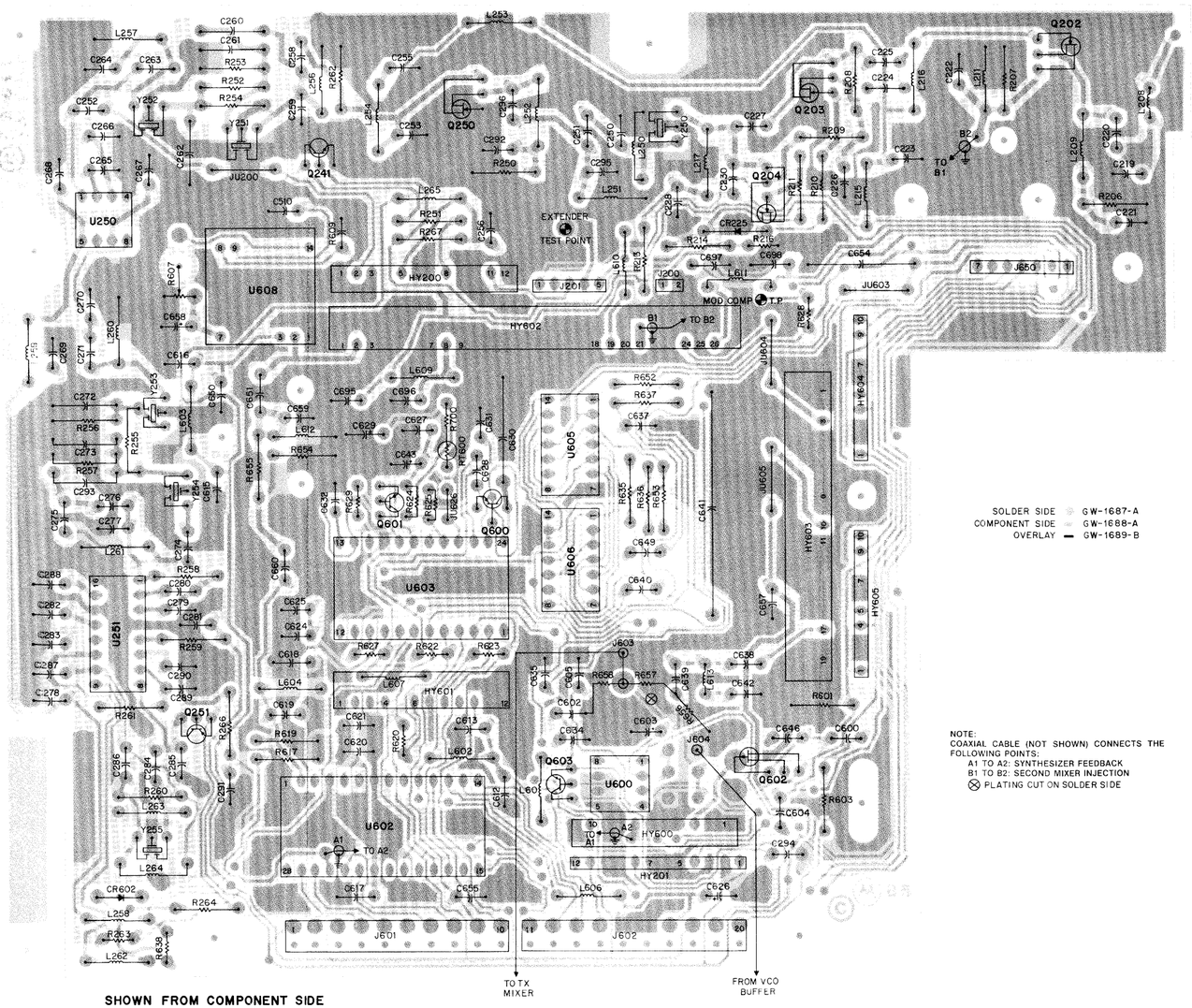
MXW–4100–B (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
Q291	48–05148G48	NPN, Darlington
Q292	48–80182D36	PNP
Q381,382	48–84939C31	NPN
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R206	06–11009A37	330
R207	06–11009A43	560
R208	06–11009A61	3.3k
R209–211	06–11009A73	10k
R213	06–11009A73	10k
R214	06–11009A97	100k
R216	06–11009F05	200k
R250	06–11009A31	180
R251	06–11009A52	1.3k
R252	06–11009A45	680
R253,254	06–11009A85	33k
R255	06–11009A49	1k
R256,256	06–11009A81	22k
R258	06–11009A49	1k
R259	06–11009A89	47k
R260	06–11009A66	5.1k
R261	06–11009A73	10k
R262	06–11009A63	3.9k
R263	06–11009E79	18k
R264	06–11009A49	1k
R266	06–11009A49	1k
R267	06–11009A73	10k
R386	06–11077A36	27, 1/8W
transformer		
TP200	29–10134A70	lug connector
integrated circuit (see note)		
U250	51–83977M55	amplifier
U251	51–80069C05	quad detector
crystal (see note)		
Y250	91–80011E04	10 MHz
Y251–255	91–80011E05	10 MHz

1/10/89

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

RF BOARD

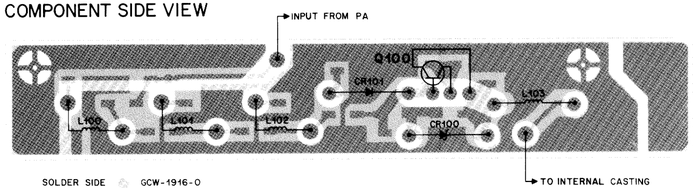


SHOWN FROM COMPONENT SIDE

Schematic, Circuit Board Diagram, and Parts List for RF Board
PW–1692–F
(Sheet 2 of 2)
9/29/89

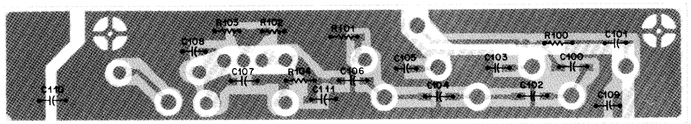
HFB4000A
HIGH–PASS FILTER/PREAMP

COMPONENT SIDE VIEW

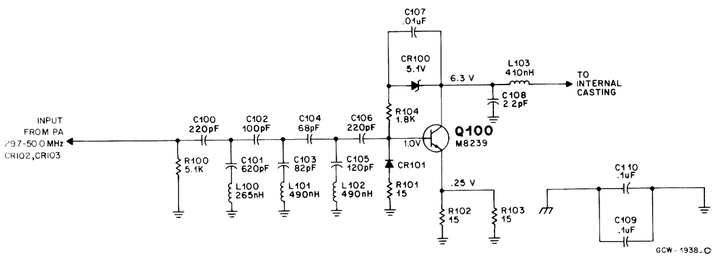


SOLDER SIDE — GCW-1916-O
COMPONENT SIDE — GCW-1917-O
OVERLAY — GCW-1919-O

SOLDER SIDE VIEW



SOLDER SIDE — GCW-1916-O
COMPONENT SIDE — GCW-1917-O
OVERLAY — GCW-1918-O



parts list

HFB4000A High Pass Filter/Preamp Board — MXW–1960–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C100	21–11031A47	220
C101	21–11031A58	620
C102	21–11031A39	100
C103	21–11031H22	82, ±2%
C104	21–11031A35	68
C105	21–11031A41	120
C106	21–11031A47	220
C107	21–11032B07	.01 uF, +80, –20%
C108	21–11031A23	22
C109,110	21–11031B13	.1 uF, +80, –20%
diode (see note)		
CR101	48–80012E01	hot carrier
coil		
L100	24–84411B02	14.5 turns, yellow
L101,102	24–84411B08	17.5 turns, violet
L103	24–82723H36	.41 uH, yellow
connector plug		
P100	28–82331G01	phono
transistor (see note)		
Q100	48–80182D39	NPN, type M8239
resistor, fixed, ohm, ±5%, 1/8W (unless otherwise stated)		
R100	06–11024A66	5.1k
R101–103	06–11024A05	15
R104	06–11024A55	1.8k
voltage regulator		
VR100	48–80007E01	zener 5.1V

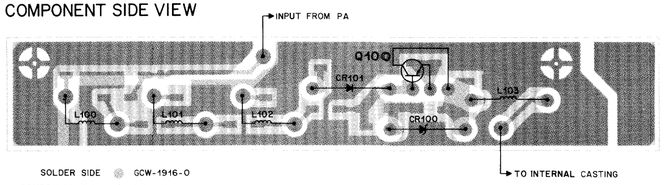
1/25/89

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

Schematics, Circuit Board Diagrams, and
Parts Lists for HFB4000A/B High Pass Filter Preamp
DW–3471–A
1/25/89

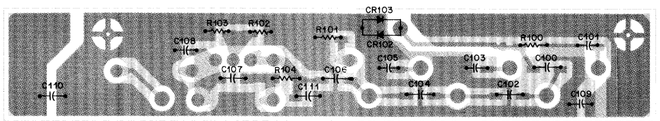
HFB4000B
HIGH–PASS FILTER/PREAMP

COMPONENT SIDE VIEW

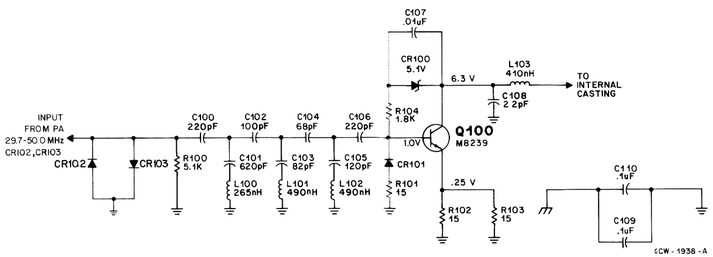


SOLDER SIDE — GCW-1916-O
COMPONENT SIDE — GCW-1917-O
OVERLAY — GCW-1919-O

SOLDER SIDE VIEW



SOLDER SIDE — GCW-1916-O
COMPONENT SIDE — GCW-1917-O
OVERLAY — GCW-1918-A



parts list

HFB4000B High Pass Filter/Preamp Board — MXW–6238–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C100	21–11031A47	220
C101	21–11031A58	620
C102	21–11031A39	100
C103	21–11031H22	82, ±2%
C104	21–11031A35	68
C105	21–11031A41	120
C106	21–11031A47	220
C107	21–11032B07	.01 uF, +80, –20%
C108	21–11031A23	22
C109,110	21–11031B13	.1 uF, +80, –20%
diode (see note)		
CR101–103	48–80012E01	hot carrier
coil		
L100	24–84411B02	14.5 turns, yellow
L101,102	24–84411B08	17.5 turns, violet
L103	24–82723H36	.41 uH, yellow
connector plug		
P100	28–82331G01	phono
transistor (see note)		
Q100	48–80182D39	NPN, type M8239
resistor, fixed, ohm, ±5%, 1/8W (unless otherwise stated)		
R100	06–11024A66	5.1k
R101–103	06–11024A05	15
R104	06–11024A55	1.8k
voltage regulator		
VR100	48–80007E01	zener 5.1V

1/25/89

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

parts list

HFB4000C High–Pass Filter Board — MXW–6239–O

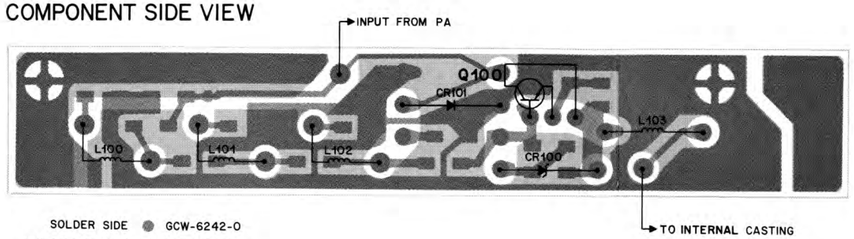
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C100	21–13740B57	220
C101	21–13740B68	620
C102	21–13740B49	12
C103	21–11031H22	82, ±1%
C104	21–13740B45	68
C105	21–13740B51	120
C106	21–13740B57	220
C107	21–11032B07	.01 uF, +80, –20%
C108	21–13740B33	22
C109,110	21–11032B13	.1 uF, +80, –20%
diode (see note)		
CR100	48–80007E01	zener 5.1V
CR101–103	48–80012E01	hot carrier
coil, RF		
L100	24–84411B02	airwound yellow
L101,102	24–84411B08	500 nH
L103	24–82723H36	.41 uH, yellow
connector plug		
P100	28–82365D02	phono coax plug
transistor (see note)		
Q100	48–80182D39	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R100	06–11077A91	5.1k
R101–103	06–11077A30	15
R104	06–11077A80	1.8k
mechanical parts		
	29–10134A89	terminal lug, 2 used
	37–00135566	heatshrink tubing
	15–80192H01	filter cover
	03–10943M09	tapping screw (3 x 0.5 x 6), 2 used

1/25/89

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

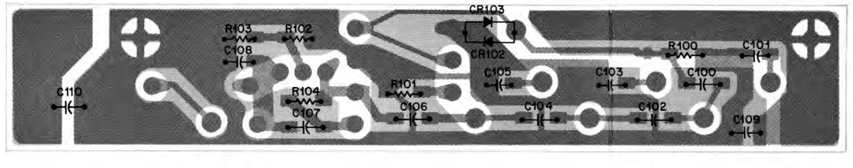
HFB4000C
HIGH–PASS FILTER/PREAMP

COMPONENT SIDE VIEW

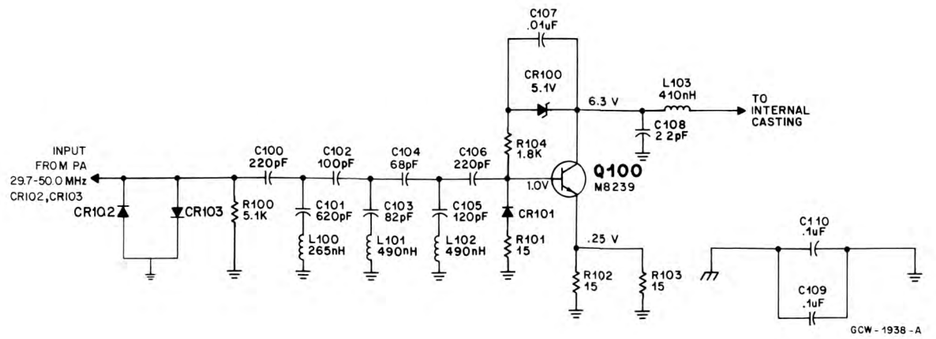


SOLDER SIDE ● GCW-6242-O
COMPONENT SIDE ● GCW-6243-O
OVERLAY — GCW-6276-O

SOLDER SIDE VIEW

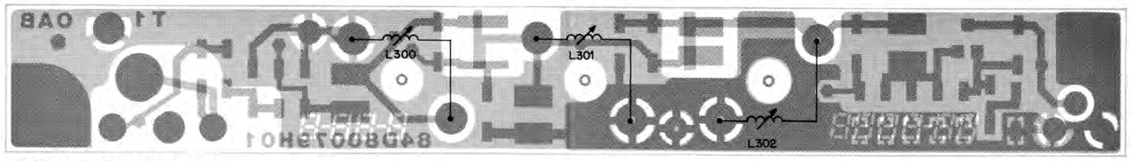


SOLDER SIDE ● GCW-6242-O
COMPONENT SIDE ● GCW-6243-O
OVERLAY — GCW-6244-O



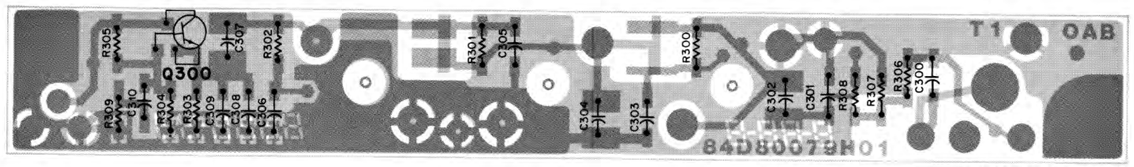
Schematic, Circuit Board Diagram, and
Parts Lists for HFB4000C High Pass Filter Preamp
PW–6241–O
1/25/89

EXTENDER FRONT END



COMPONENT SIDE VIEW

SOLDER SIDE — GDW-1895-0
COMPONENT SIDE — GDW-1896-0
OVERLAY — GDW-1898-0



SOLDER SIDE VIEW

SOLDER SIDE — GDW-1895-0
COMPONENT SIDE — GDW-1896-0
OVERLAY — GDW-1897-0

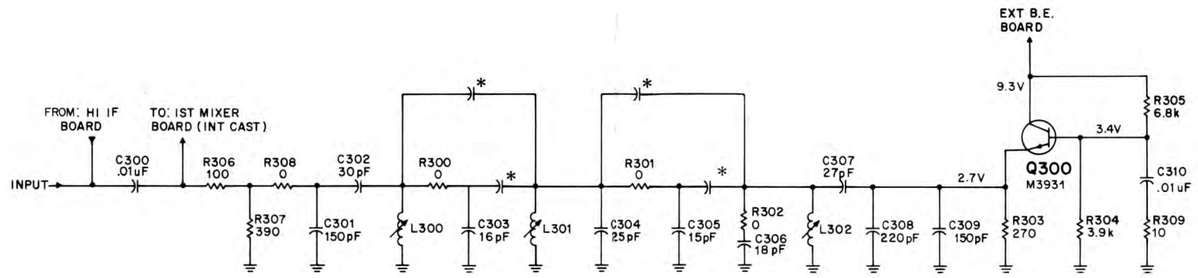
parts list

HLB4090A *Extender* Front End — MXW–1962–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C300	21–11032B07	.01 uF, +80, –20%
C301	21–13740B53	150
C302	21–11078B27	30, 100V
C303	21–13740B30	16
C304	21–11078B24	25, 100V
C305	21–13740B29	15
C306	21–13740B31	18
C307	21–11078B25	27, 100V
C308	21–13740B57	220
C309	21–13740B53	150
C310	21–11032B07	.01 uF, +80, –20%
coil, RF		
L300–302	24–80068A05	196 nH, variable
transistor (see note)		
Q300	48–84939C31	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R300–302	06–11077A01	0 ohm
R303	06–11077A60	270
R304	06–11077A88	3.9k
R305	06–11077A94	6.8k
R306	06–11077A50	100
R307	06–11077A64	390
R308	06–11077A01	0 ohm
R309	06–11077A26	10

1/10/89

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



NOTES:

1. (*) INDICATES AREA CAPACITOR
2. COIL ORIENTATION IMPORTANT

GCW-1937-B

Schematic, Circuit Board Diagrams, and Parts List for *Extender* Front End Board
PW–2191–B
1/15/89

parts list

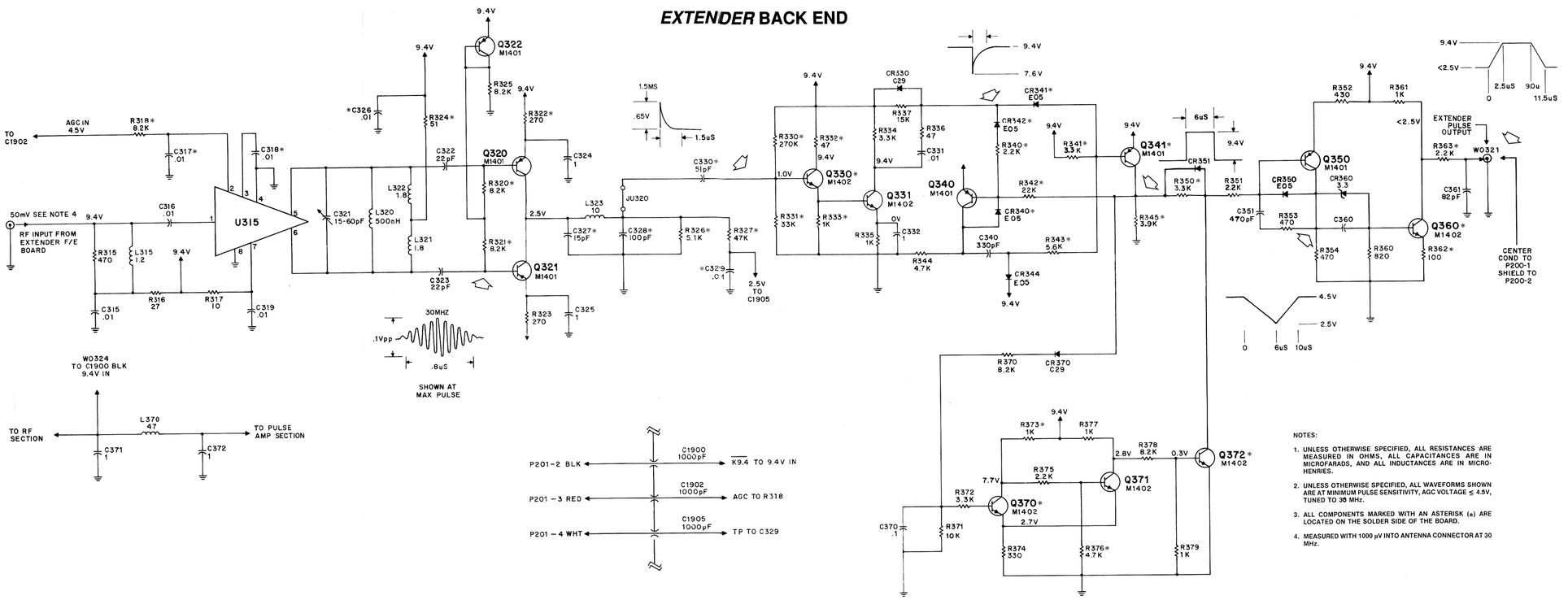
HLB4091B *Extender* Back End — MXW–1961–C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C315–319	21–11032B07	.01 uF, +80, –20%
C321	20–82399D07	15–60 pF, 200V, variable
C322,323	21–13740B33	22
C324,325	23–11049A08	1 uF, ±10%, 35V, tantalum
C326	21–11032B07	.01 uF, +80, –20%
C327	21–13740B29	15
C328	21–13740B49	100
C329	21–11032B07	.01 uF, +80, –20%
C330	21–13740B42	51
C331	21–11032B07	.01 uF, +80, –20%
C332	23–11049A08	1 uF, +10%, 35V, tantalum
C340	21–13740B61	330
C351	21–13740B65	470
C360	23–11049A08	1 uF, +10%, 35V, tantalum
C361	21–13740B47	82
C361	23–11049A08	1 uF, ±10%, 20V, tantalum
C370	21–11032B13	.1 uF, +80, –20%
C372	23–11049A08	1 uF, ±10% 35V, tantalum
diode (see note)		
CR330	48–05129M40	step recovery
CR340–342	48–80154K04	schottky
CR344	48–80154K04	schottky
CR350,351	48–80154K04	schottky
CR360	48–82256C26	3.3V, zener
CR370	48–05129M40	step recovery
jumper		
JU320	06–11009B23	0 ohm
coil, RF		
L315	24–80140E01	1.2 uH
L320	24–84411B08	500 nH
L321,322	24–80140E02	1.8 uH
L323	24–80140E16	10 uH
L370	24–82549D27	470 uH
transistor (see note)		
Q320–322	48–80141L01	PNP
Q330,331	48–80141L02	NPN
Q340,341	48–80141L01	PNP
Q350	48–80141L01	PNP
Q360	48–80141L02	NPN
Q370–372	48–80141L02	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R315	06–11077A66	470
R316	06–11077A36	27
R317	06–11077A26	10
R318	06–11077A96	8.2k
R320,321	06–11077A96	8.2k
R322	06–11077A42	47
R322,323	06–11077A60	270
R324	06–11077A43	51
R325	06–11077A96	8.2k
R326	06–11077A90	4.7k
R327	06–11077B15	47k
R330	06–11077B33	270k
R331	06–11077B11	33k
R333	06–11077A74	1k
R334	06–11077A86	3.3k
R335	06–11077A74	1k
R336	06–11077A42	47
R337	06–11077B03	15k
R340	06–11077A82	2.2k
R341	06–11077A86	3.3k
R342	06–11077B07	22k
R343	06–11077A92	5.6k
R344	06–11077A90	4.7k
R345	06–11077A88	3.9k
R350	06–11077A86	3.3k
R351	06–11077A82	2.2k
R352	06–11077A65	430
R353,354	06–11077A66	470
R360	06–11077A72	820
R361	06–11077A74	1k
R362	06–11077A50	100
R363	06–11077A82	2.2k
R370	06–11077A96	8.2k
R371	06–11077A98	10k
R372	06–11077A86	3.3k
R373	06–11077A74	1k
R374	06–11077A62	330
R375	06–11077A82	2.2k
R376	06–11077A90	4.7k
R377	06–11077A74	1k
R378	06–11077A96	8.2k
R379	06–11077A74	1k
integrated circuit (see note)		
U315	51–84320A22	AGC amplifier
mechanical parts		
	26–80121A01	IF shield

1/10/89

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

EXTENDER BACK END



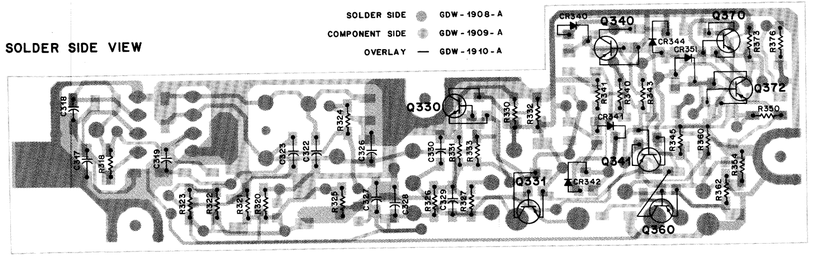
NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES ARE IN MICROFARADS, AND ALL INDUCTANCES ARE IN MICROHENRIES.
2. UNLESS OTHERWISE SPECIFIED, ALL WAVEFORMS SHOWN ARE AT MINIMUM PULSE SENSITIVITY, AGC VOLTAGE ≤ 4.5V, TUNED TO 30 MHz.
3. ALL COMPONENTS MARKED WITH AN ASTERISK (*) ARE LOCATED ON THE SOLDER SIDE OF THE BOARD.
4. MEASURED WITH 1000 µV INTO ANTENNA CONNECTOR AT 30 MHz.

CEW–1933–C

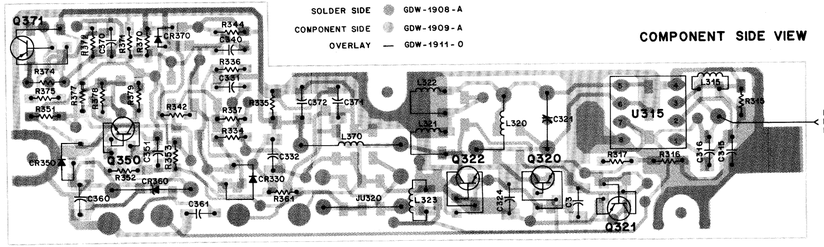
SOLDER SIDE VIEW

SOLDER SIDE — GDW–1908–A
COMPONENT SIDE — GDW–1909–A
OVERLAY — GDW–1910–A



SOLDER SIDE — GDW–1908–A
COMPONENT SIDE — GDW–1909–A
OVERLAY — GDW–1911–0

COMPONENT SIDE VIEW



Schematic, Circuit Board Diagrams, and Parts List for HLB4091B *Extender* Back End Board
PW–3472–D
6/30/89

parts list

HLB4091C *Extender* Back End — MXW–6685–O

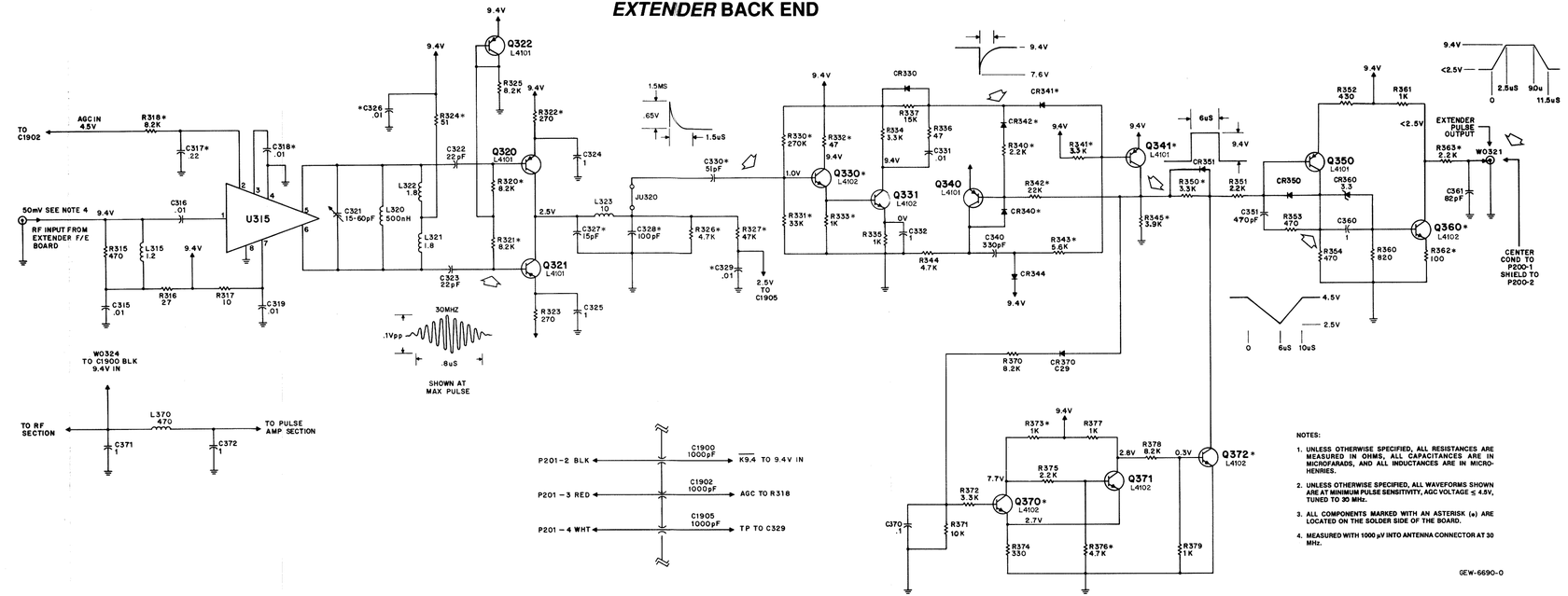
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed pF, ±5%, 50V (unless otherwise stated)		
C315,316	21–11032B07	0.01 uF, +80, –20%
C317	21–11032B15	.22, +80, –20%
C318,319	21–11032B07	0.01 uF, +80, –20%
C321	20–82399D07	variable, 15–60 pF, 200V
C322,323	21–11031A23	22
C324,325	23–84677D06	1 uF, ±10%, 20V, tantalum
C326	21–11032B07	0.01 UF, +80, –20%
C327	21–11031A19	15
C328	21–11031A39	100
C329	21–11032B07	0.01 UF, +80, –20%
C330	21–11031A32	51
C331	21–11032B07	0.01 UF, +80, –20%
C332	23–84677D06	1 uF, ±10%, 20V, tantalum
C340	21–11031A51	330
C351	21–11031A55	470
C360	23–84677D06	1 uF, ±10%, 20V, tantalum
C361	21–11031A37	82
C370	21–11032B13	0.10 UF, +80, –20%
C371,372	23–84677D06	1 uF, ±10%, 20V, tantalum
diode (see note)		
CR330	48–84939C29	silicon
CR340–342	48–80154K04	hot carrier
CR344	48–80154K04	hot carrier
CR350,351	48–80154K04	hot carrier
CR360	48–82256C26	zener, 3.3V
CR370	48–84939C29	silicon
connector receptacle		
JU320	06–11009B23	jumper
coil, inductor, RF		
L315	24–80140E01	1.2 uH
L320	24–84411B08	500 nH
L321,322	24–80140E02	1.8 uH
L323	24–82549D25	10 uH
L370	24–82549D27	470 uH
transistor (see note)		
Q320–322	48–80141L01	PNP, type 41L01
Q330,331	48–80141L02	NPN, type 41L02
Q340,341	48–80141L01	PNP, type 41L01
Q350	48–80141L01	PNP, type 41L01
Q360	48–80141L02	NPN, type 41L02
Q370–372	48–80141L02	NPN, type 41L02
integrated circuit (see note)		
U315	51–84320A22	amplifier
resistor, fixed Ω, ±5%, 1/8 watt (unless otherwise stated)		
R315	06–11024A41	470
R316	06–11024A11	27
R317	06–11024A01	10
R318	06–11024A71	8.2k
R320,321	06–11024A71	8.2k
R322,323	06–11024A35	270
R324	06–11024A18	51
R325	06–11024A71	8.2k
R326	06–11024A65	4.7k
R327	06–11024A89	47K
R330	06–11024B08	270k
R331	06–11024A85	33k
R332	06–11024A17	47
R333	06–11024A49	1k
R334	06–11024A61	3.3k
R335	06–11024A49	1k
R336	06–11024A17	47
R337	06–11024A77	15k
R340	06–11024A57	2.2k
R341	06–11024A61	3.3k
R342	06–11024A81	22k
R343	06–11024A67	5.6k
R344	06–11024A65	4.7k
R345	06–11024A63	3.9k
R350	06–11024A61	3.3k
R351	06–11024A57	2.2k
R352	06–11024A40	430
R354	06–11024A41	470
R360	06–11024A47	820
R361	06–11024A49	1k
R362	06–11024A25	100
R363	06–11024A57	2.2k
R370	06–11024A71	8.2k
R371	06–11024A73	10k
R372	06–11024A61	3.3k
R373	06–11024A49	1k
R374	06–11024A37	330
R375	06–11024A57	2.2k
R376	06–11024A65	4.7k
R377	06–11024A49	1k
R378	06–11024A71	8.2k
R379	06–11024A49	1k
non–referenced parts		
	26–80121A01	IF shield

6/30/89

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

Schematic, Circuit Board Diagrams, and Parts List for HLB4091C *Extender* Back End Board
PW–6691–O
6/30/89

EXTENDER BACK END

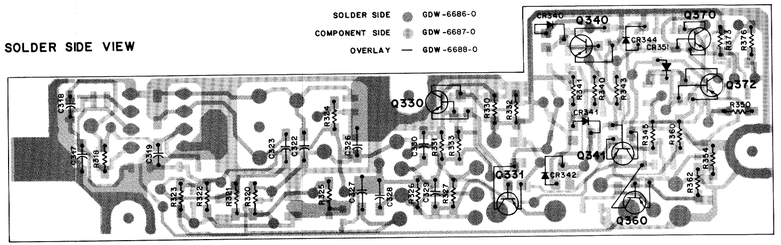


NOTES:

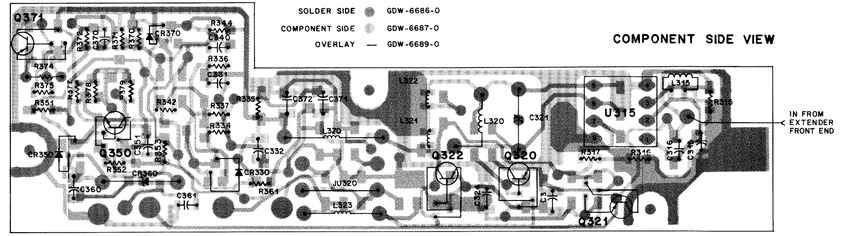
1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES ARE IN MICROFARADS, AND ALL INDUCTANCES ARE IN MICRO-HENRIES.
2. UNLESS OTHERWISE SPECIFIED, ALL WAVEFORMS SHOWN ARE AT MINIMUM PULSE SENSITIVITY, AGC VOLTAGE ≤ 4.5V, TUNED TO 30 MHz.
3. ALL COMPONENTS MARKED WITH AN ASTERISK (*) ARE LOCATED ON THE SOLDER SIDE OF THE BOARD.
4. MEASURED WITH 1000 µV INTO ANTENNA CONNECTOR AT 30 MHz.

GEW–6690–O

SOLDER SIDE VIEW

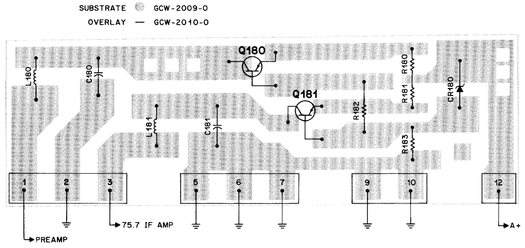


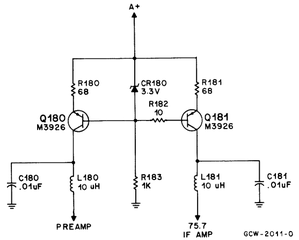
COMPONENT SIDE VIEW



HI–IF

FRONT END BIAS





parts list

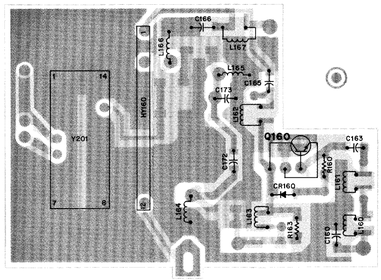
HLB4108A Hi–IF Circuit Board — MXW–4099–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C160	21–13740B43	56
C161	21–13740B48	91
C162	21–13740B42	51
C163–166	21–11032B07	.01 uF, +80, –20%
C167	21–13740B21	6.8
C169	21–13740B44	62
C172	21–13740B19	5.6
C173	20–80280D05	3–15, variable
C174	21–13740B41	47
C175	21–13740B17	4.7
C176	21–13740B48	91
C179	21–13740B55	180
C180,181	21–13741M45	.01 uF, ±10%
diode (see note)		
CR160	48–82958R01	5.1V
CR180	48–82958R39	3.3V
coil, RF		
L160,161	24–80140E06	130 nH
L162	24–80140E16	10 uH
L163	24–80140E07	680 nH
L164–166	24–11030D05	65.7 nH, blue
L167	24–80140E16	10 uH
L180,181	24–80140E16	10 uH
transistor (see note)		
Q160	48–80182D39	NPN
Q180,181	48–84939C26	PNP
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R160	06–11077A80	1.8k
R161,162	06–11077A30	15
R163	06–11077A60	270
R182	06–11077A26	10
mechanical parts		
	26–80238K01	fence shield
	29–80215H01	terminal
	01–80739T15	output coax assembly
	29–10134A89	lug terminal

1/10/89

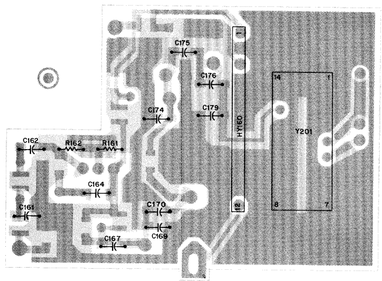
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

COMPONENT SIDE VIEW

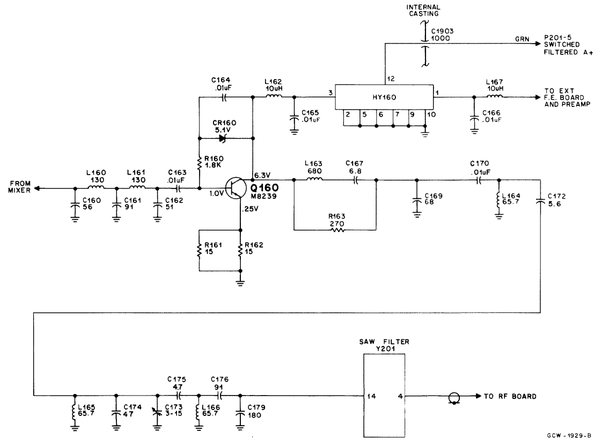


SOLDER SIDE — GCW-1900-B
COMPONENT SIDE — GCW-1901-B
OVERLAY — GCW-1903-B

SOLDER SIDE VIEW



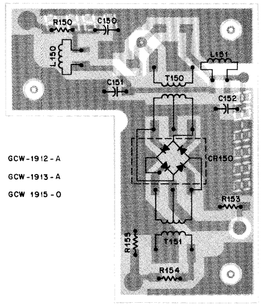
SOLDER SIDE — GCW-1900-B
COMPONENT SIDE — GCW-1901-B
OVERLAY — GCW-1902-B



NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN PICO-FARADS, AND ALL INDUCTANCES IN NANOHENRIES.

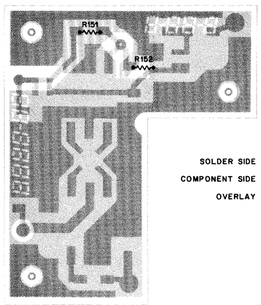
FIRST MIXER

COMPONENT SIDE VIEW

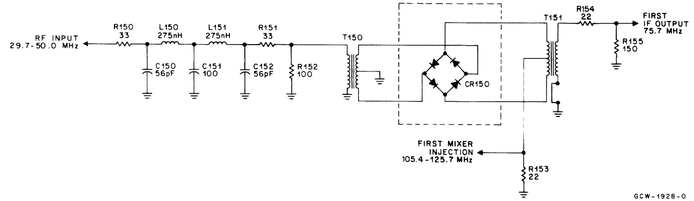


SOLDER SIDE — GCW-1912-A
COMPONENT SIDE — GCW-1913-A
OVERLAY — GCW-1915-0

SOLDER SIDE VIEW



SOLDER SIDE — GCW-1912-A
COMPONENT SIDE — GCW-1913-A
OVERLAY — GCW-1914-0



parts list

HLB4085A First Mixer Circuit Board — MXW–1698–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C150	21–13740B43	56
C151	21–13740B49	100
C152	21–13740B43	56
diode (see note)		
CR150	48–80236E09	silicon (early version)
CR150	48–80236E17	silicon (later version)
coil, RF		
L150	24–80140E15	275 nH
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R150,151	06–11077A38	33
R152	06–11077A50	100
R153–155	06–11077A34	22
transformer		
T150,151	25–80125J01	toroid

6/30/89

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

1. Theory of Operation

The *SYNTOR X* low–band transmitter uses discrete component design. It consists of four major blocks: the low–level amplifier (LLA), the power amplifier (PA), the PIN diode antenna–switch/harmonic–filter (HF) combination, and the directional coupler (DC). The harmonic filter also acts as the first low–pass section for the receiver.

The frequency synthesizer generates a 75–mW RF output at the transmit carrier frequency. This is applied to the controlled, one–stage LLA (Q801). The gain of the LLA and the output power of the radio change with variations in the control voltage.

The RF signal passes from the LLA to the final amplifier, where it is applied to the driver stage (Q802). The driver delivers as much as 30 watts of RF power to the input of the final amplifier. Consisting of two devices (Q803 and Q804) in a push–pull configuration, the final amplifier boosts the final output power to the rated 100 watts.

The power control circuit on the common circuits board monitors the following parameters: forward power, reflected power, current to the finals, temperature of the finals, and control voltage. It does so in order to level RF power and protect the PA from burnout.

The power control circuit monitors forward and reflected power with the help of the directional coupler. The directional coupler detects forward and reflected power and sends any detected DC voltage to the power control circuit. When forward power is above or below the set point, the power control circuit adjusts the gain of the low–level amplifier by adjusting the control voltage to that stage. This monitoring holds output power constant over many operating conditions. However, when reflected power reaches levels that may damage the transmitter, the power control circuit reduces the output power until the reflected power returns to a safe level. (Excessive reflected power is usually due to a poor antenna installation or a bad RF connection.)

The power control circuit monitors DC current to final devices Q803 and Q804 in order to protect them from over–dissipation. It senses this current by measuring the voltage drop across R813. The current limit cut–in point is set by R917. When current to the finals exceeds the limit set by R917, the control circuit reduces the control voltage, thus reducing power out and current drain.

The power control circuit senses the temperature of the PA through thermistor RT801, which is near the flange of Q803. When the flange temperature exceeds 95°C, the control circuit lowers the control voltage in order to protect the PA from excessive temperatures. The feedback loop through VR900 always limits the control voltage to a maximum of 11 volts, thus protecting low–level amplifier device Q801 from over–dissipation.

2. Functional Tests

Note

The Synthesizer Section of this manual has information on troubleshooting the transmit frequency, audio deviation, and modulation.

2.1 PRELIMINARY

Connect the radio to a proper wattmeter, dummy load, and 13.4 VDC supply. Make adjustments to R917 and R908 on the solder side of the common circuits board.

CAUTION

Key the transmitter only while making adjustments.

2.2 CONTROL AND PROTECTION TESTS

2.2.1 Power Set (R908)

(1) Set CURRENT LIMIT (R917) fully clockwise.

(2) Set POWER SET (R908) fully clockwise.

(3) Key the transmitter and observe the wattmeter. The power output should be 20–30 W and should increase to more than 120 W as you turn POWER SET (R908) counterclockwise.

2.2.2 Thermal Protection

(1) Set CURRENT LIMIT (R917) fully clockwise.

(2) Adjust POWER SET (R908) to 105 W.

(3) Touch a soldering iron to RT801 (near the flange of Q803). The power output should decrease as RT801 heats up.

2.2.3 Reflected Power (VSWR) Protection

(1) Set CURRENT LIMIT (R917) fully clockwise.

(2) Key the transmitter and adjust POWER SET (R908) for 110 W.

CAUTION

The following test requires transmission without a dummy load. Therefore be careful to key the transmitter only long enough verify proper operation of the equipment.

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(3) Remove the 50–ohm load from the radio. Key the transmitter briefly and verify that the output power is 30–60 watts.

2.3 RF AMPLIFICATION TESTS

2.3.1 Injection

(1) Disconnect the RF drive signal to the Low–Level Amplifier from the synthesizer (J801).

(2) Connect a 50–ohm terminated RF millivoltmeter to the synthesizer's transmitter injection plug (P801). Residual RF drive to the Low–Level Amplifier in the receive mode should be less than –5 dBm. Transmitter injection in the transmit mode should be greater than +17 dBm.

2.3.2 Low–Level Amplifier

(1) Set the POWER SET (R908) and CURRENT LIMIT (R917) to maximum.

(2) Key the transmitter. Using a millivoltmeter with a high–impedance probe, check the base and collector of the LLA (Q801), getting as close to the device as possible, and verify that the LLA has at least 10 dB of gain. (The collector pad should be 10 dB higher than the base.)

3. Power Amplifier Troubleshooting Procedure

3.1 NO POWER, LOW POWER (LESS THAN 20% RATED POWER)

If the radio has no power, or has low power, use the Power Amplifier Troubleshooting Table to help locate the problem. If that fails, check transistors Q802, Q803, and Q804 while still in the circuit. The following paragraphs detail the procedure for in–circuit transistor checkout. Do not replace these transistors unless absolutely necessary.

To check Q802 driver, isolate it from the circuit by removing the following:

L806 – base choke
R805 – base resistor

To check Q803 final amplifier, isolate it by removing the following:

L809 – base choke
R809 – base resistor
T801 – input transformer

To check Q804 final amplifier, isolate it by removing the following:

L808 – base choke
R807 – base resistor
T801 – input transformer

Measure the resistance of the base–to–emitter junction with a precise multimeter. If the resistance is less than 0.4 ohms or greater than 1.0 ohms, the transistor is defective and must be replaced.

3.2 MAXIMUM POWER LESS THAN 120 WATTS

3.2.1 Q802 Driver Test

(1) Remove all power to the radio. Measure the in–circuit resistance of Q802 driver's base–to–emitter junction. If resistance is greater than 1 ohm, replace coil L806.

(2) If the resistance is 1 ohm or less, remove coil L806 and measure Q802 base–to–emitter junction again. If that resistance is less than 9.5 ohms or greater than 10.5 ohms, either R805 is defective or there may be a short on the printed circuit board.

(3) If you have not located the problem using the above steps, replace L806 and apply power to the radio. On the common circuits board, adjust R907 fully clock wise and R908 fully counterclockwise for maximum power. Remove one lead of L814 from the board. Put a loop of wire between L814 and the PC board. Measure the current of Q802 with a DC clip–on milli–ammeter.

Current drain of Q802 should be 4 to 5 amps. If less than 4 amps, Q802 is faulty and must be replaced.

3.2.2 Q803 and Q804 Final Amplifier Check

(1) Remove all power to the radio. Measure the resistance of the base–to–emitter junction of the transistor. If the resistance is greater than 1 ohm, replace the base choke (L809 for Q803, or L808 for Q804).

(2) If the resistance is 1 ohm or less, remove the base choke and measure the resistance of the base–to–emitter junction again. If the resistance is less than 3 ohms or greater than 3.5 ohms, the base resistor (R807 for Q803, or R809 for Q804) may be defective or there may be a short on the printed circuit board.

(3) If you have not located the problem using the above steps, replace the base choke (L808 or L809) and apply power to the radio. On the common circuits board, adjust R907 fully clockwise and R908 fully counter clockwise for maximum power. Proceed with the following:

- Remove C817 and C842. Unsolder Q804's collector tab, making sure it is not in contact with the pad.
- Solder a 2500 pF silver mica capacitor (Motorola Part #21–00859773 or equivalent) between the PC pad for Q804's collector and the emitter lead of Q804. Measure the power output of Q803, and compare that value with the value in Table 1. If the power output is less than the value specified, remove power to the radio and replace Q804. Remove the 2500 pF silver mica capacitor from the PC board. Resolder Q804, C817, and C842 to the PC board.
- Remove capacitors C818 and C843. Unsolder Q803's collector tab, making sure it is not in contact with the pad. Solder a 2500 pF silver mica capacitor (Motorola Part #21–00859773 or equivalent) between the PC pad for Q803's collector and the emitter lead of Q803. Measure the power output of Q803, and compare that value with the value in Table 1. If the power output is less than the value specified, remove power to the radio and replace Q804. Remove the 2500 pF silver mica capacitor from the PC board. Resolder Q803, C818, and C843 to the PC board.

Table 1. Minimum Power Output of Q803 and Q804

Frequency (MHz)	Power Output (W)
33.0 – 37.999	45
38.0 – 43.999	50
44.0 – 50.000	30

Table 2. PA Troubleshooting Table

Step	Symptom		Procedure	Normal Indication	If Normal	If Abnormal
1	Suspected Transmitter Failure		Measure RF output power at antenna connector.	Rated power	No transmitter malfunction.	High power – perform Transmitter Power Control and Protection Circuit Troubleshooting Procedure. No power – go to 2. Low – power – go to 3.
2	No or Low Output Power	a.	Check TX injection from synthesizer at J801.	Greater that +17dBm	Go to b.	Go to Synthesizer Troubleshooting Procedure
		b.	Measure DC voltage at collector of Q801 when keyed.	5–11 V	Go to c.	Check for shorts and opens in DC path. If none, go to Transmitter Power Control and Protection Circuit Troubleshooting Procedure.
		c.	Check for keyed 9.4V and + 9.6 V on PA board.	9.4V, 9.6V	Go to d.	Repair either K9.4 V or regulated 9.6V circuitry.
		d.	Check A+ on collectors of Q802, Q803, and Q804.	Greater than 12.5 V.	Go to e.	Check for continuity in both the collectors of Q802, red lead (A+) and the black lead (A–). Check for shorts and opens DC in paths.
		e.	Check for shorts and opens on PA board.	See schematic.	Go to f.	Repair defect.
		f.	Check for continuity through directional coupler.	RF short through coupler out to antenna connector.	Perform Power Amplifier Troubleshooting Procedure.	Go to Directional Coupler Troubleshooting Procedure

Table 3. Troubleshooting Table for Power Control and Protection Circuitry

PRELIMINARY: Set R917 fully clockwise and R908 fully counterclockwise as viewed on the solder side of the common circuits board. Key the transmitter for the following tests. Voltage reference is B– (the internal casting).

Step	Symptom		Procedure	Normal Indication	If Normal	If Abnormal
1	No Control Voltage or Low Control Voltage	a.	Measure keyed 9.4V, J300–8.	9.4 V	Go to b.	Check Q3 and Q4 on personality board.
		b.	Measure PA ENABLE, J300–5.	0 volts during transmit	Go to c.	Check adapt line, Q5 or Q6
		c.	Measure U900–1.	1.5–7.5 volts	Replace Q906 or Q904.	If 0 volts, go to d.
		d.	Measure U900–3	1.67 volts	Go to e.	Check R905 and R906.
		e.	Measure U900–2.	0–1.67 volts	Replace U900.	If greater than 1.67V, go to f.
		f.	Remove CR901. Measure U900–1.	1.5–7.5 volts	Go to 2a.	Go to g.
		g.	Remove CR903. Measure U900–1.	1.5–7.5 volts	Go to 3a.	Go to h.
		h.	Remove CR900. Measure U900–1.	1.5–7.5 volts	Check VR900. & R907 for shorts	Go to i.
		i.	Remove CR902. Measure U900–1.	1.5–7.5 volts	Go to 4g.	Go to j.
		j.	Unplug P953 from the directional coupler. Measure U900 – 2.	0–1.67 volts	Check the directional coupler.	Determine source that holds U900 – 2 above 1.67 volts.
2	Current Limit Amplifier Failure	a.	Set R917 fully clockwise. Disconnect cathode of CR901. Measure cathode of CR901.	0–1.5 volts	Reconnect CR901.	Go to 2b.
		b.	Measure voltage across R930.	.46–.60 volts	Check R923.	Go to 2c.
		c.	Measure base of Q905.	.86–1.4 volts	Check R918.	If base is greater than 1.4 volts, replace Q905. If base is less than .86 volt, go to 2e.
		d.	Measure U900–7.	7.5–8.5 volts	Check R928 and VR901.	Go to 2e.
		e.	Measure U900–6.	4.0–5.9 volts	Go to 2f.	Check A+, R915, or R916.
		f.	Measure U900–5.	4.0–5.9 volts	Replace U900.	Check R922, R924, R910, R920, R917, R919, R814, L816, and R813.
3	Thermal Protection Failure	a.	Disconnect cathode CR903. Measure U900 –14.	0–1.6 volts	Check CR903. and R909.	Go to 3b.
		b.	Measure U900 –12.	1.67 volts	Go to 3c.	Check R905 and R906.
		c.	Measure U900 –13.	2.3 volts	Replace U900.	Go to 3d.
		d.	Turn off power to radio. Disconnect P951 from common circuits board. Measure resistance between B – & black temp–sense wire at P951.	101k ohms (less if chassis is warm)	Check R901, R903, R934, and R904.	Check L818, RT801, and R815 on the PA.
4	Reverse–Power–Protection Failure	a.	Disconnect cathode of CR902. Disconnect RF drive from PA. Measure U900 – 8.	0 volts	Go to 4c.	Go to 4b.
		b.	Unplug J953 from directional. coupler Measure U900 – 10.	0 volts	Go to 4c.	Determine source that holds pin 10 above 0 volts.
		c.	Connect RF drive to transmitter. Disconnect dummy load from antenna connector. Key up briefly and measure U900 – 8.	3 6 volts	System o.k.	Check R914 and R911 or replace U900.

4. HLB4092A Directional Coupler

4.1 DESCRIPTION

The HLB4092A directional coupler detects forward and reflected power. Three color coded wires on P953 connect the directional coupler to the common circuits board, and one coaxial cable connects it to the output of the PA board while another connects it to the antenna connector.

4.2 THEORY OF OPERATION

Transformer T950 induces RF voltages on the forward port and on the reflected port proportional to the forward and reflected power levels, respectively. Each port consists of a 50–ohm load and an RF–to–DC detector circuit, and both operate in the same way.

The 50–ohm load of the forward port consists of R952 and R953, and that of the reflected port consists of R954 and R955. The RF voltage on the forward port is detected, rectified, and converted to a DC level by R950, CR950, and C957. Likewise, the RF voltage on the reflected port is detected, rectified, and converted to DC by R951, CR951, and C958.

4.3 FUNCTIONAL TESTS

4.3.1 Preliminary

Connect the radio to a proper wattmeter, dummy load, and a 13.4–volt DC supply.

CAUTION

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

4.3.2 Forward DC Detected Voltage Test

(1) Set POWER SET (R908) fully clockwise.

(2) Set CURRENT LIMIT (R917) fully counter clockwise.

(3) Remove plug P953 from the common circuits board. Connect a voltmeter across FORWARD DETECT, pin 1 (brown), and REFERENCE, pin 2 (black), with pin 2 being the negative connection.

(4) Key the transmitter and observe radio output power. Slowly turn CURRENT LIMIT (R917) clockwise until the output power rises to 100 ±5 watts. The voltmeter should read between 4.0 and 6.0 DC volts.

4.3.3 Reflected DC Detected Voltage Test

Note

For this test, connect the radio to a proper through–line wattmeter, a 13.4 VDC supply, and two dummy loads in parallel.

(1) Set POWER SET (R908) fully clockwise.

(2) Set CURRENT LIMIT (R917) fully counter clockwise.

(3) Remove plug P953 from the common circuits board. Connect a voltmeter across REFLECTED DETECT, pin 3 (red), and REFERENCE, pin 2 (black), with pin 2 being the negative connection.

(4) Key the transmitter and observe radio forward output power. Slowly turn CURRENT LIMIT (R917) clockwise until the forward output power rises to 100 ±5 watts.

(5) Check the reflected output power with the through line wattmeter. It should be 11 ±3 watts. The voltmeter should read between 0.5 and 2.0 DC volts.

Table 4. Troubleshooting Table for Directional Coupler

Step	Symptom	Procedure	Normal Indication	If Normal	If Abnormal
1	Suspected Coupler Failure	Perform functional tests.	See functional test paragraphs.	No coupler problem	No power out, go to 2. Either forward or reflected voltage wrong, go to 3.
2	No power out	Check coaxes for continuity through the coupler. **Note** The coupler does have a DC short from the coax center conductor to the coax shield.	Continuous	Remove cover. Locate and fix RF shorts to the cover	Check board and coax solder connections, runners to and from T950, and T950 primary.
3	Forward or reflected DC voltages too high or low	a. Remove the coupler cover and recheck.	See functional test paragraphs.	Locate and fix DC short to cover.	Go to b.
		b. Check all circuit R–L–C's.	See schematic.	Go to c.	Repair defect.
		c. Check RF voltage on T950 side of C950 and C951 during reflected detect functional test.	Pfwd = 100 watts Prefl = 11 watts both ±3 watts VC950 = 3.5 Vrms VC951 = 1.2 Vrms both ±0.5Vrms	Locate and repair PCB problem. Cut runner, solder short, etc.	Replace T950.

Table 5. Troubleshooting Table for PIN Diode Antenna Switch: Receive Mode

Note: This analysis assumes that an applied signal is good through the LPF up to C824.

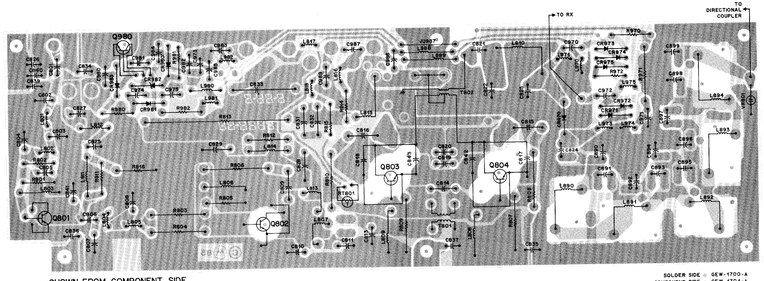
Symptom		Procedure	Normal Indication	If Normal	If Abnormal
Receive path degrades signal strength by more than 0.5 dB.	a.	Check Reg. 9.6 voltage on PA board.	9.6 V	Go to b	Repair 9.6 V circuitry and recheck signal path.
	b.	Check voltage at ungrounded lead of R970.	~1.2 VDC	If there are no shorts or opens around C824 & C972, replace CR971 & CR972.	(1) Varies significantly: check R982, R970 for right values. (2) Zero: Go to c.
	c.	Measure voltage at emitter of Q980.	~8.9 V	Go to d.	Zero: replace CR983.
	d.	Check voltage at cathode of CR980.	~2.0 VDC	Go to e.	Zero: check for opens between Q980 base and ground; if none, replace Q980.
	e.	Check voltage at collector of Q980.	—	—	(1) ~ 8.9 V: check for open path to R970. (2) Zero: check for shorts past the collector of Q980.

Table 6. Troubleshooting Table for PIN Diode Antenna Switch: Transmit Mode

Note: The following analysis assumes that the transmitter is working into a 50–ohm load, the LPF is OK, and the directional coupler is working right.

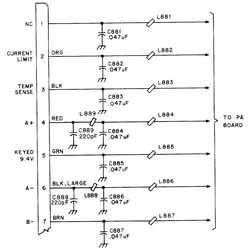
Symptom		Procedure	Normal Indication	If Normal	If Abnormal
TX PIN diode overdissipates and changes color. (Replace TX PIN diode CR970.)	a.	Check keyed 9.4 V on PA board.	9.4 V	Go to b.	Repair K9.4 V circuitry. (Note: this may be caused by a low resistance or short of the K9.4 lines on the PA board.)
	b.	Check voltage at ungrounded lead of R970.	~8.5 VDC		(1) Zero: check for opens from K9.4 through R970 to B–. (2) Low: Check components and values from K9.4 through R970 to B–. If there are no shorts or opens around C824 and C972, replace CR971 and CR972.
RX PIN diodes CR971 and CR972 discolor or their solder liquifies during transmit. (After completing this procedure, be sure to check the receiver.)	a.	Check voltage during transmit at cathode of CR980.	~8.5 VDC	Go to b.	Zero: check for opens from K9.4 to cathode of CR980, direction of CR980, and that CR980 is working properly.
	b.	Check for PA spurs (instability). (Note: This check uses a spectrum analyzer.)	No spurs	Go to c	Repair PA and check CR981 (5.6 V zener) for correct placement and operation; be sure entire switch has correct parts.
	c.	Check CR981 for correct placement and operation, and be sure entire switch has correct parts.	—	Go to d.	Take required corrective action
	d.	Measure DC voltage at anode of CR972.	–90.0 VDC	Check for AC short at anode of CR972.	Very low or zero: check loop of C970, CR973, CR974, CR975, R972 for opens or short, R971 (47k ohm) for opens.

PA BOARD

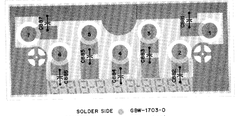


SHOWN FROM COMPONENT SIDE

7-PIN PA FEEDTHRU



SHOWN FROM SOLDER SIDE



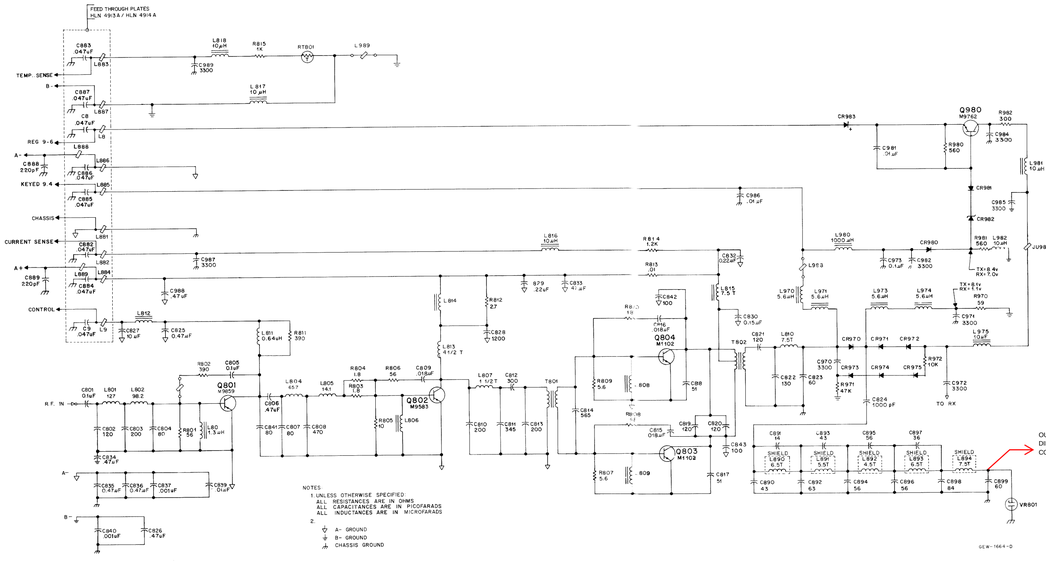
SOLDER SIDE — GEW-1703-D
COMPONENT SIDE — GEW-1704-D
OVERLAY — GEW-1705-D

HLN4913A 7 Pin Feedthru — MXW-1713-B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±20%, 100V (unless otherwise stated)		
C882–887	21–84547A07	.047
C888,889	21–11015B05	220 pF, ±10%
coil, RF		
L888,889	76–84069B04	ferrite
mechanical parts		
	28–80123J01	male connector
	28–80123J02	male connector

12/20/88

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



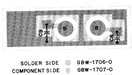
HLN4914A 2 Pin Feedthru — MXW-1714-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±10%, 50V (unless otherwise stated)		
	21–13741N01	.047
mechanical parts		
	28–80123J01	male connector
	28–80123J02	male connector

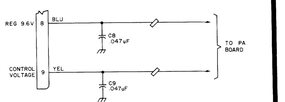
12/30/88

2-PIN PA FEEDTHRU

SHOWN FROM SOLDER SIDE



SOLDER SIDE — GEW-1706-D
COMPONENT SIDE — GEW-1707-D
OVERLAY — GEW-1708-D



HKN4202A Interconnect Cable — MXW-2141–A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
connector plug		
P951	09–80053D01	female connector housing
P952–959	09–80163D01	rectangular
mechanical parts		
	15–84301K16	2 contact connector housing
	39–82717M01	receptacle contact
	42–10217A02	nylon tie strap
	54–84697B01	label

1/10/89

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

parts list

HLB4094A Power Amplifier Circuit Board — MXW–1712–E

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C801	08–11051A13	.1 uF, 63V
C802	21–84494B06	120, 500V
C803	21–84494B11	200, 500V
C804	21–84494B03	80, 500V
C805	08–11051A13	.1 uF, 63V
C806	08–11051A17	.47 uF, 63V
C807	21–84494B03	80, 500V
C808	21–84494B19	470, 300V
C809	08–82905G21	218 pF, ±10%
C810	21–84494B11	200, 500V
C811	21–00868B23	345, ±3% 500
C812	21–84395B13	300, 250V
C813	21–84494B11	200, 500V
C814	21–84857K06	565, ±3%, 500V
C815,816	08–82905G21	.018 uF, ±10%
C819,820	21–84494B06	120, 500V
C821	21–84395B04	120, 250V
C822	21–84395B05	130, 250V
C823	21–84395B07	60, 250V
C824	21–80240G59	.001 uF, ±2%, 350V
C825,826	08–11051A17	.47 uF, 63V
C827	23–11054H08	10 uF, ±10%, 25V, tantalum
C828	08–84637L03	.0012 uF, 630V
C829	08–84637L22	22 uF, ±10%
C830	08–84637L21	.15 uF, ±10%
C832	08–84637L22	22 uF, ±10%
C833	23–82601A05	53 uF, –10, +150%, 25V, electrolytic
C834–836	08–11051A17	.47 uF, 63V
C837	21–11015A01	.001 uF, +80, –20%
C839	08–11051A07	.01 uF, 63V
C840	21–11015A01	.001 uF, +80, –20%
C841	21–84494B03	80, 500V
C890	21–84395B19	43, 250V
C891	21–84395B31	14, 350V
C892	21–84395B70	63, ±2%, 350V
C893	21–84395B67	43, ±2%, 350V
C894,895	21–84395B69	56, ±2%, 350V
C896	21–84395B68	56, ±2%, 350V
C897	21–84395B66	36, ±2%, 350V
C898	21–84395B65	24, ±2%, 350V
C899	21–84395B07	60, 250V
C970–972	21–83596E24	.0033 uF, ±10%, 200V
C973	08–11051A13	.1 uF, 63V
C980	21–82372C10	.05 uF, +80, –20%, 25V
C981	21–83596E37	.01 uF, +70, –30%
C982	21–83596E24	.0033 uF, ±10%, 200V
C984-985	21–83596E24	.0033 uF, ±10%, 200V
C986	21–83596E37	.01 uF, +70, –30%
C987	21–83596E24	.0033 uF, ±10%, 200V
C988	08–11051A17	.47 uF, 63V
C989	21–83596E24	.0033 uF, ±10%, 200V
diode (see note)		
CR970	48–80236E11	pin
CR971,972	48–83515F04	silicon
CR973–975	48–83654H01	silicon
CR980,981	48–82469H01	rectifier silicon
CR982	48–82256C12	5.6V
CR983	48–82466H01	rectifier silicon
connector receptacle		
J801	09–80001F01	phono jack
jumper		
JU987–989	01–80739T09	0 ohm wire
coil, RF		
L801	24–11030B15	10.5 turns, white
L802	24–11030B13	8.5 turns, green
L803	24–82835G30	1.3 uH, brown-orange gold
L804	24–11030D04	46.9 nH, green
L805	24–11030D01	14.1 nH, red
L806	24–82977B01	1.5 turns
L807	24–80277A17	airwound
L808,809	24–83977B01	1.5 turns
L810	24–80135J06	airwound
L811	24–82835G32	.6 uH, blue yellow
L812	24–80036A02	ferrite, 1/2 turn
L813	24–84235B04	airwound, 4 1/2 turns
L814	24–80036A02	ferrite, 1/2 turn
L815	24–82110B13	7.5 turns
L816–818	24–80139G05	10 uH, ±10%
L890	24–80135J05	airwound
L891	24–80135J04	airwound
L892	24–80135J03	airwound
L893	24–80135J02	airwound
L894	24–80135J01	airwound
L970	24–82549D50	5.6 uH
L973	24–82549D50	5.6 uH
L975	24–80139G05	10 uH, ±10%
L980	24–82549D03	1 uH
L981,982	24–80139G05	10 uH, ±10%
L987	76–80178D01	ferrite

HLN4814A Power Amplifier Hardware — MXW–1717–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 100V (unless otherwise stated)		
C889	21–11014H41	47
coil		
L880–889	76–84069B04	ferrite core bead
L900	76–83466K01	ferrite core bead
mechanical parts		
	01–80244H01	PA shield assembly
	02–00007003	hex nut (8–32 x .31 x .375)
	02–10971A63	hex nut (3.5 x .6) 2 used
	02–80006A01	spanner nut
	03–10911A11	machine screw (3 x .5 x .6), 4 used
	03–10943M15	machine screw (3.5 x .6 x .8), 5 used
	03–10943M16	machine screw (3.5 x .6 x 10)
	03–10943M17	machine screw (3.5 x .6 x 13), 2 used
	04–00114522	5/8" lockwasher
	04–82945A01	shoulder washer
	14–80103B01	exciter heatsink insulator
	15–84763M01	chassis
	26–80016B02	exciter heatsink
	26–80129K01	harmonic filter heatsink
	29–00003023	solder lug
	32–80080A01	antenna collar gasket
	32–80084A01	stud device gasket, 2 used
	43–80013B01	standoff
	55–84300B04	handle
	76–80164C01	ferrite sleeve, 2 used

1/15/89

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
transistor (see note)		
Q801	48–00868B59	NPN
Q980	48–00869762	PNP
thermistor		
RT801	06–83603K09	100k, green
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R801	06–11009C19	56
R802	06–11009C39	390
R803,804	06–00126B70	1.8, 1W
R805	06–11045A01	10, 1/2W
R806	06–00127C19	56, ±10%, 2W
R807	06–00126B63	5.6, 1W
R809	06–00126B63	5.6, 1W
R810	17–82036Q27	18, 2W
R811	06–11009C39	390
R812	06–80037G11	2.7, 1/2W
R813	17–80165C02	.01, ±10%, 12W
R814	06–11009A51	1.2k
R815	06–11009C49	1k
R970	06–11045A89	47k, 1/2W
R971	17–82291B44	59, ±3%, 3W
R972	06–11009C73	10k
R980,981	06–11009A43	560
R982	06–11045A36	300, 1/2W
transformer		
T801	24–80099B01	3 turn inductor
T802	25–80225J02	transformer
varactor		
VR801	80–83029H08	neon spark arrestor
mechanical parts		
	05–82050H03	eyn, 2 used
	26–80149J01	locking shoulder washer
	26–80287H01	harmonic filter shield, 6 used
	29–80014A03	coax terminal clip, 2 used
	29–82713M01	terminal, 6 used
	37–00134165	3/8" heatshrink tubing

4/15/90

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

Schematics, Circuit Board Diagrams, and Parts Lists for Power Amplifier
PW–1719–E
4/15/90

parts list

HLB4083B Transmit Buffer Circuit Board — MXW–1967–C

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C1504–1509	21–11032B13	.1 uF, +80, –20%, 50V
C1512,1513	21–11032B13	.1 uF, +80, –20%, 50V
C1500	21–13740B46	75
C1501,1502	21–13740B51	120
C1503	21–13740B46	75
C1510	21–13740B29	15
C1511	21–13740B46	75
C1514	23–11054H08	10 uF, ±10%, 25V, tantalum
C1515	21–13740B27	12
diode (see note)		
CR1501	48–80154K01	hot carrier
connector receptacle		
J1500	28–84324M01	2 contact
J1501	09–80001F01	phono jack
coil, RF		
L1500	24–84411B03	brown
L1501	24–84411B01	white
L1502	24–84411B03	brown
L1503	24–80138G06	10 uH, ±10%
L1504	24–82723H36	.41 uH, yellow
L1505	24–82835G14	1 uH, brown black
L1506	24–80138G06	10 uH, ±10%
L1507	24–82723H14	.075 uH, violet blue
connector plug		
P1501–1504	29–10134A70	lug connector
transistor (see note)		
Q1501	48–05128M31	NPN
Q1502	48–80182D39	NPN
Q1503	48–80141L01	PNP
resistor, fixed, ohm, 1/4 watt (unless otherwise stated)		
R1501	06–11077A29	10
R1502	06–11077A50	100
R1503	06–11077A26	10
R1504	06–11077A89	4.3k
R1505	06–11077A81	2k
R1506	06–11077A56	180
R1507	06–11077A34	22
R1508	06–11077A56	180
R1509	06–11077A81	2k
R1510	06–11077A70	680
R1511	06–11009E11	27, 1/4W
R1512	06–11077A74	1k
R1513	06–11077A89	4.3k
R1514	06–11077A60	270
R1515	06–11077A34	22
R1516	06–11077A60	270
R1517	06–11009E10	24, 1/4W
mechanical parts		
	04–00007607	flat washer, 2 used
	04–00139484	flat washer
	05–00136977	eye
	05–10344A20	pull pin rivet
	26–83595M01	detector shield, Cmponent side
	26–80189H01	transmit buffer shield
	26–80121A01	IF shield, 3 used
	29–10134A89	terminal lug
	37–00135566	1/4" heatshrink tubing
	37–00134165	3/8" heatshrink tubing
	42–84733F04	compression ring
	64–80191H03	transmit buffer plate
	75–82200H16	oscillator pad
	76–83466K01	ferrite

1/10/89

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

parts list

HLB4092A Directional Coupler — MXW–1715–B

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±5%, 63V (unless otherwise stated)		
C950	21–83596E36	.01, +60, –40%, 250V
C951	08–11051A07	.01
C953	21–11014H19	5.6 pF, ±.5 pF, 100V
C954–956	08–11051A07	.01
C957,958	08–11051A12	.068
diode (see note)		
CR950,951	48–84616A11	schottky
coil, RF		
L950–952	24–80139G05	10 uH
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R950	06–11009A25	100
R951	06–11009E25	100
R952,953	06–11045A25	100, 1/2W
R954,955	06–11009A25	100
transformer		
T950	25–80295H01	transformer
mechanical parts		
	37–00132026	3/16" heatshrink tubing

12/30/88

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

HLN4837A Directional Coupler Hardware — MXW–1716–A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF (unless otherwise stated)		
C961–963	21–82812H03	.001, +100, –10%, feedthru
connector receptacle		
J970	09–84066C02	contact
coil, RF		
L983,984	76–83466K01	ferrite
connector plug		
P952	15–84301K01	3 contact housing
mechanical parts		
	03–10943M16	tapping screw (3.5 x 0.6 x 10), 2 used
	04–80003F02	insulating washer, 3 used
	04–83755H01	shoulder washer, 3 used
	05–00135247	eye, 2 used
	09–84041D01	banana plug
	15–80107H01	directional coupler housing
	15–80108H01	directional coupler cover
	15–80196H01	antenna housing
	32–80284H01	directional coupler gasket
	37–00135566	1/4" heatshrink tubing
	37–00132562	1/8" heatshrink tubing
	39–82717M01	contact receptacle
	42–10217A02	nylon tie strap
	43–80294H02	PCB mounting spacer, 2 used
	43–82690M01	molded cap bushing
	43–82691M01	bushing
	54–84697B01	label

12/30/88

HLB4093A RF Power Transistors — MXW–1718–A

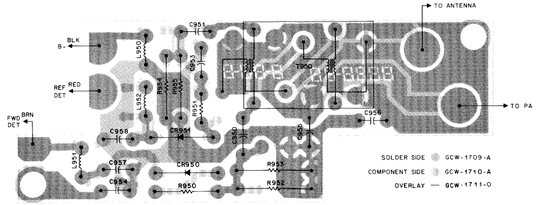
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 500V (unless otherwise stated)		
C817,818	21–84494B01	51
C842,843	21–84494B04	100
transistor (see note)		
Q802	48–00869583	NPN
Q803,804	48–84411L02	NPN
resistor, fixed, ohm, ±5%, 2 watt (unless otherwise stated)		
R808	17–82036G27	18

12/30/88

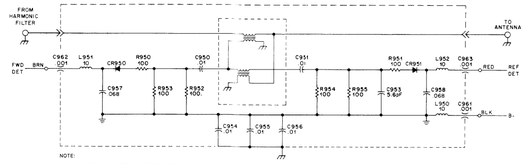
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

Schematics, Circuit Board Diagrams, and Parts Lists for Directional Coupler and Transmit Buffer
PW–3473–A
1/15/89

DIRECTIONAL COUPLER



SHOWN FROM SOLDER SIDE

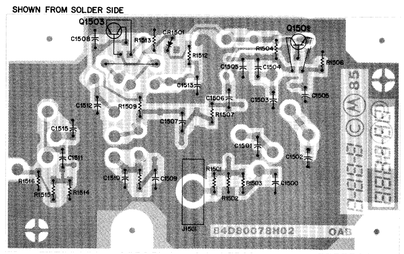


NOTE:
UNLESS OTHERWISE NOTED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL CAPACITANCES IN MICROFARADS, AND ALL INDUCTANCES IN MICROHENRIES.

GCW–1968–A

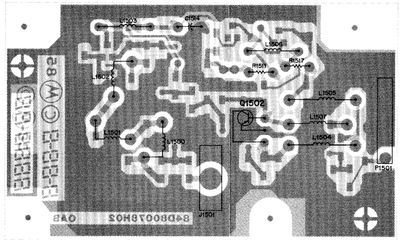
TRANSMIT BUFFER

SHOWN FROM SOLDER SIDE

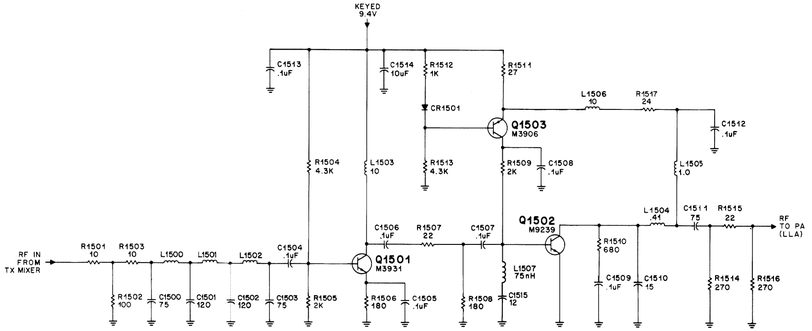


SOLDER SIDE GCW–1963–A
COMPONENT SIDE GCW–1964–A
OVERLAY GCW–1965–A

SHOWN FROM COMPONENT SIDE



SOLDER SIDE GCW–1963–A
COMPONENT SIDE GCW–1964–A
OVERLAY GCW–1965–A



NOTE:
UNLESS OTHERWISE INDICATED, ALL RESISTANCES ARE MEASURED IN OHMS, ALL INDUCTANCES IN MICROHENRIES, AND ALL CAPACITORS IN PICOFARADS

GCW–1934–B

Section Contents

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.

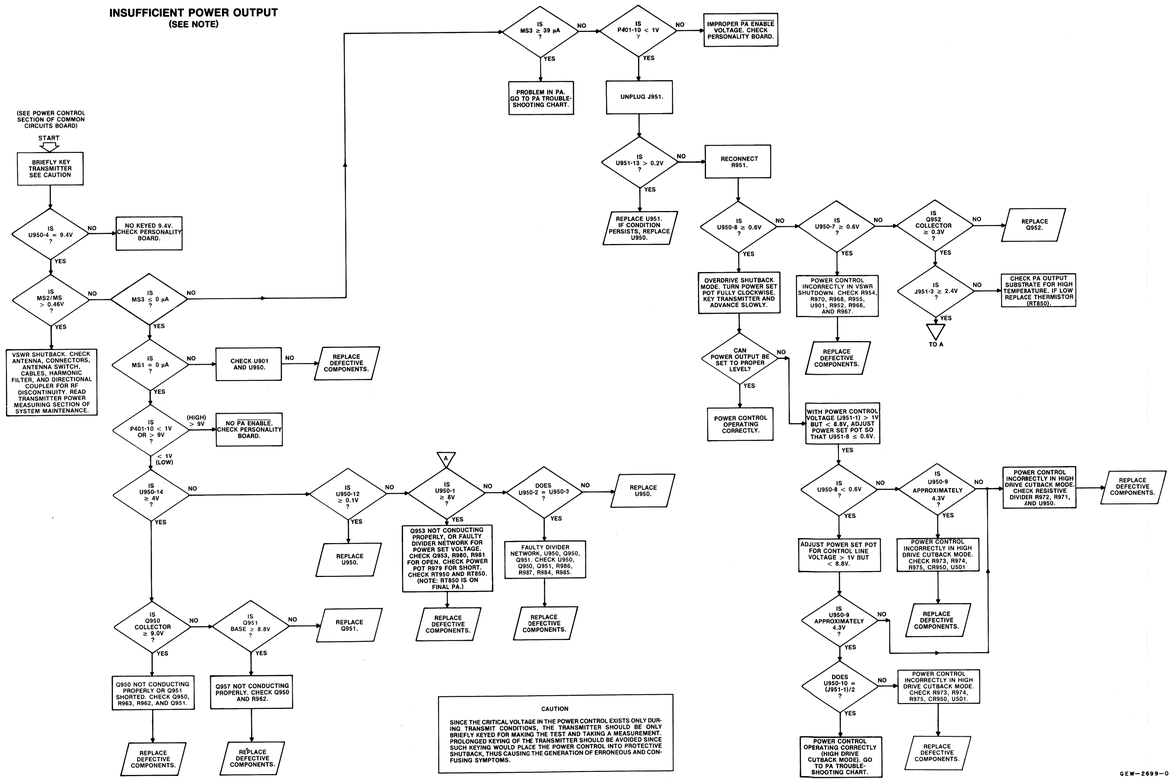
3.4 SWITCHED 5 VOLT REGULATOR FAILURE

(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)

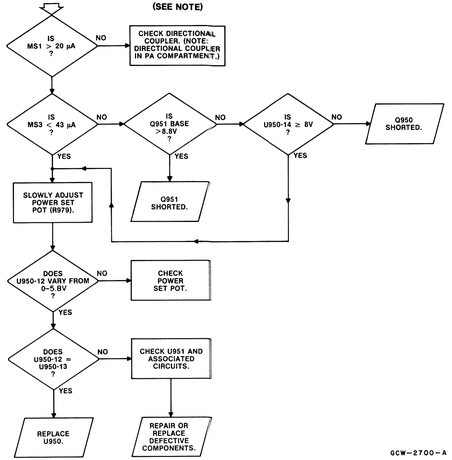


CAUTION

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.

GEW-2699-0

NO POWER CONTROL
(SEE NOTE)



GCW-2700-A

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

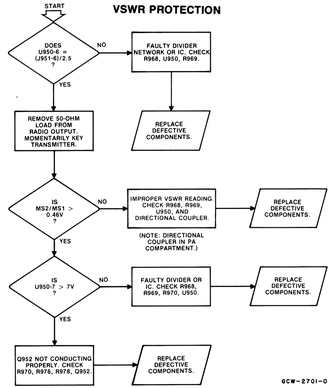
(C) HIGH-DRIVE PROTECTION

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

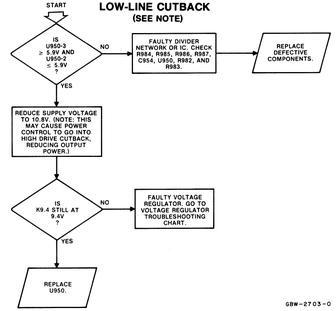
ALL VOLTAGE VALUES ARE REFERENCED TO A−.

VSWR PROTECTION



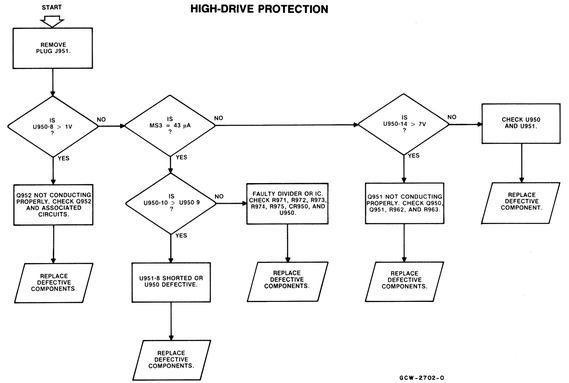
GCW-2701-0

LOW-LINE CUTBACK
(SEE NOTE)



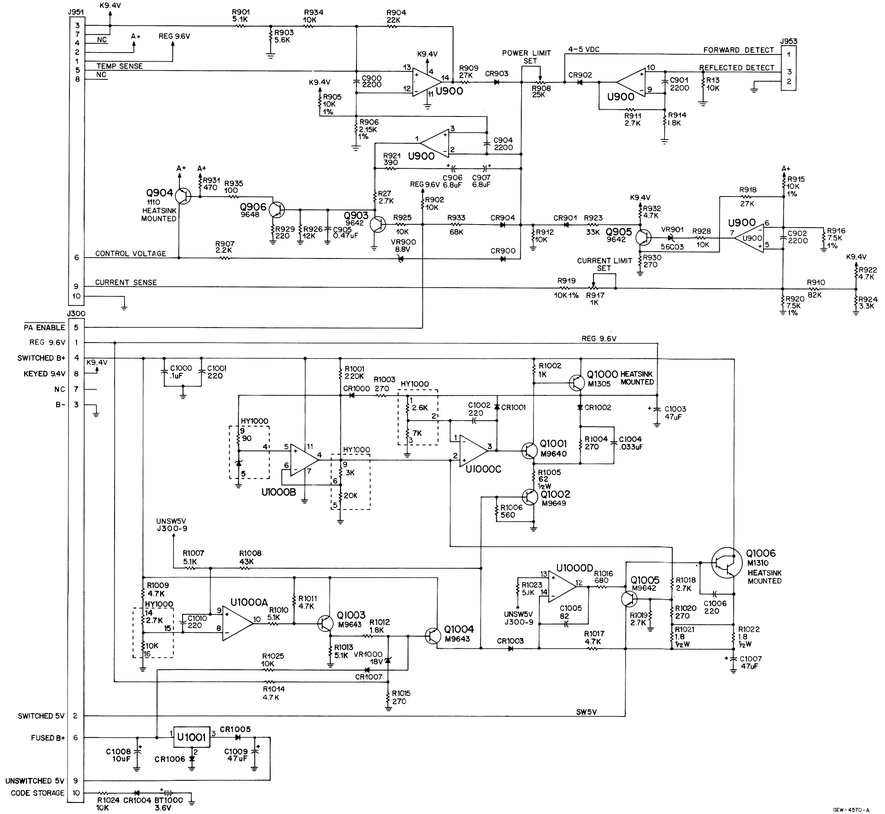
GBW-2703-0

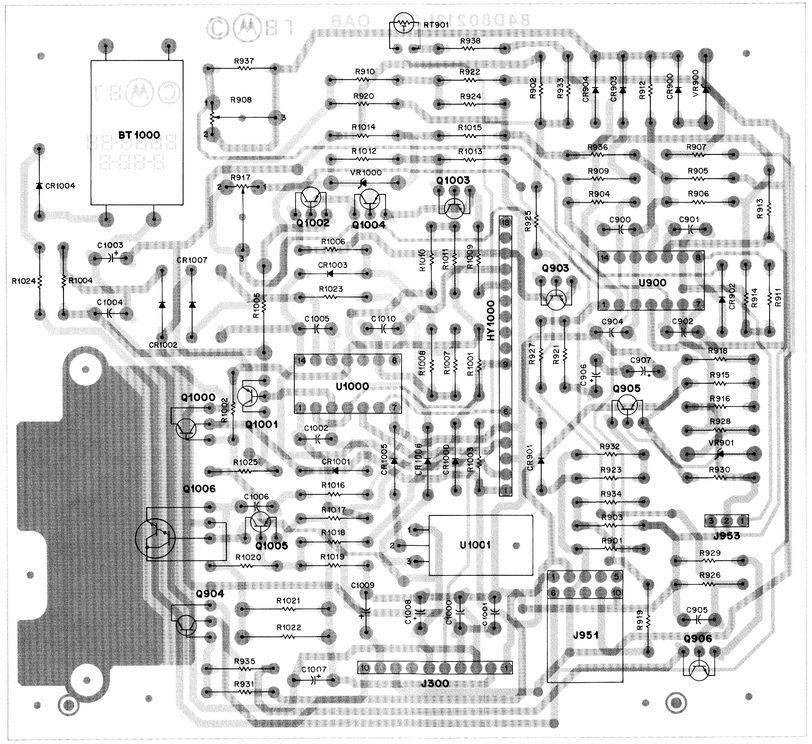
HIGH-DRIVE PROTECTION



GCW-2702-0

Troubleshooting Charts for Common Circuits Board
PW-2767-A
1/25/89





SHOWN FROM COMPONENT SIDE

SOLDER SIDE	GEW-4571-D
COMPONENT SIDE	GEW-4572-D
OVERLAY	GEW-4573-A

parts list

HLN5222B Common Circuits Board for Low Band — MXW-4574-A

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±10%, 100V (unless otherwise stated)		
C900–902	21–11015D17	.022
C904	21–11015D17	.022
C905	08–11051A17	47, ±5%, 63V
C906	23–11C54N06	3.3, 35V, tantalum
C907	23–11C54N06	3.3, 35V, tantalum
C1000	08–11051A13	1, ±5%, 63V
C1001,1002	21–11015B05	220 pF
C1003	23–11C19A39	47, ±20%, 16V, electrolytic
C1004	08–11051A10	.033, ±5%, 63V
C1005	21–11014B47	82 pF, ±5%
C1006	21–11015B05	220 pF
C1007	23–84338G06	47, ±20%, 20V, tantalum
C1008	23–11048C11	10, ±20%, 35V, electrolytic
C1009	23–84338G29	47, ±20%, 10V, tantalum
C1010	21–11015B05	220 pF
diode (see note)		
CR900–904	48–83654H01	silicon
CR1000–1007	48–83654H01	silicon
hybrid (see note)		
HY1000	01–80715D03	hybrid regulator assembly
connector receptacle		
J951	28–80052D01	male housing
J953	28–84324M02	3 contact
translistor (see note)		
Q903	48–00369642	NPN
Q905	48–00869642	NPN
Q906	48–00869648	NPN
Q1000	48–84413L05	PNP
Q1001	48–00869640	NPN
Q1002	48–00869649	PNP
Q1003,1004	48–00869643	PNP
Q1005	48–00369642	NPN
Q1006	48–84413L10	NPN
resistor, fixed, ohm, ±5%, 1/4 watt (unless otherwise stated)		
R901	06–11029A56	5.1k
R902	06–11009A73	10k
R903	06–11029A67	5.6k
R904	06–11009A81	22k
R905	06–11049C91	10k, ±1%, 1/4W
R906	06–10621C27	2.15K, ±1%, 1/4W
R907	06–11309A57	2.2k
R908	18–80087E01	25k potentiometer
R909	06–11009A83	27k
R910	06–11009A95	82k
R911	06–11009A59	2.7k
R912	06–11049C91	10k, ±1%, 1/4W
R913	06–11009A73	10k
R914	06–11009A55	1.8k
R915	06–11049C91	10k, ±1%, 1/4W
R916	06–11049C79	7.5k, ±1%, 1/4W
R917	18–80087E04	1k potentiometer
R918	06–11009A83	27k
R919	06–11049C91	10k, ±1%, 1/4W
R920	06–11049C79	7.5k, ±1%, 1/4W
R921	06–11009A39	390
R922	06–11009A65	4.7k
R923	06–11009A85	33k
R924	06–11009A61	3.3k
R925	06–11009A73	10k
R926	06–11009A75	12k
R927	06–11009A59	2.7k
R928	06–11009A73	10k
R929	06–11009A33	220
R930	06–11009A35	270
R931	06–11009A41	470
R932	06–11009A65	4.7k
R933	06–11009A93	68k
R934	06–11009A73	10k
R935	06–11009A25	100
R1001	06–11009B06	220k
R1002	06–11009A49	1k
R1003	06–11009A35	270
R1004	06–11009A35	270
R1005	06–11045A20	62, 1/2W
R1006	06–11009A43	560
R1007	06–11309A66	5.1k
R1008	06–11009A88	43k
R1009	06–11009A65	4.7k
R1010	06–11009A66	5.1k
R1011	06–11009A65	4.7k
R1012	06–11009A55	1.8k
R1013	06–11009A66	5.1k
R1014	06–11009A65	4.7k
R1015	06–11009A35	270
R1016	06–11009A45	680
R1017	06–11009A65	4.7k
R1018,1019	06–11009A59	2.7k
R1020	06–11009A35	270
R1021,1022	06–88037G07	1.8, 1/2W
R1023	06–11009A66	5.1k
R1024,	06–11009A49	1k
R1025	06–11009A73	10k
integrated circuit (see note)		
U900	51–80067C01	opamp
U1000	51–80067C04	opamp
U1001	51–80068C02	voltage regulator

MXW–4574–A (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
voltage regulator (see note)		
VR900	48–83256C56	8.8V
VR901	48–83256C03	4.7V
VR1000	48–83256C53	18V
mechanical parts		
	03–10911A11	machine screw (3 x 0.5 x 8)
	03–10943M15	tapping screw (3.5 x 0.6 x 8)
	04–84180C01	nylon shoulder washer
	05–80200K01	nylon rivet
	14–83820M02	heat conductive insulator
	26–84835M03	heat sink regulator
	54–80072G01	label
	75–80171L01	hybrid pad

1/10/89

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

Schematic, Circuit Board Diagram, and Parts List for HLN5222B Common Circuits Board

PW–4569–B

1/15/89

MOTOROLA

Control Unit, Cable Kits, and Accessories

Section Contents

Control Unit, Cable Kits and Accessories

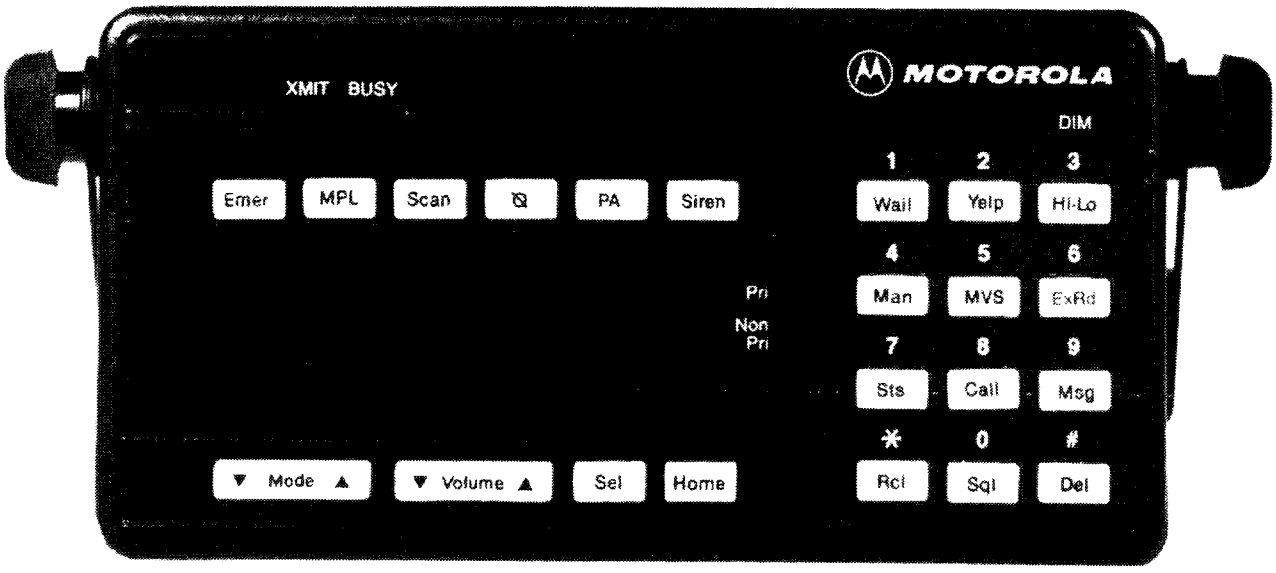


Figure 1. Typical Systems 9000 *Control Unit*

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).

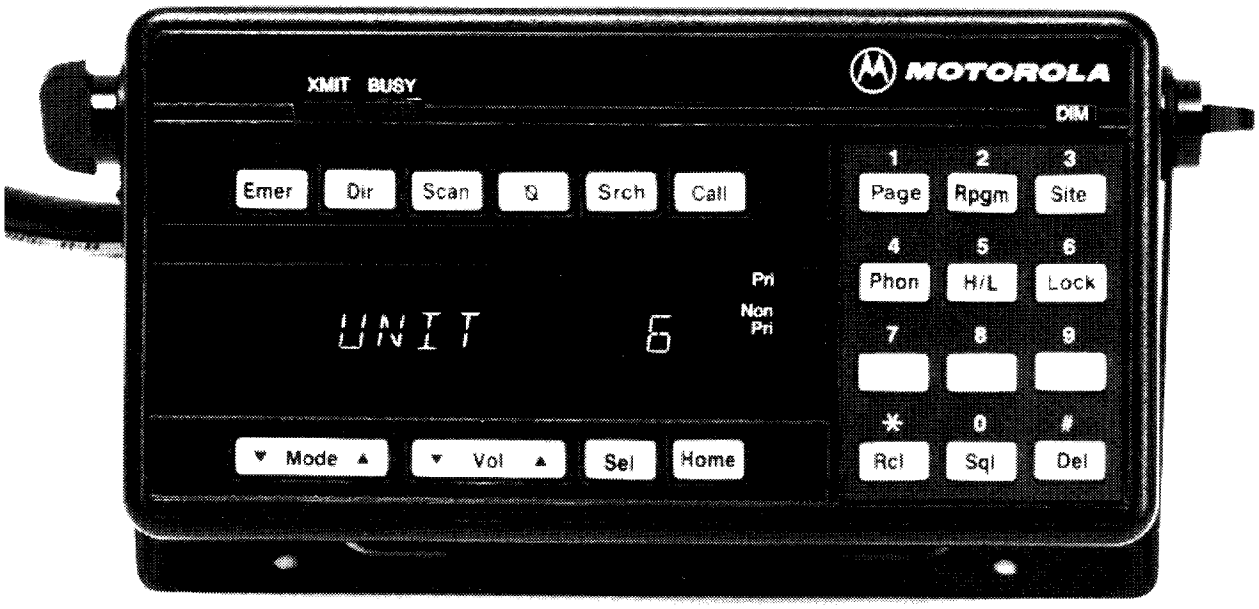
1.2 CONTROLS AND INDICATORS

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.



GPW–4141–A

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

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.

1.2.4 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.

1.2.5 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.

1.2.6 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.

1.2.7 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.

1.2.8 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.

1.2.9 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.

1.2.10 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 supply 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 discrete 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.

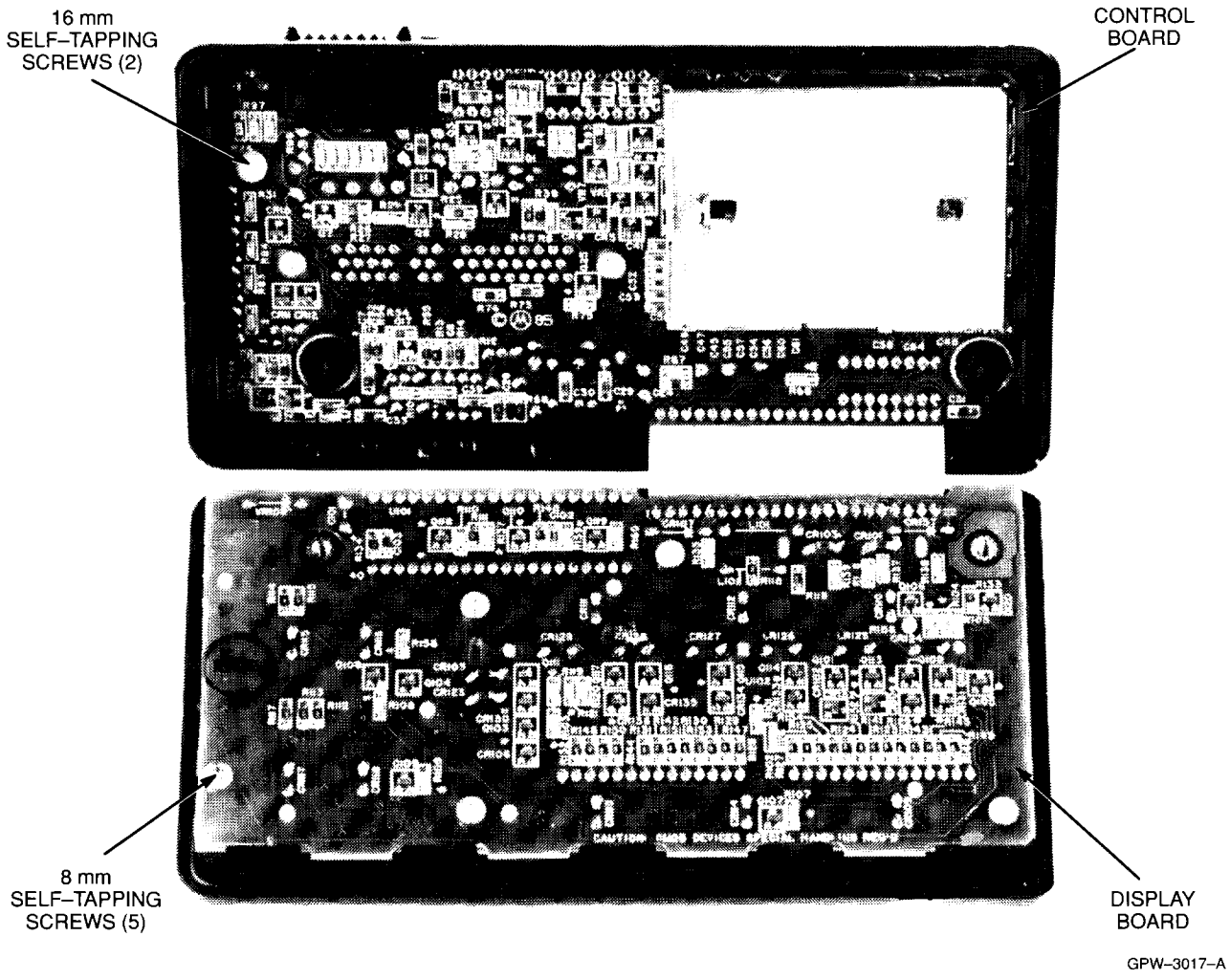


Figure 3. Disassembly of the Control Unit

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 outside 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 relay 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.

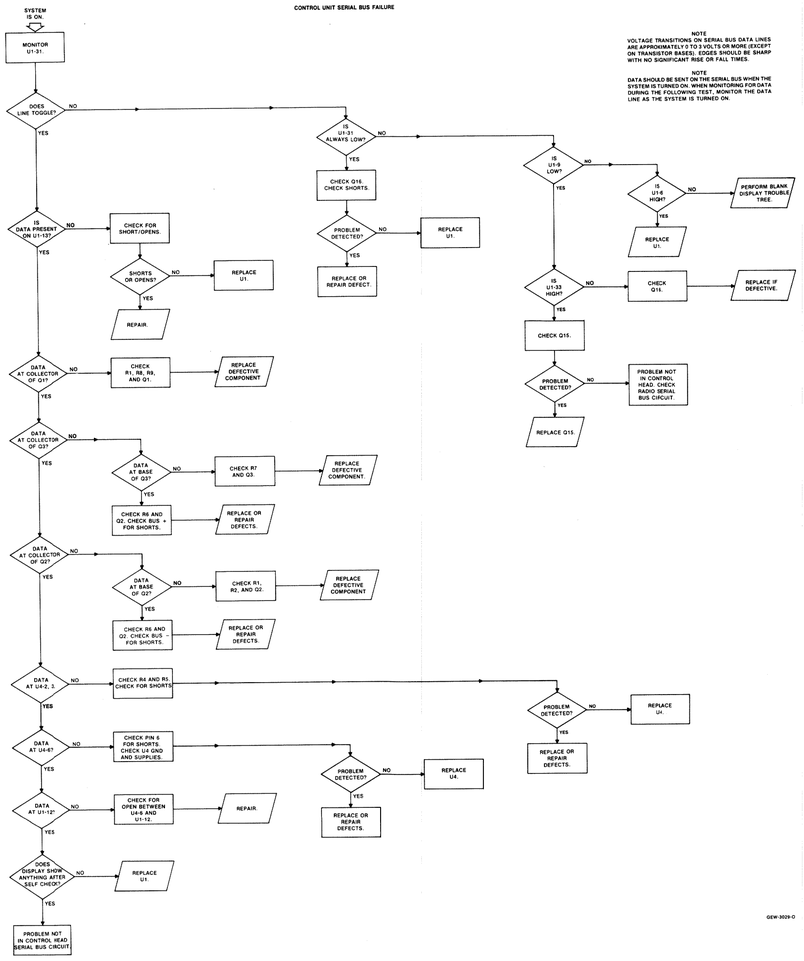
Pull all excess cabling into the trunk. Clamp the cables to the vehicle body or chassis with the cable clamps supplied. Drill 1/8" mounting holes, then attach the clamps with four #8 by 3/8" tapping screws and four 1/4" lockwashers. Finally, be sure all in–line fuses are installed.

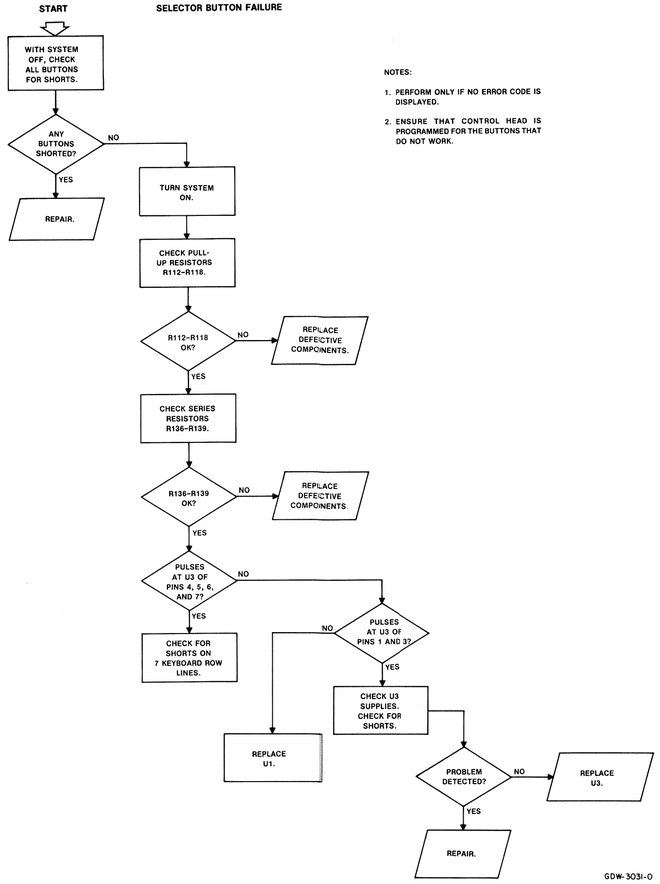
Table 3. VIP Output Connections

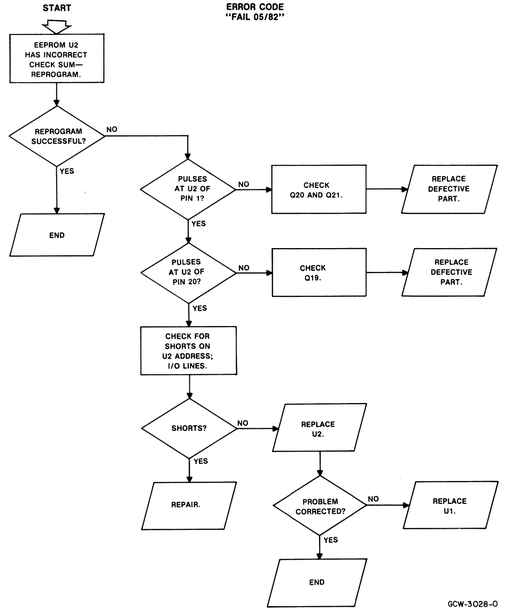
VIP OUTPUT NO.	SWITCHED B+ PIN NO.	ON/OFF SWITCH PIN NO.	DEFAULT FUNCTION IS CHANGED WITH FIELD PROGRAMMER
1	18	2	HORN RELAY (ALARM)
2	19	1	LIGHT RELAY (ALARM)
3	35	34	SIREN–HORN TRANSFER

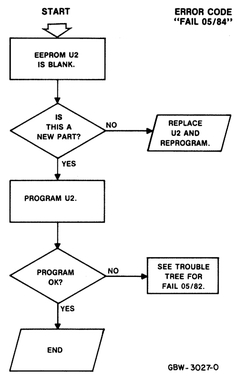
Table 4. VIP Input Connections

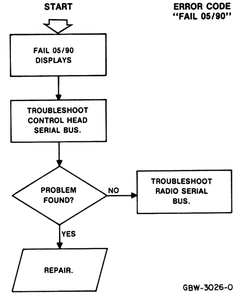
VIP INPUT NO.	GROUND PIN NO.	ON/OFF SWITCH PIN NO.	DEFAULT FUNCTION IS CHANGED WITH FIELD PROGRAMMER
1	20	4	SIREN; HORN RING
2	21	3	EMERGENCY (IF OPTION PRESENT)
3	36	37	NONE



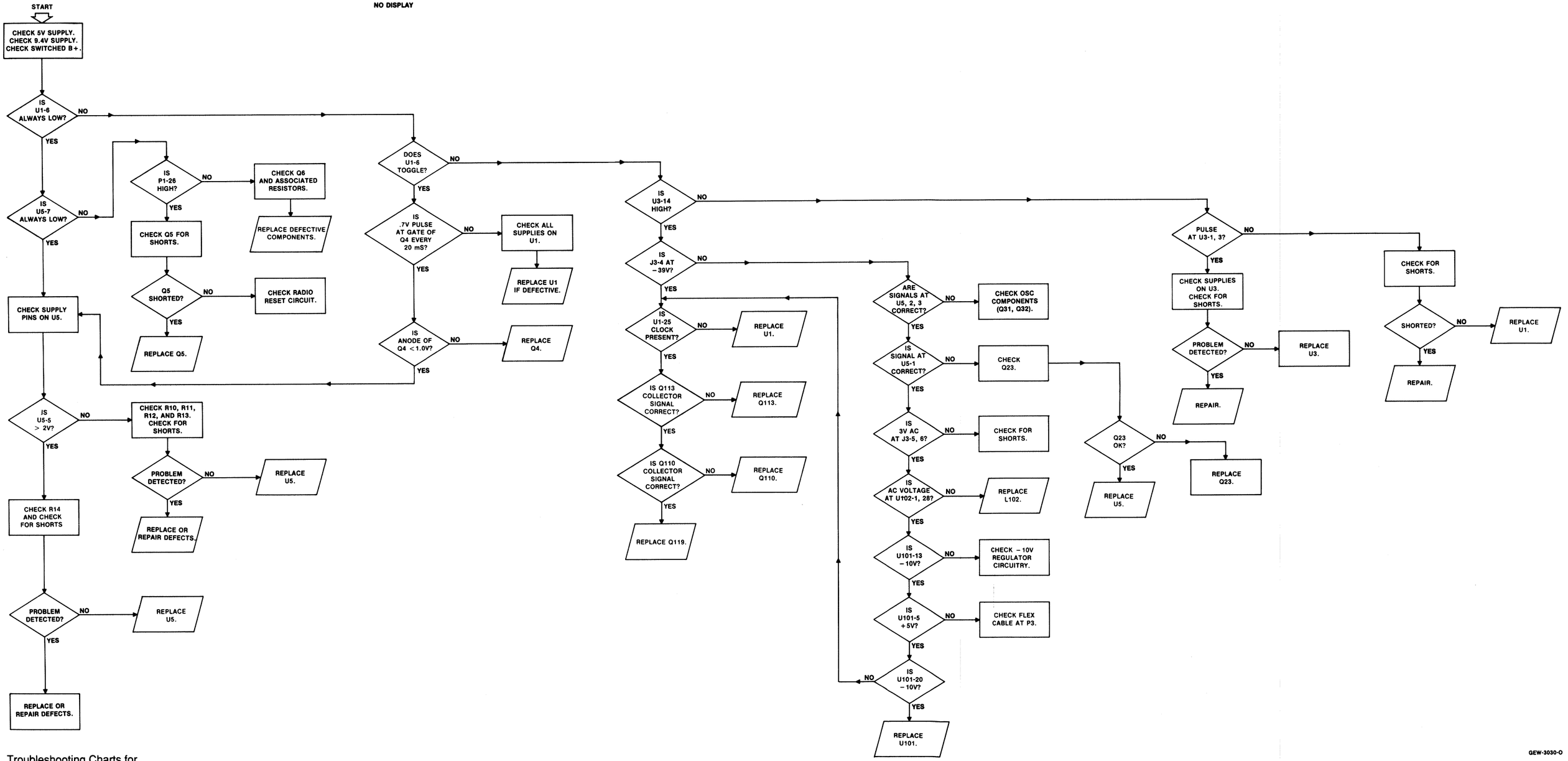








Troubleshooting Charts for
Systems 9000 Control Unit
PW–6220–O
(Sheet 1 of 2)
1/25/89



Troubleshooting Charts for
Systems 9000 Control Unit
PW–6220–O
(Sheet 2 of 2)
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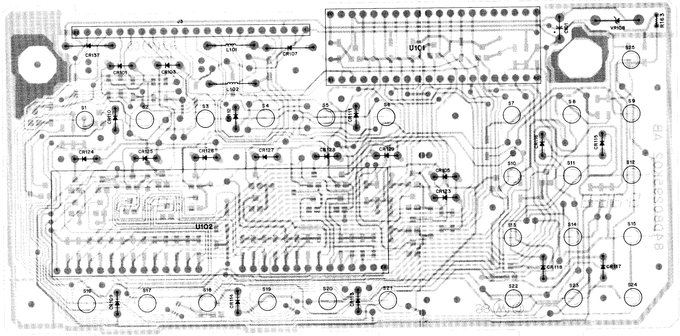
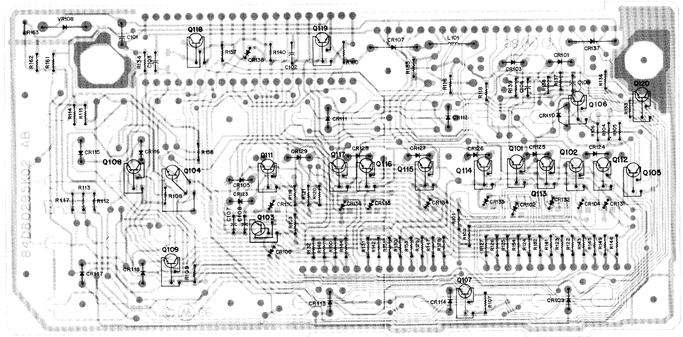
GEW-3030-O

DISPLAY BOARD



SOLDER SIDE — GDW-2513-B
COMPONENT SIDE — GDW-2513-B
OVERLAY — GDW-2514-C

COMPONENT SIDE VIEW



SOLDER SIDE — GDW-2510-B
COMPONENT SIDE — GDW-2510-B
OVERLAY — GDW-2514-C

SOLDER SIDE VIEW

parts list

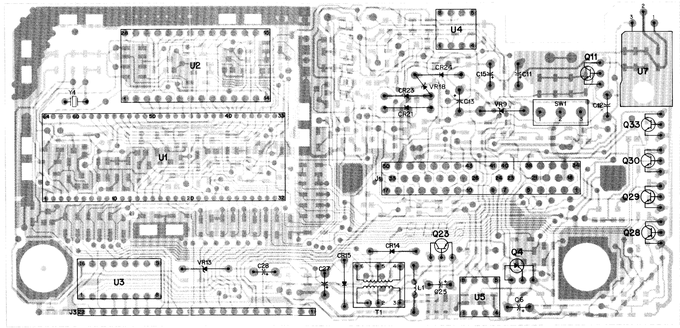
HLN4907D Control Unit (Display Board)
HLN4896C Control Unit (Display Board) — MXW–2568–D

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±10%, 100V (unless otherwise stated)		
C101	23–11048C11	10 uF, +20%, 35V, electrolytic
C102	21–13741N21	.001 uF, ±10%, 50V
C103	21–11032B13	.1 uF +80, –20% 50V
C105–108	21–11032B13	.1 uF +80, –20% 50V
diode (see note)		
CR101	48–80026P03	red LED
CR102	48–80236E08	dual
CR103	48–80026P04	yellow LED
CR104	48–80236E08	dual
CR105	48–80026P03	red LED
CR106	48–80236E08	dual
CR107	48–83654H01	silicon
CR109–118	48–80249K04	green LED
CR123	48–80026P04	yellow LED
CR124–129	48–80026P03	red LED
CR130–136	48–80236E08	dual
CR137	48–84616A11	silicon
CR139	48–80236E08	dual
coil, RF		
L101	24–11047A44	390 uH
L102	24–80138G07	15 uH, +5%
transistor (see note)		
Q101–103	48–82233P13	NPN
Q104	48–80141L04	NPN
Q105–109	48–82233P13	NPN
Q111–120	48–82233P13	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
R110,111	06–11077A01	0 ohm jumper
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
R159	06–11077A01	0 ohm jumper
R160	06–11077B11	33k
R161	06–11077A94	6.8k
R162	06–11077A92	5.6k
R163	06–83600K09	100k, +15%, thermistor
R164	06–11077A98	10k
R200	06–11077A74	1k
R201	06–11077A94	6.8k
integrated circuit (see note)		
U101	51–80236C04	display driver
U102	72–80240J01	vacuum–fluorescent display
voltage regulator (see note)		
VR106	48–82256C67	10V zener, 1W
non–referenced parts		
—	84–80294K02	display circuit board

6/6/90

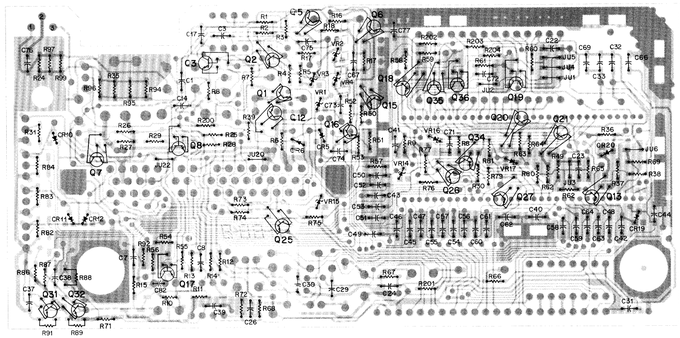
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

CONTROLLER BOARD



SOLDER SIDE — GDW–2516–C
COMPONENT SIDE — GDW–2517–C
OVERLAY — GDW–2518–E

COMPONENT SIDE VIEW



SOLDER SIDE — GDW–2516–C
COMPONENT SIDE — GDW–2517–C
OVERLAY — GDW–2518–E

SOLDER SIDE VIEW

parts list

HLN4907D Control Unit (Controller Board) — MXW–2528–G

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%, electrolytic
C7	21–11032B01	.001, +80, –20%
C8	21–13740B57	220 pF
C11	23–11048C10	10, ±20%, electrolytic
C12,13	23–11048C05	1, ±20%, 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	23–13749D79	10, ±10%, tantalum
C26	21–11032B13	.1, +80, –20%
C27,28	23–11048C10	10, ±20%, electrolytic
C29,30	21–11032B01	.001, +80, –20%
C31	21–11032B13	.1, +80, –20%
C32	21–13740B34	24 pF
C33	21–13740B51	180 pF
C37,38	21–13740B71	820 pF
C39–66	21–13740B60	300 pF
C67	21–13741N45	.01, ±10%
C69	21–13740B19	5.6 pF
C71	21–13741N45	.01, ±10%
C72	21–13740B39	39 pF
C73–76	21–13740B57	220 pF
C77	21–13740B60	300 pF
C78–80	21–13741N45	.01, ±10%
C81	21–13740B60	300 pF
C82	21–13740B57	220 pF
diode (see note)		
CR5,6	48–80236E08	dual
CR10–12	48–80236E08	dual
CR14,15	48–83654H01	silicon
CR19,20	48–80236E08	dual
CR21	48–82466H18	rectifier
CR23	48–84616A11	silicon
CR24	48–82178A01	germanium
connector receptacle		
J1	28–80228J01	50 position D connector
jumper		
JU2	06–11077A01	0 ohm resistor
JU4	06–11077A01	0 ohm resistor
JU6,7	06–11077A01	0 ohm resistor
JU23	06–11077A01	0 ohm resistor
coil, RF		
L1	24–80138G04	5.6 uH, ±5%
transistor (see note)		
Q1	48–82233P14	PNP
Q2	48–80141L03	PNP
Q3	48–80141L04	NPN
Q4	48–11043C30	SCR
Q5	48–80141L03	PNP
Q6	48–80141L04	NPN
Q7	48–80141L04	NPN
Q8	48–80141L04	NPN
Q11	48–11043C27	NPN
Q12	48–80141L04	NPN
Q13	48–82233P14	PNP
Q15	48–80141L03	PNP
Q16	48–80141L04	NPN
Q17,18	48–80141L03	PNP
Q19	48–82233P13	NPN
Q20	48–80202K01	PNP
Q21	48–82233P13	NPN
Q23	48–00897D32	PNP
Q25–27	48–80141L03	PNP
Q28–30	48–11043C11	NPN
Q31,32	48–82233P13	NPN
Q33	48–11043C05	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
R4,5	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
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

MXW–2528–G (2)

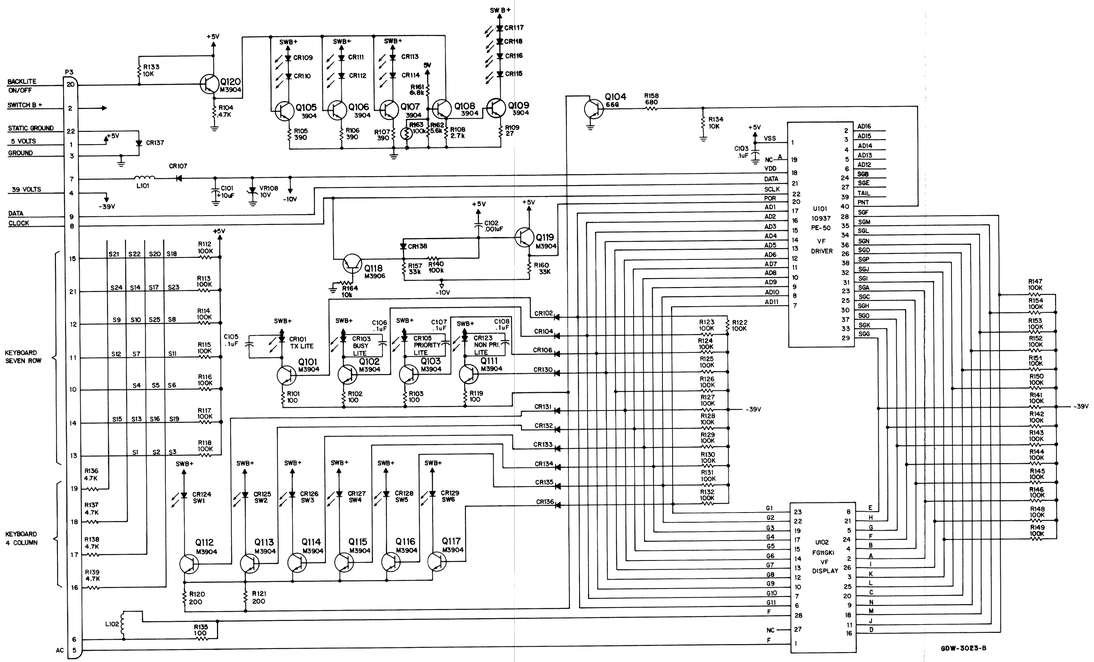
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R36–38	06–11077A82	2.2k
R39	06–11077A98	10k
R49	06–11077B15	47k
R50	06–11077A90	4.7k
R51	06–11077A86	3.3k
R52	06–11077A90	4.7k
R53	06–11077A74	1k
R54	06–11077B07	22k
R55	06–11077A98	10k
R56	06–11077A90	4.7k
R57,58	06–11077A98	10k
R59	06–11077B15	47k
R60	06–11077A90	4.7k
R61,62	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	25–80277J03	voltage conversion
integrated circuit (see note)		
U1	——	radio software (see model chart)
U2	——	EEPROM software (see model chart)
U3	51–83627M42	bipolar
U4	51–80067C05	opamp
U5	51–80046K01	voltage comparator
U7	51–80068C02	voltage regulator
voltage regulator (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
VR18	48–11034A21	18V zener
crystal (see note)		
Y1	48–80173D12	4.9152 MHz
non–referenced parts		
—	29–10134A68	connector lug, 6 used
—	29–10134A70	connector lug, 6 used
—	09–80202K01	socket
—	09–82808R10	28 contact socket
—	32–80181J01	face connector gasket
—	75–80094M04	battery shock pad
—	75–80094M05	VF shock pad
—	75–80129N01	crystal mounting pad
—	43–80011L01	8 position LED spacer
—	43–80012L01	2 position LED spacer
—	05–80206K01	nylon rivet
—	32–80179J01	D connector gasket
—	54–80111F01	PWDM label
—	75–80098J01	keypad
—	84–80296K04	controller circuit board

6/6/90

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

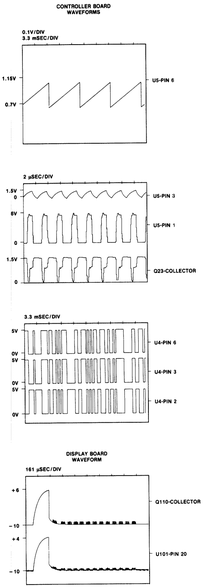
Schematics, Circuit Board Diagrams, and Parts Lists for the Control Unit
PW–6186–E
(Sheet 1 of 2)
6/10/90

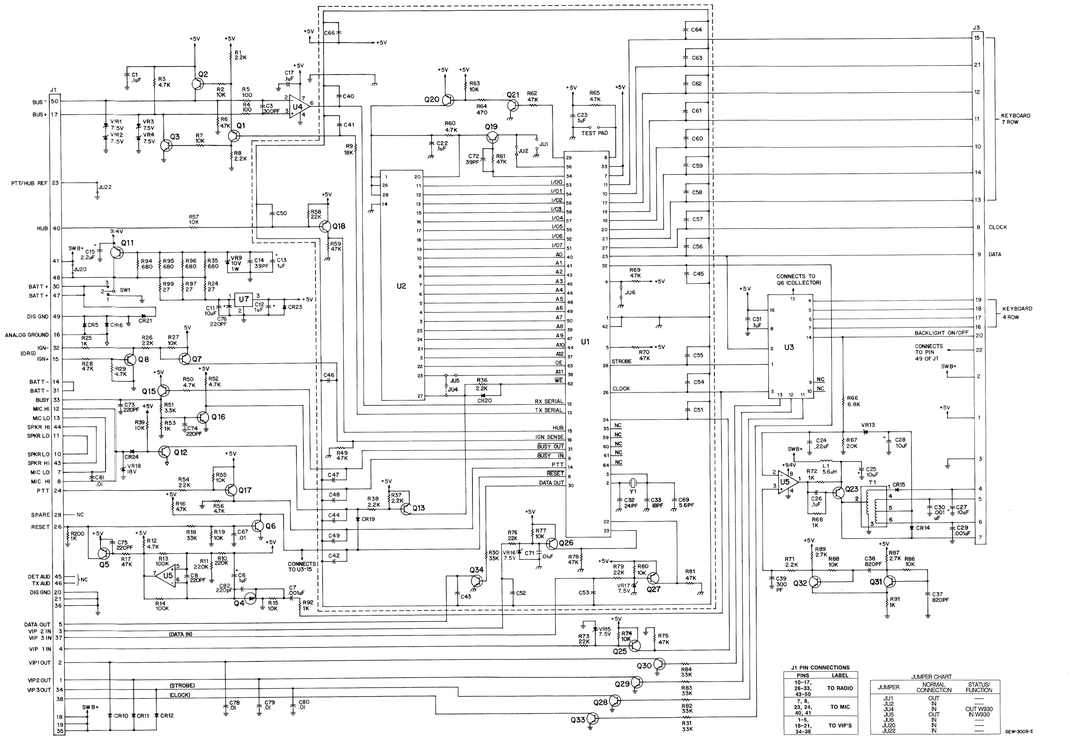
DISPLAY BOARD

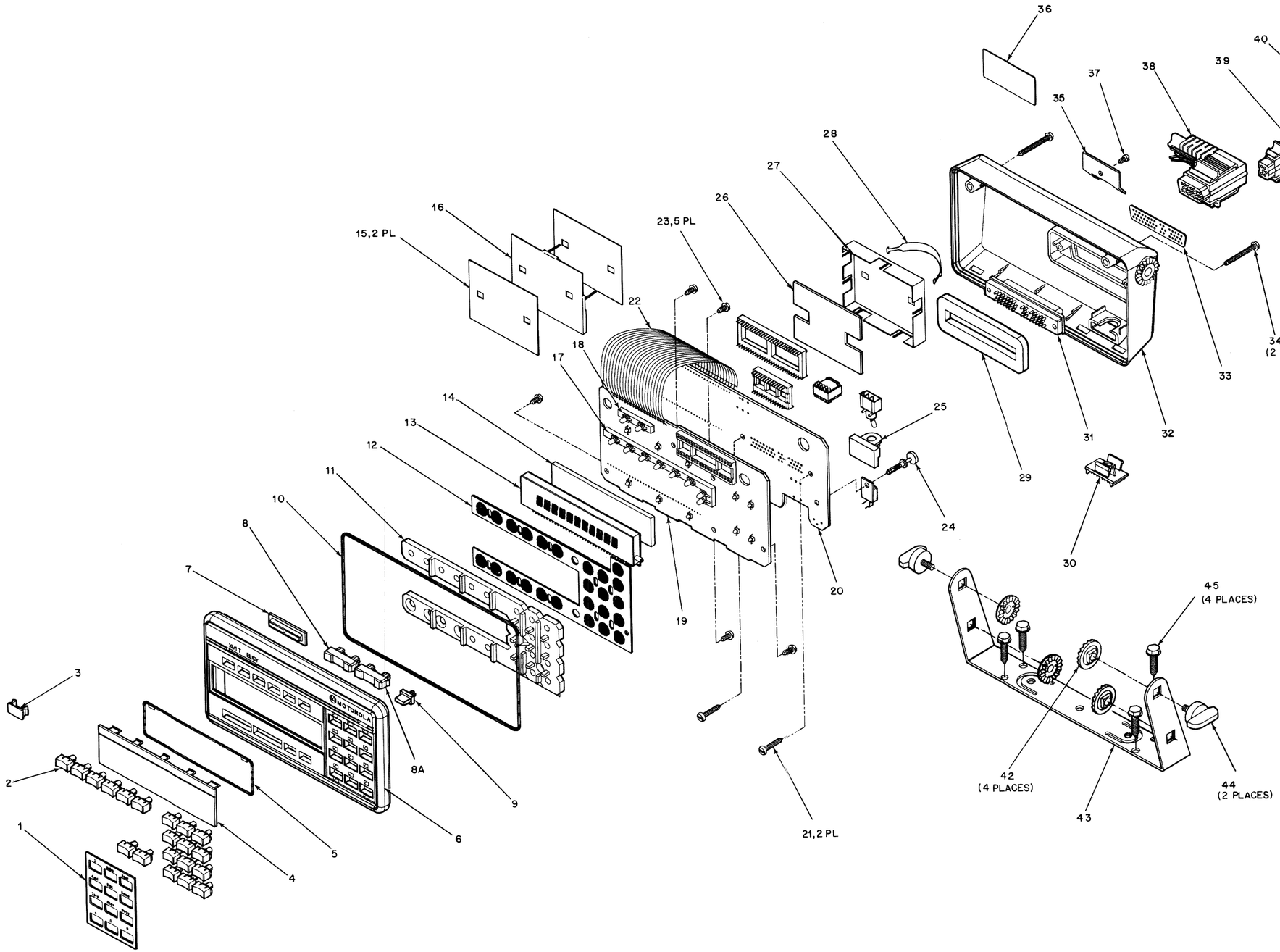


Schematics, Circuit Board Diagrams, and Parts Lists for the Control Unit
PW–6186–E
(Sheet 2 of 2)
6/10/90

CONTROLLER BOARD







GDW-2365-B

parts list

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

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	32–80057K02	lens gasket
6	15–80088J01	front housing
7	61–80097J01	LED lens
8	38–80195P03	mode rocker top
8A	38–80195P04	volume rocker top
9	38–80092J01	dimmer key top
10	32–80180J02	housing gasket
11	61–80185J02	keyboard lightpipe
12	75–80098J01	elastomeric keypad
13	72–80242J01	VF display
14	75–80094M04	VF shock pad, 3 used
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	15–80221J01	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

3/31/90

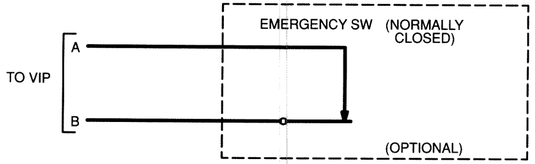
Exploded View and Parts List
for Control Unit
PW–2425–G
3/31/90

parts list

HKN4241A 17' Negative Ground Cable Kit — MXW–2046–A

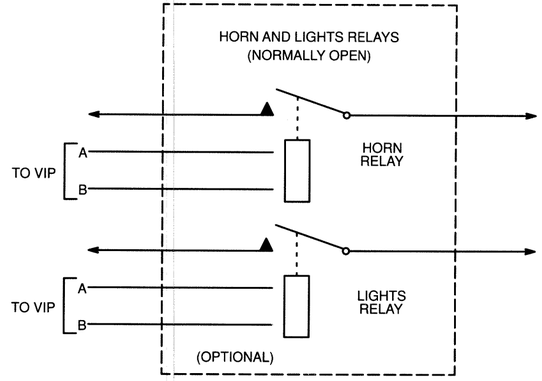
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	01–80739T54	17' cable assembly
	29–84528B05	lug
	30–00851875	battery cable, black
	01–80701T89	66" black lead and lug assembly
	09–84151B03	contact receptacle
	09–84151B05	contact receptacle
	30–80229N01	radio cable
	39–10184A44	contact receptacle, 2 used
	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

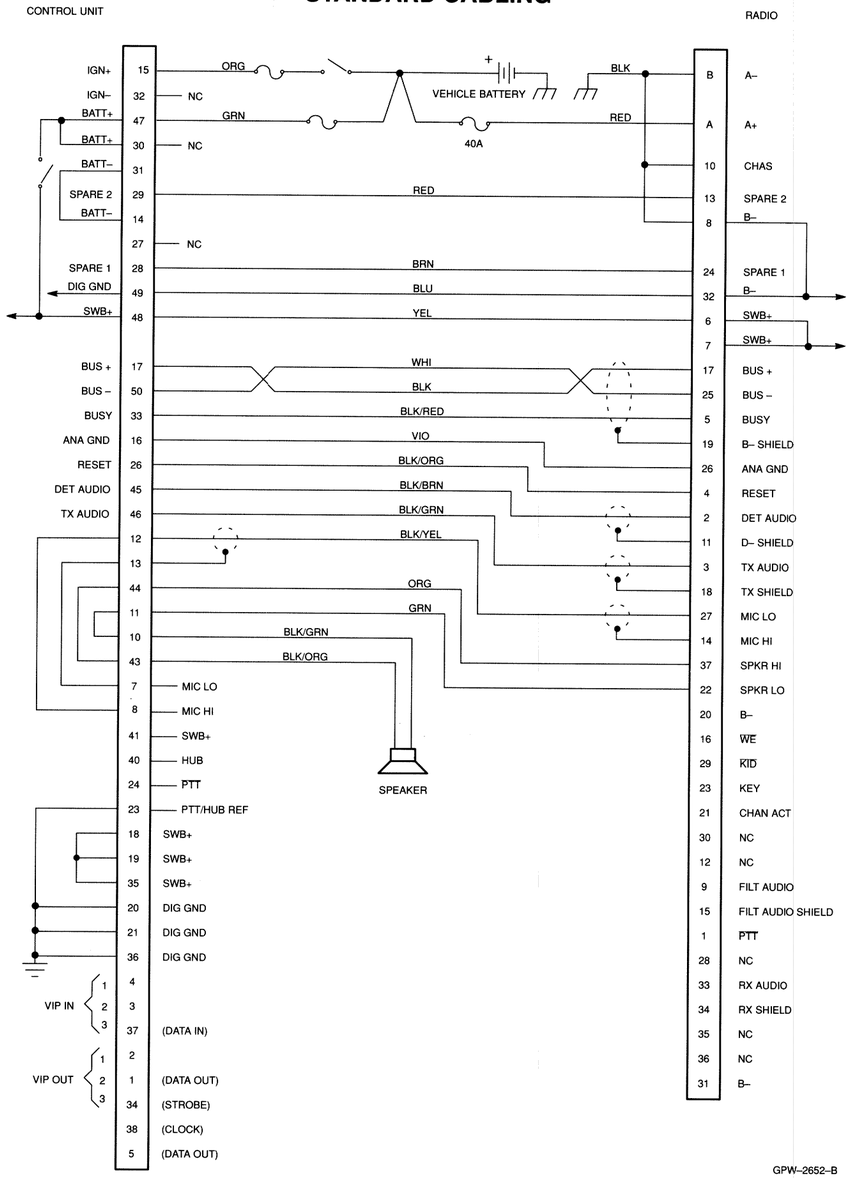


NOTE:
VIP OUTPUTS ARE PROGRAMMABLE. ONE CONTACT OF THE RELAY SHOULD BE CONNECTED TO THE VIP OUTPUT PROGRAMMED FOR THE RELAY AND THE OTHER CONTACT TO SW B+ PINS 18, 19, OR 35.

GPW–3003–A

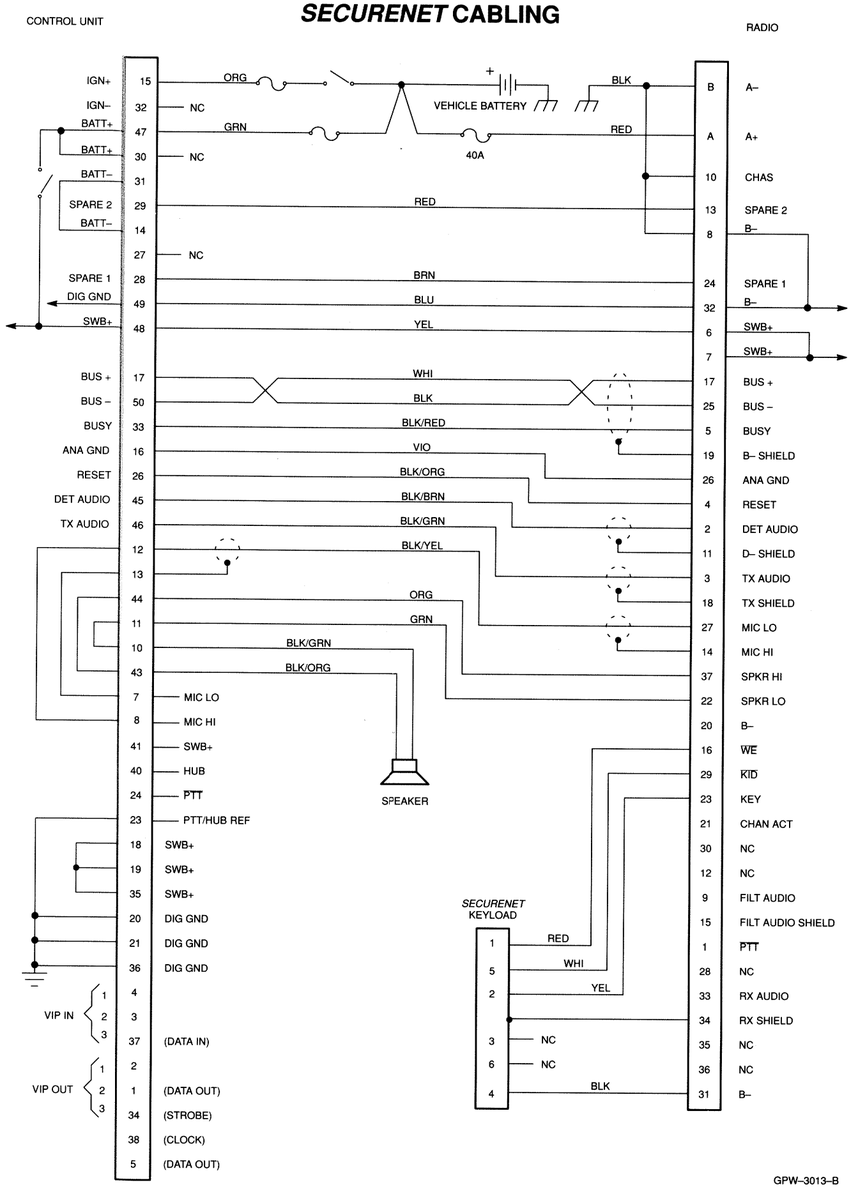
Negative Ground Cable Wiring Diagrams
PW–2779–D
7/14/89

STANDARD CABLING

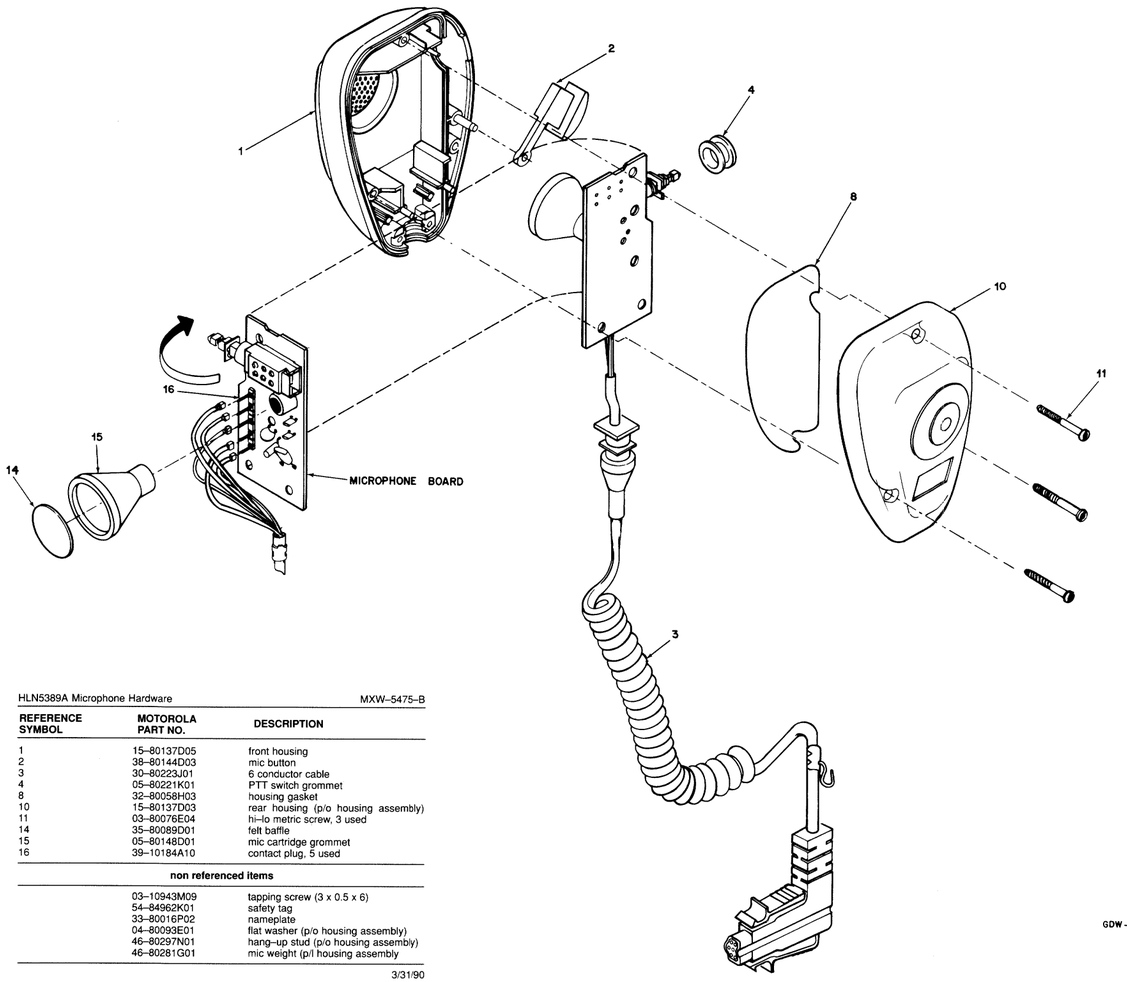


GPW–2652–B

SECURENET CABLING



GPW–3013–B



GDW-2049-A

HLN5389A Microphone Hardware MXW–5475–B

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
	33–80016P02	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

3/31/90

HLN4384B MICROPHONE BOARD (EARLY VERSION)

parts list

HLN4384B Microphone Circuit Board MXW–2051–D

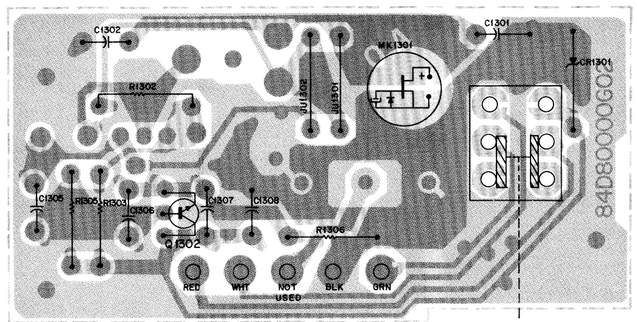
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, uF, ±5%, 50V (unless otherwise stated)		
C1301	21–11038H35	27 pF
C1302	21–11039B13	.001, ±10%
C1304	23–11019A20	10, ±20%, 25V, electrolytic
C1305	08–11051A11	.047, 63V
C1306	21–11038P50	220
C1307	21–11039B13	.001, ±10%
C1308	08–11051A14	.15, 63V
diode (see note)		
CR1301	48–82256C25	12V zener
jumper		
JU1301,1302	06–11009B23	0 ohm
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
	non–referenced parts	
	05–80148D01	cartridge grommet

9/29/89

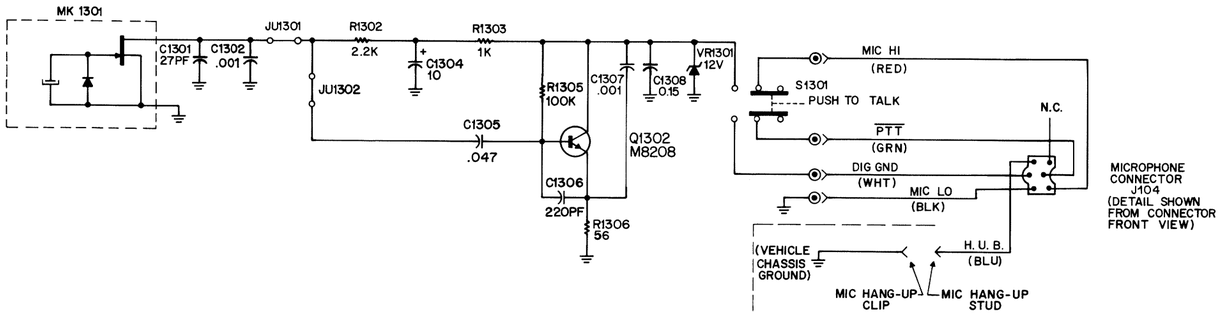
note: For best performance, order diodes, transistors, and integrated circuit devices by Motorola part number.

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.

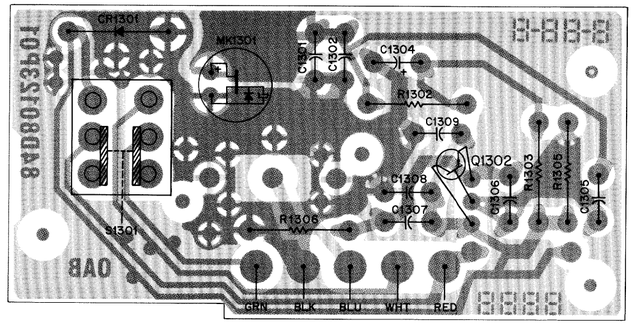


COMPONENT SIDE – GBW-3447-A
SOLDER SIDE – GBW-3448-A
OVERLAY – GBW-3449-A



GCW-2050-A

HLN5459A MICROPHONE BOARD (LATER VERSION)



SOLDER SIDE — GBW-6287-O
COMPONENT SIDE — GBW-6288-O
OVERLAY — GBW-6289-O

parts list

HLN5459A Microphone Circuit Board — MXW-6286-O

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	08-11051A11	.047
C1306	21-11038P50	220 pF
C1307	21-11039B13	.001 ±10%
C1308	08-11051A14	.15 63V
C1309	21-11014H44	62pF, 100V
diode (see note)		
CR1301	48-11034A36	12V zener ±5% 400mW
microphone		
MK1301	50-80258E04	electret cartridge
transistor (see note)		
Q1302	48-11043C05	NPN
resistor, fixed ohm, ±5%, 1/4 watt (unless otherwise stated)		
R1302	06-11009A57	2.2k
R1303	06-11009A49	1k
R1305	06-11009A97	100k
R1306	06-11009A19	56
switch		
S1301	40-80065E02	momentary switch
mechanical part		
	14-80652E01	switch insulator

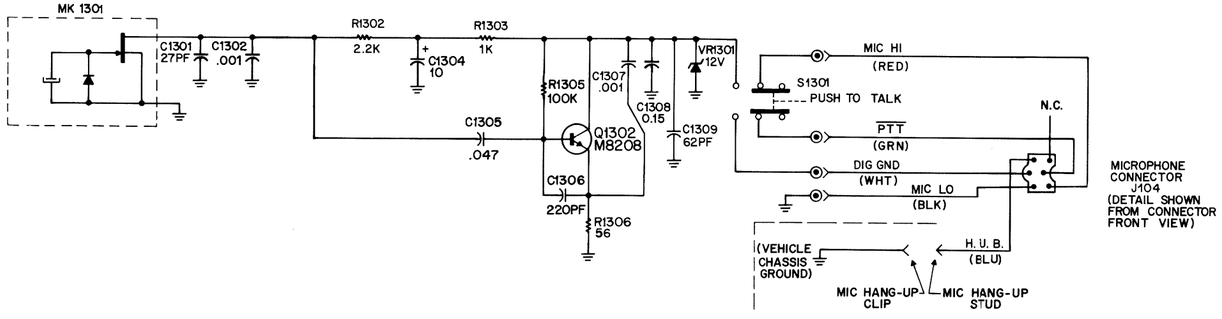
2/15/89

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

HLN5389A Microphone Hardware — MXW-5475-B

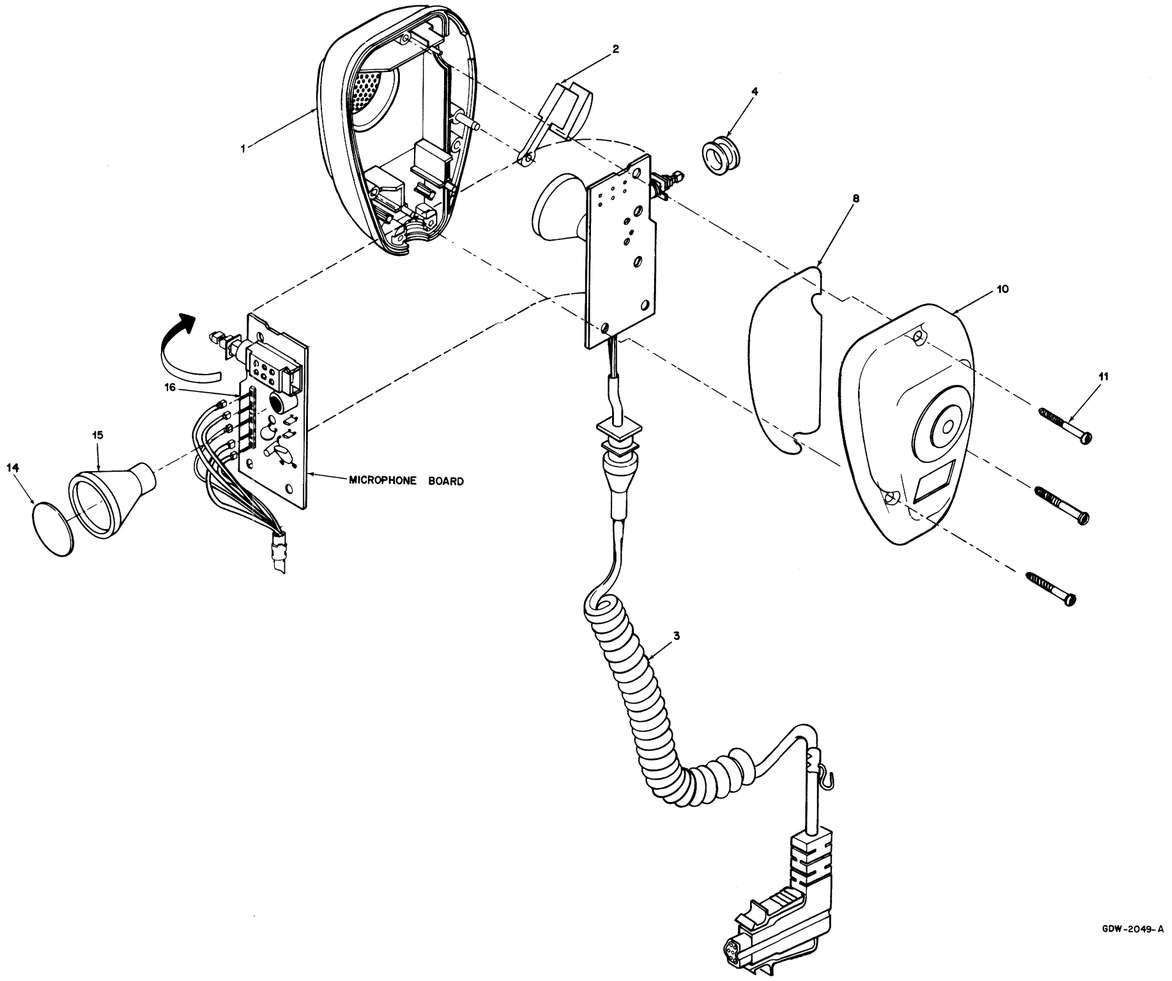
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	15-80137D05	front housing
2	38-80144D03	mic button
3	30-80223J01	6 conductor cable
4	05-80221K01	PTT switch grommet
8	32-80058H03	housing gasket
10	15-80137D03	rear housing (p/o housing assembly)
11	03-80076E04	hi-lo metric screw, 3 used
14	35-80089D01	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
	33-80016P02	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

3/31/90



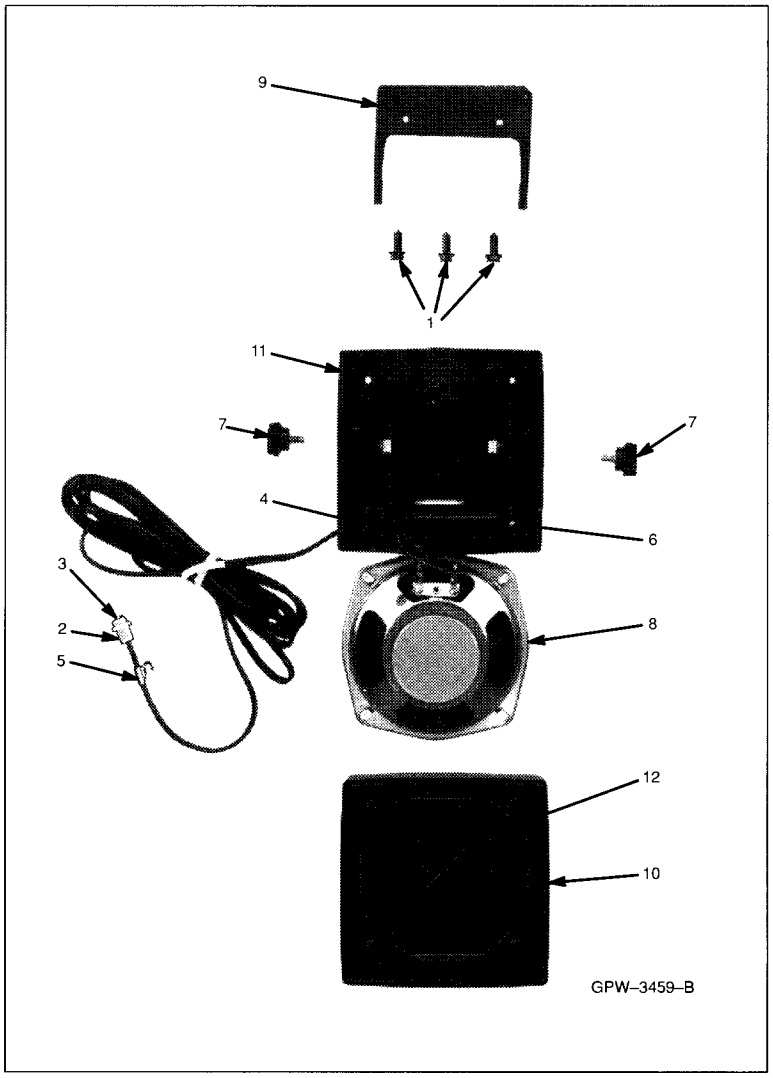
GCW-6290 O

MICROPHONE CONNECTOR J104 (DETAIL SHOWN FROM CONNECTOR FRONT VIEW)



GDW-2049-A

HSN4018A SPEAKER AND ACCESSORIES



parts list

HLN4022C Installation Kit — MXW–6475–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
	03–12002A28	screw, self–drilling, 1/4–14 x 1–1/2" (3 used)
	04–00007688	lockwasher, 1/4
	29–00812980	terminal, closed–end
	37–00081057	grommet, rubber, 1/2"
	42–80366B66	cable tie (10 used)
	43–82292M01	bushing, spacer (3 used)

4/11/89

HSN4018A Speaker — MXW–2053–D

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	50–84561B01	speaker
9	07–80200E01	black speaker trunnion bracket
10	13–82671M04	bezel
11	15–84981B07	speaker base cover
12	32–84564B01	speaker gasket

3/31/89

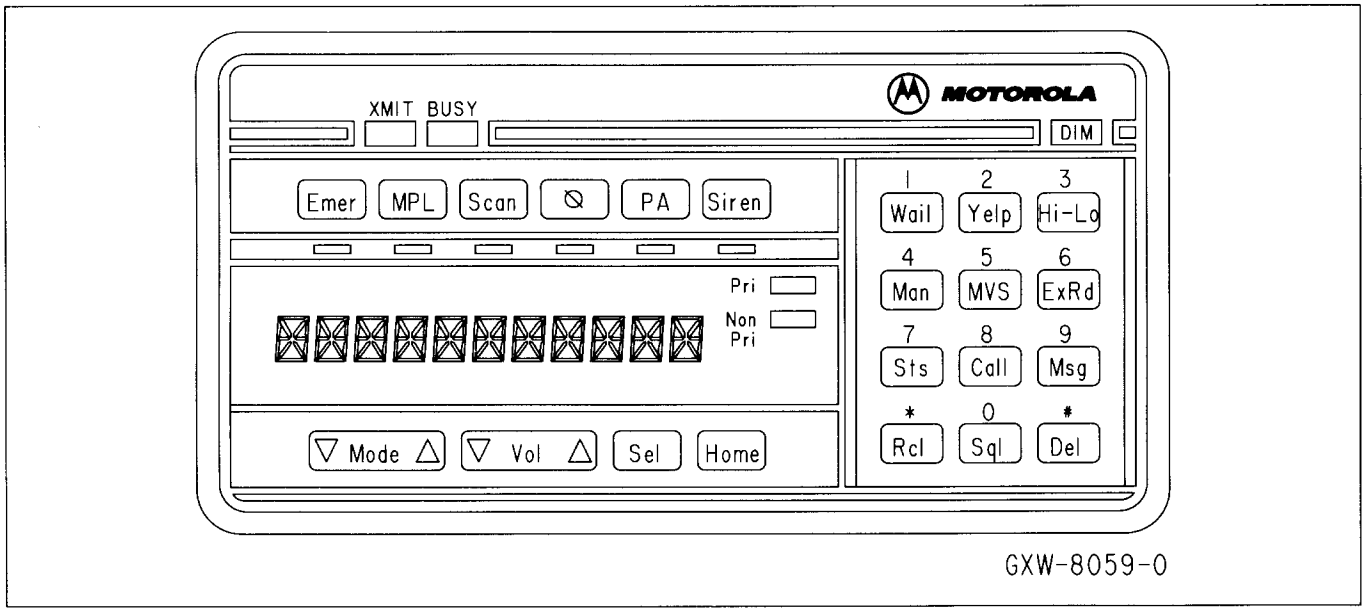


Figure 1. Typical Systems 9000 *Control Unit*

1. Description

1.1 GENERAL

Note

A variety of Motorola's 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

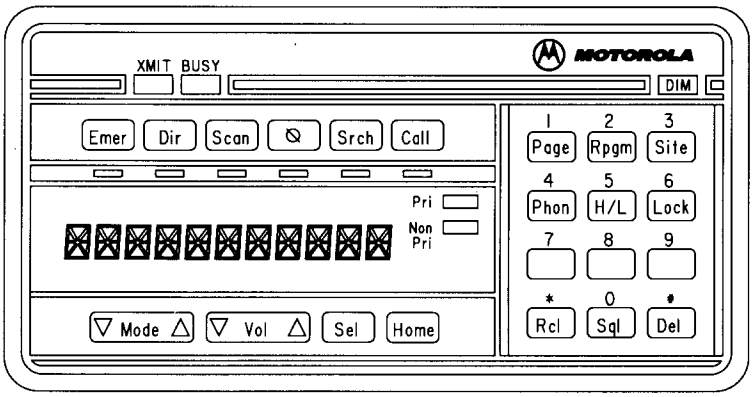
The eleven–character vacuum fluorescent display's primary function is to display mode numbers, mode names, volume level, and the status of options. It also functions as an on–off indicator for the entire system, and plays an integral role in the operator's reconfiguration of options.

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.

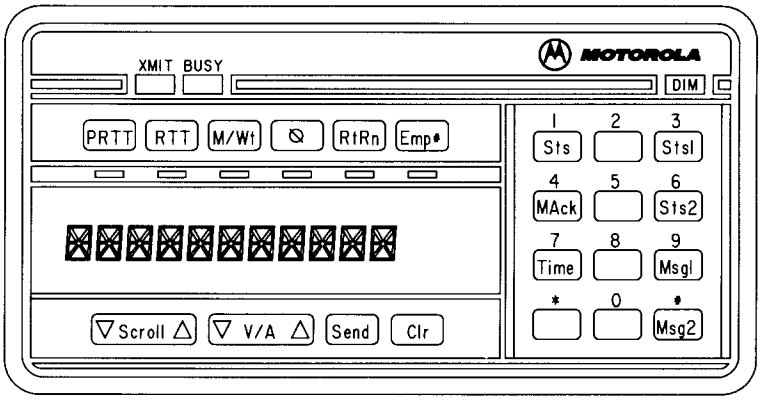
1.2.4 XMIT and BUSY Indicators

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.



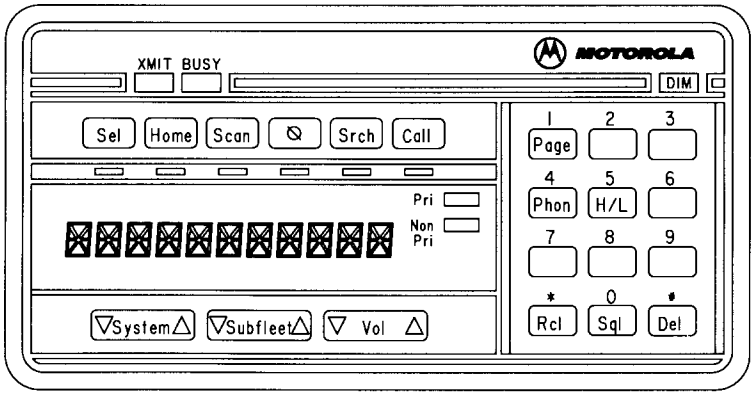
GXW-8055-0

Figure 2A. SYNTOR X 9000E *Control Unit*



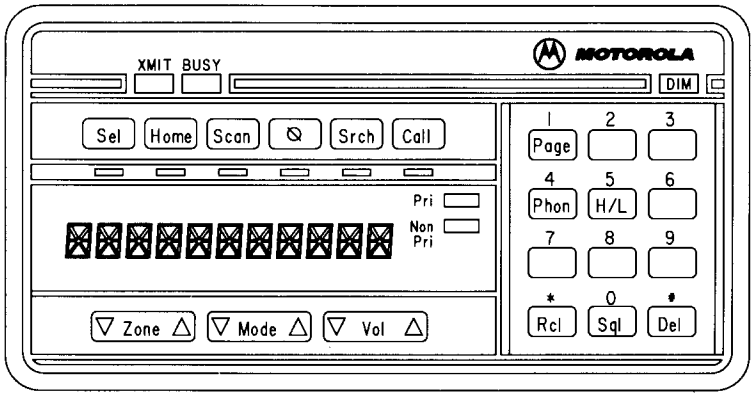
GXW-8056-0

Figure 2B. MCT–4800 *Control Unit*



GXW-8058-0

Figure 2C. System/Subfleet Control Unit



GXW-8057-0

Figure 2D. Group/Zone Control Unit

Figure 2. Alternate Control Units

1.2.5 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.

1.2.6 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.

1.2.7 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.

1.2.8 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.

1.2.9 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.

1.2.10 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. Alternate Control Units

Alternate control units are available for different applications. Two of these applications include the Systems 9000E (extended) control unit for use in trunking radio systems and the MCT–3600 / MCT–4800 control unit. Figure 2 (A through D) shows a few of the configurations available.

2.1 CONTROL UNIT FOR *SYSTEMS 9000E*

Trunking radio systems may use this control unit. It allows you to field program your own names to represent talk groups. The larger display window allows you to see all the key operating information, including the talk group selected, the channel being scanned, and the on/off status of various options. This control unit can also show Channel Scan lists, Private Conversation lists, and frequenctly called telephone numbers.

2.2 DESCRIPTION OF SYSTEMS *9000E CONTROLS*

The following list describes the custom buttons used by the Systems 9000E system. See paragraph 1.2 for information covering the standard buttons and switches. See Figure 2A for button locations.

MICROPHONE—connector; accepts any *Systems 9000* microphone or handset.

[**Page**]—button to use the individual page encode/decode feature for selectively alerting specific usnits in a trunking system.

[**Rpgm**]—button used with Dynamic Re–grouping feature for some radio systems. It temporarily reassigns fleet/subfleet information.

[**Srch**]—button initiates the Automatic Multiple Site Switching (AMSS) option to search for a new repeater (site) when your radio signal to your home site becomes too weak.

[**Site**]—button works with the AMSS option to automatically switch sites when your radio signal becomes too weak.

[**Lock**]—button prevents AMSS automatic switching.

2.3 CONTROL UNIT FOR MCT–4800

The MCT control unit has solid state microprocessor circuitry that operates the standard and optional features built into the system.

2.4 DESCRIPTION OF *MCT–4800* CONTROLS

The following list describes the custom buttons used by the *MCT–4800* system. See paragraph 1.2 for information covering the standard buttons and switches. See Figure 2B for button locations.

MICROPHONE—connector; accepts any *Systems 9000* microphone or handset.

[**Scroll**]—rocker switch for cursor movement and message scrolling.

[**V/A**]—rocker switch for selecting volume level, editing names, and making certain radio adjustments.

[**Clr**]—button clears out entry field of the display.

[**Send**]—button sends entered information to base.

[**PRTT**]—button sends a Priority Request–To–Talk transmission to the controller.

[**RTT**]—button sends Request–To–Talk transmission to the controller.

[**PA**]—button turns on the Public Address system.

[**RtRn**]—button changes the display to show Route/Run identification.

[**Emp#**]—button displays the Employee number.

[**MAck**]—button for acknowledge reception of a text message.

[**M/Wt**]—button for viewing text messages.

2.5 OTHER CONTROL UNITS

Some control unit configurations may use a [**Zone**], [**Mode**], and [**Vol**] rocker switches or [**System**], [**Subfleet**], and [**Vol**] rocker switches in place of the conventional configurations. See Figure 2, C and D.

3. Theory of Operation

3.1 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.

3.1.1 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.

3.1.2 Controls and Indicators

A twelve button keypad contains traditional alphanumeric keys. These keys double as function keys for 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.

3.2 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 data to a driver 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.

3.2.1 Microprocessor (MPU)

The MPU operates in expanded bus mode with internal ROM active. The clock frequency is 7.9488 MHz that results in an internal operating frequency of 1987 kHz. The limited number of I/O ports is augmented by using a serial–to–parallel shift register (U6) to scan the keyboard, and to switch the VIP drivers (Q71, Q72, Q73, Q74, and Q75).

3.2.2 Watchdog Timer

The watchdog timer resides in U4. On system power–up, C06 pulls U4–43 high while the output (pin 4) goes low and the microprocessor resets.

As C6 charges, the voltage on U4–43 drops causing the output to go high and the microprocessor to start operating. At this point, positive bias shifts onto U4–43 causing the voltage to begin to rise, eventually causing another reset cycle. A high on U4–9 also initiates a reset to occur.

However, when the microprocessor operates correctly, the microprocessor sends pulses to U4–2. These pulses tickle the watchdog timer and keeps the voltage on U4–43 low enough to prevent reset. If the tickle pulses stop for more than 250 milliseconds, the reset cycle repeats.

3.2.3 EEPROM

The EEPROM stores customer data including mode names, button functions, and VIP settings. The customer data can be altered only by the control unit programmer.

3.2.4 Bus Transceiver

The serial bus transceiver resides within U4. U4 pins 10, 16, and 17 connect to the external bus. Pins 11, 13, 19, and 20

connect to microprocessor U2. These pins act as a serial communication buffer.

3.2.5 Vacuum Fluorescent Voltage Converter

Voltage for the vacuum fluorescent display is generated by a fixed frequency, variable–duty cycle driven, flyback voltage converter. Resistors R56 through R60 with C54 and U3B form a triangle wave generator that has an output swing between 1.5 and 3.2 volts. This triangle goes to U3A–3 and is compared to a feedback signal on U3A–2. The feedback signal comes from the power supply output and is regulated by VR50 to 43 volts. This voltage increases or decreases as the output voltage rises or falls. Consequently, the duty cycle seen at the gate of Q50 varies inversely with power supply output voltage and regulates it. The supply runs at 160 kHz while the secondary of T60 (pins 4 and 6) supplies 3.5 VAC for the VF display (U102) filaments.

3.2.6 Vehicle Interface Ports (VIP)

The VIP outputs are driven by a serial–to–parallel shift register. Output transistors (Q71, Q72, Q73) can sink 300 mA current. Primarily, these transistors control external relays. The relay is connected between the collector and switched B+.

Each VIP input connects to a dedicated input port through zener diodes (VR8, VR9, and VR10) for input protection while U4 buffers the inputs. These VIP inputs are connected to ground with either normally–open or normally–closed switches.

3.2.7 Power Supply

The +5 volt supply is a three–terminal regulator IC to regulate the 12V SWB+ down for the digital logic hardware.

3.2.8 Ignition Sense Circuits

U4 senses the vehicle ignition's state through pin 28, 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.

Note

Q40 supplies an inverting path for positive ground ignition sevice.

3.2.9 EEPROM Write–Protect Circuit

Q161, Q162, and associated circuitry guard against inadvertently writing into the EEPROM. The circuitry guarantees the EEPROM is protected during reset and when U6 is not in the proper programming state.

3.3 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.

3.3.1 Vacuum Fluorescent Display

The vacuum fluorescent (VF) display is an eleven digit, 14–segment display that needs two separate voltages to operate: the anode and grids need +43 volts to accelerate electrons from cathode and the filament needs 3.5 volts AC at 80 mA. These voltages are obtained from the VF up–converter on the controller board.

3.3.2 Vacuum Fluorescent Display Driver

This IC (U101) receives 14 segment display data, digit enable data, and indicator state data from the microprocessor on the controller circuit board. This data is clocked using CLOCK and DATA lines, then framed using LATCH and strobed on STB to control brightness. The 32 bit data frame is updated every millisecond in such a fashion that a coherent display is maintained and totally updated every 11 milliseconds.

3.3.3 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 43 volts for control signals.

3.3.4 Backlight LEDs

The same signal that turns the VF power supply on and off also operates the backlight LEDs. Q134 supplies base current to the individual LED driver transistors. The driver transistors act as constant current sources to the LEDs. Backlight LEDs CR131, CR132, CR133, and CR134 are connected to thermistor R133 by way of Q132. This circuit allows more current to flow through these LEDs at room temperature and reduces current as the temperature rises.

3.3.5 Default Jumper Settings

The factory installs jumpers in each control unit dependent on the customer–ordered options. See the following table for the standard jumper configuration. See the foldout page with the control unit artwork for other configurations.

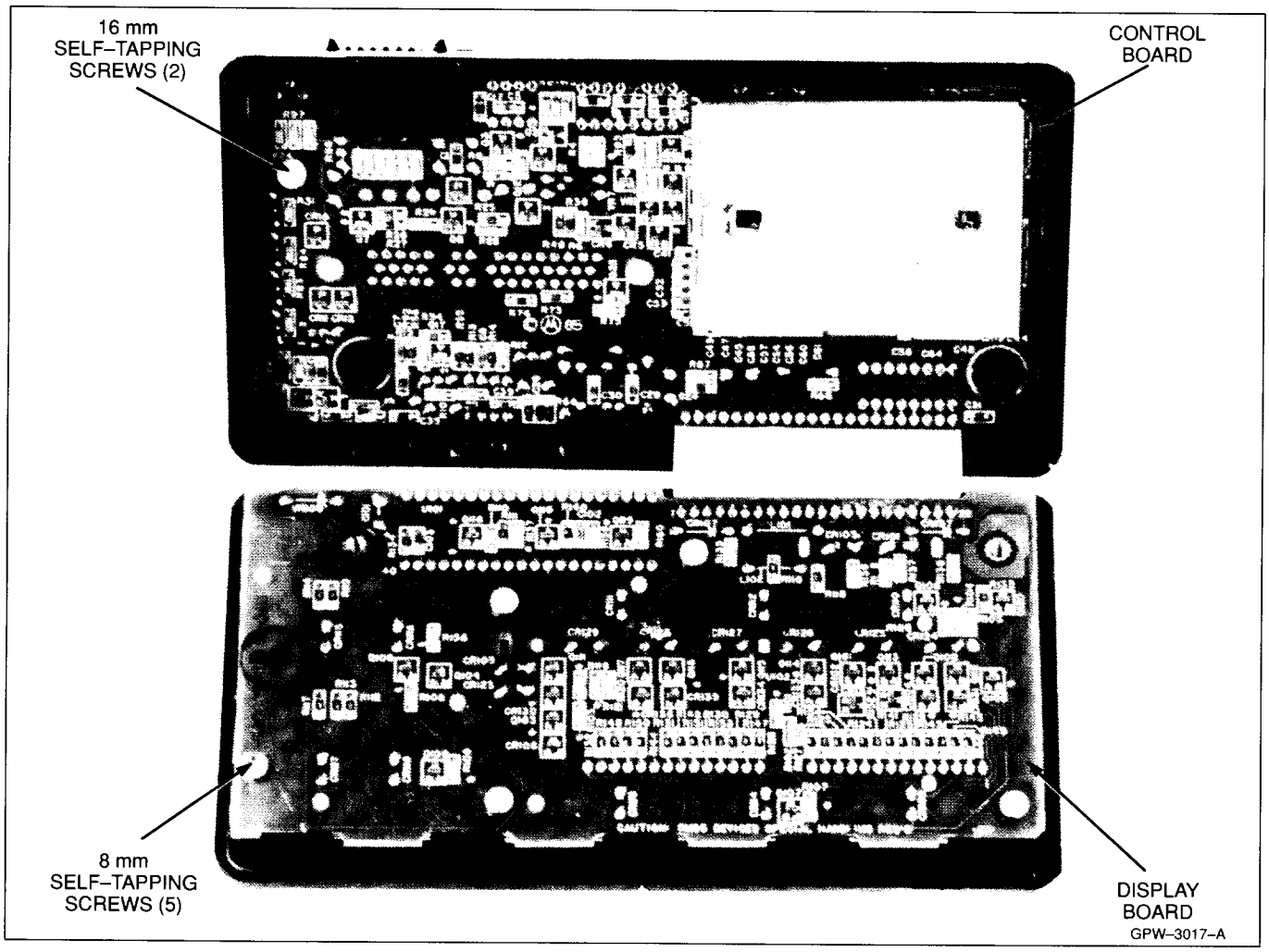


Figure 3. Disassembly of the Control Unit

Table 1. Standard Jumper Configuration

JUMPER NUMBER	NORMALLY
1	IN
2	OUT
3	IN
4	OUT
5	IN
7	IN
8	OUT
9	OUT
10	OUT
11	OUT
12	OUT
13	OUT
16	OUT
17	OUT
18	IN
19	IN
20	IN
21	OUT
22	OUT

4. Control Unit Maintenance

4.1 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.

4.2 RE–ASSEMBLY OF THE CONTROL UNIT

Be sure the orange gasket is still around the outside 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.

5. 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.

5.1 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 relay 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 2.

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.

5.2 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 3.

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.

6. Power Connections

CAUTION

Use only *Systems 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.

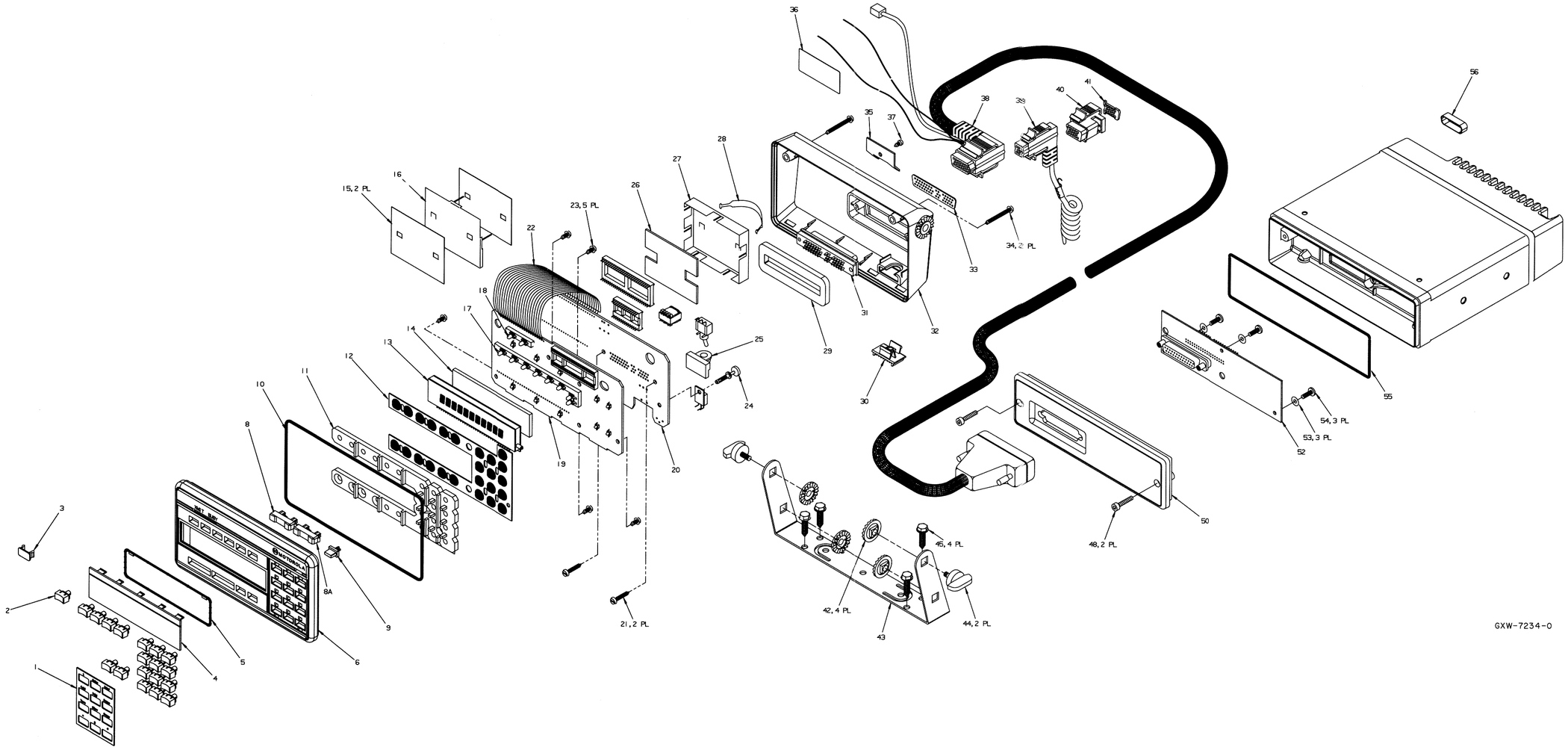
Pull all excess cabling into the trunk. Clamp the cables to the vehicle body or chassis with the cable clamps supplied. Drill 1/8" mounting holes, then attach the clamps with four #8 by 3/8" tapping screws and four 1/4" lockwashers. Finally, be sure all in–line fuses are installed.

Table 2. 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 3. 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



parts list

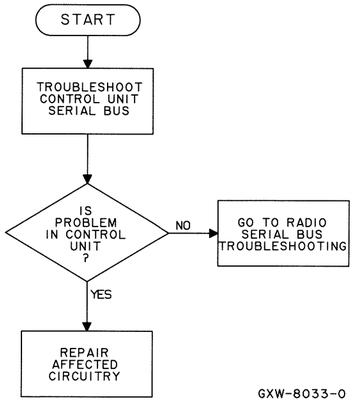
Control Head Exploded View — MXW–7978–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
1	13–80087J03	escutcheon
2	HLN5499A	button, PRTT
2A	HLN5497A	button, RTT
2B	HLN5067A	button, PA
2C	HLN5500A	button, RTRN
2D	HLN5502A	button, Emp#
2E	HLN5503A	button, CLR
2F	HLN5498A	button, SEND
2G	HLN5095A	button, blank
2H	HLN5504A	button, M/Wt
2I	HLN5505A	button, M/Ack
2J	HLN6220A	button, TIME
3	HLN5096A	plug
4	61–80095J04	lens, VF display
5	32–80057K02	gasket, lens
6	15–80088J01	housing, front
8	38–80195P08	pushbutton rocker, SCROLL
8A	38–80195P10	pushbutton rocker, V/A
9	38–80092J01	key, DIM
10	32–80180J02	gasket, housing
11	61–80185J02	lightpipe, keypad
12	75–80098J01	keypad
13	(U102)	VF display (see electrical)
14	75–80184J01	shock pad
15	14–80269K01	insulator
16	26–80220K01	solder side shield
17	43–80011L01	spacer, LED, 8 position
18	43–80012L01	spacer, LED, 2 position
19	——	display board (see electrical)
20	——	command board (see electrical)
21	03–10945A14	screw, tapping, P3.12 x 1.27 x 8 (5 used)
22		flex cable
23	03–10945A11	screw, tapping, P3.12 x 1.27 x 16 (2 used)
24	05–80200K01	rivet, nylon
25	32–80178J01	gasket, ON/OFF switch
26	75–80268K01	shock pad, IC
27	26–80003K01	shield, component side
28	55–84300B02	handle
29	32–80179J01	gasket, D–connector
30	38–80128J01	key, ON/OFF
31	(J1)	connector, mini–D, 50 contact
32	15–80089J01	housing, back
33	32–80181J01	gasket, face connector
34	03–10908A33	screw, machine, M3.5 x 0.6 x 30 (2 used)
35	07–84323C01	bracket, strain relief
36	33–80178M01	nameplate
37	03–10908A18	screw, machine, M3 x 0.5 x 6
38	30–80183P01	radio cable
39	30–80265L02	handset cable
40	15–80221J01	housing, VIP connector
–	39–84257L01	contact, plug
41	32–80275K01	gasket, VIP connector
42	43–80127J01	spacer, trunnion (4 used)
43	07–80263L01	bracket, trunnion
44	03–80160E01	wing screw, M5 x 8 x 10 (2 used)
45	03–00136756	screw, tapping, 10–16 x 5/8 (4 used)
48	03–80077M01	screw, front mount (2 used)
50	15–80062P04	housing, remote front
52	——	interconnect board (see electrical)
53	04–83045H01	washer, thrust (3 used)
54	03–10945A11	screw, tapping, P3.12 X 1.27 X 8 (3 used)
55	32–80289L01	gasket, housing
56	15–80005G01	cover, dust

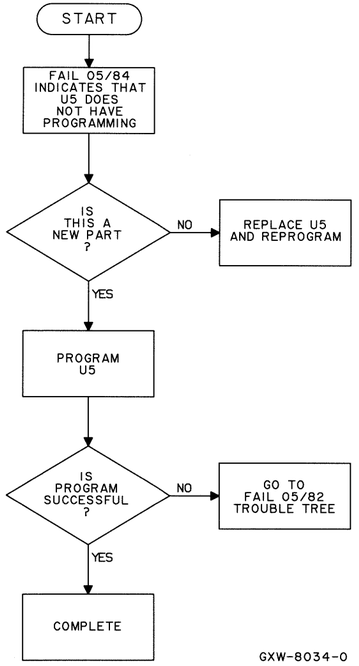
8/18/90

Exploded View and Parts List for
Systems 9000 Control Unit
PW–8017–O
8/18/90

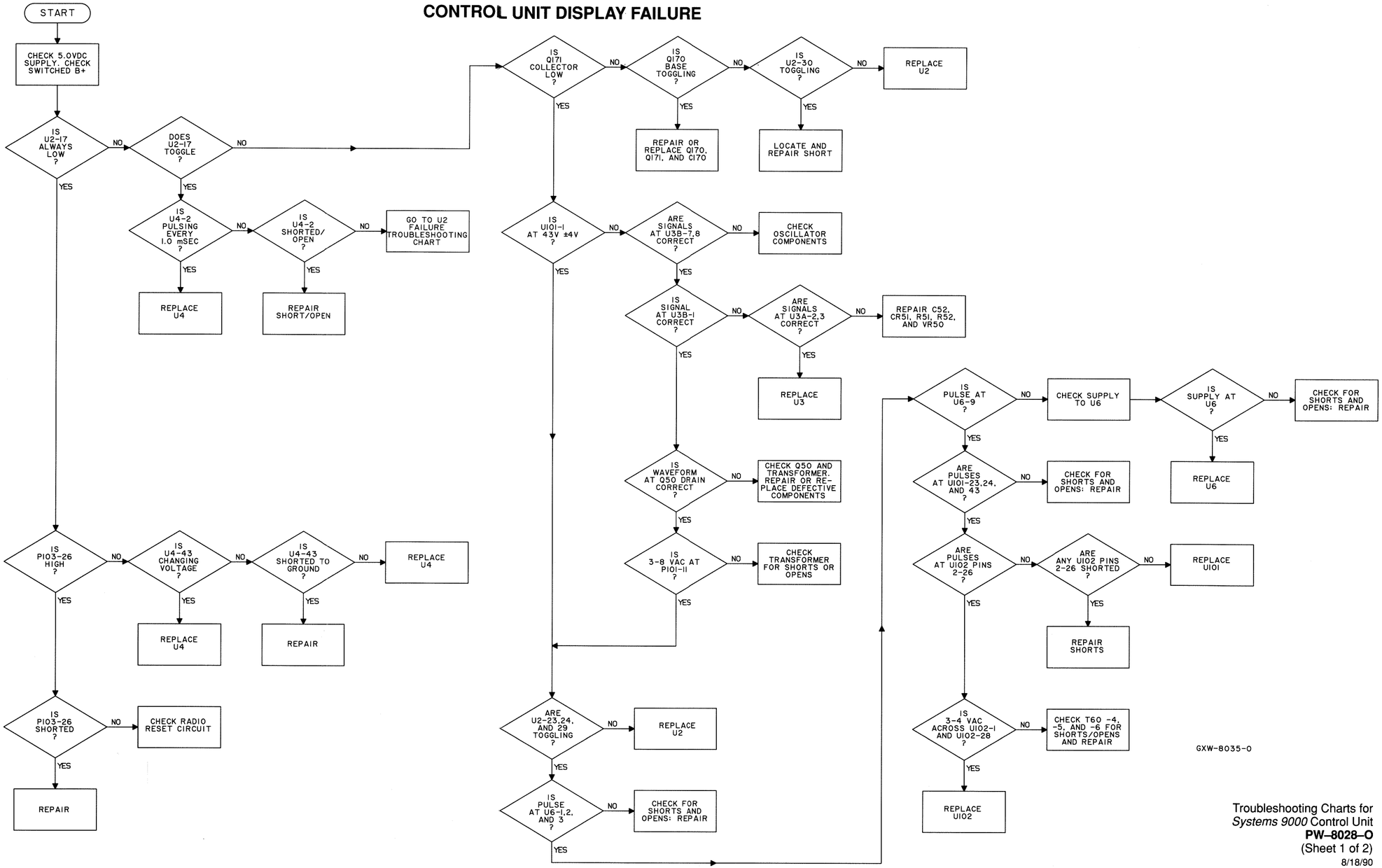
FAIL 05/90



FAIL 05/84

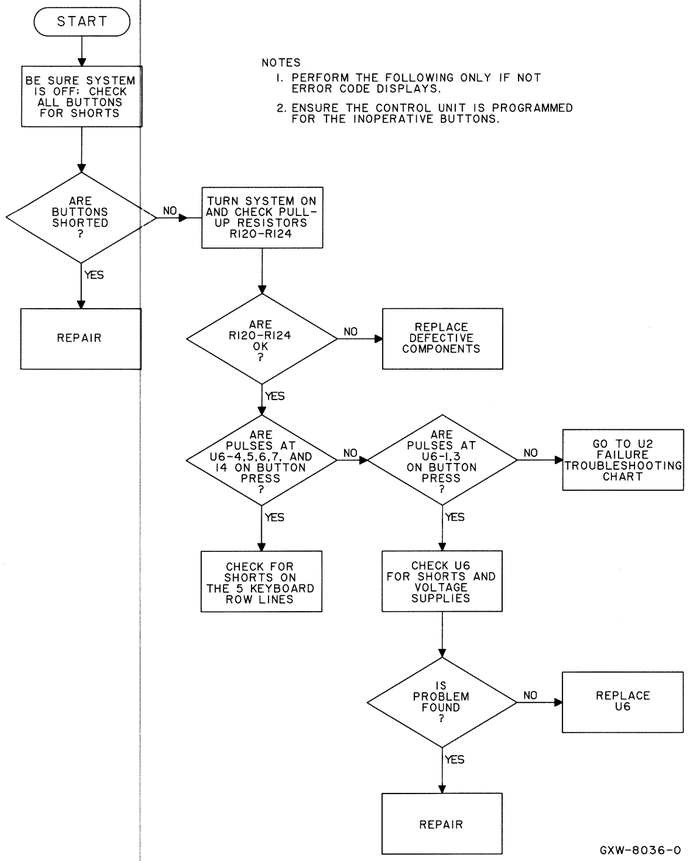


CONTROL UNIT DISPLAY FAILURE



Troubleshooting Charts for
Systems 9000 Control Unit
PW–8028–O
(Sheet 1 of 2)
8/18/90

SELECTOR BUTTON FAILURE

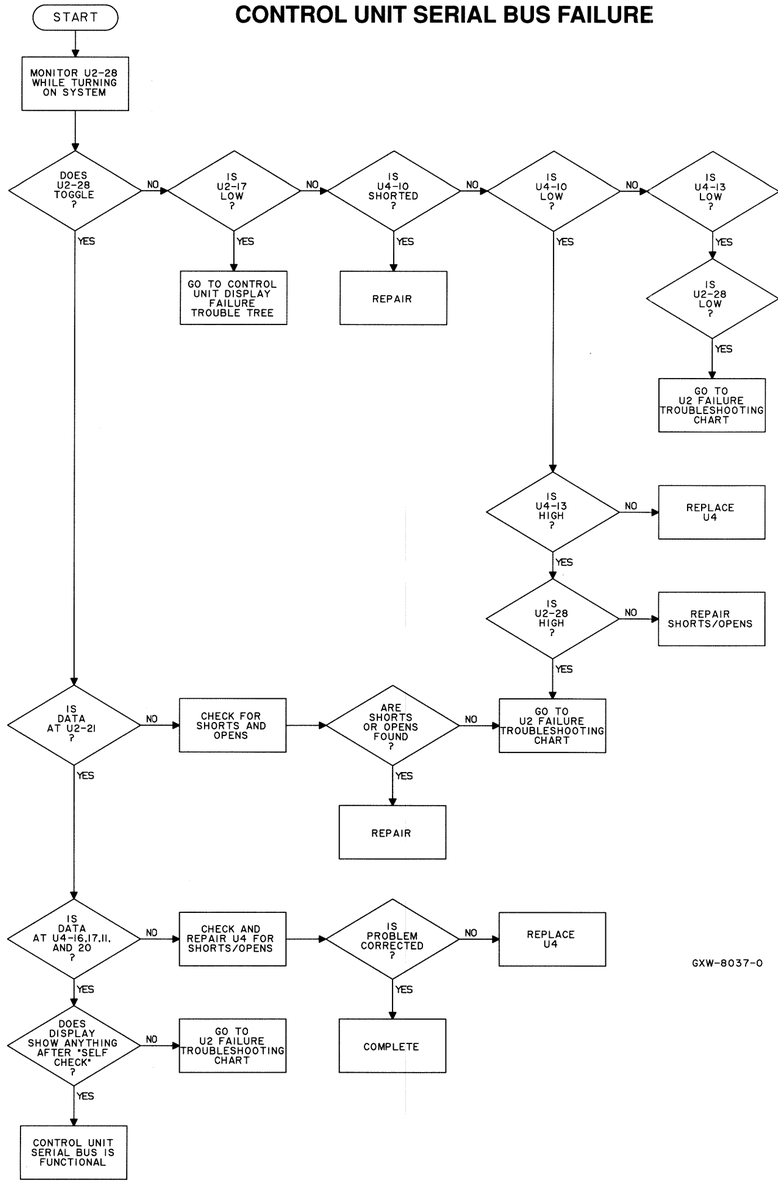


NOTES

1. PERFORM THE FOLLOWING ONLY IF NOT ERROR CODE DISPLAYS.
2. ENSURE THE CONTROL UNIT IS PROGRAMMED FOR THE INOPERATIVE BUTTONS.

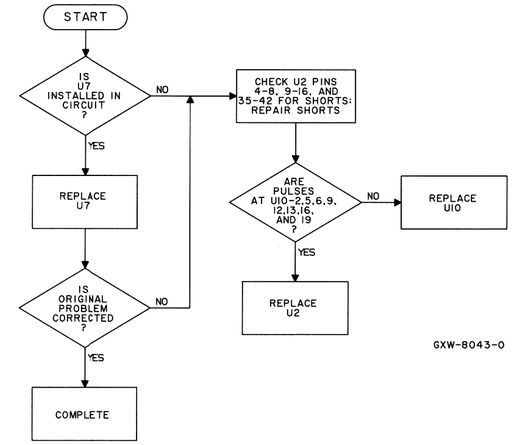
GXW-8036-0

CONTROL UNIT SERIAL BUS FAILURE



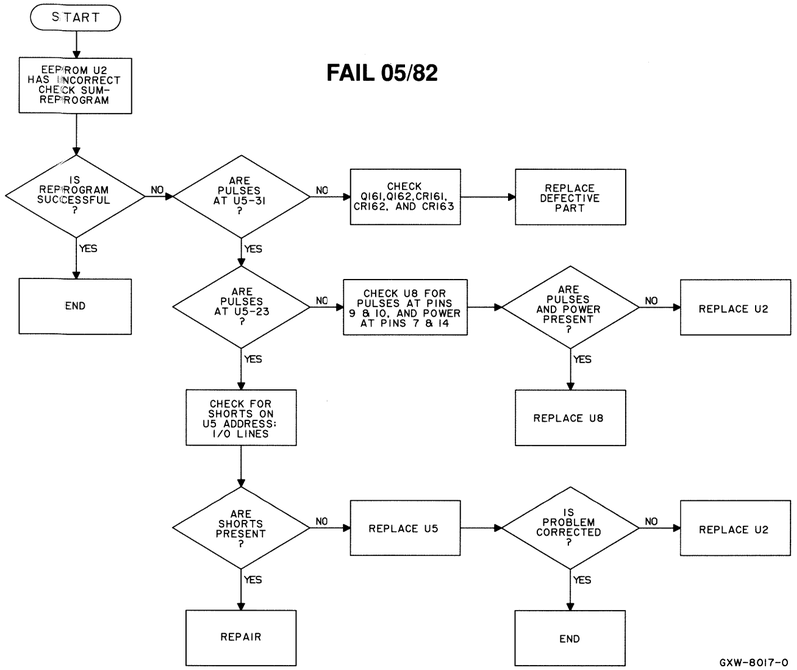
GXW-8037-0

U2 FAILURE



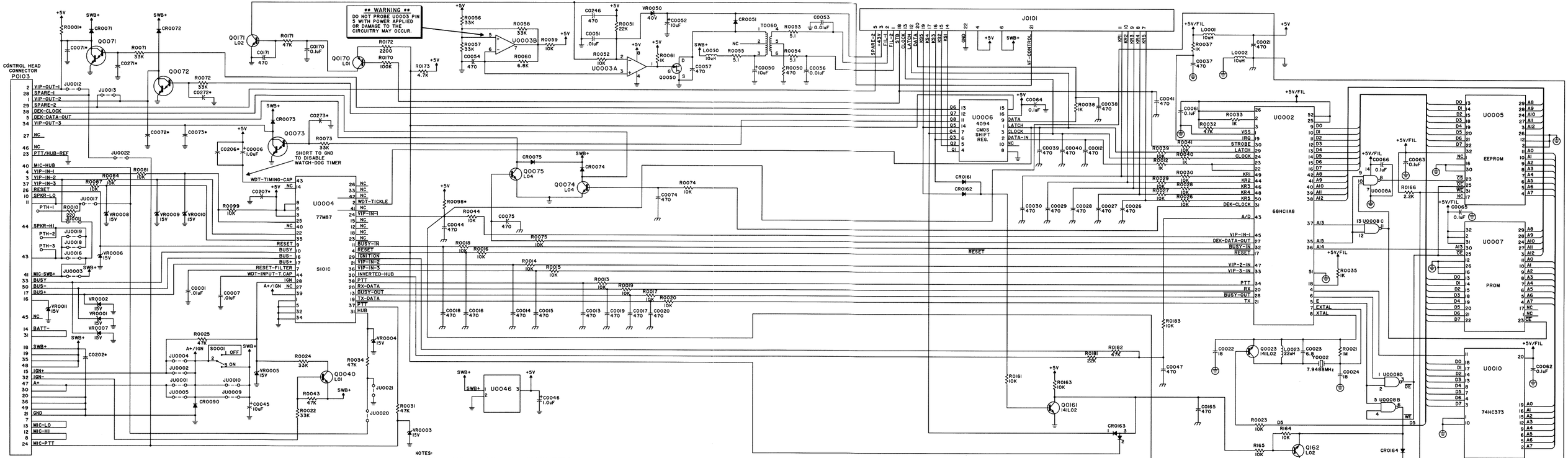
GXW-8043-0

FAIL 05/82



GXW-8017-0

CONTROLLER BOARD SCHEMATIC



NOTES:
1.) ASTERISK (*) INDICATES PARTS NOT BUILT ON SOME MODELS.
2.) ALL RESISTANCE IS IN OHMS , ALL CAPACITANCE IN PICO-FARADS UNLESS NOTED OTHERWISE.

GXW-8030-O

Schematics, Circuit Board Diagrams, Waveforms, and Parts Lists for *Systems 9000* Control Unit
PW–8032–O
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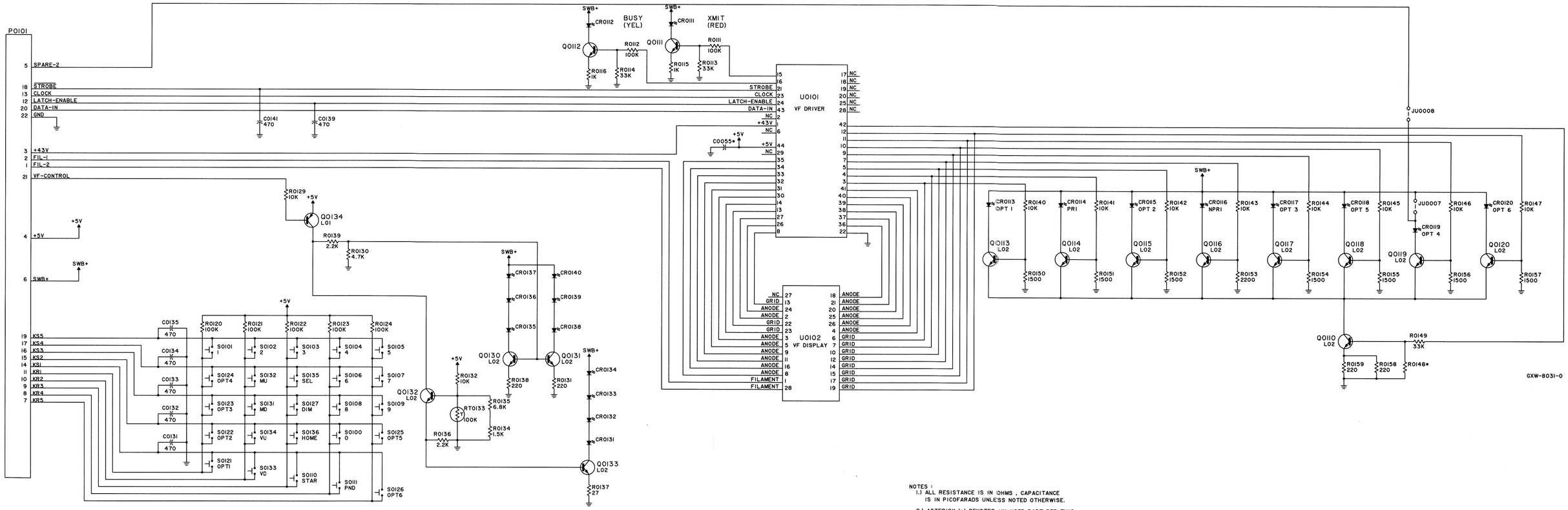
8/18/90

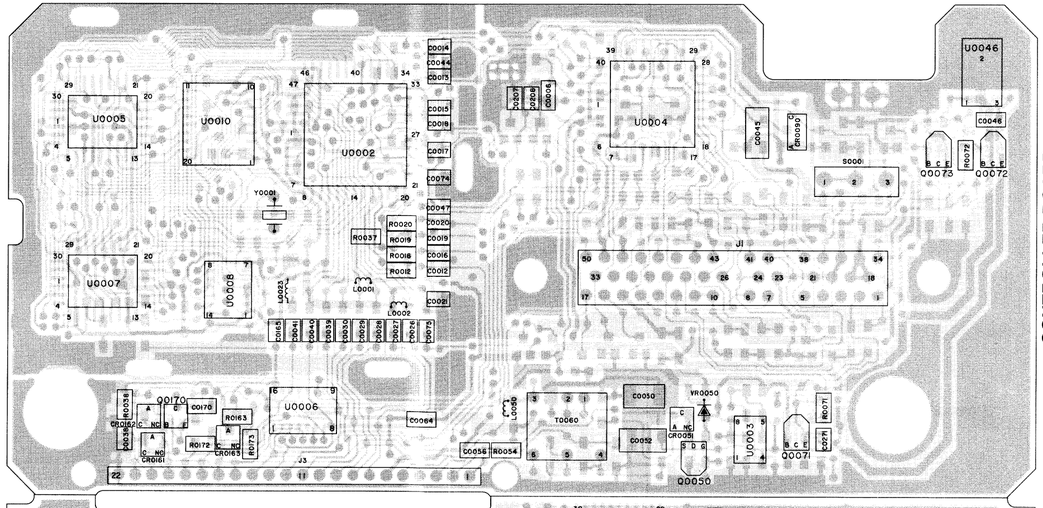
DISPLAY BOARD SCHEMATIC

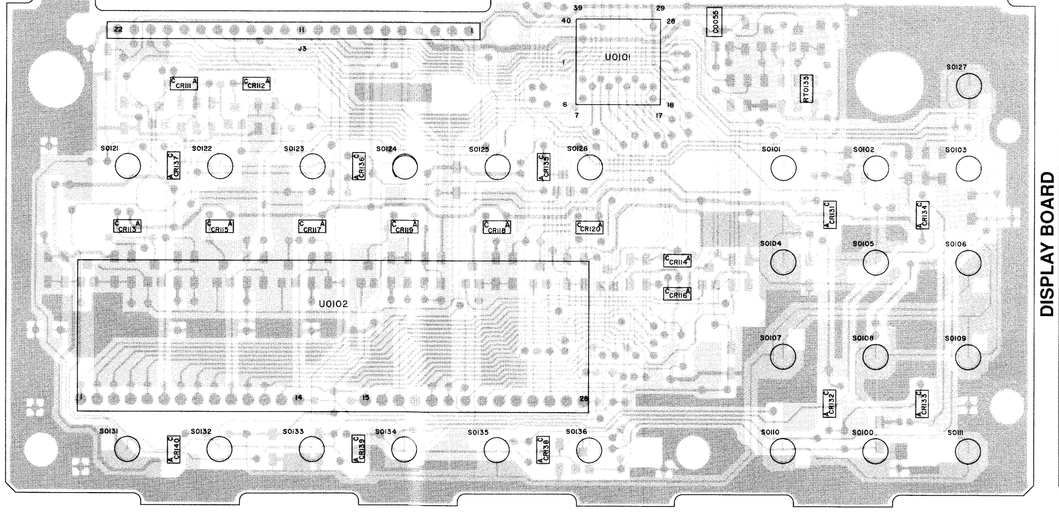


NOTES :
1.) ALL RESISTANCE IS IN OHMS , CAPACITANCE IS IN PICOFARADS UNLESS NOTED OTHERWISE.

2.) ASTERISK (*) DENOTES UN-USED PART PER THIS APPLICATION.

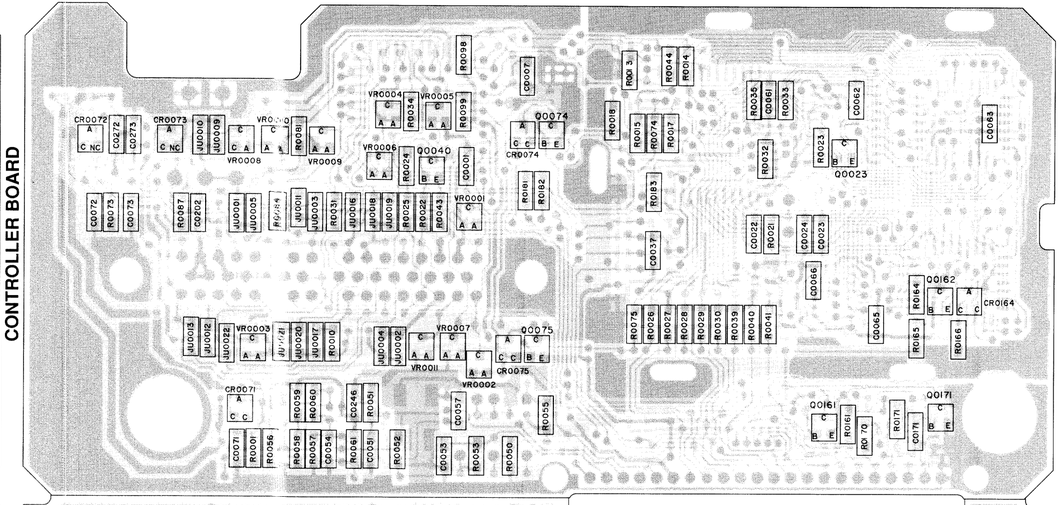
Schematics, Circuit Board Diagrams, Waveforms, and Parts Lists for *Systems 9000* Control Unit
PW–8032–O
(Sheet 2 of 4)
8/18/90

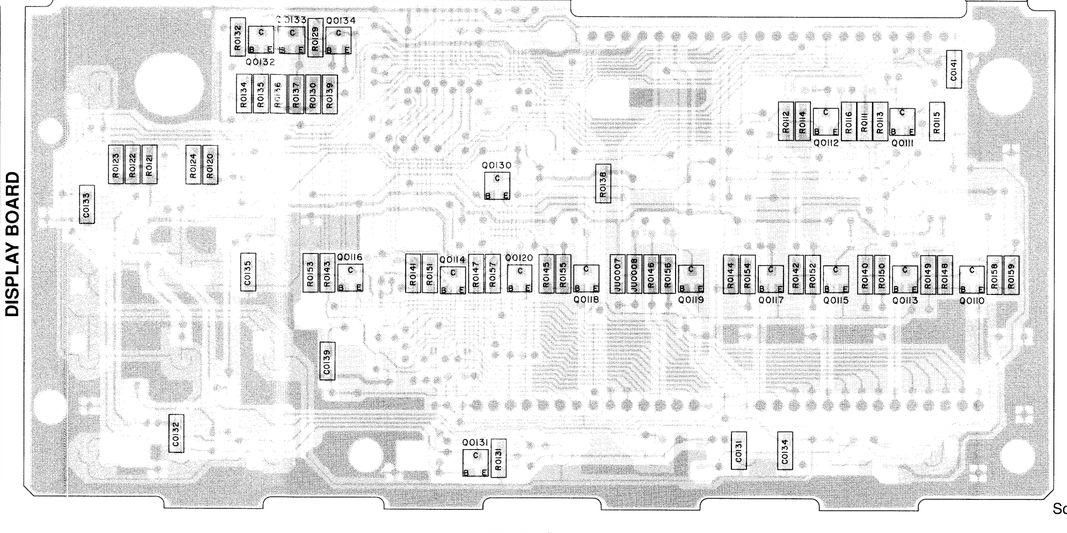




CONTROLLER BOARD

DISPLAY BOARD





SOLDER SIDE
COMPONENT SIDE
OVERLAY — GXW-8025W01-0

GPW-8024-0

COMPONENT SIDE VIEW

SOLDER SIDE
COMPONENT SIDE
OVERLAY — GXW-8025W02-0

GPW-8024-0

SOLDER SIDE VIEW

Schematics, Circuit Board Diagrams, Waveforms, and Parts Lists for *Systems 9000* Control Unit
PW–8032–O
(Sheet 3 of 4)
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parts list

HLN5464A *Systems 9000* Control Unit (Display Board) MXW–8023–O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor. fixed, pF, ±5%, 50V (unless otherwise stated)		
C55	21–13741N69	.1 uF, ±10%
C131–135	21–13740B65	470
C139	21–13740B65	470
C141	21–13740B65	470
diode (see note)		
CR111	48–80052R01	LED, red
CR112	48–80052R02	LED, yellow
CR113–115	48–80052R01	LED, red
CR116	48–80052R02	LED, yellow
CR117–120	48–80052R01	LED, red
CR131–140	48–80052R03	LED, green
transistor (see note)		
Q110–120	48–80141L02	NPN
Q130–133	48–80141L02	NPN
Q134	48–80141L01	PNP
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R111,112	06–11077B23	100k
R113,114	06–11077B11	33k
R115,116	06–11077A74	1k
R120–124	06–11077B23	100k
R129	06–11077A98	10k
R130	06–11077A90	4.7k
R131	06–11077A58	220
R132	06–11077A98	10k
R133	06–80149M02	100k, ±10%, 240mW, thermistor
R134	06–11077A78	1.5k
R135	06–11077A94	6.8k
R136	06–11077A82	2.2k
R137	06–11077A36	27
R138	06–11077A58	220
R139	06–11077A82	2.2k
R140–147	06–11077A98	10k
R149	06–11077B11	33k
R150–152	06–11077A78	1.5k
R153	06–11077A82	2.2k
R154–157	06–11077A78	1.5k
R158,159	06–11077A58	220
integrated circuit (see note)		
U101	51–80236C05	VF driver
V102	72–80242J01	VF display
non–referenced parts		
	61–80027R01	8 indicator light pipe
	61–80026R01	2 indicator light guide
	01–80740T42	VF display & shock pad assembly
	75–80094M04	battery shock pad
	75–80094M05	VF shock pad
	84–80168P01	display circuit board

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

HLN5464A *Systems 9000* Control Unit (Controller Board) MXW–8022–O

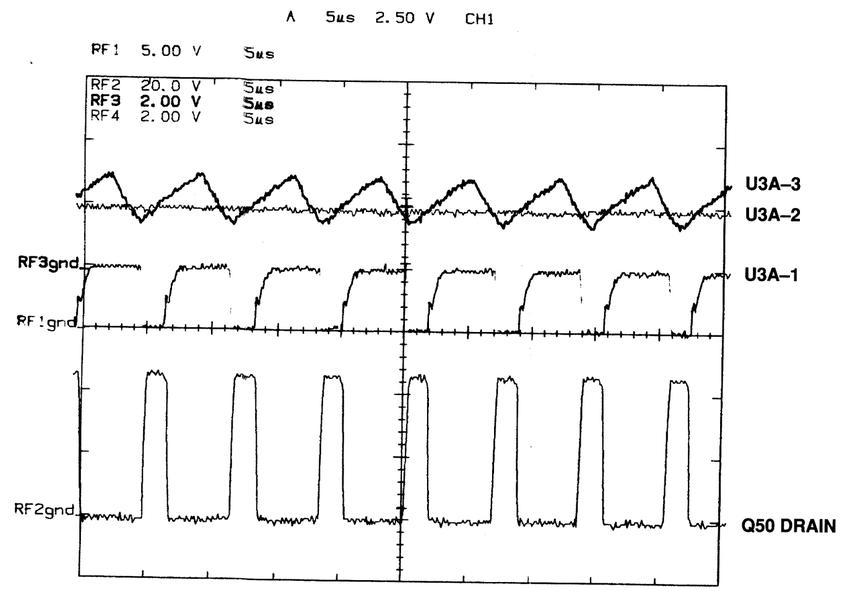
REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
capacitor, fixed, pF, ±5%, 50V (unless otherwise stated)		
C1	21–13741N45	.01 uF, ±10%
C6	23–11049A37	1 uF, ±20%, 25V, tantalum
C7	21–13741N45	.01 uF, ±10%
C12–21	21–13741M13	470, ±10%
C22	21–13740B31	18
C23	21–13740B21	6.8
C24	21–13740B31	18
C26–30	21–13741M13	470, ±10%
C36–42	21–13741M13	470, ±10%
C44	21–13741M13	470, ±10%
C45	23–80090M24	10 uF, ±20%, electrolytic
C46	23–11049A37	1 uF, ±20%, 25V, tantalum
C47	21–13741M13	470, ±10%
C50	23–11049J27	10 uF, ±10%, 25V, tantalum
C51	21–13741N45	.01 uF, ±10%
C52	23–80090M24	10 uF, ±20%, electrolytic
C53	21–13741N45	.01 uF, ±10%
C54	21–13740B65	470
C56	21–13741N45	.01 uF, ±10%
C57	21–13740B65	470
C61–66	21–13741N69	.1 uF, ±10%
C71–73	21–13740B65	470
C165	21–13741M13	470, ±10%
C170	21–13741N69	.1 uF, ±10%
C171	21–13740B65	470
C202	21–13740B65	470
C206,207	21–13741M13	470, ±10%
C246	21–13740B65	470
C271–273	21–13741M13	470, ±10%
diode (see note)		
CR51	48–11058B11	silicon
CR71–75	48–80236E08	rectifier
CR90	48–82960R02	rectifier
CR161–164	48–80236E08	rectifier
connector receptacle		
J1	28–80228J01	50 position mini–D connector
jumper		
JU1	06–11077A01	0 ohm resistor
JU3	06–11077A01	0 ohm resistor
JU5	06–11077A01	0 ohm resistor
JU7	06–11077A01	0 ohm resistor
JU18–20	06–11077A01	0 ohm resistor
relay		
KP1	75–80098J01	keypad
coil, RF		
L1,2	24–80140E16	10 uH, inductor
L23	24–80289M16	22 uH
L50	24–80140E16	10 uH, inductor
transistor (see note)		
Q23	48–80141L02	NPN
Q40	48–80141L01	PNP
Q50	48–80053M03	N–channel, MOSFET
Q71–73	48–80052M01	NPN, Darlington
Q74,75	48–80141L04	NPN
Q161,162	48–80141L02	NPN
Q170	48–80141L01	PNP
Q171	48–80141L02	NPN
resistor, fixed, ohm, ±5%, 1/8 watt (unless otherwise stated)		
R1	06–11077A98	10k
R10	06–11077A58	220
R12	06–11077A74	1k
R13–20	06–11077A98	10k
R21	06–11077B47	1 MEG
R22	06–11077B11	33k
R23	06–11077A98	10k
R24	06–11077B11	33k
R25	06–11077B15	47k
R26–30	06–11077A98	10k
R31,32	06–11077B15	47k
R33	06–11077A74	1k
R34	06–11077B15	47k
R35	06–11077A74	1k
R37,38	06–11077A74	1k
R39	06–11077A98	10k
R40	06–11077A74	1k
R41	06–11077A98	10k
R43	06–11077B15	47k
R44	06–11077A98	10k
R50	06–11077A66	470
R51	06–11077B07	22k
R52	06–11077A98	10k
R53–55	06–11077A19	5.1
R56–58	06–11077B11	33k
R59	06–11077A98	10k
R60	06–11077A94	6.8k
R61	06–11077A74	1k
R71–73	06–11077B11	33k
R74,75	06–11077A98	10k
R81	06–11077A98	10k
R84	06–11077A98	10k
R87	06–11077A98	10k
R98,99	06–11077A98	10k
R161	06–11077A98	10k
R163–165	06–11077A98	10k
R166	06–11077A82	2.2k
R170	06–11077B23	100k

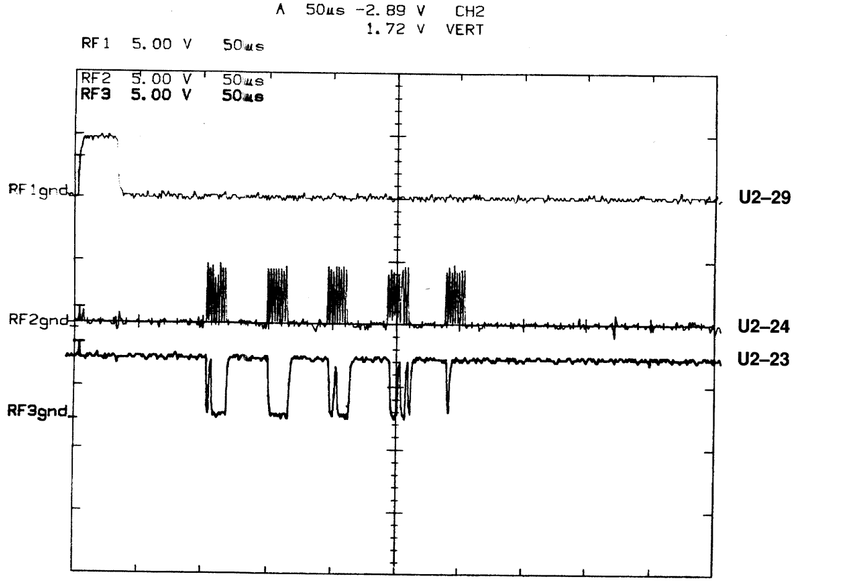
MXW–8022–O (2)

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
R171	06–11077B15	47k
R172	06–11077A82	2.2k
R173	06–11077A90	4.7k
R181	06–11077B07	22k
R182	06–11077B15	47k
R183	06–11077A98	10k
switch		
S1	40–80033K01	toggle
transformer		
T60	25–80277J03	voltage conversion
integrated circuit (see note)		
U2	51–97024A01	microcomputer
U3	51–80056M01	dual comparator
U4	51–83977M87	serial input/output
U5	51–97014A10	EEPROM
U6	51–84704M54	register
U8	51–80177M03	quad NAND gate
U10	51–80177M02	octal latch
U46	51–80068C08	voltage regulator
voltage regulator (see note)		
VR1–11	48–80140L20	15V zener
VR50	48–80056K40	43V zener
crystal (see note)		
Y2	48–80173D10	7.9488 MHz
non–referenced parts		
	09–80049R01	32 pin socket
	32–80179J01	connector gasket
	01–80740T38	mini–D connector & gasket assembly
	32–80181J01	face connector gasket
	84–80167P01	controller circuit board

8/18/90

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





GPW–8029–O

Schematics, Circuit Board Diagrams, Waveforms, and Parts Lists for *Systems 9000* Control Unit

PW–8032–O

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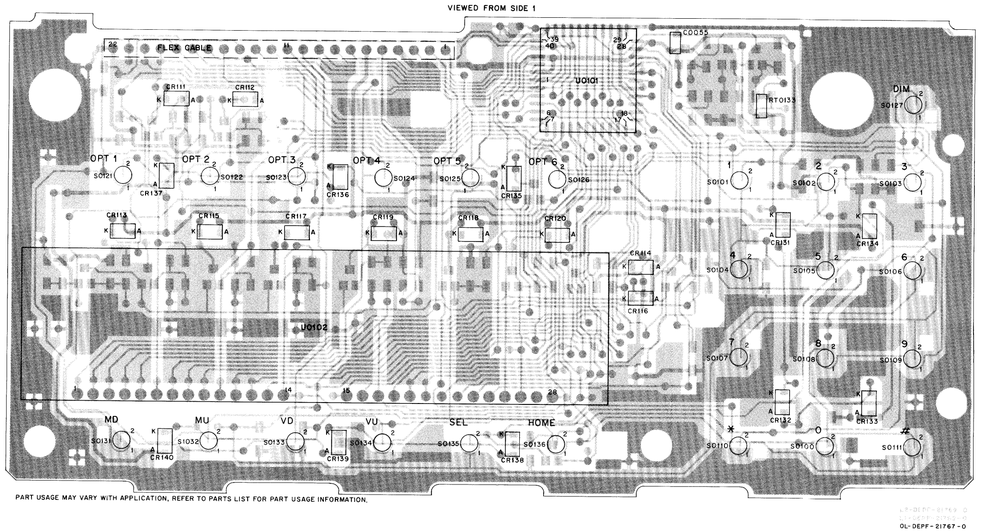
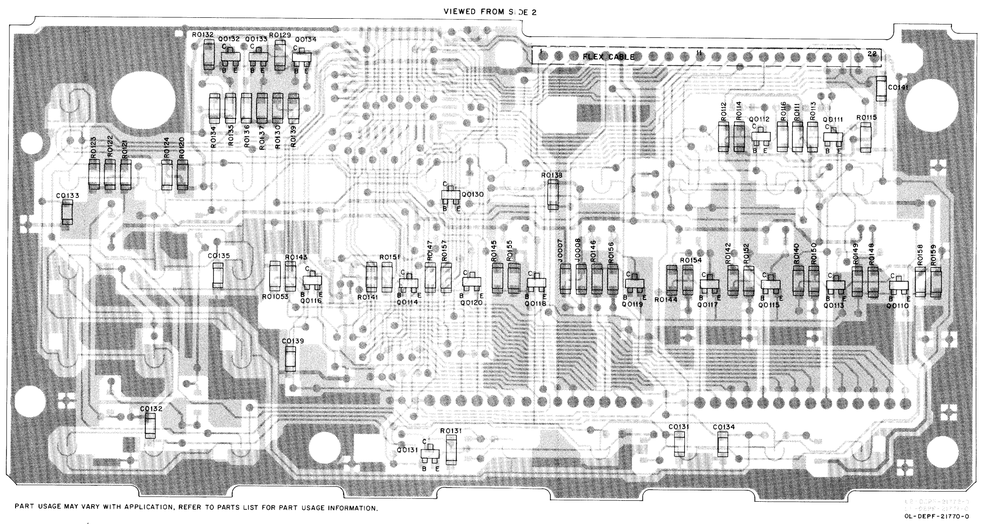




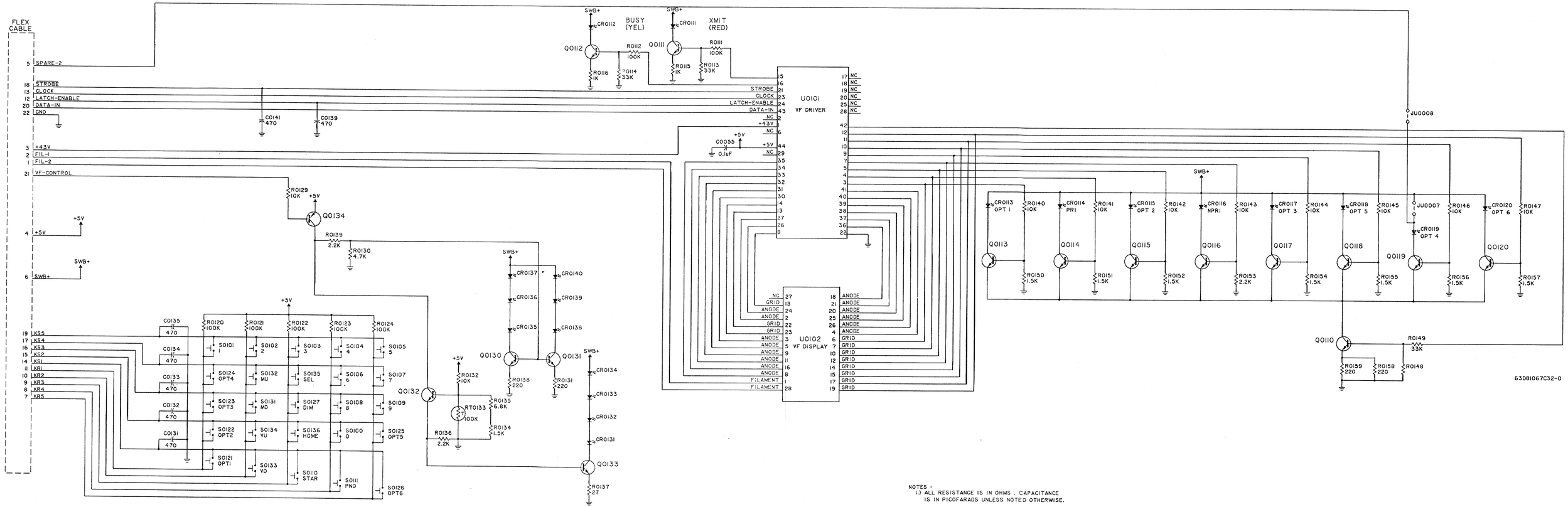
HLN6284A Display Board
Parts List

TPLF-4039-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: pF ±10% unless otherwise stated
C55	2113741N69	0.1µF
C131 thru C135	2113740B65	470 ±30%
C139	2113740B65	470 ±30%
C141	2113740B65	470 ±30%
		DIODE: See Note 1
CR111	4880052R01	LED, Red
CR112	4880052R02	LED, Yellow
CR113 thru CR115	4880052R01	LED, Red
CR116	4880052R02	LED, Yellow
CR117 thru CR120	4880052R01	LED, Red
CR131 thru CR140	4880052R03	LED, Green
		JUMPER: Refer to Jumper Table
JU7	0611077A01	Resistor, 0 Ω
JU8	- - - - - - - - -	Not used on this kit (See Note 3)
		TRANSISTOR: See Note 2
Q110 thru Q120	4880141L02	NPN
Q130 thru Q133	4880141L02	NPN
Q134	4880141L01	PNP
		RESISTOR, Fixed: Ω ±5%, 1/8W unless otherwise stated
R111, R112	0611077B23	100k
R113, R114	0611077B11	33k
R115, R116	0611077A74	1k
R120 thru R124	0611077B23	100k
R129	0611077A98	10k
R130	0611077A90	4.7k
R131	0611077A58	220
R132	0611077A98	10k
R134	0611077A78	1.5k
R135	0611077A94	6.8k
R136	0611077A82	2.2k
R137	0611077A36	27
R138	0611077A58	220
R139	0611077A82	2.2k
R140 thru R147	0611077A98	10k
R148	- - - - - - - - -	Not used on this kit (See Note 3)
R149	0611077B11	33k
R150 thru R152	0611077A78	1.5k
R153	0611077A82	2.2k
R154 thru R157	0611077A36	1.5k
R158, R159	0611077A58	220
		THERMISTOR:
RT133	0680149M02	100k, 10%, 240mW
		CIRCUIT MODULE: See Note 2
U101	5180236C05	VF Driver
U102	7280242J01	VF Display
NONREFERENCED ITEMS		
	3080034K01	CABLE, Flex
	6180027R01	LIGHT GUIDE, 8-Indicator
	6180026R01	LIGHT GUIDE, 2-Indicator
	7580098J01	KEYPAD
	8480168P02	BOARD, Circuit (part of 8480209P32)

NOTES:
1. For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.
2. When ordering crystal units, specify carrier frequency, crystal frequency, crystal type number, and Motorola part number.
3. This part is used for special applications only. If your unit is modified for a special application, your supplemental special applications manual will contain part usage information.

HLN6284A DISPLAY BOARD COMPONENT LOCATION DETAILS AND PARTS LIST

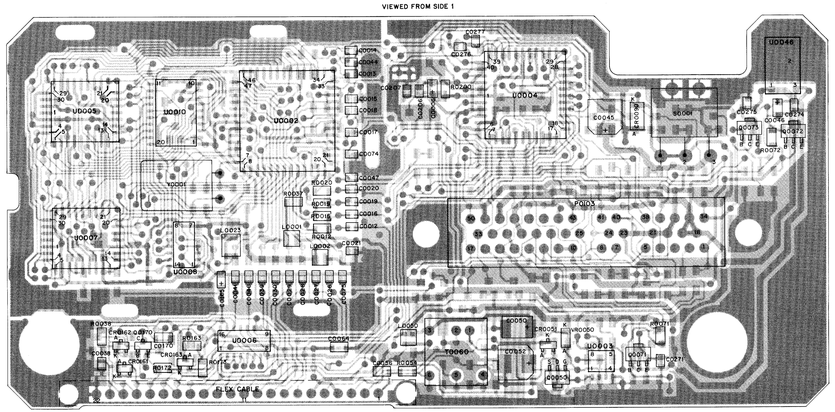


NOTES :

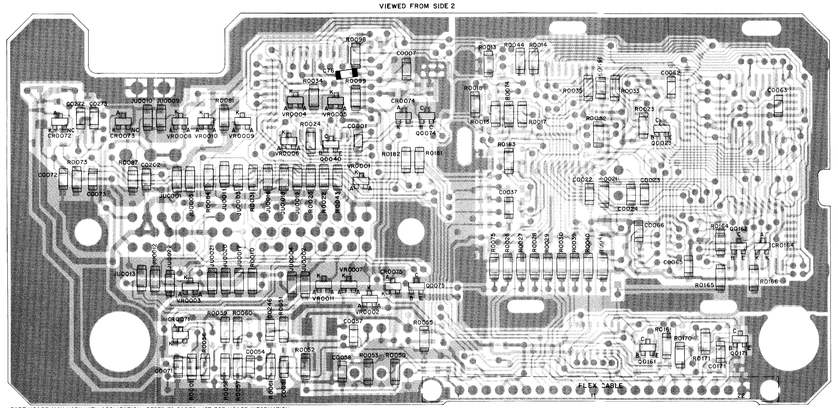
1.) ALL RESISTANCE IS IN OHMS . CAPACITANCE IS IN PICOFARADS UNLESS NOTED OTHERWISE.

2.) PART USAGE MAY VARY WITH APPLICATION. REFER TO PARTS LIST FOR USAGE INFORMATION.

HLN6284A DISPLAY BOARD SCHEMATIC DIAGRAM



PART USAGE MAY VARY WITH APPLICATION, REFER TO PARTS LIST FOR USAGE INFORMATION.



PART USAGE MAY VARY WITH APPLICATION, REFER TO PARTS LIST FOR USAGE INFORMATION.

HLN6284A Controller Board Parts List

TPLF-4040-O

REFERENCE SYMBOL	MOTOROLA PART NO.	DESCRIPTION
		CAPACITOR, Fixed: pF ±10% unless otherwise stated
C1	2113741N45	.01µF
C6	2311049A38	1.5µF; 16V
C7	2113741N45	.01µF
C12 thru C21	2113741M13	470
C22	2113740B29	15 ±30%
C23	2113740B17	4.7 ±30%
C24	2113740B27	12
C26 thru C30	2113741M13	470
C37	2113740B65	470 ±30%
C38	----------	Not used on this kit (See Note 3)
C39, C40	2113741M13	470
C41	----------	Not used on this kit (See Note 3)
C44	2113741M13	470
C45	2380090M24	10µF ±20% Electrolytic
C46	2311049A37	1µF ±20% 20V, Tantalum
C47	2113741M13	470
C50	2311049J27	10µF; 25V, Tantalum
C51	2113741N45	.01µF
C52	2380090M24	10µF ±20%, Electrolytic
C53	2113741N45	.01µF
C54	2113740B65	470 ±30%
C56	2113741N45	.01µF
C57	2113740B65	470 ±30%
C61 thru C67	2113741N69	1µF
C71 thru C73	2113740B65	470 ±30%
C74, C75	----------	Not used on this kit (See Note 3)
C76	2113740B65	470 ±30%
C165	2311049A37	1µF ±20% 20V, Tantalum
C170	2113741N69	1µF
C171	2113740B65	470 ±30%
C202	2113740B65	470 ±30%
C206, C207	2113741M13	470
C246	2113740B65	470 ±30%
C271	2113741M13	470
C272, C273	2113740B65	470 ±30%
C274 thru C277	2113741M13	470
		DIODE :See Note 1
CR51	4811056B11	Silicon
CR71 thru CR75	4802368C08	Dual
CR90	4382960R02	Silicon
CR161 thru CR164	4802369E08	Dual
		JUMPER: Refer to Jumper Table
JU1	0511077A01	Resistor, 0 Ω
JU2	----------	Not used on this kit (See Note 3)
JU3	0511077A01	Resistor, 0 Ω
JU4	----------	Not used on this kit (See Note 3)
JU5	0511077A01	Resistor, 0 Ω
JU9 thru JU17	----------	Not used on this kit (See Note 3)
JU18 thru JU20	0511077A01	Resistor, 0 Ω
JU21, JU22	----------	Not used on this kit (See Note 3)
		COIL:
L1, L2	2480140E16	22µH
L23	2480289M16	22µH
L50	2480140E16	10µH
		PLUG:
P103	2880228J01	50-Pin D-Connector
		TRANSISTOR: See Note 2
Q23	4880141L02	NPN
Q40	4880141L01	PNP
Q50	4880053M03	N-Channel
Q71 thru Q73	4880052M01	NPN Darlington
Q74, Q75	4880141L04	NPN
Q161, Q162	4880141L02	NPN
Q170	4880141L01	PNP
Q171	4880141L02	NPN
		RESISTOR, Fixed: Ω ±5%;1/8W unless otherwise stated
R1	0611077A98	10k
R10	0611077A58	220
R12	0611077A74	1k
R13 thru R20	0611077A98	10k
R21	0611077B47	1 M
R22	0611077B11	33k
R23	0611077A98	10k
R24	0611077B11	33k
R25	0611077B15	47k
R26 thru R30	0611077A98	10k
R31, R32	0611077B15	47k
R33	0611077A74	1k
R34	0611077B15	47k
R35	0611077A74	1k
R37, R38	0611077A74	1k
R39	0611077A98	10k
R40	0611077A74	1k
R41	0611077A98	10k
R43	0611077B15	47k
R44	0611077A98	10k
R50	0611077A66	470
R51	0611077B07	22k
R52	0611077A98	10k
R53 thru R55	0611077A19	5.1
R56 thru R58	0611077B11	33k
R59	0611077A98	10k
R60	0611077A94	6.8k
R61	0611077A74	1k
R71 thru R73	0611077B11	33k
R74, R75	0611077A98	10k
R81	0611077A98	10k
R84	0611077A98	10k
R87	0611077A98	10k
R98, R99	0611077A98	10k
R161	0611077A98	10k
R163	0611077A98	10k
R164, R165	0611077A98	10k
R166	0611077A82	2.2k
R170	0611077B23	100k
R171	0611077B15	47k
R172	0611077A82	2.2k
R173	0611077A90	4.7k
R181	0611077B07	22k
R182	0611077B15	47k
R183	0611077A98	10k
R200	----------	Not used on this kit (See Note 3)
		SWITCH:
S1	4080033K01	Toggle
		TRANSFORMER:
T60	2580277J02	Voltage Conversion
		CIRCUIT MODULE: See Note 1
U2	5197024A01	Microprocessor (type MC68HC11A1CFN)
U3	5180056M01	Dual Comparator
U4	5183977M87	Serial Input/Output
U5	5197014A10	EEPROM
U6	5184704M54	Shift Register
U7	HVN4026A	PROM
U8	5180177M03	Quad NAND Gate
U10	5180177M02	Octal Latch
U46	5180068C08	Voltage Regulator
		DIODE: See Note 1
VR1 thru VR11	48 80140L20	15V Zener
VR50	4880056K40	43V Zener (40V
		CRYSTAL: See Note 2
Y2	4880173D10	7.9488 MHz

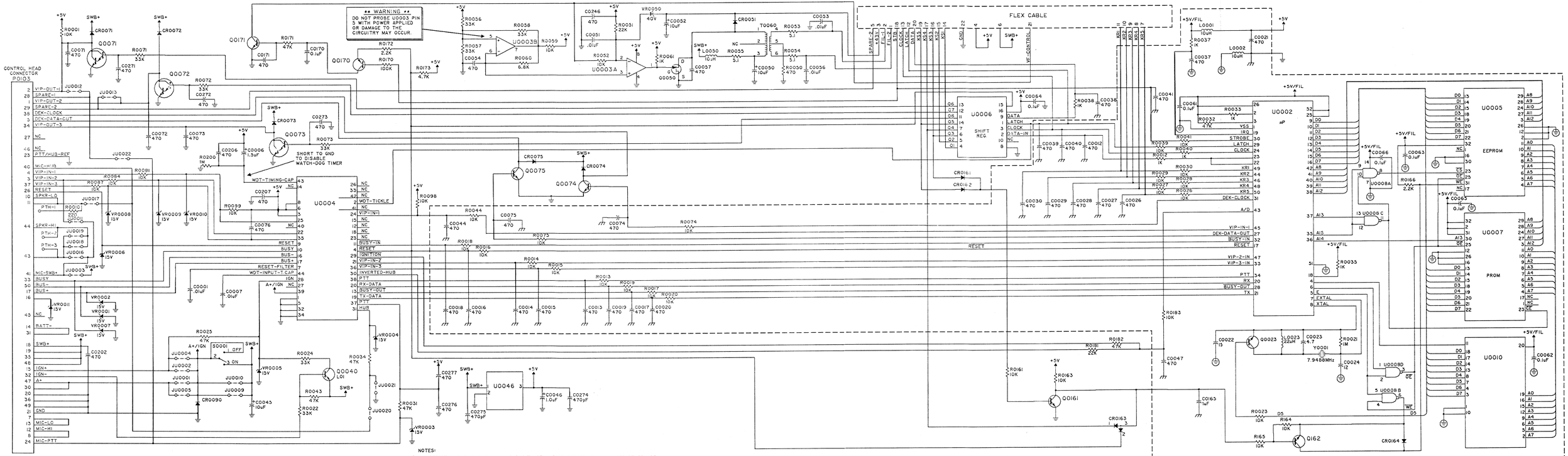
NONREFERENCED ITEMS

	0980049R01	SOCKET, 32-Pin (U7)
	1480269K01	INSULATOR, Shield (4 req'd)
	2680188P02	SHIELD, Frame
	2680190P01	SHIELD, Cover (2 req'd)
	3080034K01	CABLE, Flex
	3280178J01	GASKET, Switch (S1)
	3280179J01	GASKET, D-Connector Outside
	3280181J01	GASKET, D-Connector Face
	8480167P02	BOARD, Circuit (part of 8480209P32)

NOTES:

1. For optimum performance, order replacement diodes, transistors, and circuit modules by Motorola part number only.
2. When ordering crystal units, specify carrier frequency, crystal frequency, crystal type number, and Motorola part number.
3. This part is used for special applications only. If your unit is modified for a special application, your supplemental special applications manual will contain part usage information.

HLN6284A CONTROLLER BOARD COMPONENT LOCATION DETAILS AND PARTS LIST



HLN6284A CONTROLLER BOARD SCHEMATIC DIAGRAM

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