

# TW-PRC1099-MS1

TRANS WORLD COMMUNICATIONS TECHNICAL MANUAL

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Service and Technical Manual

## RADIO SET PRC1099



TRANS WORLD COMMUNICATIONS, INC.  
A COATRON COMPANY

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**TECHNICAL MANUAL MS1  
RADIO SET PRC1099**



## One Year Limited Warranty and Remedies

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Datron World Communications Inc. (DWC) warrants that its equipment is free from defects in design, materials and workmanship for a period of 12 months from the date of installation of the equipment, but in no event later than 15 months from the date of shipment. If the equipment does not provide satisfactory service due to defects covered by this warranty, DWC will, at its option, replace or repair the equipment free of charge.

Should it be impractical to return the equipment for repair, DWC will provide replacements for defective parts contained in the equipment for a period of 12 months from the date of installation of the equipment, but in no event later than 15 months from the date of shipment.

This warranty is limited to the original purchaser and is not transferable. Repair service performed by DWC is warranted for the balance of the original warranty or 90 days, whichever is longer.

**Exclusive Warranty:** There are no other warranties beyond the warranty as contained herein. No agent, employee, or representative of DWC has any authority to bind DWC to any affirmation, representation, or warranty concerning the equipment or its parts that is not in conformity with the warranties contained herein. EXCEPT AS EXPRESSLY SET FORTH ABOVE, NO OTHER WARRANTIES, EITHER EXPRESS OR IMPLIED, ARE MADE WITH RESPECT TO THE EQUIPMENT OR THE PARTS CONTAINED THEREIN, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND DWC EXPRESSLY DISCLAIMS ALL WARRANTIES NOT STATED HEREIN.

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- Damage to the equipment or its parts caused by lighting, static discharge, voltage transients, or application of incorrect supply voltages.
- Defects or failures caused by unauthorized attempts to repair or modify the equipment.
- Defects or failures caused by Buyer abuse or misuse.

**Return of Equipment - Domestic:** To obtain performance of any obligation under this warranty, the equipment must be returned freight prepaid to the Customer Service Department. Datron World Communications Inc., 304 Enterprise Street, Escondido, California 92029. The equipment must be packed securely. DWC shall not be responsible for any damage incurred in transit. A letter containing the following information must be included with the equipment.

- a. Model, serial number and date of installation;
- b. Name of dealer or supplier of the equipment;
- c. Detailed explanation of problem;
- d. Return shipping instructions; and
- e. Telephone or fax number where buyer may be contacted.

DWC will return the equipment prepaid by United Parcel Service, Parcel Post, or truck. If alternate shipping is specified by Buyer, freight charges will be made collect.

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**Parts Replacement:** The following instructions for the supply of replacement parts must be followed:

- a. Return the parts prepaid to "Parts Replacement" Datron World Communications Inc., 304 Enterprise Street, Escondido, California 92029; and
- b. Include a letter with the following information:
  1. part number;
  2. serial number and model of equipment; and
  3. date of installation.

Parts returned without this information will not be replaced. In the event of a dispute over the age of the replacement part, components date-coded over 24 months previously will be considered out of warranty.

**Remedies:** Buyer's sole remedies and the entire liability of DWC are set forth above. In no event will DWC be liable to buyer or any other person for any damages, including any incidental or consequential damages, expenses, lost profits, lost savings, or other damages arising out of use of or inability to use the equipment.

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FIGURE 1-1. PRC1099 1.6-30 MHz Manpack Transceiver.



# CHAPTER 1

## INTRODUCTION & TECHNICAL SPECIFICATIONS

### 1-1 GENERAL

This manual provides detailed information on the service and repair of the PRC1099 transceiver. Full technical information is given, including schematic diagrams, theory of operation, and test and alignment procedures. Detailed parts lists are also included.

### 1-2 OPERATOR'S MANUAL

The Operator's Manual TW-PRC1099-TM1 should be

used in conjunction with this one. It includes full installation, operating and field maintenance instructions.

### 1-3 TECHNICAL SPECIFICATIONS

Chapter 1 contains technical specifications (Table 1-1), semiconductors (Table 1-2), a block diagram (Figure 1-2) and module location diagrams (Figures 1-3 and 1-4).

**TABLE 1-1.**  
**Technical Specifications, PRC1099.**

<b>GENERAL</b>	
Frequency Range:	1.6 - 30 MHz.
Number Of Channels:	284,000 in 100-Hz steps.
Preset Memory Channels:	10 (field programmable).
Display:	Backlit 6-digit LCD.
Power Source:	12 Vdc (10.5-15 V operational).
Battery Pack:	BB-LA6 12-V, 6-Ah sealed lead-calcium. BA5598/U lithium (case holds spare battery). BA4386/U (limited to 5-W operation). PRC-77 nicad battery packs.
Low Battery:	LCD display flashes.
Modes:	Voice/Data/CW, USB/LSB, AME optional.
Operating Temperature:	-30° C to +60° C.
Frequency Stability:	±20 Hz at 5 MHz, 1 ppm (optional). ± 1 ppm (optional).
Size:	28.2 cm W, 10.4 cm H, 23.5 cm D.
Weight:	Basic radio unit 5.2 kg; Battery case with BA5598/U Battery 0.9 kg.
Design:	To MIL Standard 188C.
Environmental:	Designed to MIL Standard 810D including shock, vibration, humidity, immersion and rough handling.
Interfaces:	Per MIL Standard 188C (audio and RF).
<b>TRANSMITTER</b>	
Power Output:	High: 20-W PEP/AVG ± 1 dB into 50 Ω. Low: 5-W PEP/AVG.
Output Protection:	Infinite VSWR including short or open circuits.
Duty Cycle:	Continuous—power output automatically reduced to 5 W at heat sink temperatures > 80° C.
Carrier Suppression:	-45 dB.
Unwanted Sideband:	-60 dB at 1 kHz.
Spurious Suppression:	-50 dB
Harmonic Suppression:	-50 dB typical (except below 2 MHz).



**TABLE 1-1.  
Technical Specifications, PRC1099, Continued.**

Intermodulation Distortion:	-26 dB.
Audio Inputs:	150- $\Omega$ automatic gain control and 600 $\Omega$ , 0 dBm.
Audio Bandwidth:	350-2700 Hz.
Audio Compression:	+30 dB above nominal.
ALC:	< + 1-dB change for + 30-dB audio increase.
Sidetone:	Audio sidetone all modes.
Current Drain:	5 A maximum, all modes. 1.5 A typical voice.

**RECEIVER**

SENSITIVITY:	0.5 $\mu$ V for 10-dB SINAD.
SELECTIVITY:	350-2700 Hz at -6 dB, -60 dB at 5 kHz.
IMAGE REJECTION:	80 dB.
IF REJECTION:	80 dB.
AGC CHARACTERISTICS:	<6-dB audio change from 3 $\mu$ V to 300,000 $\mu$ V RF input.
INTERCEPT POINT:	+10 dBm.
INTERMODULATION:	-80 dB.
SQUELCH:	Audio derived, noise immune.
AUDIO OUTPUT:	500 mW @ 16 $\Omega$ , 50 mW @ 150 $\Omega$ , 0 dBm @ 600 $\Omega$ .
CURRENT DRAIN:	Squelched: 120 m A typical @ 20°C. Non-squelched: maximum 170 mA.

**ANTENNA TUNER**

ANTENNAS:	10-ft. (3-m) manpack whip for 2-30 MHz. 16-50 ft. (4.8 m - 15 m) whip or long wire for 1.6-30 MHz. External adapter available for longer antennas.
TUNING TIME:	One second typical.
TUNE MEMORY:	Last tune stored on all 10 channels.
SWITCHING TIME:	20 ms for stored tune information.
TUNE POWER:	500 mW (no output when switching stored tune information).
MAXIMUM OUTPUT VOLTAGE:	1 kV (power automatically reduced if this terminal voltage is exceeded).
ANTENNA SWITCHING:	Antenna tuner disconnects and switches output to 50- $\Omega$ port when whip or long wire terminal is removed.

**OPERATING CONTROLS**

VOLUME:	Sets audio output level.
MODE:	Squelch on, USB, LSB, display backlight and optional mode.
POWER:	Off, Low power (5 W), High power (20 W), external amplifier.
TUNE:	Tunes transceiver frequency up or down.
DIGIT:	Selects tuning rate of 1 MHz, 100 kHz, 10 kHz, 1 kHz or 100 Hz (automatically reverts to 100 Hz).
CHANNEL:	Selects stored channels (store push switch must be depressed to reprogram CH 1-9).
WHIP/TUNE:	Momentary—activates antenna tune cycle.
STORE:	Hold down to change stored channel.

TABLE 1-2.  
Semiconductors, PRC1099.

DESIGNATOR	FUNCTION	DESCRIPTION
M1 D1	Gate	1N4148 Diode
M1 D2	RF Protection RX	BA482 PIN Diode
M1 D3	Rectifier	1N4148 Diode
M1 D4	Rectifier	1N4148 Diode
M1 D5	Gate	1N4148 Diode
M1 D6	Gate	1N4148 Diode
M1 D7	Gate	1N434A Diode
M1 D8	Gate	1N434A Diode
M1 D9	Gate	1N4148 Diode
M1 D10	RF Rectifier	1N4148 Diode
M1 D11	RF Rectifier	1N4148 Diode
M1 D12	Transient Suppressor	1N4148 Diode
M1 D13	Transient Suppressor	1N751 Zener Diode
M1 Q1	Oscillator 1647/1650 kHz	2N3567 NPN Transistor
M1 Q2	Switch	2N3565 NPN Transistor
M1 Q3	Switch	2N3565 NPN Transistor
M1 Q4	Squelch Switch	2N3565 NPN Transistor
M1 Q5	Squelch Switch	2N3565 NPN Transistor
M1 Q6	Squelch Switch	2N2907A PNP Transistor
M1 Q7	Relay Switch	2N3567 NPN Transistor
M1 Q8	Relay Switch	2N3567 NPN Transistor
M1 Q9	Relay Switch	2N3567 NPN Transistor
M1 Q10	Relay Switch	2N3567 NPN Transistor
M1 Q11	Relay Switch	2N3567 NPN Transistor
M1 Q12	Relay Switch	2N3567 NPN Transistor
M1 Q13	Relay Switch	2N3567 NPN Transistor
M1 Q14	Amplifier	2N3567 NPN Transistor
M1 Q15	DC Clamp	2N3567 NPN Transistor
M1 Q16	DC Clamp	2N3567 NPN Transistor
M1 Q17	Switch	2N3567 NPN Transistor
M1 Q18	ALC Amplifier	2N3638 PNP Transistor
M1 Q19	Low Power Switch	2N3565 NPN Transistor
M1 Q20	CW Hold Switch	MPSD54 PNP Darlington Transistor
M1 Q21	RF Gate	2N3565 NPN Transistor
M1 U1	Mic Amp/VOGAD	SL6270 Integrated Circuit
M1 U2	Balanced Modulator	SL1640 Integrated Circuit
M1 U3	Product Detector	CA3028 Integrated Circuit
M1 U4A	Audio Amplifier	LM358 Integrated Circuit (1/2)
M1 U4B	RF Gate Comparator	LM358 Integrated Circuit (1/2)
M1 U5	Audio Power Amplifier	LM386 Integrated Circuit
M1 U6A/B/C	Squelch Amplifiers	LM324 Integrated Circuit (3/4)
M1 U6D	Squelch Rectifier	LM324 Integrated Circuit (1/4)
M1-U7A/B	One Shot	4001 Integrated Circuit (1/2)
M1 U7C/D	Squelch Hold Timer	4001 Integrated Circuit (1/2)
M1 U8	Filter Select Logic	4094 Integrated Circuit
M2 D1	Bias	1N4148 Diode
M2 D2	Bias	1N4148 Diode
M2 D3	AGC Rectifier	1N4148 Diode
M2 D4	AGC Rectifier	1N4148 Diode
M2 D5	Bias	1N4148 Diode
M2 D6	Gate	1N4148 Diode
M2 Q1	RX IF Amplifier	3N204 MOSFET
M2 Q2	RX IF Amplifier	2N5770 NPN Transistor

**TABLE 1-2.  
Semiconductors, PRC1099, Continued.**

<b>DESIGNATOR</b>	<b>FUNCTION</b>	<b>DESCRIPTION</b>
M2 Q3	TX IF Amplifier	2N5770 NPN Transistor
M2 Q4	AGC Amplifier	2N3565 NPN Transistor
M2 Q5	AGC Amplifier	2N3565 NPN Transistor
M3 D1	RF Switch	BA482 PIN Diode
M3 D2	Bias	1N4148 Diode
M3 D3	Bias	1N4148 Diode
M3 D4	Bias	1N4148 Diode
M3 D5	RF Switch	BA482 PIN Diode
M3 D6	RF Switch	BA482 PIN Diode
M3 D7	Bias	1N4148 Diode
M3 D8	Gate	1N4148 Diode
M3 D51	RF Switch	BA482 PIN Diode
M3 D52	RF Switch	BA482 PIN Diode
M3 D53	RF Switch	BA482 PIN Diode
M3 D54	Clamp	1N4148 Diode
M3 D55	Bias Clamp	1N4148 Diode
M3 D56	Bias Clamp	1N4148 Diode
M3 Q1	RX IF Amplifier	3N204 MOSFET
M3 Q2	RX Mixer	3N204 MOSFET
M3 Q3	RX Switch	2N3565 NPN Transistor
M3 Q4	Synthesizer Buffer	2N5770 NPN Transistor
M3 Q5	TX IF Amplifier	3N204 MOSFET
M3 Q6	ALC Amplifier	2N3565 NPN Transistor
M3 Q51	Synthesizer Buffer	2N5770 NPN Transistor
M3 Q52	Squelch Switch	2N3565 NPN Transistor
M3 Q53	RX IF Amplifier	2N5109 NPN Transistor
M3 Q54	Squelch Switch	2N3565 NPN Transistor
M3 Q55	Current Regulator	2N3638 PNP Transistor
M3 Q56	TX Switch	2N3565 NPN Transistor
M3 U1	RX/TX Mixer	SRA1 Double Balanced Mixer
M3 U51	TX Mixer	MC1946 Integrated Circuit
M3 U52	TX Amplifier	MAR8 MMIC
M4 D1	Bias	1N4005 Diode
M4 D2	Bias	1N4005 Diode
M4 Q1	Final Pre Driver	MRF476 RF Transistor
M4 Q2	Final Driver	MRF476 RF Transistor
M4 Q3	Final Driver	MRF476 RF Transistor
M4 Q4	Final Power Amplifier	MRF406 RF Transistor
M4 Q5	Final Power Amplifier	MRF406 RF Transistor
M4 Q6	Bias Regulator	2N5191 NPN Transistor
M4 Q7	Bias Regulator	2N5191 NPN Transistor
M4 Q8	Overtemp Switch	2N3565 NPN Transistor
<b><u>M5 Tuner Board</u></b>		
M5 D1	RF Current Rectifier	1N34 Diode
M5 D2	Clamp	1N4148 Diode
M5 D3	Clamp	1N4148 Diode
M5 U1	Op Amp	LM324 Integrated Circuit
M5 U2	Shift Register	CD4094 Integrated Circuit
M5 U3	Shift Register	CD4094 Integrated Circuit
M5 U4	Shift Register	CD4094 Integrated Circuit
M5 U5	Relay Drivers	MPQ2222 Transistor Array

**TABLE 1-2.**  
**Semiconductors, PRC1099, Continued.**

<u>DESIGNATOR</u>	<u>FUNCTION</u>	<u>DESCRIPTION</u>
M5 U6	Relay Drivers	MPQ2222 Transistor Array
M5 U7	Relay Drivers	MPQ2222 Transistor Array
M5 U8	Relay Drivers	MPQ2222 Transistor Array
<u>M5 Tuner Driver Board</u>		
M5 D1	Clamp	IN4148 Diode
M6 D1	Varactor Tuning	MV2205 Varactor Diode
M6 D101	Varactor Tuning	MV209 Varactor Diode
M6 D102	Varactor Tuning	MV209 Varactor Diode
M6 D103	Clamp	1N4148 Diode
M6 D104	Switch	BA482 PIN Diode
M6 D105	Voltage Regulator	1N4099 Zener Diode
M6 D106	Level Shifter	1N751A Zener Diode
M6 D107	Varactor Tuning	MV209 Varactor Diode
M6 D108	Clamp	1N4148 Diode
M6 D109	Switch	BA482 PIN Diode
M6 D110	Voltage Regulator	1N4099 Zener Diode
M6 D111	Voltage Reference	LM385Z2.5 Zener Diode
M6 Q1	Oscillator 5120 kHz	2N5770 NPN Transistor
M6 Q2	Switch	2N2907A PNP Transistor
M6 Q3	5V Regulator	2N6427 Darlington Transistor
M6 Q101	Oscillator Syn. 2	2N5770 NPN Transistor
M6 Q102	Buffer Syn. 2	2N5770 NPN Transistor
M6 Q103	Oscillator Syn. 1	J310 FET Transistor
M6 Q104	Buffer Syn. 1	J310 FET Transistor
M6 Q105	Switch	2N2907A PNP Transistor
M6 Q106	Oscillator Syn. 1	J310 FET Transistor
M6 Q107	Buffer Syn. 1	J310 FET Transistor
M6 Q108	Switch	2N3638 PNP Transistor
M6 Q109	Switch	2N3565 NPN Transistor
M6 Q110	Buffer Syn. 1	3N204 MOSFET Transistor
M6 Q111	Buffer Syn. 1	J310 FET Transistor
M6 Q112	Buffer Syn. 2	2N5770 NPN Transistor
M6 Q113	Switch	PN2907A PNP Transistor
M6 U1	Prescaler	MC12015 Integrated Circuit
M6 U2	Charge Pump	MC1458 Integrated Circuit
M6 U3	Synthesizer 1	MC145158 Integrated Circuit
M6 U4	Synthesizer 2	MC145157 Integrated Circuit
M6 U5	Programmable Divider	MC14526 Integrated Circuit
M6 U6	Programmable Divider	MC14526 Integrated Circuit
M6 U7	Prescaler	MC12017 Integrated Circuit
M6 U8	Shift Register/Latch	74HC595 Integrated Circuit
M6 U101	Bar/Dot Driver	LM3914N Integrated Circuit
M6 U102	Temperature Compensation	Selected Resistors 1%
M6 U103	Voltage Regulator	LM317LZ Integrated Circuit
M7 D1	Polarity Protection	1N4005 Diode
M7 D2	Polarity Protection	1N4005 Diode
M7 D3	Gate	1N4148 Diode
M7 D4	Gate	1N4148 Diode
M7 D5	Regulator	RH5VA21AC Diode
M7 D6	Clamp	1N4148 Diode

**TABLE 1-2.**  
**Semiconductors, PRC1099, Continued.**

<b>DESIGNATOR</b>	<b>FUNCTION</b>	<b>DESCRIPTION</b>
M7 Q1	Mute Switch	BC818-40L NPN Transistor
M7 Q2	ATU Tune Switch	BC818-40L NPN Transistor
M7 Q3	Lo Power Switch	BC818-40L NPN Transistor
M7 Q4	Tone Key Switch	BC818-40L NPN Transistor
M7 Q5	5 V Switch	MMBT222AL NPN Transistor
M7 Q6	PTT Switch	BC818-40L NPN Transistor
M7 Q7	Amp PTT Switch	MMBT222AL NPN Transistor
M7 Q8	Oscillator Switch	2N7002 FET Transistor
M7 Q9	IRQ Switch	BC818-40L NPN Transistor
M7 U1	Latch	MC74HC259D Integrated Circuit
M7 U2	Buffer	MC74HC244ADW Integrated Circuit
M7 U3	Supervisory	MAX695CNE Integrated Circuit
M7 U4	Voltage Regulator	LM317MDT Integrated Circuit
M7 U5	Microprocessor	MC68HC705C8FN Integrated Circuit
M7 U6	Voltage Regulator	LM317T Integrated Circuit
M7 U7	Amplifier	LM358D Integrated Circuit
M7 U8	Tone Oscillator	TLC272CD Integrated Circuit
M7 U9	Parity Tree	MC14531BD Integrated Circuit
M7 U10	Hex Inverter	MC74HCO4AD Integrated Circuit
M7 U11	Multivibrator	MC14528BD Integrated Circuit
M7 U12	Multiplexer	74HC4067D Integrated Circuit
M8 Q1	Backlight Oscillator	2N3567 NPN Transistor
M8 U1	Display Driver	MD4332B Integrated Circuit
M8 U2	Display Driver	MD4332B Integrated Circuit
M8 U3	Backplane Generator	CD4060B Integrated Circuit
M8 U4	Bar/Dot Driver	LM3914N Integrated Circuit
M8 U5	Decimal-to-BCD Decoder	74HC147N Integrated Circuit
M8 D1-D4	Gate	1N4148 Diode
M8 Q2-Q4	Buffer	2N2222A NPN Transistor

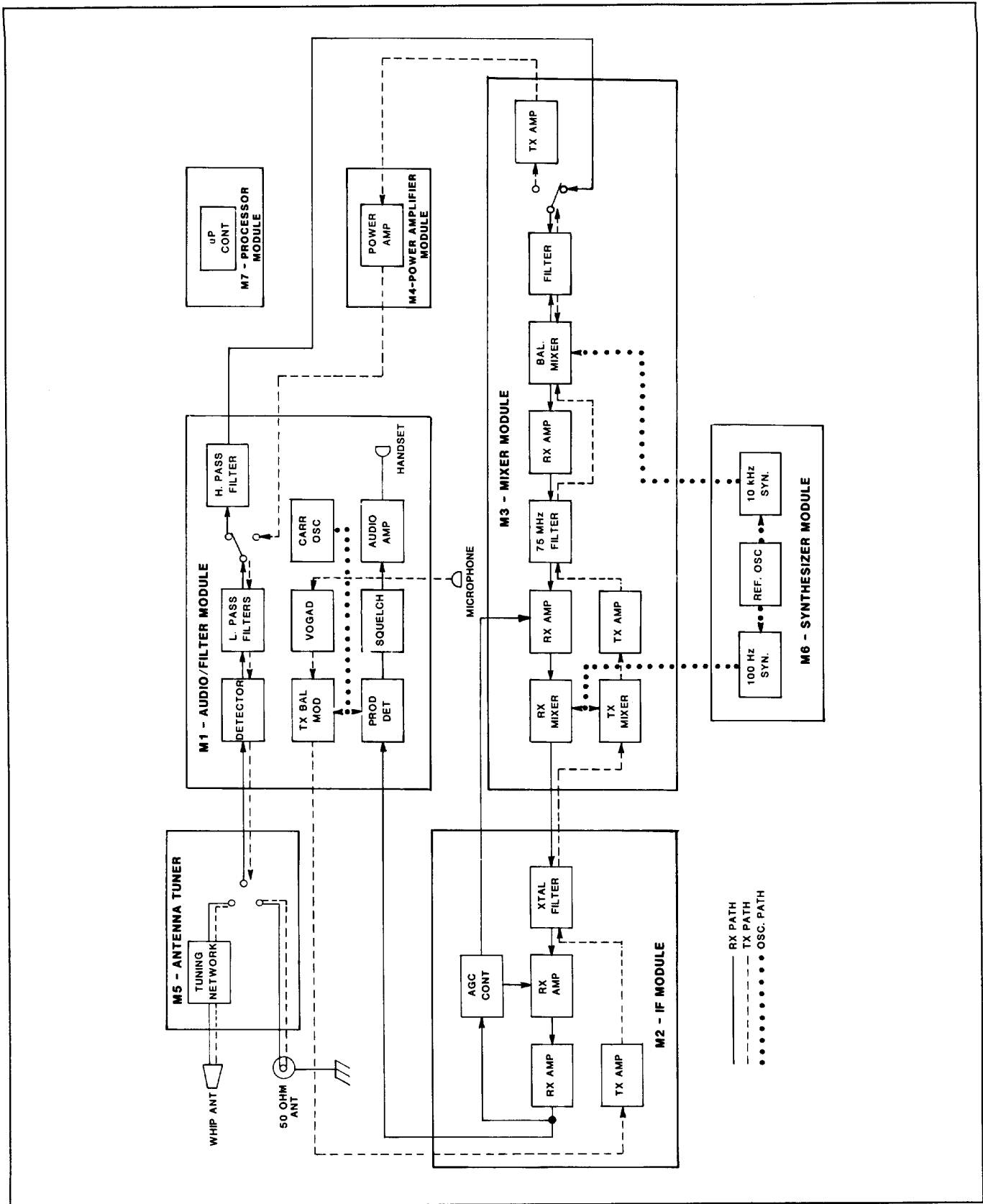
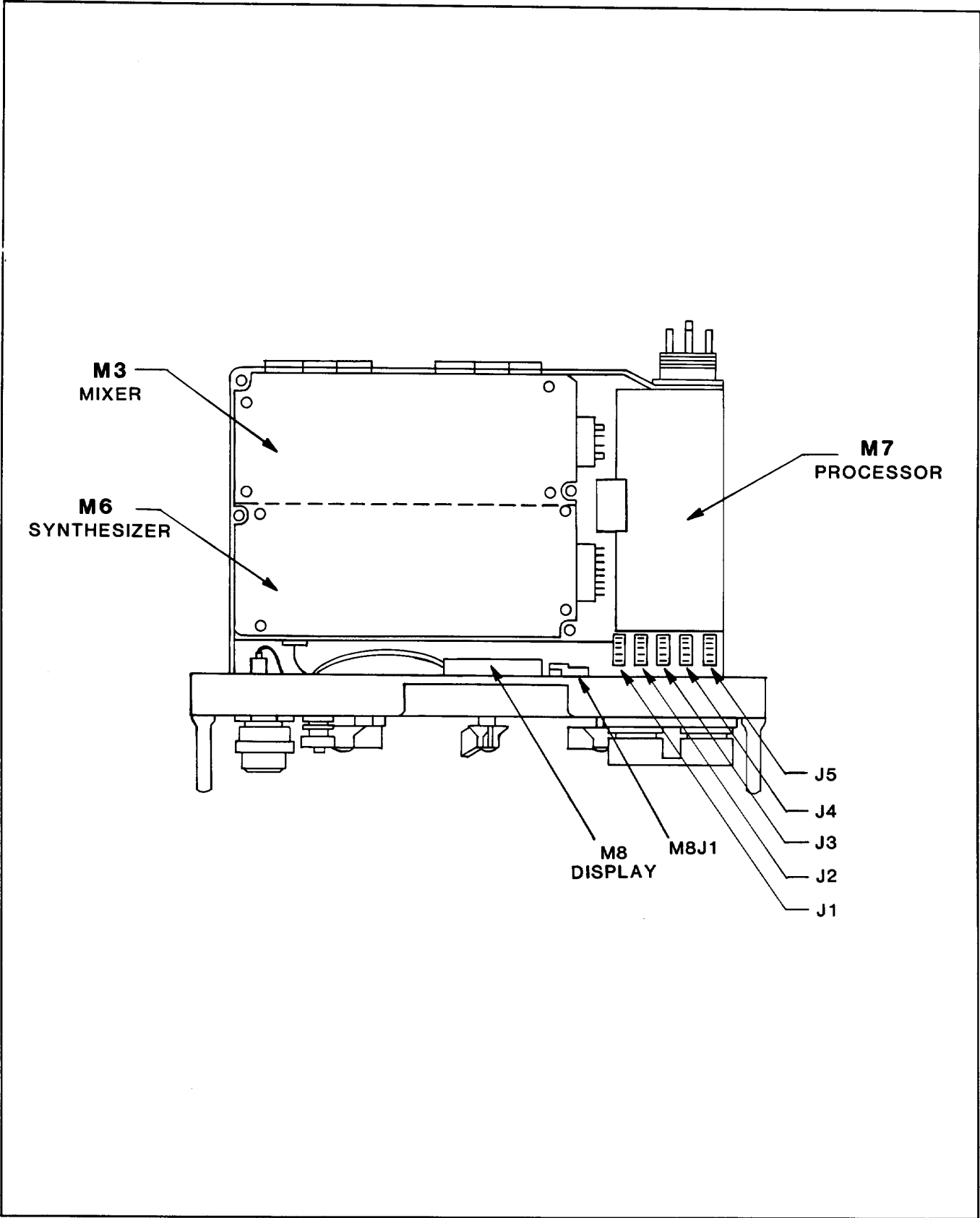
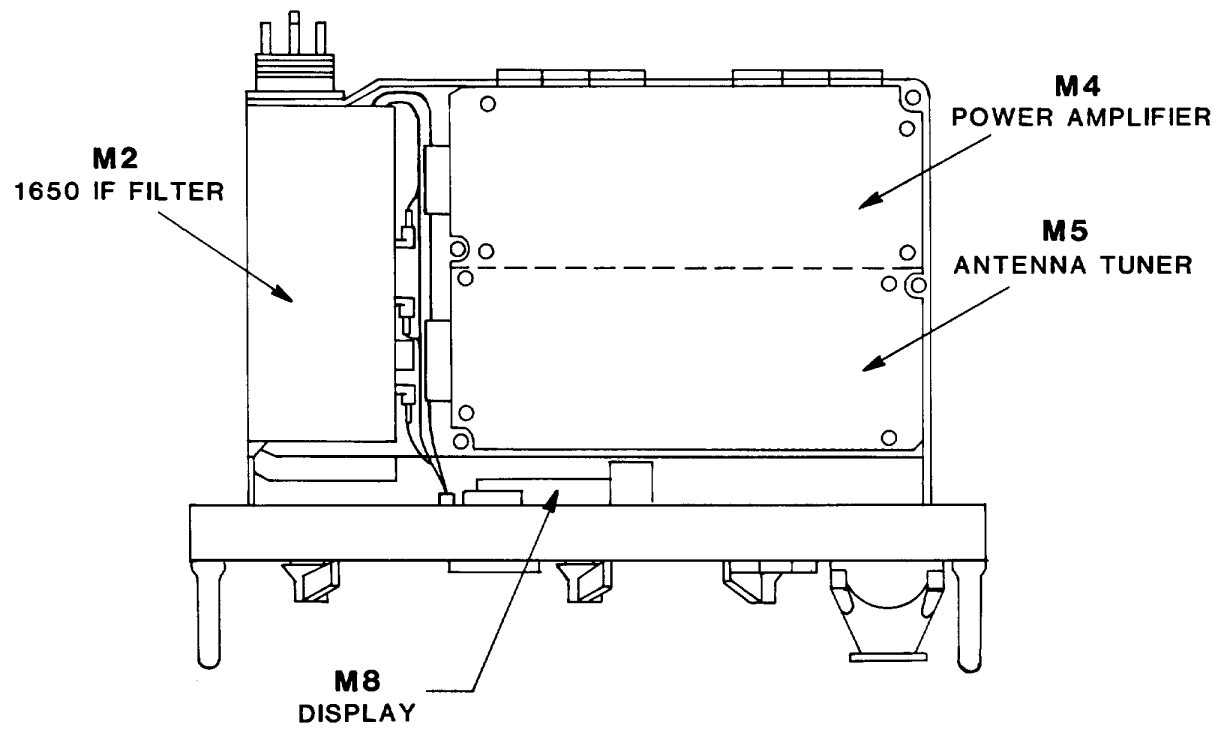


FIGURE 1-2.  
Block Diagram.



**FIGURE 1-3.**  
**Module Locations - Top.**



**FIGURE 1-4.**  
**Module Locations - Bottom.**



## CHAPTER 2 SERVICE & MAINTENANCE

### 2-1 SCOPE

This section contains information on the routine maintenance of the transceiver, the method of replacement of modules and components, the methods for locating defective modules, and a description of the recommended test equipment. This section does not cover the maintenance and service of the modules. Reference should be made to the chapters of this manual on the individual modules.

### 2-2 GENERAL

The PRC1099 is a complex transceiver using advanced design techniques to ensure high-performance, trouble-free service. It is essential to recognize that the PRC1099 must be serviced by skilled personnel using the correct test equipment and with a full understanding of the operation of the transceiver.

Two separate levels of service are recommended—field service and depot service. The PRC1099 has been constructed so that the complex circuitry is contained on individual modules that may be easily replaced in the field. This section of the manual gives instruction on how to locate the defective module. The modules are designed so that no adjustments will be required after replacement, and the defective module can be returned to the service depot or factory for repair.

### 2-3 TEST EQUIPMENT

Specific models of test equipment have been recommended for servicing the PRC1099. A description of the key characteristics relevant to the PRC1099 is given for each instrument.

**TABLE 2-1.  
Test Equipment.**

<u>ESSENTIAL</u>	
Synthesized Signal Generator:	Frequency Range = 1-105 MHz (minimum) Calibration x Setting Accuracy = 1 kHz (minimum) Output = .1 $\mu$ V to 1 V (with accurate attenuator)
Sinad/Audio Level Meter:	Measures SINAD at 1000 Hz/Audio Level
Electronic Multimeter:	General Purpose Input Impedance 11 M $\Omega$ (minimum)
Digital Voltmeter:	General Purpose Accuracy 1% (10 V Range)
Frequency Counter:	Frequency Range = 1-105 MHz Accuracy = 1 ppm (minimum)
Wattmeter:	Impedance = 50 $\Omega$ Power = 50 W (full scale) Frequency = 2-30 MHz (Thru-line, 50 W Element x Load)
Power Supply:	12 V 5 A Regulated
<u>OPTIONAL</u>	
Oscilloscope:	General Purpose Frequency response 100 MHz
Audio Signal Generator:	300-3000 Hz
RF Millivoltmeter:	Frequency Range = .5-100 MHz Ranges 10 mV to 3 V
Spectrum Analyzer:*	Frequency Range = 1-105 MHz Resolution = 100 Hz

## 2-4 MEASUREMENT TECHNIQUES

The following information will be helpful to technicians and engineers who have not had previous experience in testing modern synthesized equipment.

### 2-4.1 POWER MEASUREMENT

The power output of the PRC1099 is 20 W PEP (peak envelope power) or average. This means that the power output will be 20 W average in the CW mode and will have an instantaneous peak output of 20 W on voice peaks. In the CW mode or on a continuous sinewave tone, an average reading power meter such as the Bird Model 43 will indicate the correct output. On voice or a two-tone test signal, the meter will indicate the average power, which is much lower than the peak power. The meter will typically indicate 5-7 W on a voice waveform. On a two-tone test signal the correct power output will be 8 W as read on the Bird Model 43. Refer to Figures 2-1 and 2-2.

The power output must be read at the 50-ohm BNC connector with no antenna mount in the antenna connector. It should be noted that the 50-ohm connector is disconnected when the mount is placed in the antenna connector.

The supply voltage should be at least 12V under load when making power measurements. It should be noted that the current drain for voice operation is much lower than when operating CW. This means that even when the battery voltage is too low for high-power CW operation, there may be sufficient capacity for satisfactory voice operation.

The power amplifier in the PRC1099 has a substantial reserve capacity and is capable of 25-30 W output. It is not recommended that the power level be set higher than 20 W, as this will simply increase power consumption without any perceptible improvement in signal strength. It is necessary to at least double the output power before there will be any noticeable improvement in performance.

### 2-4.2 SPECTRUM ANALYZER

Although a spectrum analyzer is not an essential test instrument for servicing the transceiver, it is a useful instru-

ment for testing SSB equipment. The spectrum analyzer operates in the frequency domain and permits simultaneous examination of both frequency and amplitude. This characteristic is very useful for examining the various RF signals for spectral purity and spurious products. For example, the output from the phase-locked loop in the transceiver can be examined to ensure that the loop is locking correctly, the phase noise is satisfactory and there are no spurious outputs. The spectrum analyzer may be connected, through an attenuator, to the transceiver output and will display harmonics and unwanted spurious outputs. It is very important not to overload the spectrum analyzer when making harmonic measurements. If the input level is too high, the mixer in the spectrum analyzer will generate harmonics internally.

The spectrum analyzer may also be used to measure distortion by using a two-tone test signal. Two equal amplitude audio tones in the transmitter audio passband are used to drive the transmitter to full power output (20 W PEP). The distortion products will appear as signals displaced by the separation of the tone frequencies. It should be noted that the PEP of the transmitter is 6 dB higher than the level of each tone in the two-tone test waveform. This means that if the third order distortion products are 26 dB below each wanted tone, the intermodulation distortion level is -32 dB relative to PEP.

### 2-4.3 SIGNAL GENERATOR

The signal generator is primarily considered an instrument for testing the receiver. It is also a most convenient instrument for injecting controlled signals of known frequency and amplitude into different parts of the transceiver. For example, the signal generator may be used as a temporary substitute for one of the synthesizers.

### 2-4.4 FREQUENCY COUNTER

Apart from the important function of frequency calibration, the frequency counter is a useful tool for servicing the synthesizer. By connecting the counter to different points in the circuitry, it is possible to check that the correct divide ratios are occurring in the synthesizer.

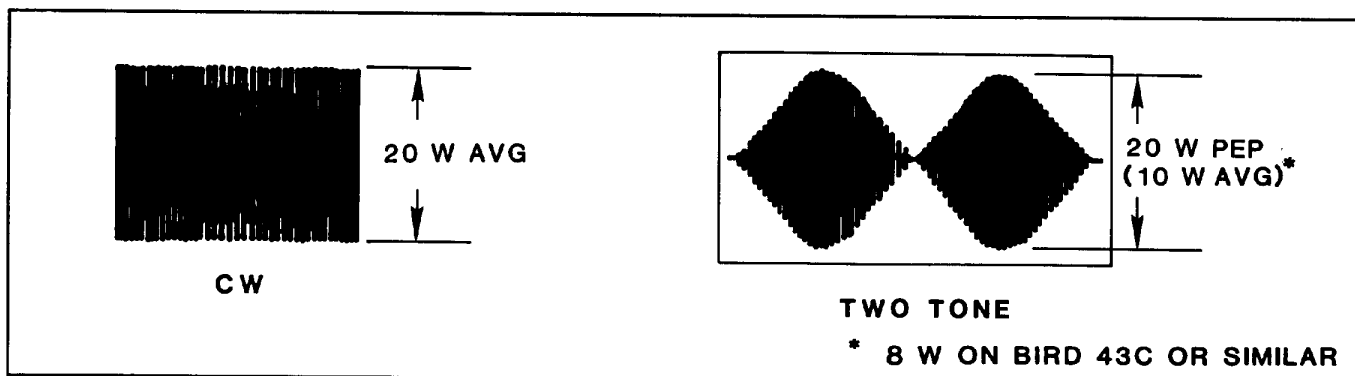
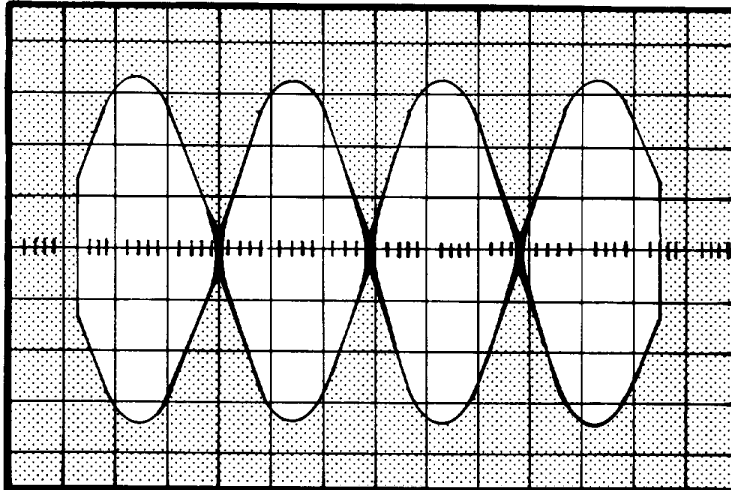


FIGURE 2-1.  
Power Measurement Waveforms.



**FIGURE 2-2.**  
**Two-Tone Test Signal.**

## 2-5 ROUTINE MAINTENANCE

Refer to Chapters 4 and 5 of the PRC1099-TM1 Operator's Manual.

## 2-6. ACCESS & MODULE REMOVAL

### 2-6.1. CASE REMOVAL

Stand the PRC1099 on its front panel (Figure 2-3). Remove the battery case and the battery. Loosen the captive screws and pull the case from the chassis (Figure 2-4). If necessary, insert a flat-blade screwdriver between the front panel and the case to pry the case off.

### 2-6.2. ACCESS

All of the modules, except M1, the Audio Module, are directly accessible when the transceiver is removed from the case. The covers on the modules may be removed, for access to adjustments, while the modules are in place. The Audio Module M1 is mounted in the center of the transceiver between modules M3/M6 and M4/M5 and is accessed by removing the two retaining screws. This permits modules M4/M5 to hinge from the back of the transceiver as shown in Figure 2-5.

### 2-6.3. REMOVAL OF MODULES

#### 2-6.3.1. M1 REMOVAL

Access the module as described in Section 2-6.2. Remove the connectors from M4 and M5 and the antenna connection from M5. This permits the M4/M5 mounting bracket to swing full open. Disconnect the two RF connectors to the underneath side of M4 and M5 and the multipin connectors at the side of the circuit board. The circuit board is retained by four mounting screws at the corners and a center mounting screw.

### NOTE

There is an RF connector underneath the circuit board. Make sure that this connector is correctly engaged when reinstalling M1 and that the grounding sleeve on the connector is in place.

#### 2-6.3.2. M4 REMOVAL

Remove the RF connector from underneath the module (2-6.3.1). Remove the end connector. Unscrew the two retaining bolts.

#### 2-6.3.3. M5 REMOVAL

Remove the RF connector from underneath the module (2-6.3.1). Remove the end connector. Disconnect the antenna wire. Unscrew the two retaining bolts.

#### 2-6.3.4. M3/M6 REMOVAL

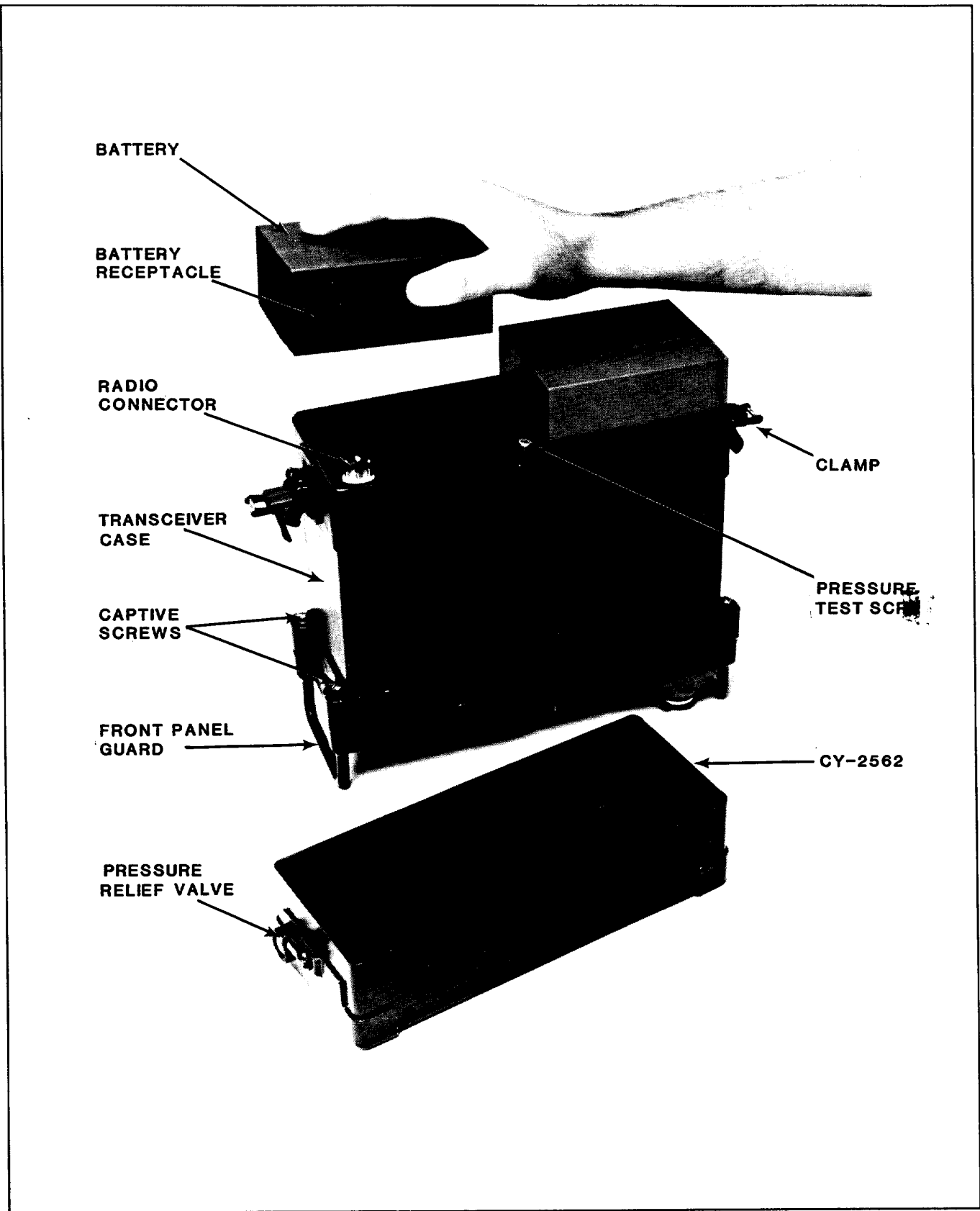
Those two modules are interconnected. Remove the cover from M3 (4 screws) and disconnect the 6 push connectors on the wires connecting M3 and M6. The modules are now separated and each may be removed by removing the end connector and the two retaining bolts.

### NOTE

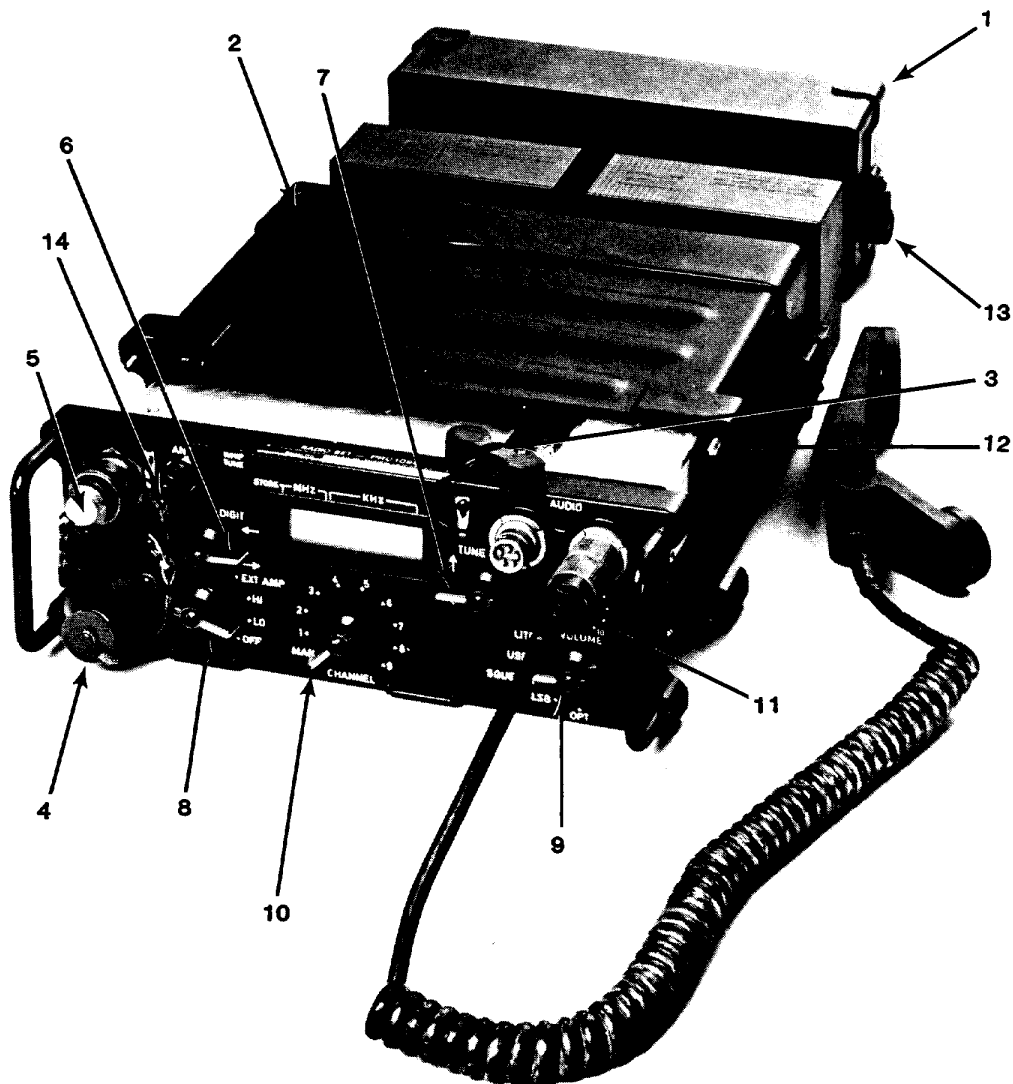
There is an RF connector under M3. Make sure this connector is correctly engaged when reinstalling the assembly.

#### 2-6.3.5. M2 REMOVAL

Remove the two side retaining screws. Loosen the two retaining screws on the center plate next to M1. The module should be tilted sideways to disengage the slots in the cover from these screws. Remove the three RF connectors and the power connector and the module can be lifted out.



**FIGURE 2-3.**  
**Installation of Battery in Transceiver.**



- |   |   |
|---|---|
| 1. CY-2562                                  | 8. Knob, long-handled (power switch)    |
| 2. Case, transceiver                        | 9. Knob, long-handled (mode switch)     |
| 3. Cover, double rubber connector protector | 10. Knob, long-handled (channel switch) |
| 4. Cover, antenna dust                      | 11. Knob (VOLUME)                       |
| 5. Cover, BNC                               | 12. Screw, captive                      |
| 6. Knob, long-handled (DIGIT Select)        | 13. Hook                                |
| 7. Knob, long-handled (TUNE)                | 14. Dummy connector, plug               |

**FIGURE 2-4.**  
**Receiver/Transmitter, Radio Set PRC1099--Organizational Repair Parts.**

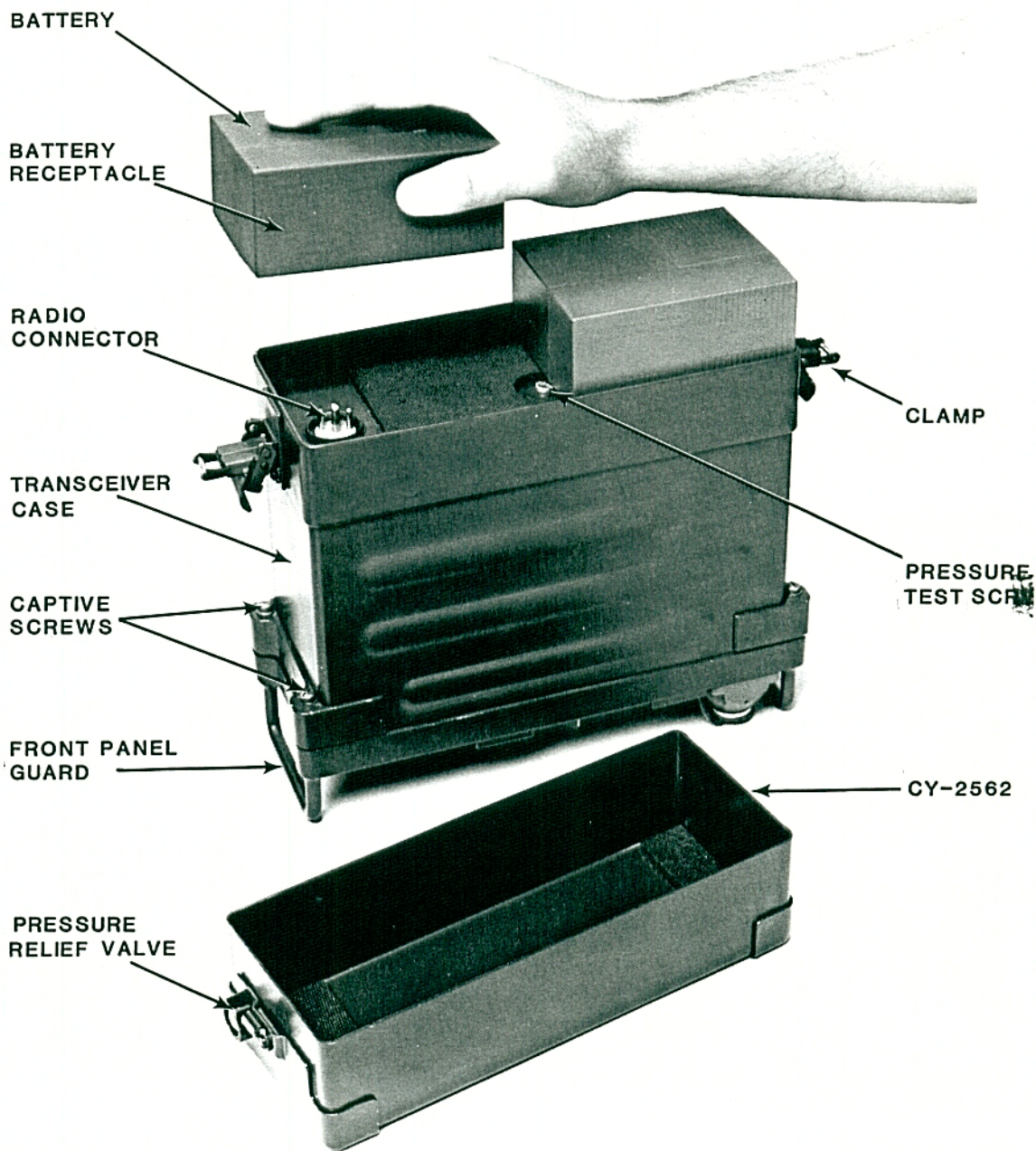
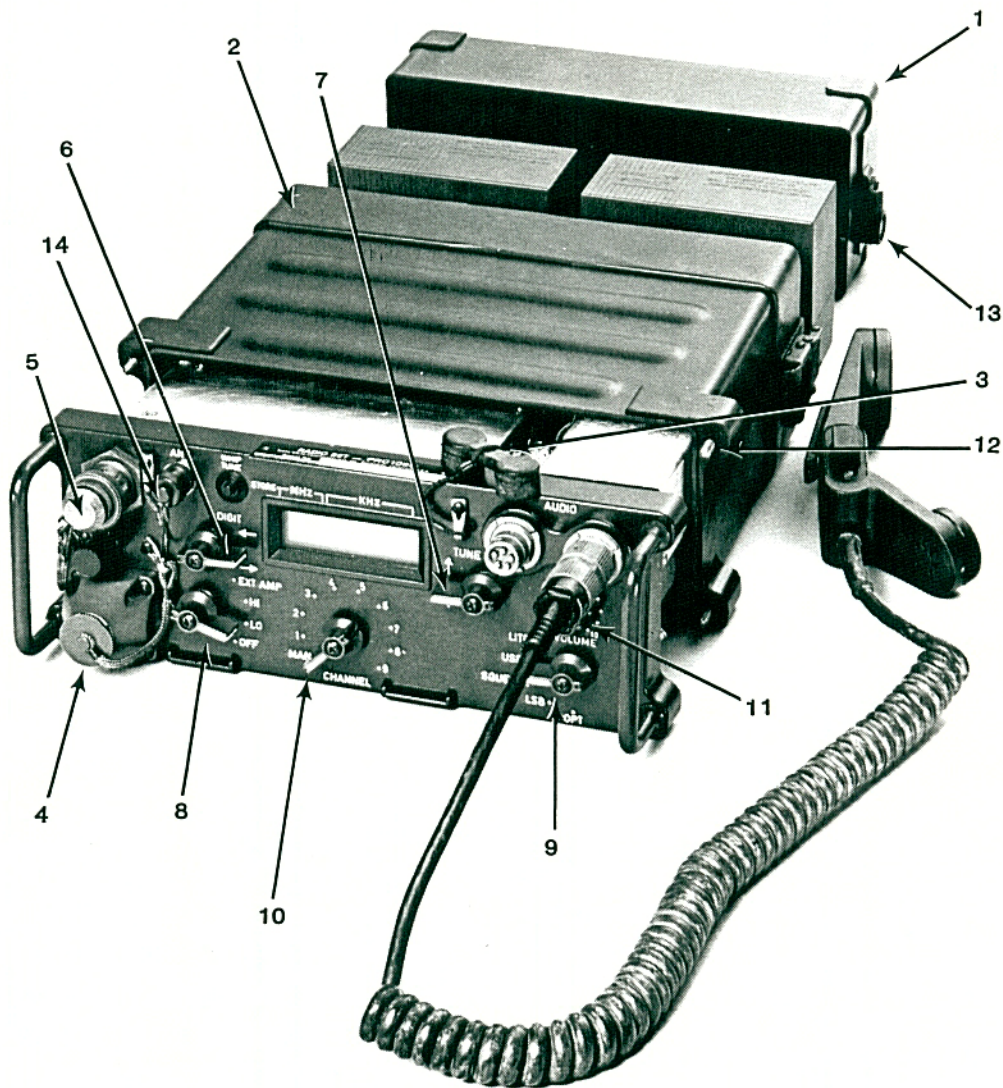
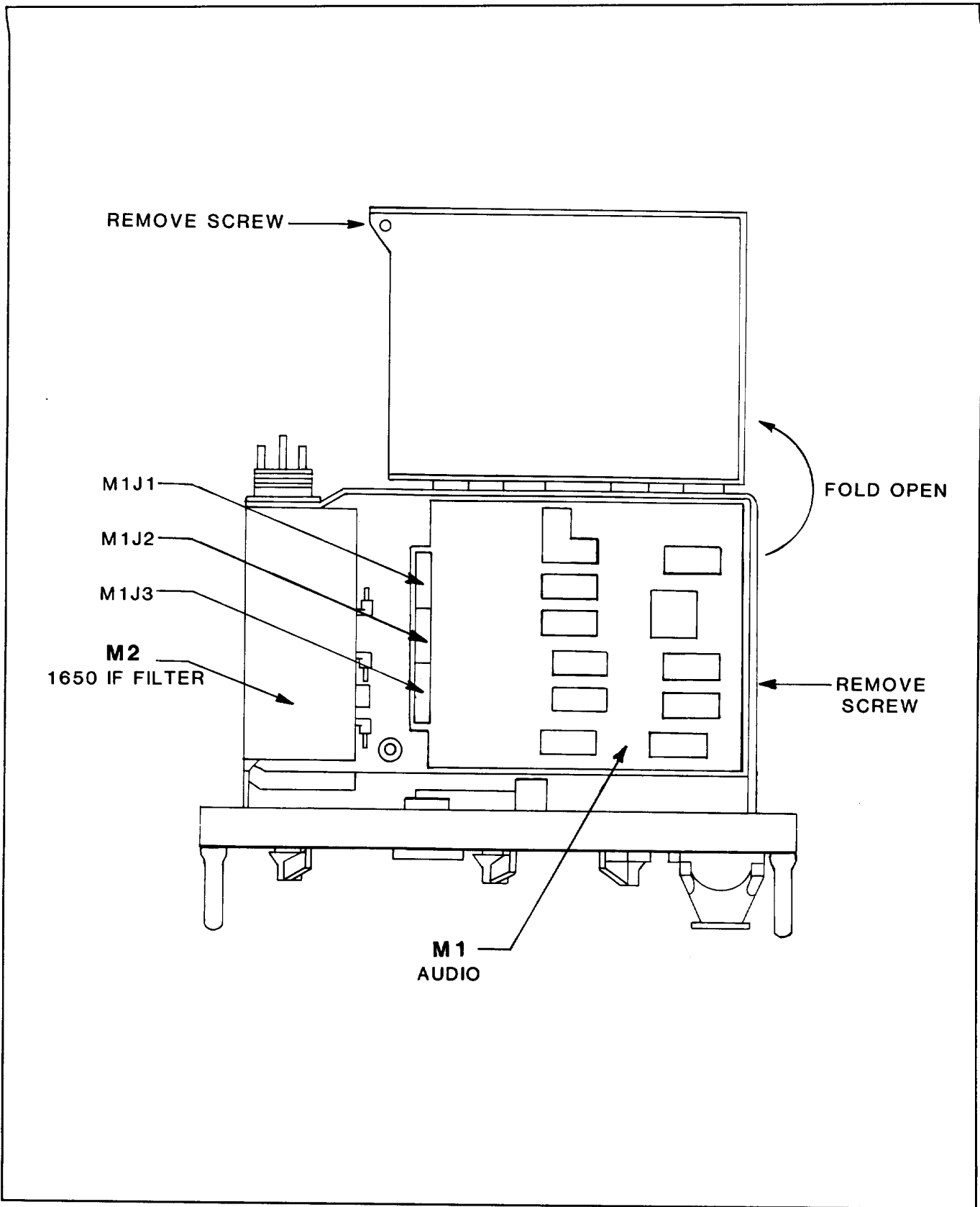


FIGURE 2-3.  
Installation of Battery in Transceiver.



- |   |   |
|---|---|
| 1. CY-2562                                  | 8. Knob, long-handled (power switch)    |
| 2. Case, transceiver                        | 9. Knob, long-handled (mode switch)     |
| 3. Cover, double rubber connector protector | 10. Knob, long-handled (channel switch) |
| 4. Cover, antenna dust                      | 11. Knob (VOLUME)                       |
| 5. Cover, BNC                               | 12. Screw, captive                      |
| 6. Knob, long-handled (DIGIT Select)        | 13. Hook                                |
| 7. Knob, long-handled (TUNE)                | 14. Dummy connector, plug               |

FIGURE 2-4



**FIGURE 2-5.**  
**Module Location Diagram - M1 Access.**



### 2-6.3.6. M7 REMOVAL

Remove the four screws holding the shield cover in place. Remove the outer cover to access the module. Remove the two retaining screws from the corners of the module. Disconnect the five end connectors and one side connector. The module can then be lifted out.

### 2-6.3.7 DISPLAY MODULE

Remove the front panel (2-6.3.8). Unscrew the four retaining screws and the connector. When replacing this module, ensure that the waterproof seal to the display window is not disturbed.

### 2-6.3.8 FRONT PANEL

Remove the four screws (two on each side) and hold the front panel to the chassis. This allows the panel to be pulled away from the chassis and still be operated. For complete removal, the harness connectors must be removed from the chassis.

## 2-7 SEMICONDUCTOR SERVICING

### General

There are two distinct classes of semiconductors used in the transceiver: discrete devices, such as transistors and diodes, and monolithic integrated circuits (see Table 1-2). Considerable information can be found about the operation of the transistors and diodes by measuring the voltage on the various leads. With integrated circuits, there is no external access to much of the circuitry, and it is often necessary to use the "black box" or substitution approach to servicing.

### Signal & Switching Diodes

All diodes may be checked with an ohmmeter. They should show a low forward resistance and a very high back resistance. Check the circuit before making any measurements, as the diode will frequently be shunted by other components—requiring one lead to be lifted before the measurement can be made.

Many of the diodes are used as switches or gates. If the diode is operating correctly, there will be a drop of approximately 0.7 V across the diode junction in the ON state.

### Varactor Diodes

The varactor diode is designed to change capacitance across the reverse-biased junction as the voltage applied to it is changed. Varactors exhibit the same resistance characteristics as signal diodes and can be checked in the same way.

### Bipolar Transistors

An out-of-circuit method of checking bipolar transistors is to consider the base-emitter and the base-collector junctions as two separate diodes. One lead of the ohmmeter is connected to the base and the other is first connected to

the collector and then to the emitter. The ohmmeter leads are then reversed in polarity and the test repeated. This test should indicate high resistance with the leads in one polarization and low resistance in the other. Only in rare instances will a transistor passing this test prove to be faulty in other ways.

A simple, in-circuit check of a transistor can be made with a VTVM. The potential across the base-emitter junction should be about 0.7 V. A substantial difference indicates a fault in the transistor or possibly in the surrounding circuitry.

### Integrated Circuits

Complex, internal IC circuitry makes it impractical to do any analytical fault finding in the device itself. The best approach to servicing them is to isolate the fault to a particular stage. Pin voltages should then be checked against typical values given in the charts. If there are any substantial variations, first check the surrounding circuit components. Finally, the IC may be checked by substitution.

## 2-8 COMPONENT REPLACEMENT

### Circuit Boards

All transceiver printed circuit boards are heavy epoxy fiberglass with 2-oz. tinned copper foil, which meets applicable military specifications. Faults in the board are not likely to occur unless careless procedures are used when replacing components. If correct procedures are followed, components can be replaced many times without damage to the board. All integrated circuits are installed in sockets, which makes replacement very simple.

Begin with the correct tools. The soldering iron must have a small, instrument-type tip no larger than the circuit board pads. However, do not use a tiny, low-temperature, instrument-type iron. It must have sufficient heat to melt the solder quickly, otherwise component and/or board damage can occur.

Use the iron to melt the solder at the connection. While still molten, remove it with a desoldering tool. (These come in many forms, but even a simple type, consisting of a suction pump with a teflon tip will be satisfactory.) After all solder has been removed, the component can be taken out by giving it a gentle tug. To reduce the risk of board damage, do not exert any stress on the foil while removing the component, especially when the connection is hot. The copper foil adhesive forms an extremely strong bond to the board when cold, but can be removed fairly easily at soldering temperature.

Before installing the new component, it is important to clear the holes of any remaining solder. This can be achieved by again applying heat and using the desoldering tool. A frequent cause of foil damage is to push the component through the hole and melt the solder at the same time. If the lead catches, it will frequently lift the foil from the board.

## 2-9 GENERAL FAULT LOCATION - TABLE 2-2

It is possible for non-technical personnel to deduce the reason for numerous faults without opening the transceiver case. Table 2-2 lists those faults that can be identified by operation of the controls and through various indications.

## 2-10 BASIC MODULE FAULT LOCATION - TABLE 2-3

This information is a basic guide to locating faulty modules without the use of test equipment (some fault conditions cannot be recognized in this manner). If this approach is not successful, the modules should be replaced systematically until the faulty one is located. Remember that some of the preliminary tests can indicate which modules are operational. For example, the synthesizer module M6 is used in both the receive and transmit modes. This means that M6 is not faulty if either the transmitter or receiver is operational.

Before replacing any modules, check all cable connections carefully. A broken wire or a loose connector may prevent the module from operating. When modules are replaced, it is not normally necessary to make any adjustments or to realign the transceiver.

All modules may be replaced using a screwdriver. The correct procedure is described in Section 2-6.

## 2-11 MODULE FAULT LOCATION - DETAILED PROCEDURE

### 2-11.1 INTRODUCTION

This section gives more specific information on the methods for measuring the performance of each module. Expert technical knowledge is not required but it is necessary to understand the operation of test equipment. It is recommended that Section 2-10 be followed to locate the fault area and then use 2-11 to confirm the nature of the fault.

### 2-11.2 POWER SUPPLY & SWITCHING

The transceiver should be connected to an external 12.6-V, 5-A power supply. Use either the PRC1099-PS ac power supply or the PRC1099-CA12V battery cable. It should be noted that the PRC1099-CA12V contains a protective diode to prevent damage if the polarity of the power supply is accidentally reversed. There will be a small voltage drop across this diode.

Switch the transceiver on (LO power) and ensure that the supply voltage is 12 V, the regulated voltage is 8 V, and the voltage on the R+ line is 8 V. Press the microphone switch and check that the voltage on the T8 line is 8 V.

The voltage regulator, driver, and voltage-adjustment control are located on M7 (Q106/U105/R127). The 5-V regulator Q101 and the 16-V voltage-doubler driver U105

are located on M7. The T/R relay controlling the T+ and R+ lines is located on M1 (K1).

It is essential that the correct operating voltages are present before checking the transceiver. Check the power supply, wiring and module connections before replacing M1 or M7.

### 2-11.3 SYNTHESIZER & MIXER MODULES M3/M6

If the radio works correctly in either the transmit or receive mode, the synthesizers (M6) are operating correctly.

To make the following measurements, remove the eight screws and the covers from modules M3 and M6. This gives simple access to the RF input and output connections on the modules.

**Synthesizer 1.** Connect a frequency counter to SYN1 output from M6. The frequency should be the operating frequency (10-kHz steps) + 75 MHz. For example, if the operating frequency is 5 MHz, the synthesizer output should be 80 MHz.

**Synthesizer 2.** Connect the frequency counter to SYN2 output from M6. The frequency should be between 73.3401 and 73.350 MHz. The exact frequency depends on the 1-kHz and 100-Hz steps at the operating frequency.

**Transmit Mode.** Connect oscilloscope to "TX OUT" and the signal generator to "1650-kHz I/O." Set the frequency to 1650 kHz and the output level to -10 dBm. The output measured on the oscilloscope should be approximately 0.5 V PEP at the transceiver operating frequency.

**Receive Mode.** Connect the oscilloscope to "1650 kHz I/O" and the signal generator to "RX IN." Set the signal generator to the transceiver operating frequency and the output level to -60 dBm. The output measured on the oscilloscope should be approximately 20 mV PEP at 1650 kHz.

#### NOTE

If the receiver is not operating, check the AGC voltage at J1-5 (4 V). The AGC voltage is supplied by M2, and a fault in this module could prevent M3 from operating correctly in the receive mode.

### 2-11.4 M2 IF MODULE

**Receive Mode.** The sidetone is generated by using the receive stages in this module to listen to the transmitter-exciter low-level output. Normal sidetone confirms this module is operating correctly in the receive mode.

**Transmit Mode.** Connect the signal generator to "TX IN." Adjust the output level to -18 dBm at 1650 kHz. The transmitter will have normal output if M2 is operating correctly.

### 2-11.5 M1 AUDIO/RF FILTER MODULE

First check for normal operation of M2 and M3/M6.

**Receive Mode.** The transmit audio sidetone indicates this module is operating correctly. Check for low-level hiss with audio gain at maximum.

**Transmit Mode.** Check that the transmitter is operating normally (2-11.4). The presence of the audio sidetone then indicates the TX audio stages are operating correctly. If the transmitter operates normally in the CW mode but not on voice, the problem will be in the handset or the audio connections to the module.

**T/R Switching.** The T/R relay can be examined visually for closure when the PTT switch is depressed.

**RF Filters.** The filters switch at 3.1, 5.1, 8.0, 13 and 20 MHz. Incorrect operation in one filter range indicates a fault in the switching relays or the filter.

**USB/LSB Switching.** Incorrect operation on only one sideband indicates a defective BFO crystal (1650-kHz USB, 1647-kHz LSB) or a faulty switch connection.

### 2-11.6 M4 PA MODULE

Connect the signal generator to "TX IN." Set the frequency to that of the transceiver. Increase the output level until the power output is 20 W. The drive level should be approximately +3 dBm.

### 2-11.7 M5 ANTENNA TUNER MODULE

Press the tune button. The tuner should go through the tune cycle. If the pulse tune tone indicates that the tuner did not achieve a correct match, check the antenna connections and try retuning on a different frequency. If the tune

cycle does not initiate, ensure that the antenna mount or long-wire adapter is opening the switch at the base of the antenna post.

#### NOTE

The antenna tuner is controlled by the microprocessor. A fault in M7 will normally also cause many other transceiver control malfunctions.

### 2-11.8 M7 MICROPROCESSOR MODULE

The synthesizer, display, antenna tuner, and many of the control functions are under direct control of the microprocessor. A fault in this module will normally cause multiple malfunctions in the transceiver and the module should be checked by direct replacement.

**Voltage Regulators & Doubler.** The 8-V and 5-V regulators and the driver for the voltage doubler providing the 16-V supply to the synthesizers are located on M7.

**Tone Oscillator.** The tone oscillator used for CW and antenna tuning is located on M7.

**Loss of Memory.** The lithium battery for memory backup is located on M7. This battery should be replaced if channel memory is not retained when the transceiver is switched off.

#### NOTE

The microprocessor is "asleep" unless a control function is required. No oscillator or clocking signals will be present unless a control function is occurring.

### 2-11.9 M8 DISPLAY MODULE

Only if all other transceiver functions are normal should the display module be replaced.

**TABLE 2-2.  
General Fault Location Chart.**

<b>SYMPTOM</b>	<b>POSSIBLE FAULT</b>	<b>ACTION</b>
1. No Display	Battery Dead	Turn mode switch to USB and listen for receiver noise. No noise indicates a dead battery. Receiver noise indicates a display fault.
2. No Audio	Handset Fault	Check for sidetone during TX. If sidetone is present, handset is operative and a receiver fault is indicated.
3. No Sidetone (RX Audio Present)	Transmitter Not Operating	Absence of an audible tone in the handset speaker means that the transmitter is not providing the correct output power. Sidetone audio is inhibited by lack of RF output. Retune the antenna as an incorrect match may restrict output power.
4. Sidetone distorted	Fault in transmitter exciter or receiver.	The sidetone is generated by listening to the transmitted signal in the receiver. This provides a positive test that the low-level stages are operating correctly.
5. Display flashes	Battery Voltage Low	Replace battery.
6. Receiver Audio Garbled	One of the stations is set to the wrong frequency or out of calibration.	Use tune control to retune receiver.
7. No communication: Receiver & Transmitter appear to operate normally	Incorrect frequency. Incorrect sideband.	Check displayed frequency. Check Mode Switch (USB normal).

**TABLE 2-3.  
Module Fault Location Chart.**

<p><b><u>PRELIMINARY</u></b>  Check power switching.  Measure R8. Should read 8 V.  Press PTT switch. Relay K1 on M7 should close.  Measure T8. Should read 8 V.</p>	
<p><b><u>M1 AUDIO/FILTER MODULE</u></b>  Transceiver operates in either TX or RX mode USB.  Operates only USB or LSB.   Audio completely dead, not even slight hiss, squelch off, and maximum audio gain.  TX has no output except in CW mode.</p>	<p>1650-kHz carrier oscillator is operational.  1650-kHz OSC (USB) or 1647-kHz OSC (LSB) defective.  Module or handset defective.   Handset defective.</p>
<p><b><u>M2 1650-kHz IF MODULE</u></b>  Receiver operational.   Disconnect "RX Out" coax connector.</p>	<p>Module should also be operating in transmit mode.  If noise level does not decrease, module is defective.</p>
<p><b><u>M3 MIXER MODULE</u></b>  Disconnect 1650-kHz coax connector from M2 IF module.</p>	<p>If receiver noise level does not decrease, module is defective.</p>
<p><b><u>M4 RF POWER AMPLIFIER</u></b>  No simple check without instruments.</p>	<p>Voltages and connections should be carefully checked before replacement.</p>
<p><b><u>M5 TUNER MODULE</u></b>  Tuner does not tune when tune button is pressed.</p>	<p>Check antenna mount or long-wire adapter is screwed into antenna post.</p>
<p><b><u>M6 SYNTHESIZER</u></b>  Transceiver operates in either transmit or receive mode.  Channel frequencies do not operate below 15 MHz.  Channel frequencies do not operate above 15 MHz.</p>	<p>Module is operational.  Defective 1.6 to 15-MHz VCO in module.  Defective 15 to 30-MHz VCO in module.</p>
<p><b><u>M7 MICROPROCESSOR MODULE</u></b>  Multiple operating malfunctions.   Memory functions not retained.</p>	<p>The microprocessor controls all of the tuning, mode and many switching functions. The 8-V and 5-V regulators are also contained in this module.  Replace lithium battery. (Nominal life is 10 years).</p>
<p><b><u>M8 FREQUENCY DISPLAY MODULE</u></b>  Transceiver appears to be operating correctly but display is not operating.</p>	<p>Check connections.</p>
<p><b><u>MICROPHONE</u></b>  Transmitter does not operate.</p>	<p>Check by replacement of handset.  Ground pin C of connector and touch pin B with hand. If transmitter shows RF output, microphone is faulty.</p>

## CHAPTER 3

# GENERAL THEORY OF OPERATION

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### 3-1 INTRODUCTION

This is a general description of the transceiver. Chapters 4-11 give a detailed circuit description of each module as well as technical specifications and servicing data.

### 3-2 FREQUENCY CONVERSION PLAN

The transceiver uses an up conversion plan with the first IF at 75 MHz. This system is used so that the major spurious products fall between 151.6 and 180 MHz, where they can be easily removed by simple low-pass filters. Transmitter spurious responses from a correctly designed double-balanced mixer will be below -70 dBc across the entire operating range. The double-balanced mixers have a level response well into the VHF range and both the receiver and the transmitter exciter have a level response from 1.6-30 MHz. This broadband response is achieved without any tuning adjustments.

A special VHF crystal filter provides selectivity at 75 MHz. The 3-dB bandwidth is 30 kHz and the stopband is -70 dB. This filter provides sufficient selectivity at the first IF to prevent overload of the second mixer by powerful out-of-band signals. It is necessary to provide a high degree of selectivity to eliminate interference from adjacent in-band signals, and to generate a clean SSB signal. The transceiver uses a second IF of 1650 kHz. At this frequency, it is easy to provide a stable, high-selectivity crystal filter. The transceiver uses a high-performance, 6-pole crystal filter for USB and LSB operation.

To produce the first IF output at 75 MHz, the first loop in the synthesizer must generate an oscillator signal between 76.6 and 105 MHz. The synthesizer generates this frequency range in 10-kHz steps.

The second conversion from 75 MHz to 1650 kHz requires an oscillator injection frequency of 73.35 MHz. As the first synthesizer moves in 10-kHz steps, it is necessary to change the second oscillator frequency over a 10-kHz range to provide complete frequency coverage. The second loop in the synthesizer operates from 73.3401 to 73.350-MHz in 100-Hz steps. Refer to Figure 3-1 for the frequency-conversion plan.

Selectable USB/LSB operation is provided by using separate BFO frequencies of 1650 and 1647 kHz, respectively. The synthesizer is automatically offset by 3 kHz when the sidebands are switched and there is no change in the output frequency.

### 3-3 SYNTHESIZER

The synthesizer uses separate loops controlling the first and second conversion oscillators. Both loops use a

stable, temperature-compensated, 5120-kHz oscillator as a reference standard. The use of direct synthesis with no mixing or other special techniques makes the synthesizers simple and easy to understand. Modern LSI circuitry reduces the number of necessary parts. Another advantage of the system is the almost complete freedom from spurious responses.

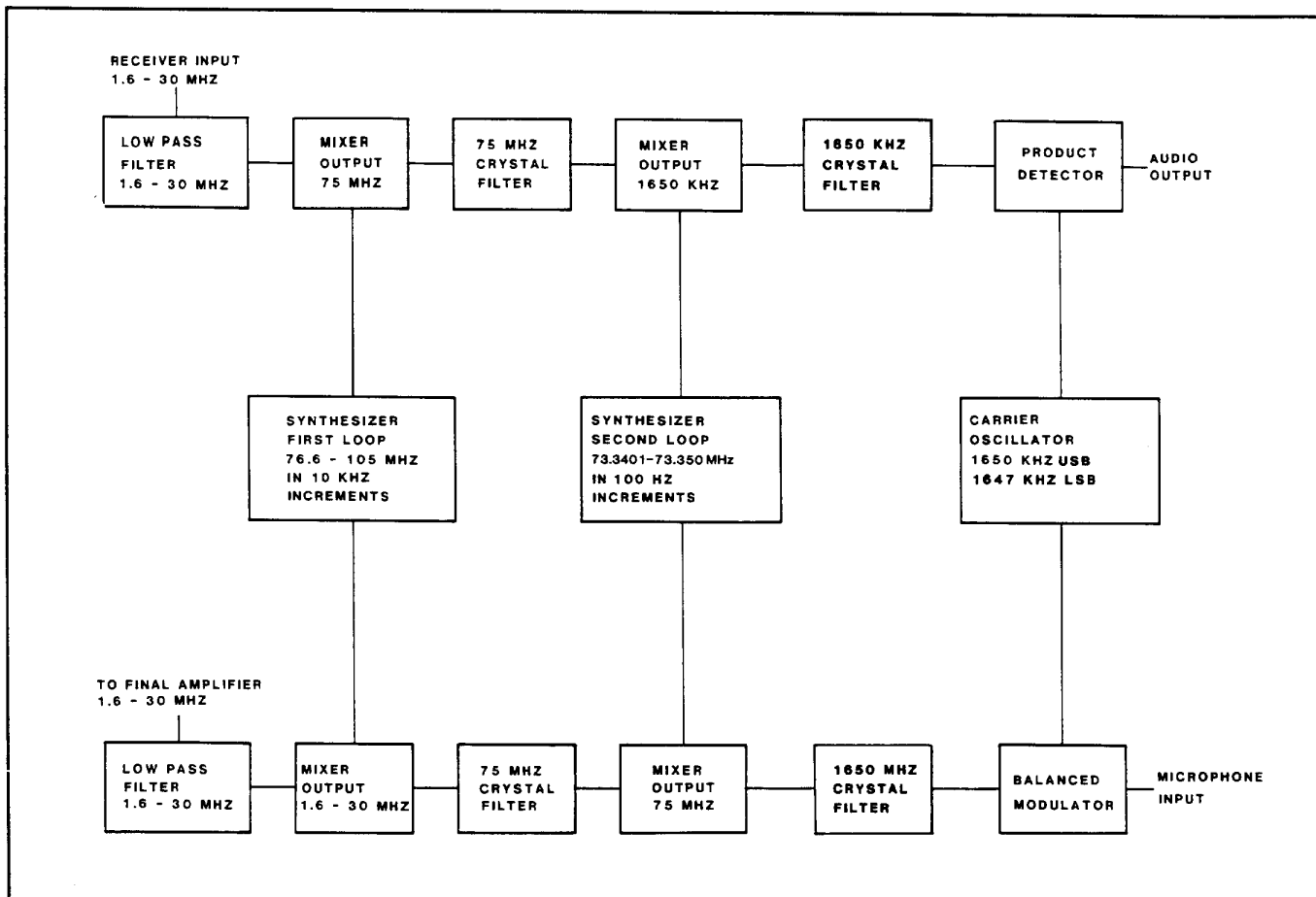
The first loop of the synthesizer covers the range 76.6 - 105 MHz in 10-kHz increments. Operating in 10-kHz steps simplifies the loop design, which gives a high slew speed and good spectral purity. The 5120-kHz oscillator is divided down to provide the 10-kHz reference frequency. The synthesizer uses a programmed divider to give a variable division ratio of 7,660-10,500 controlled by the serial bus. The divided-down output from the VCO is compared and an error voltage is generated that shifts the VCO frequency until lock is achieved. Two separate VCO's are used to cover the frequency range.

The second loop of the synthesizer must cover 73.3401-73.350 MHz in 100-Hz increments. It is very difficult to design a VCO operating at this frequency in a 100-Hz loop. This problem was solved by using a VCXO (variable crystal controlled oscillator). A special 5th-overtone oscillator circuit was designed with the capability of more than 10-kHz tuning range at 73.35 MHz.

The synthesizer output is almost indistinguishable from a good crystal oscillator—a very important factor in simplifying the synthesizer design. The 5120-kHz reference is divided down to provide the 100-Hz reference frequency. The programmed divider gives a variable division ratio of 733,401-733,500 controlled by the serial bus. Using the same reference oscillator for both loops gives a special advantage. Any frequency drift will cancel in the loops and the overall stability of the system is not affected by the high conversion frequencies. A single frequency adjustment sets all channel frequencies.

### 3-4 FREQUENCY AND FUNCTION CONTROL

The synthesizers, display, antenna tuner and many other operating functions are under the control of the microprocessor, with the software program instructions stored in permanent memory (ROM). In addition, programmable functions such as channel frequencies and antenna-tune information are stored in memory (RAM) backed up by a lithium battery with a nominal life of 10 years. The transceiver is controlled by a serial bus and the data are decoded in the individual modules. The front panel controls also interface with the microprocessor, and the serial data extends to the accessory connector to control external accessories such as power amplifiers.



**FIGURE 3-1.**  
**Frequency-Conversion Plan.**

### 3-5 RECEIVER

Input signals from the antenna pass through one of six 5-pole, elliptic-function filters, then through a 1600-kHz high-pass filter to prevent overload from MF broadcast stations, and finally through a 30-MHz low-pass filter to prevent VHF responses. The signal is applied to a high-level, double-balanced mixer; and the 75-MHz output is amplified by a high dynamic range amplifier before passing through the 4-pole, monolithic, 75-MHz filter. The +11-dBm intercept point is maintained through to the output of the 75-MHz filter.

Output from the 75-MHz filter is amplified by an AGC-controlled, dual-gate MOSFET amplifier and is then downconverted to 1650 kHz in a dual-gate MOSFET mixer. The signal then passes through the 6-pole crystal filter and is then amplified by an AGC-controlled dual-gate MOSFET amplifier. The final IF amplification is provided by a fixed-gain bipolar amplifier. A two-stage AGC amplifier provides excellent fast-attack, slow-release characteristics. This AGC system is so effective that no separate RF gain control is required. The audio signal passes through the squelch circuit, where it is processed and applied to a pulse counter which detects the low-frequency FM component in human speech. This output controls the

squelch which opens in the presence of speech and not on background noise.

### 3-6 TRANSMITTER EXCITER

The microphone amplifier is a VOGAD which automatically adjusts the gain to provide constant audio output. A balanced modulator with a 1650-kHz carrier injection frequency produces 1650-kHz, double-sideband, suppressed carrier output (1647 kHz for LSB operation).

The 1650-kHz DSB signal passes through an amplifier to the crystal filter. The 75-MHz IF amplifier has ALC applied that is derived from the currents and voltages at the transmitter output. The ALC system limits the maximum current and voltage from the power amplifier so that the transceiver may be safely operated at any VSWR level.

The 1650-kHz SSB signal is applied to a balanced mixer where it is up-converted to 75 MHz. This signal passes through one stage of amplification to the 75-MHz crystal filter. The 75-MHz signal is then down converted to the operating frequency in a double-balanced mixer. A MMIC broadband 1.6 to 30-MHz amplifier increases the exciter output to approximately +3 dBm. A low-pass filter at the output removes the image frequencies.

### 3-7 FINAL AMPLIFIER AND FILTERS

The high-power final amplifier consists of a Class A pre-driver, a push-pull driver stage and a push-pull final output stage. Special broadband transformers are used for inter-stage and output coupling. The first amplifier operates Class AB and the final stage in Class B using a stabilized bias supply. The final amplifier has low spurious output except for the harmonics. Six separate high-performance, elliptical function filters are used to cover the operating range and provide effective attenuation of the harmonic spectrum. The selection of the filters is controlled by the microprocessor.

### 3-8 AUTOMATIC ANTENNA TUNER

The automatic antenna tuner uses a series of inductors, in a binary progression and switched by latching relays, to provide variable inductive loading for the antenna. A variable ratio impedance transformer is used to provide the correct impedance match to the final amplifier. Shunt capacitors are switched into circuit for use with inductive antennas. The tuner uses detectors at the tuner input and follows a tuning routine, under control of the micro-processor, to match the antenna for maximum output. When the whip or long-wire antenna is removed, the output is automatically switched to the 50-ohm antenna connector.

### 3-9 TRANSMIT-RECEIVE SWITCHING

The transmit-receive switching is through the T/R relay, which switches the antenna input between the receiver input and the transmitter output. A second pole on this relay switches the regulated 8-V line to give T+ 8-V and R+ 8-V outputs. These control lines are used to switch the transceiver circuitry. Transistor and diode gates are used extensively for the switching function. The input to the double-balanced mixer is switched by a relay to minimize high-level intermodulation distortion.

### 3-10 POWER SOURCE

The transceiver operates from a 12 to 15-V supply source. The critical circuitry operates from the regulated 8-V and 5-V supply lines. The higher-power circuitry operates direct from the 12-V supply but will continue to operate down to 10.5 V with only minimal reduction in performance specifications.

### 3-11 SIGNAL FLOW CHARTS

Table 3-2 indicates the signal levels at the various stages of the receive signal path, while Table 3-3 does the same for the squelch circuits. The signal levels for the transmit path are shown in Table 3-4.

**TABLE 3-1.**  
**Module Function Chart.**

<b>M1 AUDIO/RF FILTER MODULE</b>	
<b>FUNCTION</b>	<b>I/O</b>
VOGAD. Amplifies microphone input and automatically controls gain.	Input from front-panel handset. Output to balanced modulator.
Balanced Modulator. Generates DSB 1650-kHz signal, suppresses carrier.	Input from mic. amplifier. Output to J2 1650-kHz IF Filter.
BFO. Provide USB (1650 kHz), LSB (1647 kHz) signal source.	Input from microprocessor selects sideband. Output to balanced modulator and product detector.
Product Detector. Demodulates 1650-kHz SSB signal.	Input from M2 IF amplifier. Output to squelch and audio PA.
Squelch. Detects low-frequency FM voice components to actuate squelch.	Input from product detector. Output to squelch gates.
Audio PA. Amplifies audio for handset or loudspeaker.	Input from product detector through audio gain control. Output to handset.
Audio AMP. Provides 0 dBm 600- $\Omega$ audio output.	Input from product detector. Output to accessory socket.



**TABLE 3-1.  
Module Function Chart, Continued.**

RF Gate. Detects RF output and opens sidetone gate.	Input from ALC circuitry. Output to squelch gates.
Squelch Gates. Switches on Audio PA. Controls current in RX front end.	Input from squelch control. Output to Audio PA gate and gates M3.
DC Clamps. Control switching times.	Input from T/R Relay. Output to T+, R+ (8-V lines).
CW Hold. Provides semibreak-in CW and ATU tune signal.	Input from CW key and microprocessor. Output to tone generator M7.
Filter Switching. Decodes serial data & selects correct filter range.	Input from serial data M7 microprocessor. Output to RF filters.
ALC. Measures RF current & RF voltage. Provides 5-W and 20-W level output control.	Input from TX PA output. Output to Sidetone Gate, ALC gain M3.
T/R Relay. Switches TX/RX RF and R+ 8-V and T+ 8-V lines.	Input from PTT, microprocessor M7.
RF Filters - Low-pass filters TX/RX. High-pass filters RX.	Input from filter control selection.

**M2 1650-kHz IF MODULE**

<b>FUNCTION</b>	<b>I/O</b>
1650-kHz Filter. Generates SSB signal. Provides narrowband RX selectivity.	Input from mixer module M3 or TX amp. Output to M3 mixer module or RX IF amp.
RX IF Amps. Amplifies 1650-kHz IF signal.	Input from filter. Output to M1 audio module.
AGC. Amplifies AGC Control IF gain.	Input from RX IF output. Output to 1650-kHz IF Amp, 75-MHz IF Amp M3.
TX IF Amp. Amplifies 1650-kHz DSB signal.	Input from balanced modulator M1. Output to 1650-kHz sideband filter.

**M3 MIXER & RF MODULE**

<b>FUNCTION</b>	<b>I/O</b>
Double-Balanced Mixer. Converts received signal to 75-MHz IF.	Input from RX antenna through M1. Output to RX 75 MHz IF amp.

**TABLE 3-1.  
Module Function Chart, Continued.**

Converts 75-MHz SSB signal to TX output frequency.	Input from TX 75-MHz filter. Output to TX 2 to 30-MHz amplifier. Osc. - 76.6 to 105-MHz Syn. 1 buffer.
IF Amp 75-MHz Q3 RX.	Input from double-balanced mixer. Output to 75-MHz filter.
75-MHz Crystal Filter.	Filters 75-MHz IF TX and RX.
IF Amp 75-MHz Q11 RX.	Input from 75-MHz filter. Input from AGC control. Output to mixer Q12.
Mixer. 75-MHz to 1.65-MHz RX.	Input from 75-MHz IF Amp. Osc. 73.35-MHz Syn. 2 buffer. Output to 1.65-MHz M2.
Mixer. 1.65-MHz to 75-MHz TX.	Input from 1.65-MHz M2. Osc. 73.35-MHz Syn. 2 buffer. Output to 75-MHz IF Amp TX.
IF Amp 75-MHz TX.	Input from 75-MHz Mixer. Input from ALC control M1. Output to 75 MHz - Filter 75 MHz.
TX Amp 1.6-30 MHz.	Input from balanced mixer. Output to TX PA M4.
SYN 1 BUFFER.	Input from Syn. 1 M6. Output to Mixers.
SYN 2 BUFFER.	Input from Syn. 2 M6. Output to Mixers.
<b><u>M4 TX POWER AMPLIFIER MODULE</u></b>	
<b>FUNCTION</b>	<b>I/O</b>
TX Power Amplifier.	Input from Exciter M3. Output to LP filters M1.
<b><u>M5 AUTOMATIC ANTENNA TUNER MODULE</u></b>	
<b>FUNCTION</b>	<b>I/O</b>
Antenna Tuner.	Input from LP filters M1. Output to Antenna—Whip or 50 ohm.
Serial Decoders & Relay Drivers.	Input from microprocessor M7. Output to latching relays.

**TABLE 3-1.  
Module Function Chart, Continued.**

**M6 SYNTHESIZERS - SYN1/SYN2 MODULE**

<b>FUNCTION</b>	<b>I/O</b>
Syn. 1: 76.60-104.99 MHz.	Output to Syn. 1 buffer M3.
Syn. 2: 73.3401 - 73.35 MHz.	Output to Syn. 2 buffer M3.
Serial Decoders.	Input from microprocessor M7.

**M7 MICROPROCESSOR & CONTROL MODULE**

<b>FUNCTION</b>	<b>I/O</b>
Serial Bus.	Input from microprocessor. Output to all serial ports.
Control Switches.	Read by microprocessor.
Tone Generator.	Input from microprocessor and CW key. Output to TX audio M1.
Voltage Doubler Driver.	Output to voltage doubler.
Voltage Regulator 5 V.	Output to M8, M5.
Voltage Regulator 8 V.	Output to various modules.

**M8 DISPLAY & DRIVER MODULE**

<b>FUNCTION</b>	<b>I/O</b>
Backplane Generator.	Output to LCD Display
Backlight Generator.	Output to LCD Display Backlight.
Serial Decoders & Segment Drivers.	Input from microprocessor M7. Output to LCD Display.
Signal Buffers	Input from microprocessor M7. Output to accessory connector.
Channel Decoder	Input from optional remote-control handset. Output to microprocessor M7.

**TABLE 3-2.  
Receive Signal Flow.**

**INITIAL CONDITIONS**

Mode: USB.  
 Frequency: 29.9999 MHz.  
 Power Level: High.  
 Volume: Fully CW.

Signal Generator Settings:  
 Frequency: 30.0009 MHz.  
 Level: 107  $\mu$ V.  
 Modulation: 0%.

**LOCATION**

**SIGNAL**

**COMMENTS**

**1. M3 Mixer Module**

M3Q51 Collector	1.2 V <sub>p-p</sub>	104.9999-MHz Synth 1.
M3U51, Pin 3	0.2 V <sub>p-p</sub>	75-MHz IF Signal.
M3Q53 Collector	1.5 V <sub>p-p</sub>	75-MHz IF Signal.
M3Q1, Pin 1	0.15 V <sub>p-p</sub>	75-MHz IF Signal.
M3Q4 Collector	1.5 V <sub>p-p</sub>	73.3499-kHz Synth 2.
M3Q2, Pin 1	0.4 V <sub>p-p</sub>	1650-kHz IF Signal.

**2. M2 1650 IF Module**

M2J3 1650 Input	60 mV <sub>p-p</sub>	1650-kHz IF Signal.
M2Q1, Pin 1	0.4 V <sub>p-p</sub>	1650-kHz IF Signal.
M2Q2 Collector	1.2 V <sub>p-p</sub>	1650-kHz IF Signal.

**3. M1 Audio Module**

M1U3, Pin 1	2.5 V <sub>p-p</sub>	1650-BFO Signal.
M1U3, Pin 8	0.7 V <sub>p-p</sub>	1000-Hz Audio.
M1U5, Pin 2	0.2 V <sub>p-p</sub>	1000-Hz Audio.
M1U5, Pin 5	3.2 V <sub>p-p</sub>	1000-Hz Audio.
M1J2, Pin 2	3.0 V <sub>p-p</sub>	1000-Hz Audio.
M1J2, Pin 6	5.0 V <sub>p-p</sub>	1000-Hz Audio.

**TABLE 3-3.  
Squelch Circuit Signal Flow.**

**INITIAL CONDITIONS**

Same As Receive Signal Flow Initial Conditions.

<u>LOCATION</u>	<u>SIGNAL</u>	<u>COMMENTS</u>
<b>1. M1 Audio Module</b>		
M1U6, Pin 9	0.7 V <sub>p-p</sub>	1000-Hz Audio Sine Wave.
M1U6, Pin 8	6.4 V <sub>p-p</sub>	1000-Hz Square Wave.
M1U6, Pin 14	6.4 V <sub>p-p</sub>	1000-Hz Square Wave.
M1U7, Pin 11	8.0 V <sub>p-p</sub>	1000-Hz Square Wave.
M1U7, Pin 10	8.0 V <sub>p-p</sub>	1000-Hz Square Wave.
M1U6, Pin 7	3.9 Vdc	Squelch Control Signal.
M1U6, Pin 1	6.7 Vdc	Squelch Control Signal.
M1U7, Pin 3	8.0 Vdc	Squelch Control Signal.
M1U7, Pin 4	0.0 Vdc	Squelch Control Signal.
M1Q5 Emitter	0.0 Vdc	Radio Squelched.
M1Q4 Collector	11.5 Vdc	Radio Squelched.
M1Q6 Collector	0.0 Vdc	Radio Squelched.

**TABLE 3-4.  
Transmit Signal Flow.**

**INITIAL CONDITIONS**

Mode: USB.  
 Frequency: 29.9999.  
 Power Level: High.

**NOTE:** A CW Keyer is required for this test. All tests CW keyed.

<b><u>LOCATION</u></b>	<b><u>SIGNAL</u></b>	<b><u>COMMENTS</u></b>
<b>1. M7 Processor Module</b>		
M7U8, Pin 1	5.8 V <sub>p-p</sub>	1000-Hz CW Tone.
M7J2, Pin 1	1.4 V <sub>p-p</sub>	1000-Hz CW Tone.
<b>2. M1 Audio Module</b>		
M1J3, Pin 8	1.4 V <sub>p-p</sub>	1000-Hz CW Tone.
M1U2, Pin 3	0.6 V <sub>p-p</sub>	1650-kHz BFO Signal.
M1U2, Pin 5	0.25 V <sub>p-p</sub>	1650-kHz IF Signal.
<b>3. M2 1650 IF Module</b>		
M2Q3 Collector	3.0 V <sub>p-p</sub>	1650-kHz IF Signal.
M2J3 1650 Output	0.6 V <sub>p-p</sub>	(Measured with cable removed.)
<b>4. M3 Mixer Module</b>		
M3Q4 Collector	1.5 V <sub>p-p</sub>	73.3499-kHz Synth 2.
M3Q5, Pin 1	0.1 V <sub>p-p</sub>	75-MHz IF Signal.
M3D5 Anode	0.3 V <sub>p-p</sub>	75-MHz IF Signal.
M3D53 Anode	0.15 V <sub>p-p</sub>	75-MHz IF Signal.
M3Q51 Collector	1.2 V <sub>p-p</sub>	104.9999-MHz Synth 1.
M3U52 Output	1.2 V <sub>p-p</sub>	29.9999-MHz RF Signal.
<b>5. M4 Power Amplifier Module</b>		
M4 TX Input	0.9 V <sub>p-p</sub>	29.9999-MHz RF Signal.
M4Q1 Collector	15 V <sub>p-p</sub>	29.9999-MHz RF Signal.
M4Q2(3) Collector	15 V <sub>p-p</sub>	29.9999-MHz RF Signal.
M4Q4(5) Collector	25-35 V <sub>p-p</sub>	29.9999-MHz RF Signal.
M4 TX Output	90-120 V <sub>p-p</sub>	29.9999-MHz RF Signal.

# CHAPTER 4

## AUDIO/FILTER MODULE, M1 - TECHNICAL DESCRIPTION

### 4-1 BLOCK DIAGRAM

A block diagram of the module is shown in Figure 4-1. This shows that the module is used for the transmitter and receiver audio circuits, the RF filtering of the transmitter and receiver, the transmit/receive switching and other control functions. The module has the following block components:

1. Receiver Product Detector.
2. Receiver Squelch Circuit.
3. Receiver Audio Amplifier—Handset/Loudspeaker.
4. Receiver Audio Amplifier—600  $\Omega$ .
5. Squelch Gates.
6. Transmitter VOGAD.
7. Transmitter Balanced Modulator.
8. BFO.
9. Low-Pass Filters.
10. Relay Drivers and Serial Decoder.
11. Receiver High-Pass Filter.
12. ALC Detectors and Amplifiers.
13. Low-Power Switch.
14. Sidetone Switch.
15. T/R Switching.
16. CW Hold Timer and Gates.

#### 4-1.1 RECEIVER PRODUCT DETECTOR

The product detector U3 is used to down convert the output from the 1650-kHz IF to the audio base band. U3 is an integrated circuit differential amplifier. The 1650-kHz IF is injected into pin 2, one of the two input ports. The 1650-kHz carrier oscillator (1647-kHz LSB) is injected into pin 1, the other input port. The output at pin 8 is the sum and difference frequencies from the two input signals. The sum frequency at 3.3 MHz is filtered by C34; and the difference frequency, the audio baseband, is left at the output.

#### 4-2 RECEIVE SQUELCH CIRCUIT

The squelch circuit operates by detecting the syllabic rate of change found in the human voice. The squelch is immune to impulse noise, static, carriers and general background noise. The squelch is preset internally and is activated in the USB mode when the mode switch is turned to the "squelch" position.

The audio output from the product detector is fed into 2 sections of the quad operational amplifier, U6. The stages operate at high gain and the noise or signal is amplitude limited, which provides square wave output to trigger the one shot U7A and U7B. The output from the one shot is a series of pulses which go through the high-pass filter C61, R43, C62, R44 and the low-pass filter R45, C52, R46,

C67. At this point a dc level proportional to the input frequency of the one shot is present.

The dc level changes as the frequency shifts, which represents the change in frequency of the human voice at a syllabic rate between 0.5 and 2.5 Hz. This signal is ac coupled through C64 to the low-frequency differentiation amplifier U6C. The output is fed into U6D, which will pull down D14 if any signal appears at D3/D4 with a positive or negative amplitude of 0.9 V or greater. This unipolar converter enables the squelch to detect the first syllabic rate change at the output of the product detector.

D14 is connected to U7C and U7D, which form a timer with C47 and R34 to hold the audio on for approximately 4 seconds after the last syllabic change is detected. The squelch is turned off when the timer output is grounded through R32.

#### 4-3 RECEIVER AUDIO AMPLIFIER - HANDSET/SPEAKER

The output from the product detector is coupled through the front panel audio gain control potentiometer to a monolithic integrated circuit, U5, with a gain of 26 dB. This device has essentially constant voltage output into a wide range of load impedances, provides direct output to the handset or earphones and is capable of 500-mW output to a separate loudspeaker.

#### 4-4 RECEIVER AUDIO AMPLIFIER - 600 $\Omega$

U4A is half of a fixed-gain operational amplifier providing a separate fixed-level audio output for external devices such as RTTY modems. The amplifier has low impedance output and provides a level of 0 dBm into a 600- $\Omega$  load connected to the accessory socket.

#### 4-5 SQUELCH GATES

The receiver audio is switched by the squelch circuit. The dc supply to U5 is switched by the PNP transistor, Q6, in the +12-V lead. This method of switching is used so that U5 draws no quiescent current when squelched. Q6 is controlled by the input from the RF gate or by Q4 and Q5, which are in turn driven by the squelch timer U7C and U7D or the microprocessor mute signal. The output from Q5 also controls the current reduction circuitry in the mixer module, M3. This circuitry is also controlled by the T8 line, which is isolated by the diode gates D16 and D17.

#### 4-6 TRANSMITTER VOGAD

The microphone and other audio signals are applied to U1, a single integrated circuit VOGAD (Voice Operated Gain Adjusting Device). The VOGAD is a high-gain audio amplifier and automatic gain control circuit. R1 and C13 control the AGC time constants and are set to provide distortion-free, constant output over a wide range of input

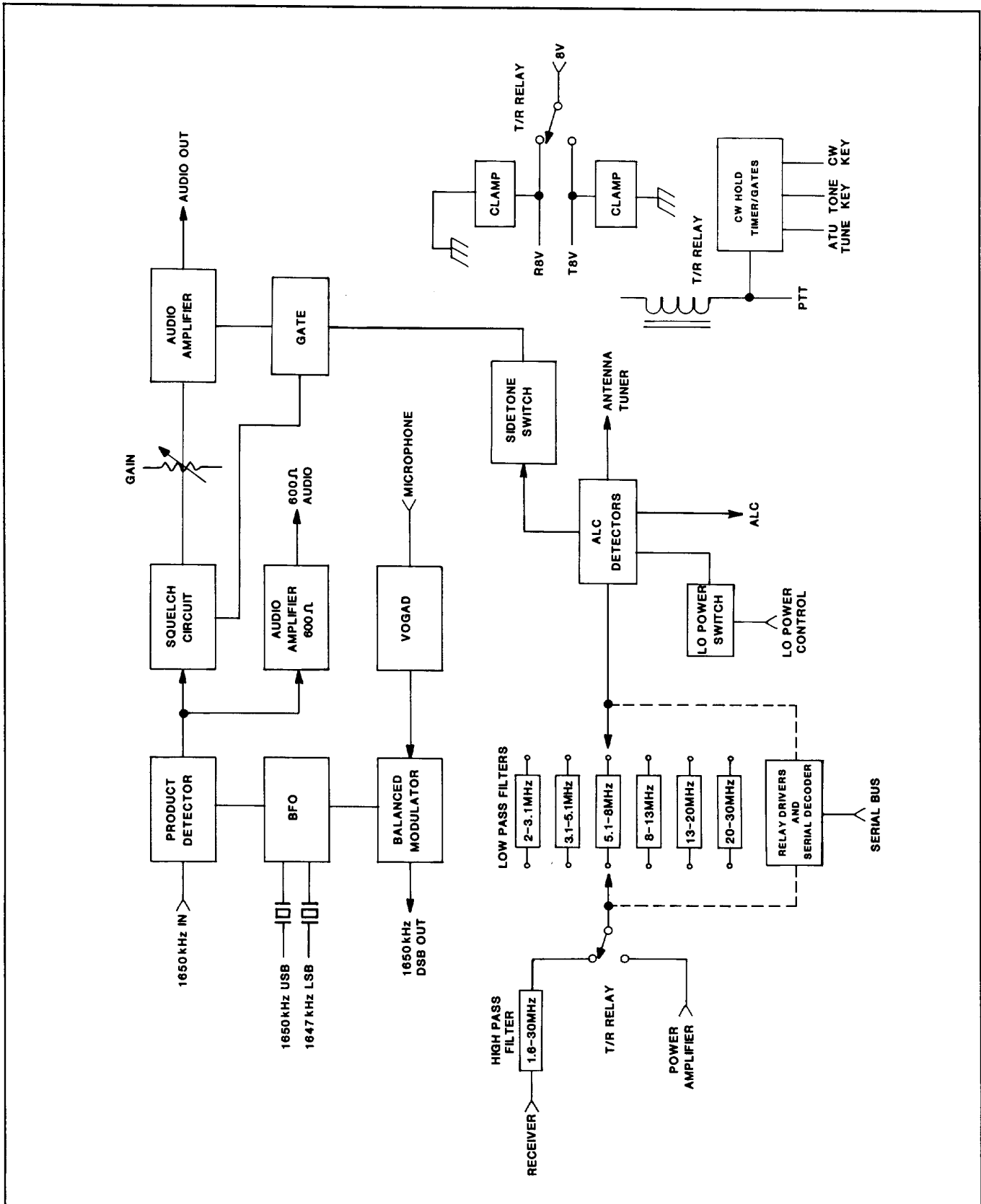


FIGURE 4-1.  
Block Diagram - Audio/Filter Module, M1.



signal levels. R70 sets the gain control of the amplifier which is set at a higher than normal level to provide full output for low-level voice inputs (whisper mode). The excellent AGC characteristics maintain level output from a whisper to a shout. C1, L7, C4 filter RF picked up by the microphone lead. The CW tone oscillator is applied through R5. The attenuator and RF filter C3, L8, C2 and R69 are used for the high-level, 0-dBm audio input.

#### 4-7 TRANSMITTER BALANCED MODULATOR

The amplified and leveled audio output is applied to one input (pin 7) of U2. The 1650-kHz (1647-kHz LSB) carrier oscillator is applied to the other input (pin 3) of the stage, which is a quad amplifier driven by differential current sources. U2 uses internal bias and load resistors to minimize the number of external components required. The potentiometer R4, applies an adjustable offset current to pin 7. This permits precise balance of the modulator to give maximum carrier suppression. The output from U2 is a low-distortion, 1650-kHz, double-sideband, suppressed carrier signal.

The voltages for the balanced modulator and the VOGAD are normally supplied from the T8 line which prevents any current drain in the receive mode. In the data mode (OPT), these stages are supplied from the +8-V line and are not switched off in the receive mode. This is necessary to eliminate disturbances when using high speed switching in the ARQ mode.

#### 4-8 BFO (Carrier Oscillator)

The BFO is a stable, low-frequency crystal oscillator operating at 1650 kHz (USB) or 1647 kHz (LSB). The large-value feedback capacitors, C23 and C24, isolate the crystal from variations in the base capacitance of the oscillator transistor, Q1. The transistor switches Q2 (1650-kHz) and Q3 (1647-kHz) to select the USB or LSB crystals. C19 and C20 are used to adjust the oscillator to the exact carrier frequencies. A high Q tuned circuit, L4/C25/C95, in the collector circuit of Q1 provides low harmonic output to the balanced modulator and product detector.

#### 4-9 LOW-PASS FILTERS

The input and output to the antenna or antenna tuners pass through one of six high-performance, 5-pole, elliptic function filters. These filters cover the frequency range as follows:

- 2.0 - 3.1 MHz
- 3.1 - 5.1 MHz
- 5.1 - 8.0 MHz
- 8.0 - 13 MHz
- 13 - 20 MHz
- 20 - 30 MHz

The filters use high Q toroidal inductors and precision silver mica capacitors. The filters are used in both the transmit and receive modes to ensure low harmonic output from the transmitter and minimize out-of-band signals to the receiver input.

#### 4-10 RELAY DRIVERS & DECODER

The correct filters are selected by the microprocessor using the latching relays K2 through K13. The latching relays use dual windings and require separate current pulses to open or close the relay. No holding current is required; this is an important consideration in a battery powered transceiver. The switching transistors Q7 through Q12 control the "on" switching current pulse to each pair of relays while the reset transistor Q13 controls the "off" switching pulse to all relays. The microprocessor serial output data is decoded by the shift register U8 and used to drive the switching transistors. The microprocessor software program ensures that all relays are reset before selecting a new filter. The program performs the same function whenever the transceiver is switched on or there is a power interruption. This ensures that the relays are always correctly reset.

#### 4-11 RECEIVER HIGH-PASS FILTER

The antenna input to the receiver passes through a 7-pole Chebyshev filter with a cutoff frequency of 1.6 MHz (C77, L1, C78, L2, C79, L3 and C80). This filter ensures a high level of attenuation to signals below 1.6 MHz in the broadcast band and prevents overload when operating in the vicinity of a powerful broadcast station. The diode D2 shorts the receiver input in the transmit mode and provides transient protection to the user while in the receive mode.

#### 4-12 ALC DETECTORS & AMPLIFIER

The primary control of the transmitter power output is by the ALC system controlled by the output from a current detector. The current detector uses a transformer, T1/R55, which uses a ferrite toroid with the antenna lead passing through the core to form a one turn primary winding. The RF output is rectified by D11 when the RF voltage exceeds the adjustable back bias applied through the power adjustment control R62. The rectified output is amplified and the polarity reversed by Q18, which in turn drives the ALC amplifier in the mixer module. A separate voltage detector, C73/C74/D10, operates with a fixed bias threshold of 8 V and limits the maximum voltage output to 36 V.

For normal operation the current is set to 630 mA, which corresponds to 20-W output into a 50-ohm load. The current detector controls the output level in loads of 50 ohms or less and limits the maximum output current to 630 mA, even when there is a short circuit on the antenna. If the impedance is higher than 50 ohms (most mismatches present high impedance loads), the voltage detector limits the maximum output voltage to 36 V. This system prevents the rapid fall in output power into mismatched loads yet ensures the transistors will not be operated outside of their ratings.

#### 4-13 LOW-POWER SWITCH

The low-power switch Q19 causes R62, the low-power control, to shunt the bias voltage at the current detector so that the ALC activates at a lower power level. R62 is adjusted for 5-W output after the high-power level is set.

**TABLE 4-1.**  
**Specifications, Audio/RF Filter Module, M1.**

**Transmit**

Current: 8 Vdc @ 31 mA.  
12 Vdc @ 0 mA. <sup>1</sup>  
Output: 1650 kHz, DSB, 80 mV, PEP.  
Input: Microphone or 1000 Hz.

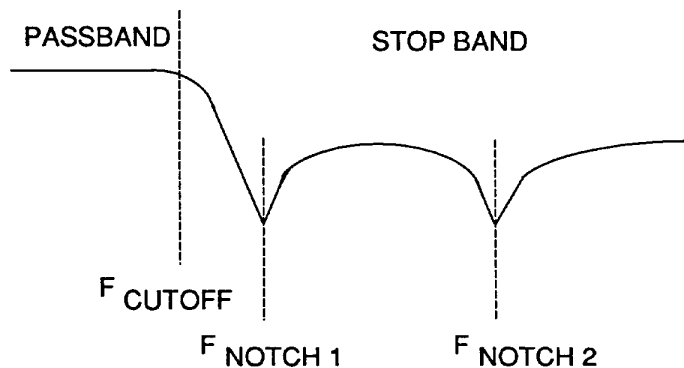
**Receive**

Current: 8 Vdc @ 8 mA.  
12 Vdc @ 0 mA (squelched). <sup>2</sup>  
Output: 1000 Hz.  
Input: 1651 MHz.  
System Gain: 48 dB.

**Low Pass Filters**

Return Loss: 15 dB, minimum.  
Stopband: Filter adjusted for specified stopband with frequencies.

<u>Range</u>	<u>Notch 1</u>	<u>Notch 2</u>
2-3 MHz	4.2 MHz	6.1 MHz
3-5 MHz	6.6 MHz	9.9 MHz
5-8 MHz	10.8 MHz	16.35 MHz
8-13 MHz	17.2 MHz	27.0 MHz
13-20 MHz	27.6 MHz	43.0 MHz
20-30 MHz	40.5 MHz	60.4 MHz



**Oscillator**

USB: Y1 @ 1650 kHz.  
LSB: Y2 @ 1647 kHz.

**Injection Level**

280 mV, PEP.

Notes: <sup>1</sup> Momentary high +12 Vdc current during relay switching.  
<sup>2</sup> Current increases with high audio output into low impedance loads.

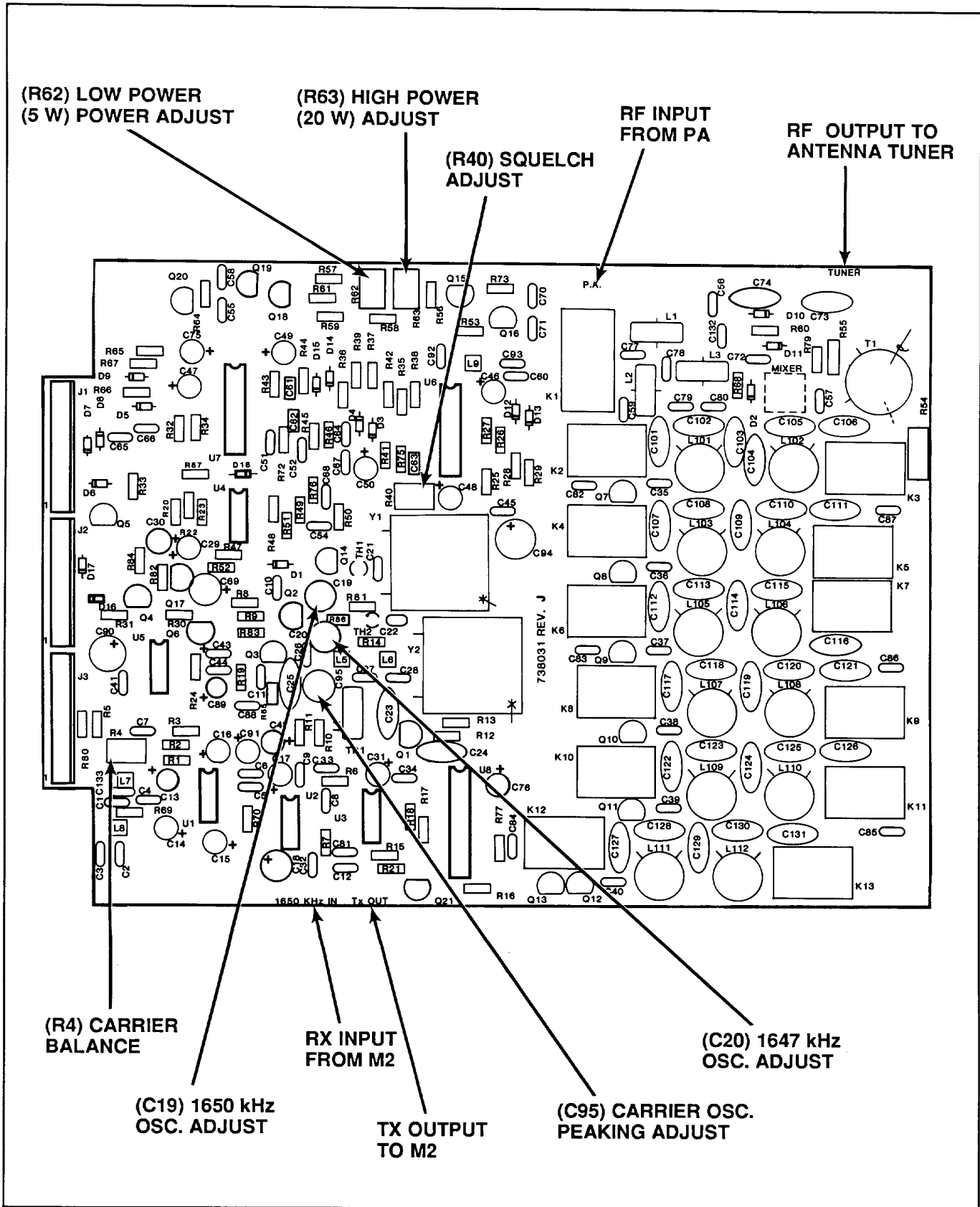


FIGURE 4-2.  
Signal Connections and Adjustment Points.

switched to LO power or EXT AMP by the front panel switch, the final amplifier thermostat or the microprocessor in the antenna tune mode.

#### 4-14 SIDETONE SWITCH

The sidetone switch is an important BITE function. The sidetone will only be present when the transmitter is operating at the correct RF output power. The switch automatically compensates when switched from HI to LO power output. The sidetone switch detects the ALC output voltage. As the detector diodes in the ALC system are biased so that there is no output until the correct current or voltage level is reached, the system automatically checks for correct operation of the final amplifier. U4B is used as a voltage comparator on the ALC line and Q14/Q17 form a hold timer so that the switch will not operate at a syllabic rate on voice signals. Q17 controls Q6, which in turn switches off the audio amplifier when there is no RF output.

#### 4-15 T/R SWITCHING

The T/R switching is controlled by the PTT line. Closing the PTT line activates relay K1, which is a double-pole, high-reliability, fast-acting relay. One pole of this relay switches the antenna from the receive to the transmit function. The other pole switches the regulated +8-V line to give transmit (T8) and receive (R8) control lines. These two control lines are used for transmit/receive functions throughout the receiver. The two clamp transistors, Q15 and Q16, ensure immediate switching by shorting the disconnected line to ground when the T/R function is used.

#### 4-16 CW HOLD TIMER AND GATE

Q20 and the associated components R65/R67/D9/C75 and R66 form a hold timer that holds the transmitter in the transmit mode for a short time after the key is released. The diode gates D6, D7 and D8 isolate the following different functions – ATU tune, tone key, CW key.

#### 4-17 SERVICE DATA

Figure 4-2 is a component location diagram with adjustments and signal input/outputs indicated. The following is a summary of the module adjustments:

1. C19. Used to set the 1650-kHz oscillator on frequency.
2. C20. Used to set the 1647-kHz oscillator on frequency.
3. R40. Adjusts the squelch setting; generally factory set for the lowest setting that permits the squelch to open as an incoming signal is swept through the passboard.
4. R4. Used to adjust the carrier balance; factory set for minimum RF output in a keyed, unmodulated condition.
5. R63. Sets the transmit output to 20 W in high-power mode.
6. R62. Sets the transmit output to 5 W in low-power mode.
7. C95. Set for maximum output of carrier oscillator.

#### 4-18 MODULE INTERCONNECTIONS

The M1 module has the following interconnections with the transceiver.

##### Connector M1J1

- Pin 1 Squelch ON/OFF. 7.00 Vdc with MODE selector in the SQUELCH position, 0 Vdc otherwise.
- Pin 2 PTT. 0 Vdc in transmit, 13.8 Vdc in receive.
- Pin 3 ATU TUNE/. Normally 13.8 Vdc, 0 Vdc when tuning remote antenna tuning unit.
- Pin 4 12 Vdc from power supply.
- Pin 5 8 Vdc from power supply.
- Pin 6 T8. 8 Vdc when radio is in transmit, 0 Vdc in receive.
- Pin 7 TONE KEY. 1000-Hz tone used with CW and antenna tuners. 0 Vdc when activated, 6.2 Vdc normally.
- Pin 8 CW KEY. 0 Vdc with CW key, 13.8 Vdc normally.
- Pin 9 LOW POWER. switches the amplifier to the low power position. 5 Vdc in low power, 0 Vdc in high.
- Pin 10 ALC. Automatic level control, used to set the output power level in transmit. In receive, 0 Vdc.

##### Connector M1J2

- Pin 1 GROUND.
- Pin 2 AUDIO OUT. Receive audio out to the handset connectors Pin B.
- Pin 3 LSB SELECT. 5 Vdc with the MODE selector in LSB, 0 Vdc otherwise.
- Pin 4 USB SELECT. 0 Vdc with the MODE selector in LSB, 5 Vdc otherwise.
- Pin 5 SQUELCH. 0 Vdc when the radio is squelched, 6.8 Vdc when radio is not squelched.
- Pin 6 600-OHM AUDIO. Receive audio out to the accessory connector pin P.
- Pin 7 RF DETECT. Not currently used.
- Pin 8 5 Vdc from power supply.
- Pin 9 R8. 8 Vdc when radio is in receive, 0 Vdc in transmit.

Pin 10 MUTE. Used to mute the receive audio in transmit. 0 Vdc in transmit, 8 Vdc in receive.

Connector M1J3

Pin 1 600-OHM TRANSMIT AUDIO IN. Audio from the accessory connector, pin R.

Pin 2 MIC AUDIO. Microphone audio input from the handset connectors pin D.

Pin 3 X8. 8 Vdc when the MODE SELECTOR is in the option position, 0 Vdc otherwise.

Pin 4 AM. Connects to the test point on the display module.

Pin 5 CLOCK. Internal radio clock information.

Pin 6 DATA. Internal radio data.

Pin 7 SELECT. Internal select data.

Pin 8 CW TONE. Approximate 1000-Hz tone used to modulate the transmitter in CW.

Pin 9 VOLUME. Output to front-panel volume potentiometer.

Pin 10 VOLUME WIPER. Input from front-panel volume potentiometer wiper.

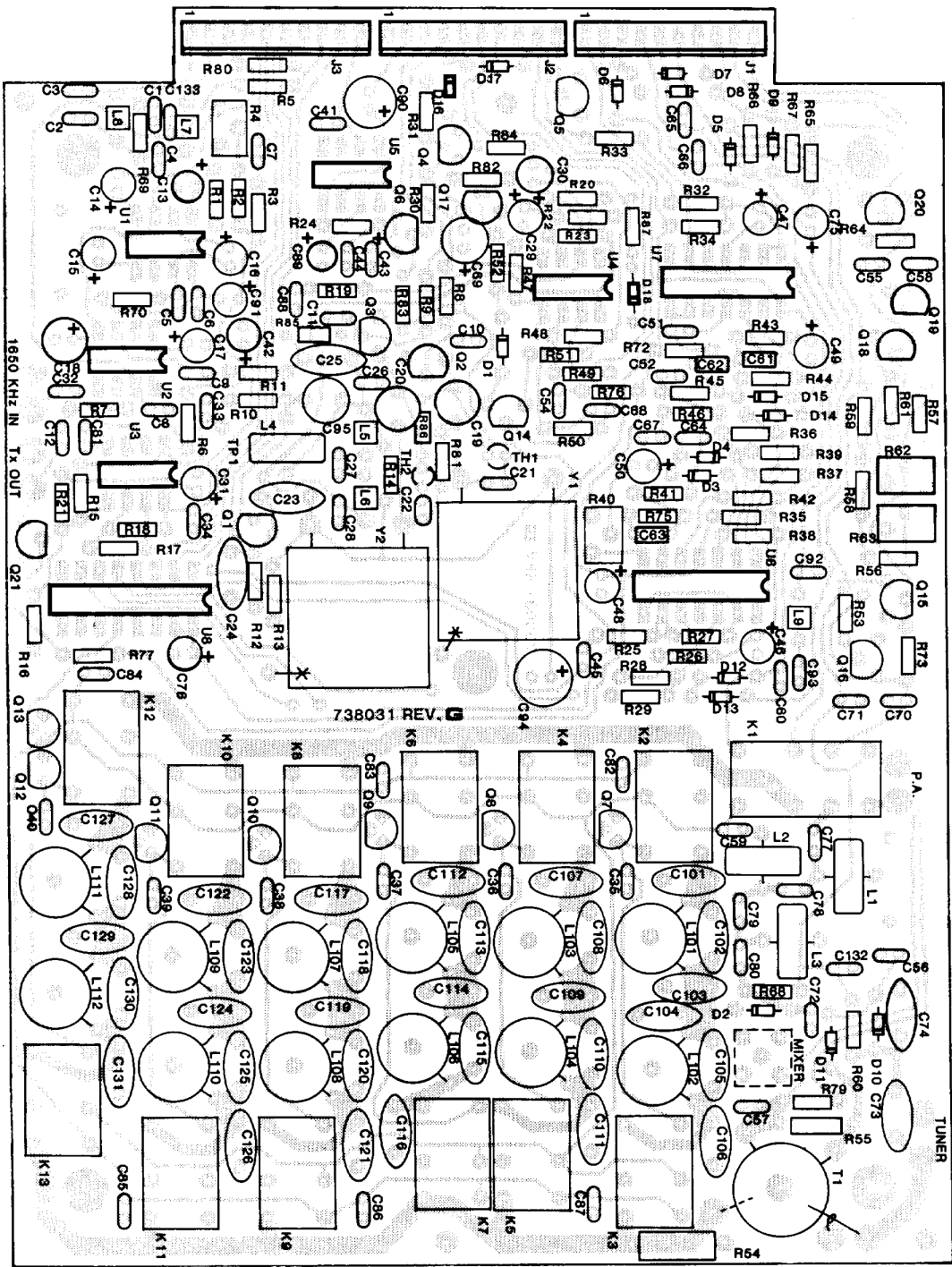


FIGURE 4-3.  
Component Locations, Audio/Filter Module, M1.

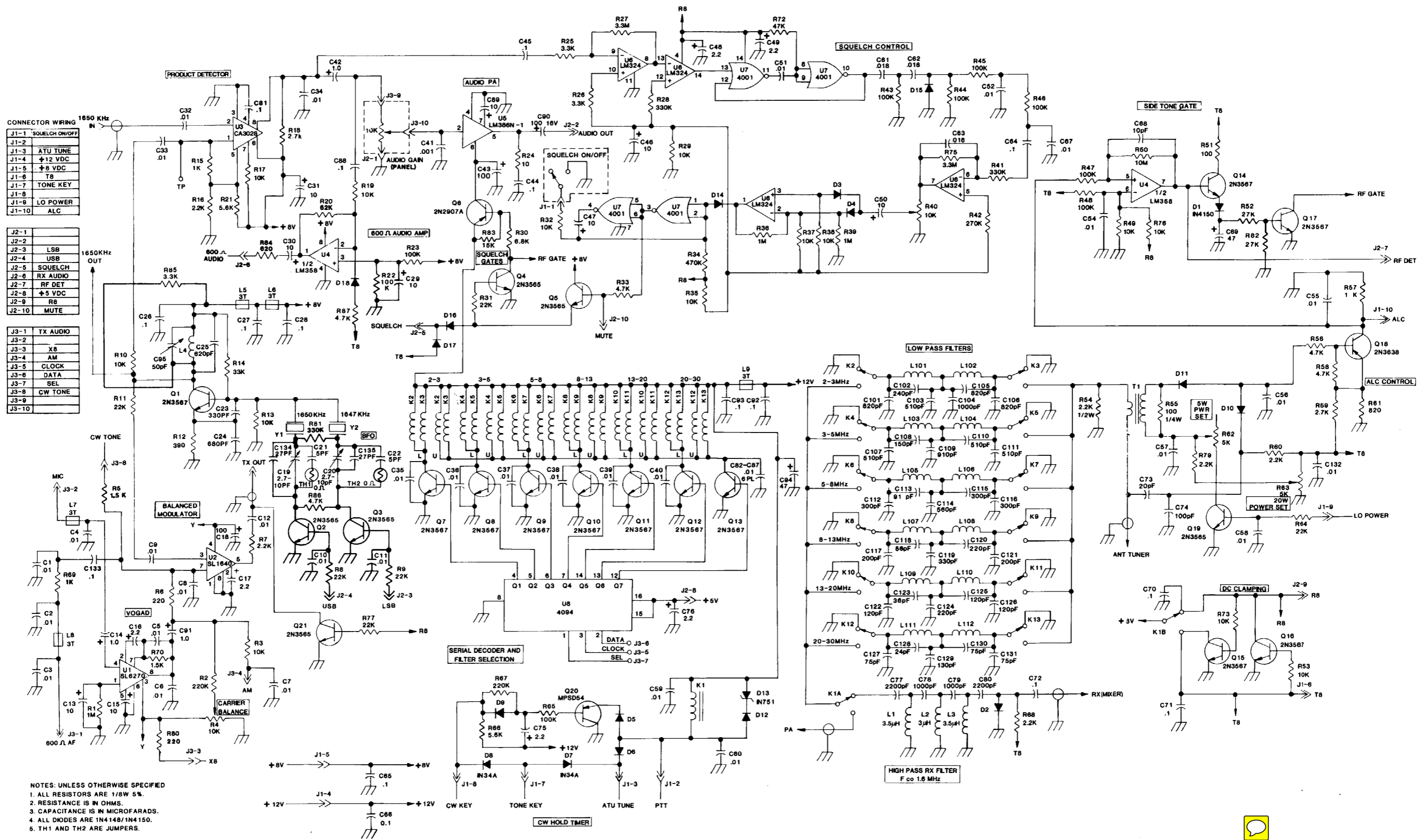


FIGURE 4-4.  
Schematic Diagram, Audio/Filter Module, M1.

**TABLE 4-2.**  
**Parts List, Audio/Filter Module, M1.**

C1-C12	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C13	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C14	237010	Capacitor, Electrolytic 50 V 1.0 $\mu$ F
C15	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C16,C17	237022	Capacitor, Electrolytic 50 V 2.2 $\mu$ F
C18	237010	Capacitor, Electrolytic 16 V 100 $\mu$ F
C19,C20	261040	Capacitor, Trimmer 2.7-10 pF
C21,C22	210050	Capacitor, Disc NPO 5 pF
C23	220331	Capacitor, Mica Dipped 330 pF
C24	220681	Capacitor, Mica Dipped 680 pF
C25	220621	Capacitor, Mica DM15 620 pF
C26-C28	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C29-C31	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C32-C40	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C41	210102	Capacitor, Disc 25 V 0.001 $\mu$ F
C42	237010	Capacitor, Electrolytic 50 V 1.0 $\mu$ F
C43	237101	Capacitor, Electrolytic 16 V 100 $\mu$ F
C44,C45	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C46,C47	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C48,C49	237022	Capacitor, Electrolytic 50 V 2.2 $\mu$ F
C50	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C51,C52	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C53		Not Used
C54-C60	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C61-C63	274183	Capacitor, Monolithic 0.018 $\mu$ F
C64-C66	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C67	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C68	210100	Capacitor, Disc NPO 10 pF
C69	237470	Capacitor, Electrolytic 16 V 47 $\mu$ F
C70-C72	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C73	220200	Capacitor, Mica DM15 20 pF
C74	220101	Capacitor, Mica DM15 100 pF
C75	241020	Capacitor, Tantalum 2.2 $\mu$ F
C76	237022	Capacitor, Electrolytic 50 V 2.2 $\mu$ F
C77	257222	Capacitor, Mylar 2200 pF
C78,C79	257102	Capacitor, Mylar 0.001 $\mu$ F
C80	257222	Capacitor, Mylar 2200 pF
C81	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C82-C87	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C88	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C89	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C90	237101	Capacitor, Electrolytic 16 V 47 $\mu$ F
C91	237010	Capacitor, Electrolytic 50 V 1.0 $\mu$ F
C92,C93	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C94	237470	Capacitor, Electrolytic 16 V 47 $\mu$ F
C95	261500	Capacitor, Trimmer 50 pF
C96-C100		Not Used
C101	220821	Capacitor, Mica DM15 820 pF
C102	220241	Capacitor, Mica Dipped 240 pF
C103	220511	Capacitor, Mica Dipped 510 pF
C104	220102	Capacitor, Mica DM15 1000 pF
C105,C106	220821	Capacitor, Mica DM15 820 pF
C107	220511	Capacitor, Mica Dipped 510 pF
C108	220151	Capacitor, Mica DM15 150 pF
D109	220911	Capacitor, Mica DM15 910 pF
C110,C111	220511	Capacitor, Mica Dipped 510 pF
C112	220301	Capacitor, Mica DM15 300 pF



**TABLE 4-2.**  
**Parts List, Audio/Filter Module, M1, Continued.**

C113	220910	Capacitor, Mica DM15 91 pF
C114	220561	Capacitor, Mica DM15 560 pF
C115,C116	220301	Capacitor, Mica DM15 300 pF
C117	220201	Capacitor, Mica DM15 200 pF
C118	220560	Capacitor, Mica DM15 56 pF
C119	220331	Capacitor, Mica Dipped 330 pF
C120	220221	Capacitor, Mica DM15 220 pF
C121	220201	Capacitor, Mica DM15 200 pF
C122	220121	Capacitor, Mica Dipped 120 pF
C123	220360	Capacitor, Mica DM15 36 pF
C124	220221	Capacitor, Mica DM15 220 pF
C125,C126	220121	Capacitor, Mica Dipped 120 pF
C127	220750	Capacitor, Mica DM15 75 pF
C128	220240	Capacitor, Mica DM15 24 pF
C129	220131	Capacitor, Mica DM15 130 pF
C130,C131	220750	Capacitor, Mica DM15 75 pF
C132	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C133	275104	Capacitor, Monolithic 0.1 $\mu$ F
C134,C135	210270	Capacitor, Disc NPO 27 pF
D1-D6	320002	Diode, 1N4148
D7,D8	320003	Diode, 1N34A
D9-D12	320002	Diode, 1N4148
D13	320204	Diode, Zener 1N751
D14-D18	320002	Diode, 1N4148
K1	540045	Relay, 12 VDC DPDT 2 A
K2-K13	540066	Relay, Latchseal
L1	459023	Inductor, Toroid 20 turns
L2	459022	Inductor, Toroid 18 turns
L3	459023	Inductor, Toroid 20 turns
L4	459024	Inductor, Toroid 40 turns
L5-L9	459032	Inductor, Ferrite 3 turns
L10-L100		Not Used
L101	459013	Inductor, Toroid 17 turns
L102	459014	Inductor, Toroid 20 turns
L103	459143	Inductor, Toroid 19 turns
L104	459139	Inductor, Toroid 11 turns
L105	459117	Inductor, Toroid 15 turns
L106	459016	Inductor, Toroid 14 turns
L107	459059	Inductor, Toroid 12 turns
L108	459164	Inductor, Toroid 7 turns
L109	459017	Inductor, Toroid 10 turns
L110,L111	459019	Inductor, Toroid 8 turns
L112	459021	Inductor, Toroid 6 turns
Q1	310003	Transistor, NPN 2N3567
Q2-Q5	310006	Transistor, NPN 2N3565
Q6	310052	Transistor, PNP PN2907A
Q7-Q17	310003	Transistor, NPN 2N3567
Q18	310007	Transistor, PNP 2N3638
Q19	310006	Transistor, NPN 2N3565
Q20	310060	Transistor, Darlington MPSD54
Q21	310006	Transistor, NPN 2N3565
R1	113105	Resistor, Film 1/8 W 5% 1 M $\Omega$

**TABLE 4-2.**  
**Parts List, Audio/Filter Module, M1, Continued.**

R1	113105	Resistor, Film 1/8 W 5% 1 M $\Omega$
R2	113224	Resistor, Film 1/8 W 5% 220 k $\Omega$
R3	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R4	170221	Resistor, Trimmer 10 k $\Omega$
R5	113152	Resistor, Film 1/8 W 5% 1.5 k $\Omega$
R6	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R7	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R8,R9	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R10	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R11	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R12	113391	Resistor, Film 1/8 W 5% 390 $\Omega$
R13	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R14	113333	Resistor, Film 1/8 W 5% 33 k $\Omega$
R15	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R16	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R17	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R18	113272	Resistor, Film 1/8 W 5% 2.7 k $\Omega$
R19	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R20	113623	Resistor, Film 1/8 W 5% 62 k $\Omega$
R21	113562	Resistor, Film 1/8 W 5% 5.6 k $\Omega$
R22,R23	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R24	113100	Resistor, Film 1/8 W 5% 10 $\Omega$
R25,R26	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R27	113335	Resistor, Film 1/8 W 5% 3.3 M $\Omega$
R28	113334	Resistor, Film 1/8 W 5% 330 k $\Omega$
R29	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R30	113682	Resistor, Film 1/8 W 5% 6.8 k $\Omega$
R31	113223	Resistor, Film 1/8 W 5% 10 k $\Omega$
R32	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R33	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
R34	113474	Resistor, Film 1/8 W 5% 470 k $\Omega$
R35	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R36	113105	Resistor, Film 1/8 W 5% 1.0 M $\Omega$
R37,R38	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R39	113105	Resistor, Film 1/8 W 5% 1.0 M $\Omega$
R40	170221	Resistor, Trimmer 10 k $\Omega$
R41	113334	Resistor, Film 1/8 W 5% 330 k $\Omega$
R42	113274	Resistor, Film 1/8 W 5% 270 k $\Omega$
R43-R48	113104	Resistor, Film 1/8 W 5% 100k $\Omega$
R49	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R50	113106	Resistor, Film 1/8 W 5% 10 M $\Omega$
R51	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R52	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R53	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R54	134222	Resistor, Film 1/2 W 5% 2.2 k $\Omega$
R55	124101	Resistor, Film 1/8 W 5% 100 $\Omega$
R56	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
R57	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R58	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
R59	113272	Resistor, Film 1/8 W 5% 2.7 k $\Omega$
R60	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R61	113821	Resistor, Film 1/8 W 5% 820 $\Omega$
R62,R63	170223	Resistor, Trimmer 5 k $\Omega$
R64	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R65	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R66	113562	Resistor, Film 1/8 W 5% 5.6 k $\Omega$
R67	113224	Resistor, Film 1/8 W 5% 220 k $\Omega$

**TABLE 4-2.**  
**Parts List, Audio/Filter Module, M1, Continued.**

R68	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R69	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R70	113152	Resistor, Film 1/8 W 5% 1.5 k $\Omega$
R71		Not Used
R72	113473	Resistor, Film 1/8 W 5% 47 k $\Omega$
R73	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R74		Not Used
R75	113335	Resistor, Film 1/8 W 5% 3.3 M $\Omega$
R76	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R77	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R78		Not Used
R79	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R80	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R81	113334	Resistor, Film 1/8 W 5% 330 k $\Omega$
R82	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R83	113153	Resistor, Film 1/8 W 5% 15 k $\Omega$
R84	113621	Resistor, Film 1/8 W 5% 620 $\Omega$
R85	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R86,R87	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
T1	459100	Transformer, 10 turns
TH1,TH2	350102	Thermistor, 1 k @ 25 $^{\circ}$ C
U1	330029	IC, SL6270CDP
U2	330036	IC, SL1640C
U3	330274	IC, CA3028AE
U4	330081	IC, LM358N
U5	330083	IC, LM386N-1
U6	330030	IC, LM324N
U7	330134	IC, CD4001BE
U8	330126	IC, CD4094BE/MC14094BCP
Y1	360060	Crystal, 1650 kHz
Y2	360061	Crystal, 1647 kHz

# CHAPTER 5

## 1650-KHZ IF MODULE, M2 - TECHNICAL DESCRIPTION

### 5-1 BLOCK DIAGRAM

A block diagram of the module is shown in Figure 5-1. This shows that the SSB filter is used in both the transmit and receive modes. Separate amplifiers are used in the transmit and receive modes. The AGC control system is generated in this module. The module has the following block components and operating functions:

1. 1650-kHz SSB Filter.
2. 1650-kHz RX IF AMP 1.
3. 1650-kHz RX IF AMP 2.
4. AGC RF Amplifier.
5. AGC dc Amplifier.
6. 1650-kHz TX IF AMP.
7. Sidetone Generation.

### 5-2 1650-KHZ SSB FILTER

The 1650-kHz SSB filter is a 6-pole Chebyshev design with a -6-dB passband of 2400 Hz and a -60-dB passband

of less than 5000 Hz or a 2:1 shape factor. The filter is computer designed for low group delays within the passband. As the group delays are a function of the percentage bandwidth, the use of the low-frequency IF permits superior performance with much lower group delays than equivalent filters operating at higher frequencies (10.7 MHz for example). For this reason the PRC1099 can be used for data transmission and COMSEC applications usually requiring higher bandwidths (3000 Hz for example). The filter is used in the receive mode to provide rejection of unwanted signals outside the passband. In the transmit mode, the filter removes one of the sidebands from the double-sideband suppressed carrier signal generated by the balanced modulator. It should be noted that the signal path through the filter is reversed between the transmit and receive modes. The filter passband is symmetrical, and this permits the use of one filter for both upper and lower sideband operation. For upper sideband operation the BFO frequency is 1650 kHz on the high side

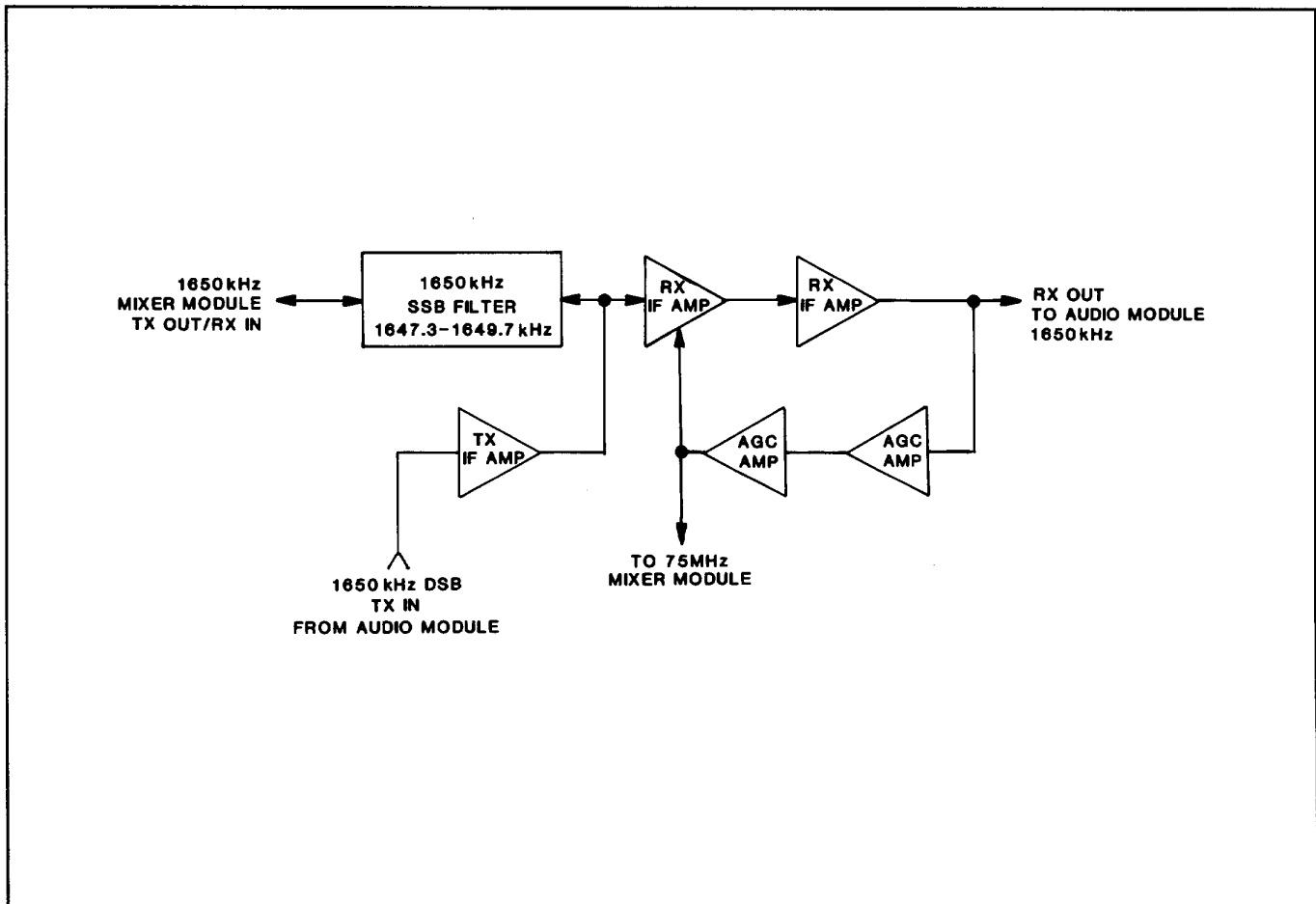


FIGURE 5-1.  
Block Diagram - 1650-kHz IF Module, M2.

of the filter passband (it should be noted that the sidebands are reversed in the conversion process and that upper sideband is generated at the 1650-kHz IF frequency as lower sideband). For lower sideband the BFO frequency is 1647 kHz on the lower side of the filter passband. The synthesizer output is automatically shifted 3 kHz when sidebands are switched, so that the carrier frequency remains unchanged.

### 5-3 1650-KHZ RX IF AMPLIFIER 1

The first 1650-kHz IF amplifier Q1 is a dual gate MOSFET connected directly to the filter output. The stage has a high input impedance which facilitates correct filter matching. The stage gain is controlled by the application of the AGC control voltage applied to gate #2 (Q1, pin 2). A dual gate MOSFET has a low distortion control range of approximately 60 dB by controlling the gate #2 voltage. It is necessary for the gate #2 voltage to go negative with respect to gate #1 in order to achieve the full range of control. The series diodes D1/D2/D5 provide a 1.8 V voltage drop so that gate #1 (Q1, pin 3) is 1.8 V above ground. This means that when gate #2 is at 0 V it is 1.8 V negative with respect to gate #1. The output is transformer coupled through T3 to the next stage.

### 5-4 1650-KHZ RX IF AMPLIFIER 2

The second 1650-kHz IF amplifier Q2 is a fixed-gain common emitter stage with an unbypassed emitter. The output is transformer coupled (T4) to the audio module through the 6-dB attenuator R10/R11.

### 5-5 AGC RF AMPLIFIER

The AGC RF amplifier Q5 is an emitter-follower bipolar transistor. The low impedance output drives the voltage doubler rectifier D3/D4.

### 5-6 AGC DC AMPLIFIER

The AGC dc amplifier Q4 is a common emitter bipolar transistor with R18 as the high impedance collector load. This gives a negative going AGC output of 4 V to 0 V. The low impedance of the transistor relative to the collector load results in a fast AGC attack, while R19/C13 provide a controlled delayed AGC decay characteristic. The AGC output controls the 1650-kHz and 75-MHz IF amplifiers.

### 5-7 1650-KHZ TX AMPLIFIER

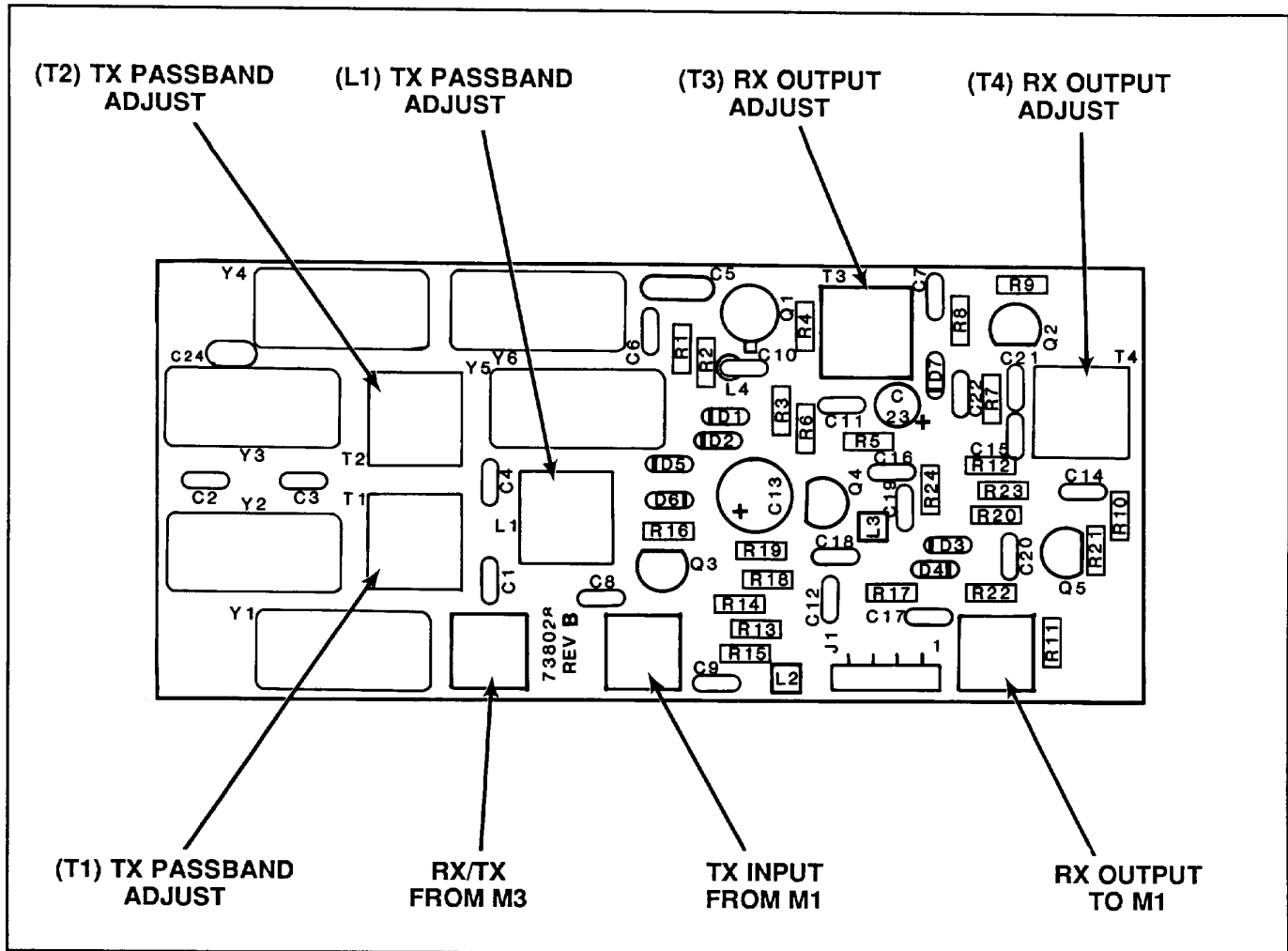
The transmit IF amplifier Q3 is a common emitter bipolar transistor with an unbiased emitter resistor. The collector load L1 is isolated from Q3 in the receive mode by the gate D6. This stage provides amplification of the low level DSB signal from the balanced modulator and correct matching to the 1650-kHz filter. It should be noted that the signal path through the filter is reversed in the transmit mode. The output from the filter is a 1650-kHz SSB signal.

### 5-8 SIDETONE GENERATOR

The 1650-kHz IF system also generates the transmit sidetone. The receive IF amplifiers remain switched on in the transmit mode and the receiver "listens" to the low level transmitter exciter output. The diode switch D7 is connected to the drain of Q1 and shorts the drain load of T3. This prevents overload of the receive IF amplifiers. This method of sidetone generation provides a complete check of the entire audio, balanced-modulator, product-detector and 1650-kHz IF system. When coupled with the RF sidetone gate, the sidetone becomes a powerful diagnostic tool in determining the complete system performance (BITE).

TABLE 5-1.  
Specifications, 1650-kHz If Module, M2.

<b>Transmit</b>	
Current:	8 Vdc @ 4 mA.
Output:	1650 kHz, SSB.
Input:	1650 kHz, DSB.
System Gain:	14 dB.
<b>Receive</b>	
Current:	8 Vdc @ 6 mA.
Output:	1650 kHz.
Input:	1650 kHz.
System Gain:	44 dB.
AGC Range:	55 dB.
<b>Filter</b>	
-6 dB:	1647.3-1649.7 kHz.
-60 dB:	1646.0-1651.0 khz.



**FIGURE 5-2.**  
Signal Connections and Adjustment Points.

**5-9 SERVICE DATA**

Figure 5-2 is a component location diagram with adjustments and signal input/output points indicated.

They are summarized as follows:

1. T1, T2, L1. Used to align the crystal filter for flattest passband response; factory set for  $\pm 0.5$  dB ripple in transmit mode.
2. T3, T4. Factory set for maximum output in receive mode.

**5-10 MODULE INTERCONNECTIONS**

The M2 module has the following interconnections with the transceiver:

Connector M2J1

- Pin 1 AGC. Automatic Gain Control, used to set the audio level in receive. Typically 4 Vdc.
- Pin 2 R8. 8 Vdc when radio is in receive, 0 Vdc in transmit.
- Pin 3 8 Vdc from power supply.
- Pin 4 T8. 8 Vdc when radio is in transmit, 0 Vdc in receive.

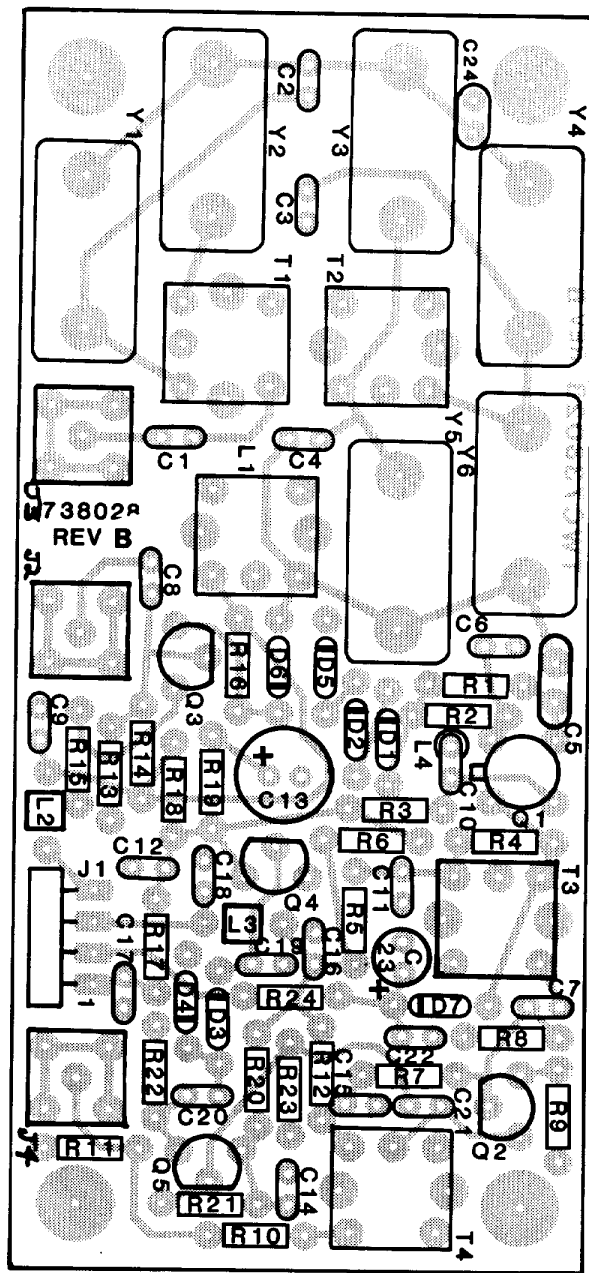
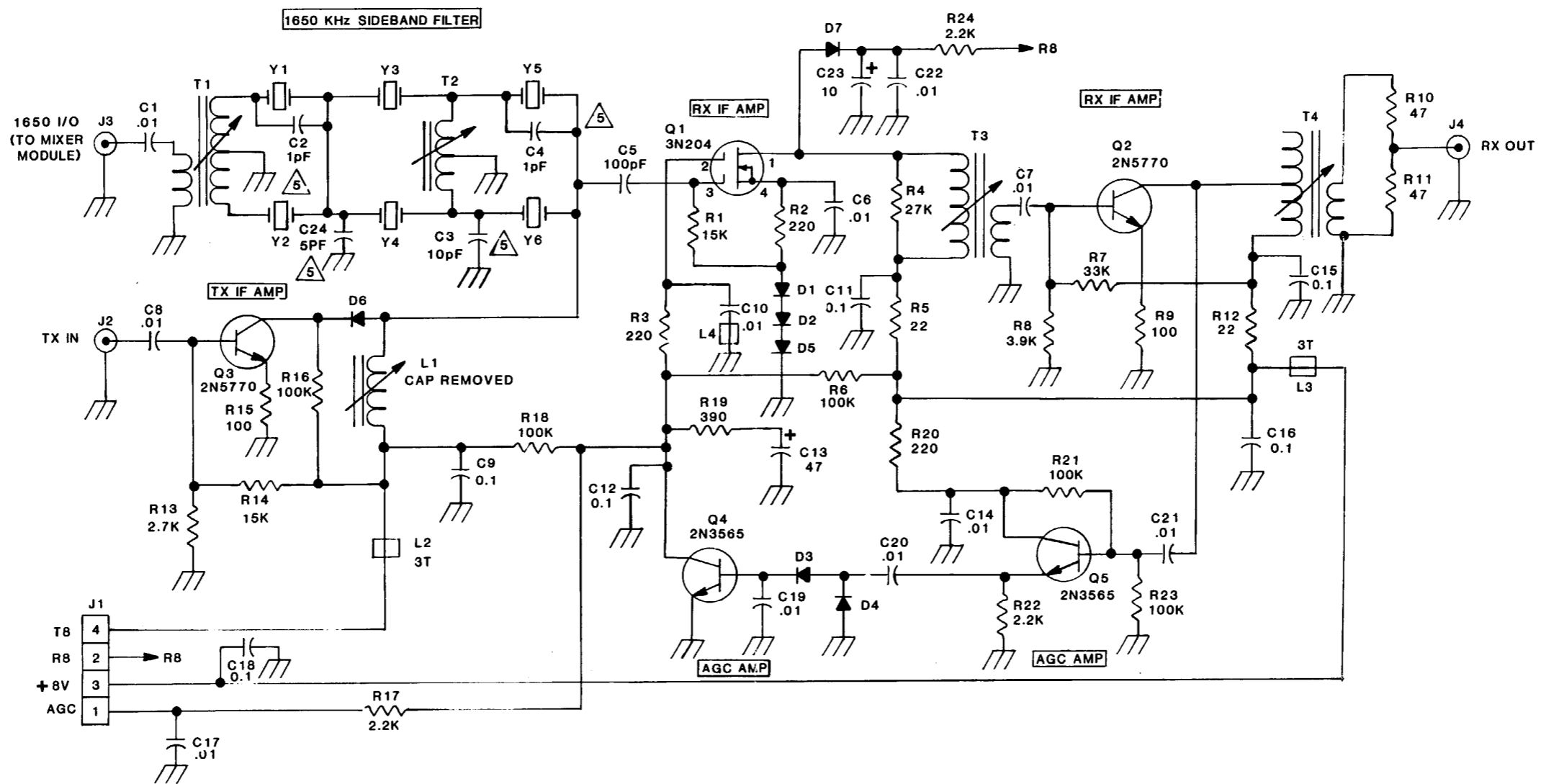


FIGURE 5-3.  
Component Locations, 1650-kHz IF Module, M2.



CONNECTOR WIRING

J1-1	AGC
J1-2	R8
J1-3	+8 VDC
J1-4	T8

NOTE: UNLESS OTHERWISE SPECIFIED.  
 1. ALL RESISTORS ARE 1/8W 5%.  
 2. RESISTANCE IS IN OHMS.  
 3. CAPACITANCE IS IN MICROFARADS.  
 4. ALL DIODES ARE IN4148/IN4150.  
 5. PARTS C2, C3, C4 FITTED OR C24 FITTED.

FIGURE 5-4.  
 Schematic Diagram, 1650-kHz IF Module, M2.



**TABLE 5-2.**  
**Parts List, 1650-kHz IF Module, M2.**

C1	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C2*	210010	Capacitor, Disc NPO 1.0 pF
C3*	210100	Capacitor, Disc NPO 10 pF
C4*	210010	Capacitor, Disc NPO 1.0 pF
C5	221101	Capacitor, Mica DM5 100 pF
C6-C8	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C9	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C10	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C11,C12	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C13	237470	Capacitor, Electrolytic 16 V 47 $\mu$ F
C13†	241040	Capacitor, Tantalum 16 V 4.7 $\mu$ F
C14	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C15,C16	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C17	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C18	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C19-C22	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C23	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C24**	210050	Capacitor, Disc NPO 5 pF
D1-D7	320002	Diode, 1N4148
L1	420051	Inductor, 1650 kHz IF
L2,L3	459032	Inductor, Ferrite 3 turns
Q1	310001	Transistor, MFT 3N204
Q2,Q3	310032	Transistor, NPN 2N5770
Q4,Q5	310006	Transistor, NPN 2N3565
R1	113153	Resistor, Film 1/8 W 5% 15 k $\Omega$
R2,R3	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R4	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R5	113220	Resistor, Film 1/8 W 5% 22 $\Omega$
R6	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R7	113333	Resistor, Film 1/8 W 5% 33 k $\Omega$
R8	113392	Resistor, Film 1/8 W 5% 3.9 k $\Omega$
R9	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R10,R11	113470	Resistor, Film 1/8 W 5% 47 $\Omega$
R12	113220	Resistor, Film 1/8 W 5% 47 $\Omega$
R13	113272	Resistor, Film 1/8 W 5% 2.7 k $\Omega$
R14	113153	Resistor, Film 1/8 W 5% 15 k $\Omega$
R15	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R16	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R17	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R18	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R19††	113391	Resistor, Film 1/8 W 5% 390 $\Omega$
R20	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R21	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R22	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R23	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R24	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
T1-T4	420018	Transformer, 1650 kHz IF
Y1	361001	Crystal, Filter
Y2	361004	Crystal, Filter

**TABLE 5-2.**  
**Parts List, 1650-kHz IF Module, M2 (Continued).**

Y3	361003	Crystal, Filter
Y4	361002	Crystal, Filter
Y5	361001	Crystal, Filter
Y6	361004	Crystal, Filter

\* Parts fitted when C24 not installed.

\*\* Part fitted when C2, C3, C4 not installed

† Part used for TRANSADAPT option.

†† R19 is replaced with a jumper for TRANSADAPT option.

## CHAPTER 6

# MIXER MODULE, M3 - TECHNICAL DESCRIPTION

### 6-1 BLOCK DIAGRAM

A block diagram of the module is shown in Figure 6-1. This module contains the first and second conversion mixers. In the receive mode the signal from the antenna is up converted to 75 MHz, amplified, filtered, amplified and then down converted to 1650 kHz. In the transmit mode the 1650-kHz low-level SSB signal is up converted to 75 MHz, amplified, filtered, down converted to the 1.6 to 30-MHz range and amplified to approximately +3 dBm. The module has the following block components:

1. 30-MHz Low-Pass Filter.
2. Double-Balanced Mixer—RX Mode.
3. 75-MHz IF Amplifier 1—RX Mode.
4. 75-MHz Filter—RX Mode.
5. 75-MHz IF Amplifier 2—RX Mode.
6. 75-MHz to 1650-kHz Mixer—RX Mode.
7. 1650-kHz to 75-MHz Mixer—TX Mode.
8. 75-MHz TX Gain-Controlled Amplifier.
9. 75-MHz Filter—TX Mode.
10. Double Balanced Mixer—TX Mode.
11. SYN 1 Buffer.
12. SYN 2 Buffer.
13. Squelch Gates.
14. 1.6 to 30-MHz Amplifier—TX Mode.
15. Current Regulator.

### 6-2 30-MHZ LOW-PASS FILTER

The low-pass filter C81/L55/C82/L56/C83 is located at the mixer port used as the receiver input and the transmitter output. This filter removes the unwanted image and spurious responses above 30 MHz.

### 6-3 DOUBLE-BALANCED MIXER - RX MODE

The balanced mixer U51 is a high-level, packaged, double-balanced mixer using matched hot-carrier diodes for optimum performance. This mixer is also used in the transmit mode. The receiver input is routed from the antenna tuner or antenna through one of the six low-pass filters and the 1.6-MHz high-pass filter on M1, and is switched to the mixer through the 30-MHz low-pass filter by the relay K51. A relay is used at this point to minimize input cross modulation. The diode switch D51 shorts the input to the receiver in the transmit mode.

The SYN 1 synthesizer provides the injection to the oscillator port. This synthesizer covers the range 76.6-105 MHz in 10-kHz steps; the incoming signal in the 1.6 to 30-MHz range is up converted to the first IF frequency of 75 MHz. The image frequency range is 151.6-180 MHz. This means that the image, IF and other lower level spurious responses are easily eliminated by a simple 30-MHz low-pass filter. No tuned circuits are required in the

receiver, which is broadband over the entire frequency range.

The mixer is one of the most important elements in a broadband, high-performance receiver. The SRA1 double-balanced mixer is a high-performance packaged mixer with very low distortion. The oscillator levels and terminations are optimized for best performance, and a third order intercept point in excess of 11 dBm is achieved. This means that the mixer can handle high level signals without the generation of spurious responses.

### 6-4 75-MHZ IF AMP 1 - RX MODE

The 75-MHz IF amplifier Q53 provides a broadband 50-ohm match to the double-balanced mixer. The bipolar transistor used in the amplifier is selected for low noise and high linearity. Emitter degeneration (R61) and collector feedback (R59) ensure low intermodulation distortion. The collector is matched to the filter by the Pi network C79/L54/C80.

### 6-5 75-MHZ FILTER - RX MODE

The 75-MHz filter Y51 is a four-pole, monolithic crystal filter with a bandwidth of 25 kHz. This filter provides the primary selectivity to prevent overload of the IF stages and second mixer before the narrowband SSB filter at 1650 kHz. The filter has a stopband of -70 dB and rejects the IF image and other spurious frequencies. The filter output is matched to 50 ohms by the Pi network C10/L5/C11.

### 6-6 75-MHZ IF AMPLIFIER 2 - RX MODE

The second 75-MHz IF amplifier Q1 is a dual gate MOSFET with AGC applied to gate #2. The AGC voltage has a control range of 0-4 V, and it is necessary to swing gate #2 negative with respect to gate #1 to get the maximum control range of 60 dB. This is achieved by the series diodes D2/D3/D4 in the source circuit of Q1. Gate #1 is connected to the anode of D2 and is biased at +1.8 V. When the AGC control voltage is at 0 V, gate #2 will be 1.8 V negative with respect to gate #1. The 50-ohm output from the filter is selected by D1 and is matched to the input of Q1 by T2, a 50-ohm to 450-ohm broadband transformer. A Pi network, C6/L3/C7, provides the interstage coupling to the mixer Q2.

### 6-7 75-MHZ TO 1650-KHZ Mixer - RX MODE

The second conversion mixer Q2 is a dual-gate MOSFET with the signal input to gate #1 and the oscillator input to gate #2. This circuit provides reasonable gain, good linearity, and a low noise figure. The output is coupled through T1 to the IF module (1650 kHz at 50 ohms). Q3 switches the 1650-kHz output in the receive mode. The oscillator output from SYN 2 is at 73.35 MHz and covers

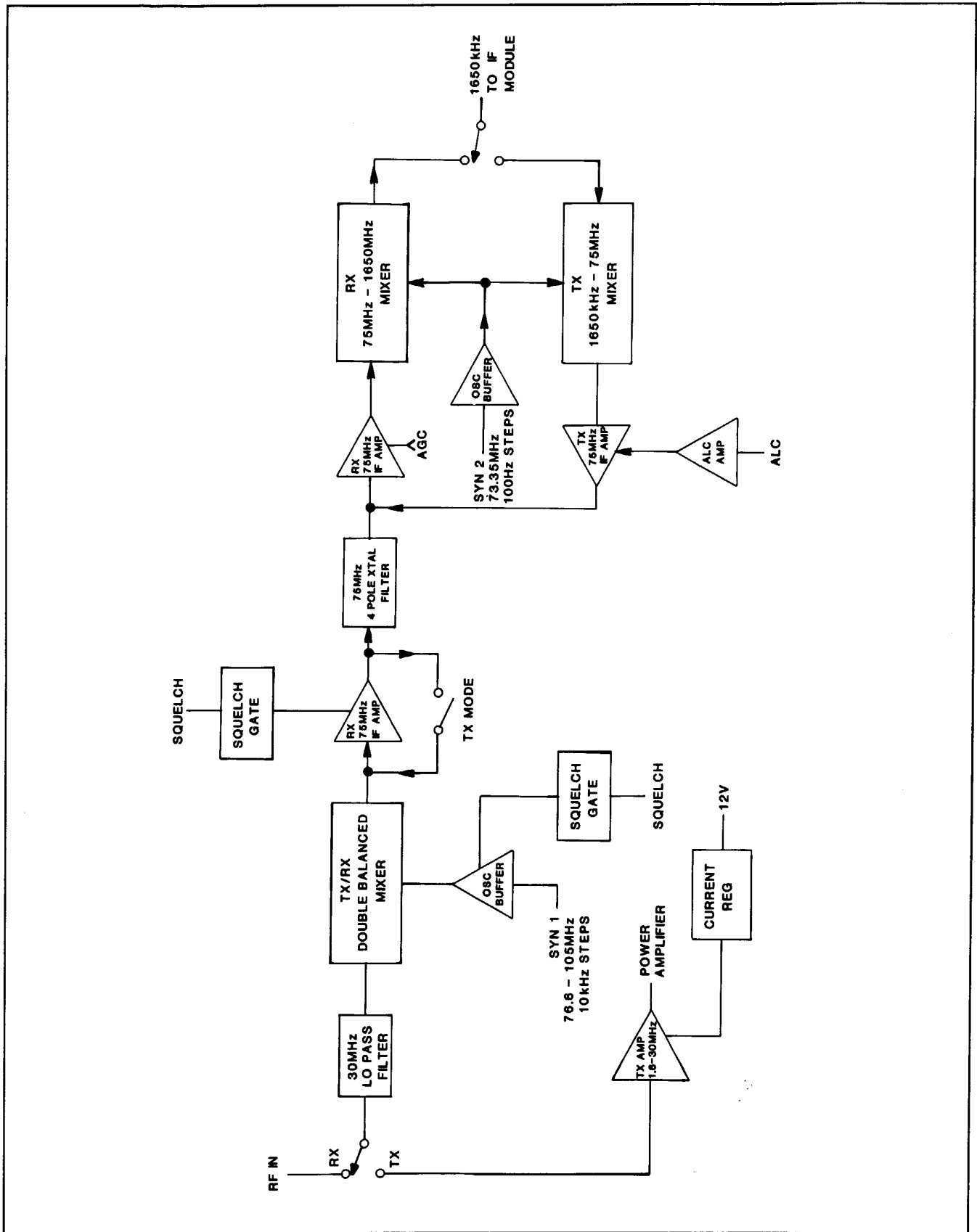


FIGURE 6-1.  
Block Diagram - Mixer Module, M3.

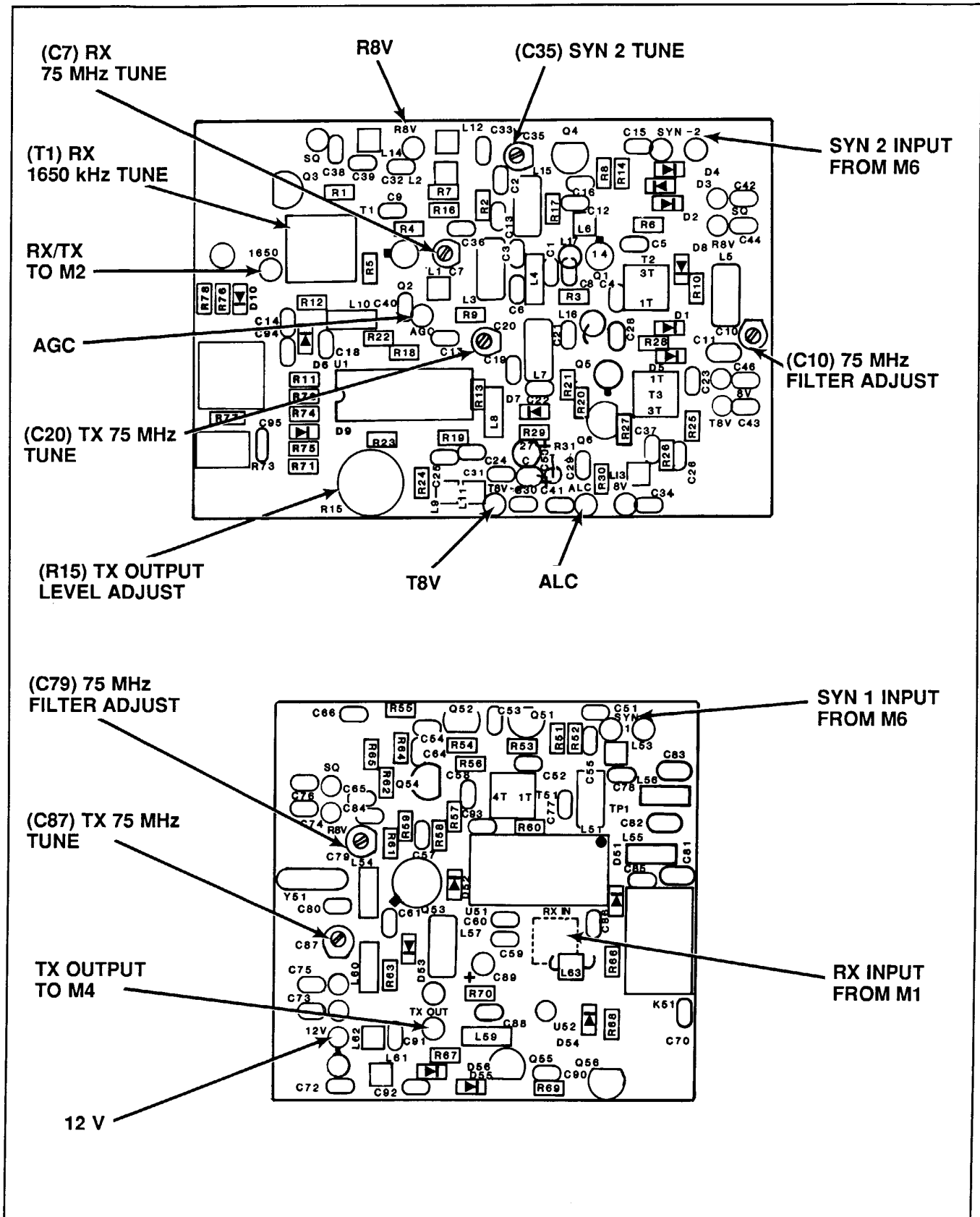


FIGURE 6-2.  
Signal Connections and Adjustment Points.

**TABLE 6-1.**  
**Specifications, Mixer Module, M3.**

<b>Transmit</b>	
Current:	8 Vdc @ 43 mA. 12 Vdc @ 44 mA.
Output:	Channel Frequency (Fs).
Input:	1650 kHz.
Gain:	31 dB.
<b>Receive</b>	
Current:	8 Vdc @ 20 mA. 8 Vdc @ 12.5 mA (squelled). 12 Vdc @ 17.5 mA. 12 Vdc @ 5.7 mA (squelled).
Output:	1650 kHz.
Input:	Channel Frequency (Fs).
Gain:	32 dB.
<b>Oscillators</b>	
Level @ U1-7:	+7 dBm @ 76.6-105 MHz.
Level @ Q5-G2:	2 V, RMS, @ 73.35 MHz.
Level @ U1-10:	100 mV, RMS, @ 73.35 MHz.

a 10-kHz range in 100-Hz steps, which provides continuous coverage in conjunction with SYN 1.

#### **6-8 1650-KHZ TO 75-MHZ MIXER - TX MODE**

This stage up converts the 1650-kHz SSB signal for the IF module to 75 MHz. U1 is an integrated circuit, active double-balanced mixer which gives good oscillator suppression. The gain of the exciter is set by R15. The output is coupled to Q5 through the Pi network C20/L7/C21. The input is switched to the 1650-kHz IF module by D6. The SYN 2 at 73.35 MHz provides the oscillator injection (100 Hz steps).

#### **6-9 75-MHZ TX GAIN-CONTROLLED AMPLIFIER**

Q5 is a dual gate MOSFET using gate #2 to control the stage gain. The ALC (automatic level control) voltage is supplied from module 1 and is applied to Q6, the ALC amplifier. When there is no ALC voltage present, Q6 does not draw collector current, and the maximum voltage of 4 V is applied through the voltage divider R27/R29 to gate #2 of Q5. In the receive mode the voltage is held at approximately 3 V by R28 and D8 connected to R8 (the receive 8-V line). When ALC voltage is applied, Q6 conducts, which causes the collector and gate #2 voltage to drop. This causes the gain of Q5 to drop and is the same system of control as used for the AGC system (refer Q1). However, a smaller control range is required, and only one diode, D7, is used to provide the fixed reference voltage for gate #1. The collector impedance of Q6 is low in comparison with the collector load R27, and the slow release is provided by C27 discharging through the high impedance load. The ALC system is normally peak reading, and the peak envelope power (PEP) and average power output will be equal. The power amplifier in the PRC1099 has considerable reserve power capability (30-40 W).

The drain of Q5 is connected through the broadband transformer T3 to the 50-ohm input of the 75-MHz filter through the diode switch D5.

#### **6-10 75-MHZ FILTER - TX MODE**

The 75-MHz filter rejects the image output from the mixer U1 and provides additional attenuation of the second conversion oscillator. The output from the filter passes through the Pi network C80/L54/C79 (Q53 is switched off in the TX mode), through the diode switch D53 to the additional section C87/L57 and the diode switch D52 to the double balanced mixer U51. It should be noted that the signal path through the filter is bilateral, and that the TX signal bypasses the RX IF amplifier Q53 in the transmit mode.

#### **6-11 DOUBLE-BALANCED MIXER - TX MODE**

The double-balanced mixer U51 is used in the reverse direction in the TX mode. The 75-MHz signal is mixed with the SYN 1 output (76.6-105 MHz) to give complete coverage of the 1.6-30 MHz range. The image frequency is removed by the 30-MHz low-pass filter, and the mixer is run at very low level to minimize spurious outputs.

#### **6-12 SYN 1 BUFFER**

The SYN 1 buffer Q51 amplifies the low level synthesizer output to a level of approximately +7 dBm for injection into the 50-ohm oscillator port of U51. The output from Q51 is coupled through T51, a broadband transformer and the 105-MHz, low-pass filter C77/L51/C78. The response is substantially flat over the SYN 1 output range 76.6-105 MHz.

### 6-13 SYN 2 BUFFER

The SYN 2 buffer Q4 amplifies the low level 73.35-MHz output from synthesizer 2 to an output level of 2-V RMS. The tuned output circuit, L15/C35 provides good spectral purity. The output is coupled directly into gate #2 of Q2 the receiver mixer, and the level is dropped to 100 mV through R16 for injection into the transmitter mixer U1.

### 6-14 SQUELCH GATES

The squelch gates Q52 and Q54 are used to reduce the receiver current drain in the receive mode. The PRC1099 has a high dynamic range receiver with a performance fully equivalent to most base station receivers. In order to achieve this performance, it is necessary to run high level oscillator injection levels to the double-balanced mixer U51. The following IF amplifier Q53 must also run at high levels. It is possible to make a substantial decrease in the current drain of the receiver by making a reduction in the dynamic range. The PRC1099 has an intercept point of +11 dBm and a dynamic range exceeding 100 dB. The squelch circuit is used to lower the oscillator injection level and reduce the current drain of the first IF amplifier, which lowers the intercept point to approximately +1 dBm. There is virtually no change in sensitivity or SINAD. Even with the reduced dynamic range, the performance of the receiver meets or exceeds the specification of most HF manpacks.

Q52 is the squelch gate controlling the current drain of the synthesizer buffer Q51. In the squelch mode Q52 is open circuit, so that the emitter resistor for Q51 is comprised of R53 (47 ohms) and R54 (820 ohms). When the squelch is off, the gate Q52 closes, which shorts R54 to ground and reduces the emitter resistance to 50 ohms. Similarly, Q54 switches in and out the emitter resistor, R64 (150 ohms) for the IF amplifier Q53. In the transmit mode, a diode gate on M1 closes the squelch gates so that the double-balanced mixer is supplied with the high-level oscillator injection.

### 6-15 AMPLIFIER 1.6 TO 30 MHZ - TX MODE

The low-level output from the double-balanced mixer U51 is amplified by the MMIC (monolithic, microwave, integrated circuit) U52. This is a new class of three terminal devices providing stable 50 ohms to 50 ohms amplification over a very wide frequency range without any external components.

### 6-16 CURRENT REGULATOR

The MMIC (U52) is designed to operate from a 20-V supply using a series bias resistor in the supply load. Since the PRC1099 is designed to operate over a supply range in excess of 10-15 V, a current regulator, Q55, is used to provide a constant current source for U52. The current output is determined by R67. The current to U52 is switched on by the TX gate Q56, which is controlled by the T8 line.

### 6-17 AME OPTION

The purpose of this circuit is to inject a 1650-kHz signal from the carrier oscillator directly into the transmit chain at the highest possible level. This is necessary as the carrier level should not be controlled by the ALC circuit, and it is not desirable to pass the carrier through the crystal filter. The carrier is applied to the input of the mixer U1 via the PIN diode attenuator D9/D10. In the off position, D10 is forward biased, which shorts the carrier to ground. D9 is reverse biased. This gives approximately 60 dB of attenuation. When the carrier switch is grounded, D9 is forward biased, and D10 is reverse biased, and the carrier is not attenuated. The carrier level is adjusted by the input potentiometer R73.

### 6-18 SERVICE DATA

Figure 6-2 is a component location diagram with adjustment and signal input/output points indicated. A summary of adjustments is as follows:

1. C35. Used to set the Syn. 2 level for maximum. The Syn. 2 level can be monitored at TP2 (Q2 and R7) and should be approximately 2 V RMS. **NOTE:** The Syn. 1 level is checked at TP1 (U51-7 and L51) and should be about +7-10 dBm.
2. C7, T1. Used to set the receiver output level; adjusted at the factory for maximum RX output.
3. C10, C79. With the signal generator set to 7.0 MHz and the level at -50 dBm, adjust C10 and C79 for maximum output. Then alternate the adjustments for C10 and C79 between synthesizer settings of 7.0 MHz and 6.9999 MHz until the levels are equal. This serves to optimize the 75 MHz filter passband.
4. R15, C20 and C87. With the radio set to 7.0000 MHz, and a wattmeter and dummy load connected to the 50-ohm output, key the radio using a CW keyer and adjust C20 and C87 for maximum output. Now adjust R15 until the power output reads approximately 15 watts, record this value. Set the radio to 6.9999 MHz and readjust C20 and C87 for maximum. Alternate between 7.0000 MHz and 6.9999 MHz and adjust C20 and C87 for balance between the two frequencies. Once C20 and C87 have been adjusted, increase the output power with R15 until the power stops increasing. Check all test frequencies and insure the output power does not deviate more than 3 watts.

### 6-19 MODULE INTERCONNECTIONS

The M3 module has the following interconnections with the transceiver:

#### Connector M3J1

- Pin 1 12 Vdc from the power supply.
- Pin 2 R8. 8 Vdc when radio is in receive, 0 Vdc in transmit.

Pin 3	T8. 8 Vdc when radio is in transmit, 0 Vdc in receive.	From Synthesizer:
Pin 4	ALC. Automatic level control, used to set the output power level in transmit. In receive, 0 Vdc.	Squelch. 0 Vdc when the radio is squelched, 6.8 Vdc when radio is unsquelched.
Pin 5	AGC. Automatic Gain control, used to set the audio level in receive. Typically 4 Vdc.	8 Vdc from power supply. 12 Vdc supplied to synthesizer.



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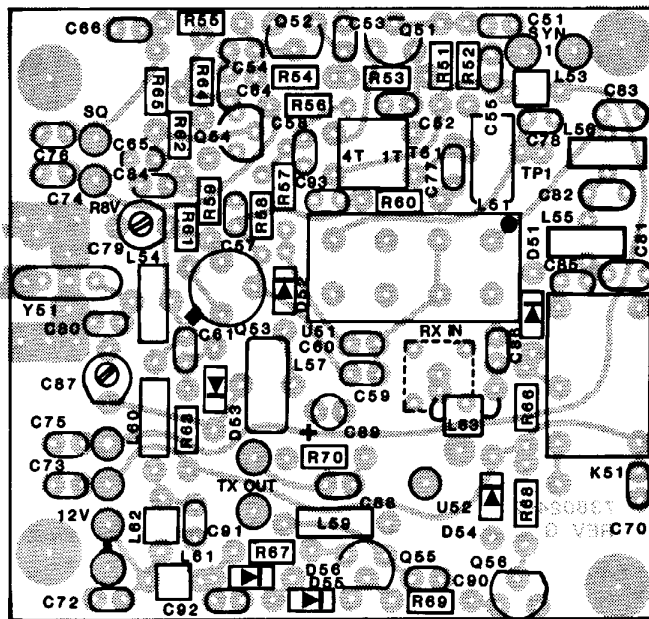
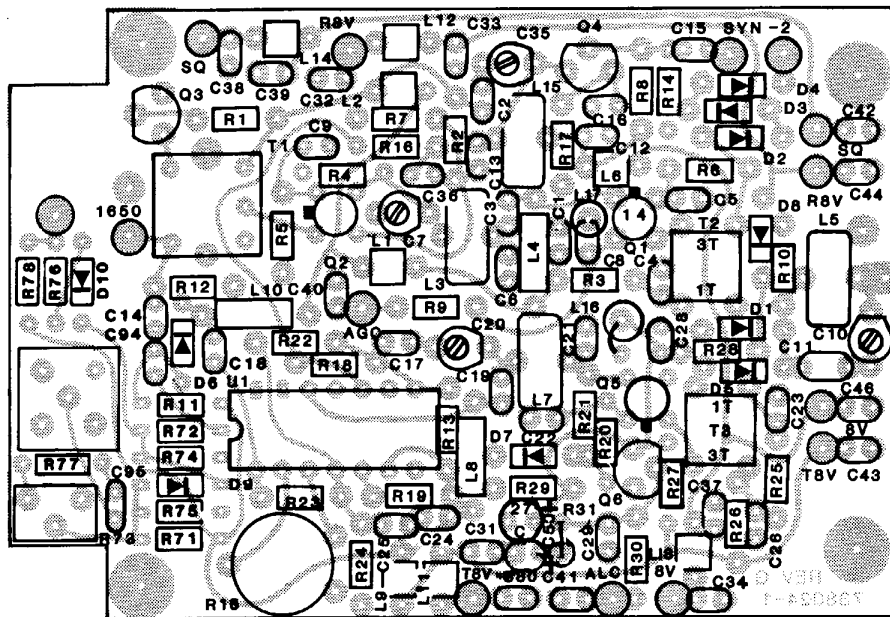
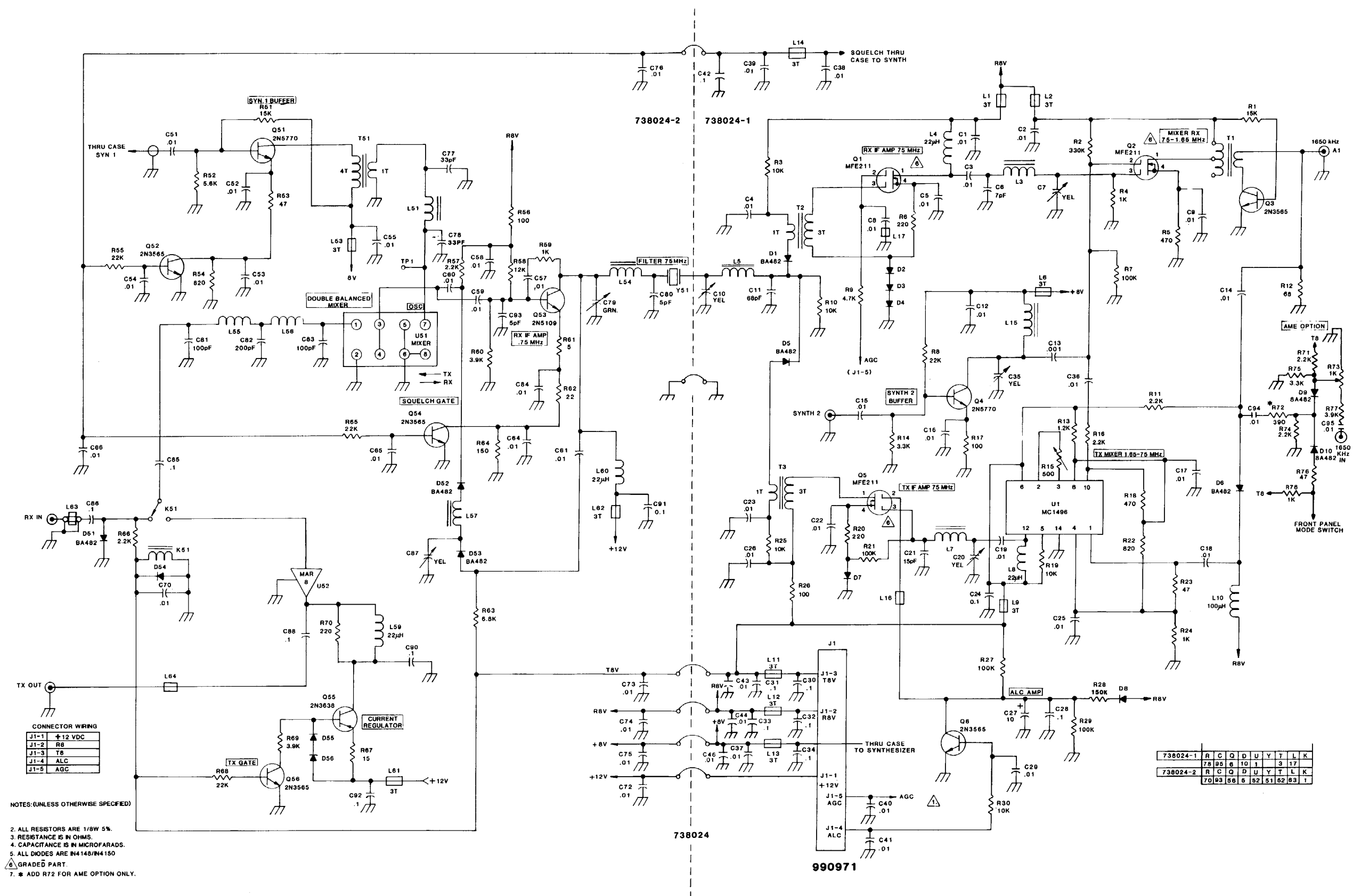


FIGURE 6-3.  
Component Locations, Mixer Module, M3.



738024-1	R	C	O	D	U	Y	T	L	K	
738024-2	7	8	9	5	6	1	0	1	3	1
	7	0	9	3	6	6	5	2	5	1

**FIGURE 6-4.**  
Schematic Diagram, Mixer Module, M3.

**TABLE 6-2.**  
**Parts List, Mixer Module, M3. Assembly-1.**

C1-C5	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C6	210070	Capacitor, Disc NPO 7 pF
C7	261250	Capacitor, Trimmer 1-25 pF
C8,C9	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C10	261250	Capacitor, Trimmer 1-25 pF
C11	221680	Capacitor, Mica DM5 68 pF
C12	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C13	210102	Capacitor, Disc 25 V .001 $\mu$ F
C14-C19	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C20	261250	Capacitor, Trimmer 1-25 pF
C21	210150	Capacitor, Disc NPO 15 pF
C22,C23	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C24	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C25,C26	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C27	237100	Capacitor, Electrolytic 16 V 10 $\mu$ F
C28	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C29	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C30-C34	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C35	261250	Capacitor, Trimmer 1-25 pF
C36-C44	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C45		Not Used.
C46	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C47-C93		Not Used.
C94, C95	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
D1	320005	Diode, PIN BA482
D2-D4	320002	Diode, 1N4148
D5,D6	320005	Diode, PIN BA482
D7,D8	320002	Diode, 1N4148
D9, D10	320005	Diode, PIN BA482
L1,L2	459032	Inductor, Ferrite 3 turns
L3	459025	Inductor, Toroid 17 turns
L4	430021	Inductor, Fixed 22 $\mu$ H
L5	459025	Inductor, Toroid 17 turns
L6		Inductor, Ferrite 3 turns
L7	459026	Inductor, Toroid 16 turns
L8	433021	Inductor, Fixed 22 $\mu$ H
L9	459032	Inductor, Ferrite 3 turns
L10	430014	Inductor, Molded 100 $\mu$ H
L11-L14	459032	Inductor, Ferrite 3 turns
L15	459027	Inductor, Ferrite 9 turns
L16,L17	490201	Inductor, Ferrite 3 turns
Q1,Q2	310001	Transistor, MFT 3N204
Q3	310006	Transistor, NPN 2N3565
Q4	310032	Transistor, NPN 2N5770
Q5	310001	Transistor, MFT 3N204
Q6	310006	Transistor, NPN 2N3565
R1	113153	Resistor, Film 1/8 W 5% 15 k $\Omega$
R2	113334	Resistor, Film 1/8 W 5% 330 k $\Omega$
R3	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R4	113102	Resistor, Film 1/8 W 5% 1.0 k $\Omega$
R5	113471	Resistor, Film 1/8 W 5% 470 $\Omega$
R6	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R7	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$

**TABLE 6-2.**  
**Parts List, Mixer Module, M3. Assembly-1, Continued.**

R8	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R9	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
R10	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R11	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R12	113680	Resistor, Film 1/8 W 5% 68 $\Omega$
R13	113122	Resistor, Film 1/8 W 5% 1.2 k $\Omega$
R14	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R15	170110	Resistor, Trimmer 10 mm 500 $\Omega$
R16	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R17	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R18	113471	Resistor, Film 1/8 W 5% 470 $\Omega$
R19	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R20	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R21	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R22	113821	Resistor, Film 1/8 W 5% 820 $\Omega$
R23	113470	Resistor, Film 1/8 W 5% 47 $\Omega$
R24	113102	Resistor, Film 1/8 W 5% 1.0 k $\Omega$
R25	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R26	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R27	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R28	113154	Resistor, Film 1/8 W 5% 150 k $\Omega$
R29	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R30	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R31-R70		Not Used.
R71	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R72*	113391	Resistor, Film 1/8 W 5% 390 $\Omega$
R73	170224	Resistor, Variable 1 k $\Omega$
R74	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R75	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R76	113470	Resistor, Film 1/8 W 5% 47 $\Omega$
R77	113392	Resistor, Film 1/8 W 5% 3.9 k $\Omega$
R78	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
T1	420018	Inductor, IF 1650 kHz
U1	330006	IC, MC1496P

\* Part used in AME Option.

**TABLE 6-3.**  
**Parts List, Mixer Module, M3. Assembly-2.**

C51-C55	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C56		Not Used
C57-C61	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C62,C63		Not Used
C64-C66	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C67-C69		Not Used
C70	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C71		Not Used
C72-C76	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C77,C78	221330	Capacitor, Mica DM5 33 pF
C79	261500	Capacitor, Trimmer 50 pF
C80	210050	Capacitor, Disc 5 pF
C81	221101	Capacitor, Mica DM5 100 pF
C82	221201	Capacitor, Mica DM5 200 pF
C83	221101	Capacitor, Mica DM5 100 pF
C84-C86	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C87	261250	Capacitor, Trimmer 1-25 pF
C88	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C89		Not Used.
C90-C92	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C93	210050	Capacitor, Disc 5 pF
D51-D53	320005	Diode, Pin BA482
D54-D56	320002	Diode, 1N4148
K51	540060	Relay, SPDT 9Vdc
L51	459030	Inductor, Toroid 7 turns
L52	Not Used	
L53	459032	Inductor, Ferrite 3 turns
L54	459028	Inductor, Toroid 20 turns
L55,L56	459031	Inductor, Toroid 16 turns
L57	459029	Inductor, Toroid 11 turns
L58	Not Used	
L59,L60	430021	Inductor, Fixed 22 $\mu$ H
L61,L62	459032	Inductor, Ferrite 3 turns
L63,L64	490203	Bead, Ferrite
Q51	310032	Transistor, NPO 2N5770
Q52	310006	Transistor, NPN 2N3565
Q53	310059	Transistor 2N5109
Q54	310006	Transistor, NPN 2N3565
Q55	310007	Transistor, PNP 2N3638
R51	113153	Resistor, Film 1/8 W 5% 15 k $\Omega$
R52	113562	Resistor, Film 1/8 W 5% 5.6 k $\Omega$
R53	113470	Resistor, Film 1/8 W 5% 47 $\Omega$
R54	113821	Resistor, Film 1/8 W 5% 820 $\Omega$
R55	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R56	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R57	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R58	113123	Resistor, Film 1/8 W 5% 12 k $\Omega$
R59	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$

**TABLE 6-3.**  
**Parts List, Mixer Module, M3. Assembly-2, Continued.**

R60	113392	Resistor, Film 1/8 W 5% 3.9 k $\Omega$
R61	113050	Resistor, Film 1/8 W 5% 5 $\Omega$
R62	113220	Resistor, Film 1/8 W 5% 22 $\Omega$
R63	113682	Resistor, Film 1/8 W 5% 6.8 k $\Omega$
R64	113151	Resistor, Film 1/8 W 5% 150 $\Omega$
R65	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R66	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R67	113150	Resistor, Film 1/8 W 5% 15 $\Omega$
R68	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R69	113392	Resistor, Film 1/8 W 5% 3.9 k $\Omega$
R70	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
T51	459033	Inductor, Ferrite 4 Turns / 1 turn
T52		Not Used
U51	380006	IC, Mixer
U52	380010	IC, Amplifier
Y51	370007	Crystal, Filter 75 MHz

# CHAPTER 7

## POWER-AMPLIFIER MODULE, M4 - TECHNICAL DESCRIPTION

### 7-1 BLOCK DIAGRAM

A block diagram of the module is shown in Figure 7-1. The power-amplifier module is used to amplify the low-level (+3 dBm) transmitter signal from the mixer module, M3, to a power level of 20 W with a low level of distortion. Apart from the predriver, the module operates in class AB to minimize current drain. The module has the following block components:

1. Predriver Amplifier.
2. Driver Amplifier.
3. Final Amplifier.
4. Bias Regulator.
5. Overtemperature Switch.

### 7-2 PREDRIVER AMPLIFIER

The predriver amplifier Q1 is a class A amplifier with fixed bias—R3/R2 and emitter resistor—R4. Collector-

base feedback is provided by R3/C5. The network C1/R1 provides gain levelling. The output is coupled from the collector through the broadband transformer T1. The stage operates from the regulated transmit 8-V line (T8-V line) and is switched off in the receive mode.

### 7-3 DRIVER AMPLIFIER

The driver amplifier Q2/Q3 is a push-pull amplifier using two RF power-amplifier transistors designed for linear broadband RF service. The driver amplifier operates in class AB with a regulated bias supply and grounded emitters. Collector base feedback is provided by C14/R7 and C10/R10. The input is coupled from the push-pull secondary on T1. The output is coupled to the final amplifier through T2, a broadband tubular-type, ferrite-loaded transformer with a push-pull primary and secondary. The

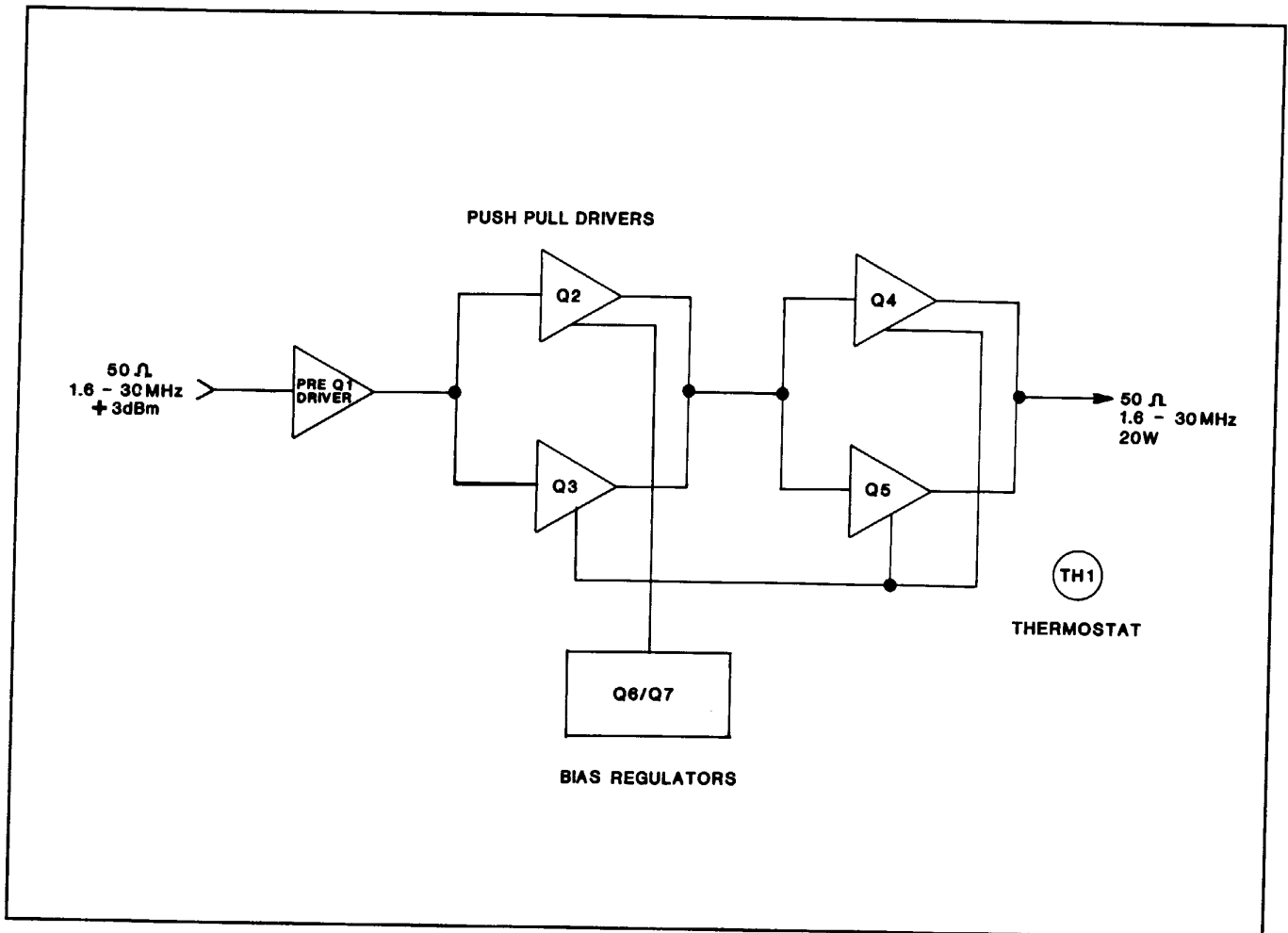
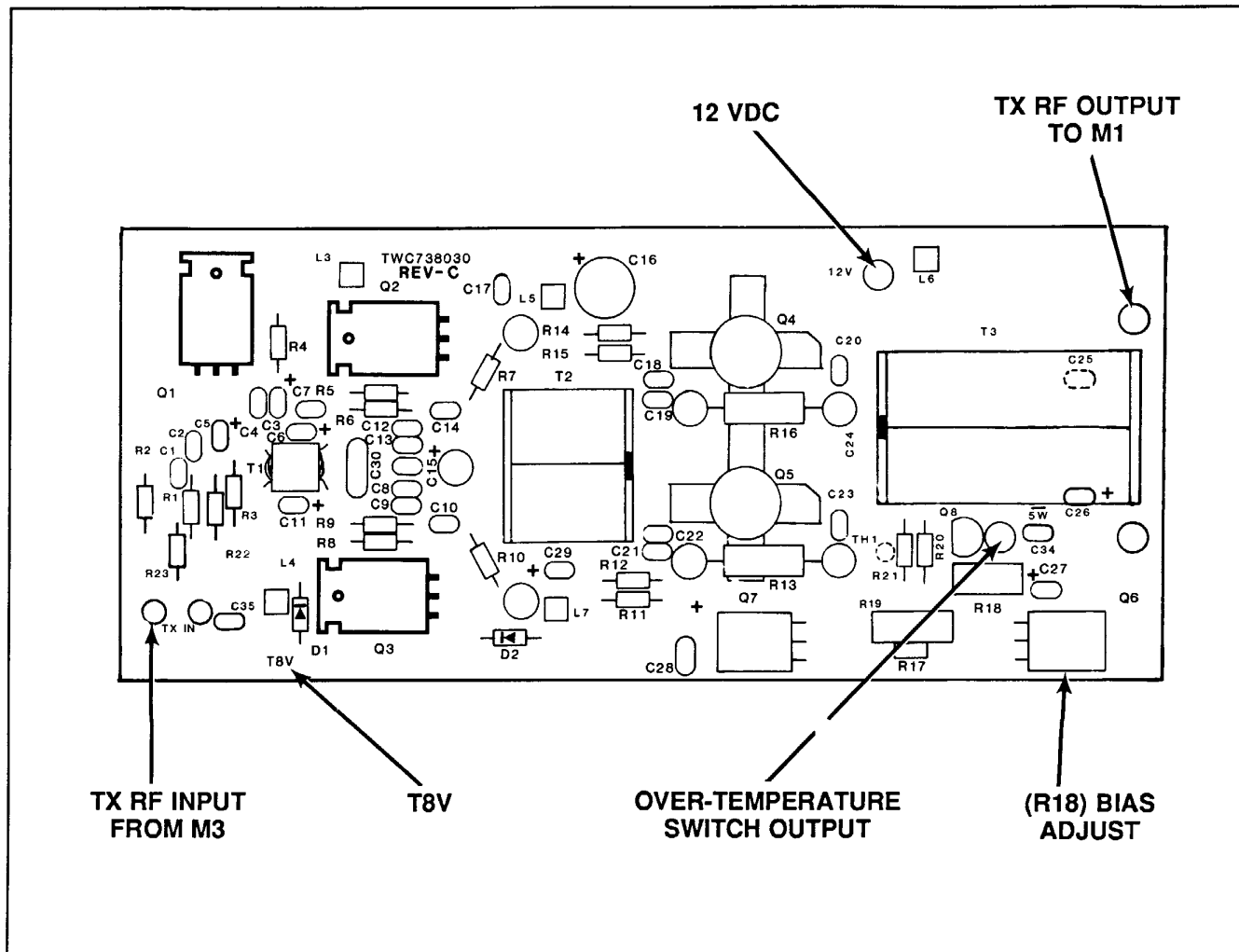


FIGURE 7-1.  
Block Diagram - PA Module, M4.





**FIGURE 7-2.**  
Signal Connections and Adjustment Points.

driver amplifier operates directly from the 12-V supply and is switched off by the bias supply.

#### 7-4 FINAL AMPLIFIER

The final amplifier Q4/Q5 is two push-pull, RF power-amplifier transistors designed for SSB service in the HF range. The transistors operate in class AB with the bias derived from the bias regulator circuit. The emitters are grounded. The input is coupled from the push-pull secondary on T2, and the output transformer T3 is a tubular-type, ferrite-loaded transformer with a push-pull primary and a single ended 50-ohm secondary. The final amplifier operates directly from the 12-V supply and is switched on and off by controlling the bias supply. The output transistors have been chosen for their rugged construction and are operated at much reduced ratings. The final amplifier is actually capable of power outputs of 30-40 W and provides excellent reliability and very good linearity, even at reduced battery voltages. The amplifier uses collector-base feedback R16/C20 and R13/C23.

#### 7-5 BIAS REGULATORS

The bias regulator Q6/Q7 operates directly from the regulated T8-V line and is switched off in the receiver mode. The final amplifier and driven amplifier are connected permanently to the battery supply but cannot draw current until the bias is applied in the transmit mode. The bias regulator uses the dc coupled regulators Q6 and Q7 to provide a very stable, fixed bias source for the two stages. The quiescent current is set by adjusting R18.

#### 7-6 OVERTEMPERATURE SWITCH

TH1 is a temperature-sensitive resistor with a positive temperature coefficient. This means as the resistor gets hotter, its resistance goes up. By forming a voltage divider with this thermistor, Q8 is made to conduct when the heat sink temperature exceeds 80°C. This forces the power output to 5 W or less until the unit cools. TH1 is mounted in a hole in the heat sink and normally measures about 150 ohms at room temperature.

**TABLE 7-1.**  
**Specifications, Power-Amplifier Module, M4.**

<b><u>Transmit</u></b>	
Current:	+8 Vdc @ 65 mA. +12 Vdc @ 200 mA (quiescent). +12 Vdc @ 3.6 A (20 W, CW, output).
Frequency:	1.6-30 MHz (Fs).
Output:	20 W, CW, into 50 $\Omega$ .
Input:	0 dBm, $\pm$ 2 dB.
Gain:	43 dB.

**7-7 SERVICE DATA**

Figure 7-2 is a component location diagram with signal input/output points and adjustments indicated. The following is the only M4 adjustment.

1. R18. Used to set the bias current; factory set for 200 mA on the 12-volt line.

**7-8 MODULE INTERCONNECTIONS**

The M4 module has the following interconnections with the transceiver:

Connector M4J1

Pin 1 12 Vdc from the power supply.

Pin 2 12 Vdc from the power supply.

Pin 3 LOW POWER. Switches the amplifier to the low-power position when the amplifier overheats, or when the front-panel switch is in LOW POWER.

Pin 4 T8. 8 Vdc when radio is in transmit, 0 Vdc in receive.

Pin 5 Ground.

Pin 6 Ground.

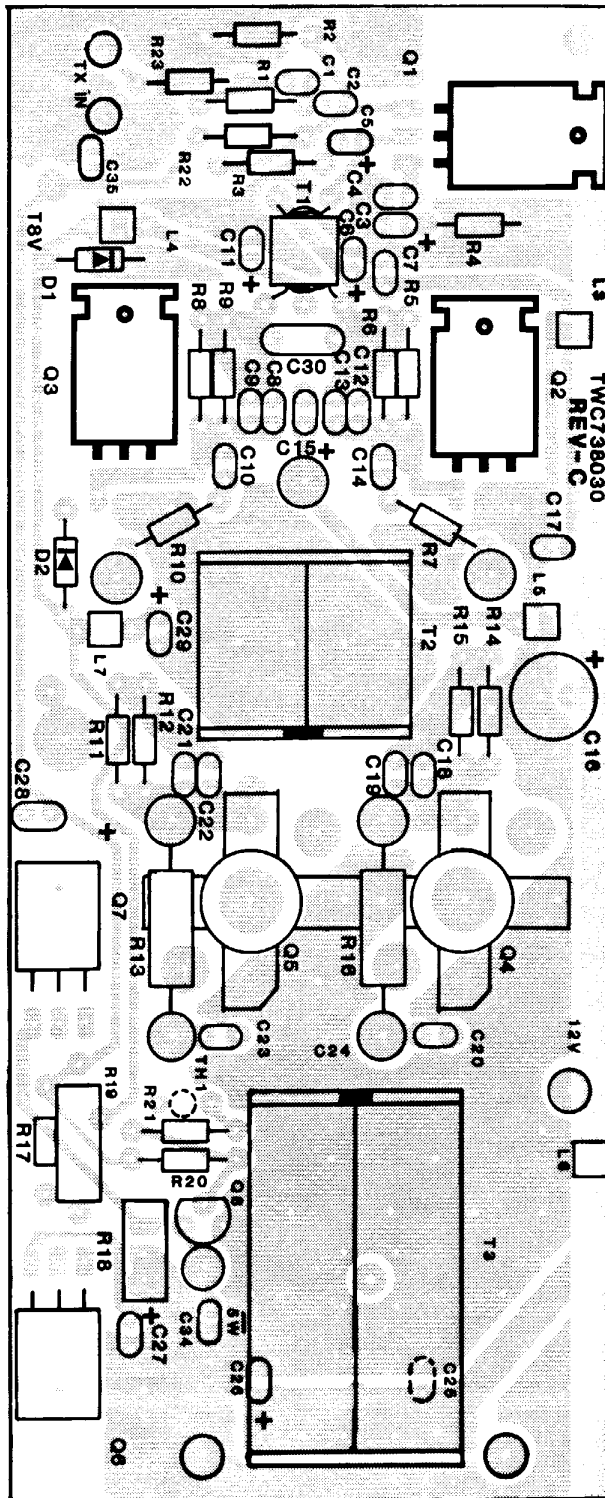
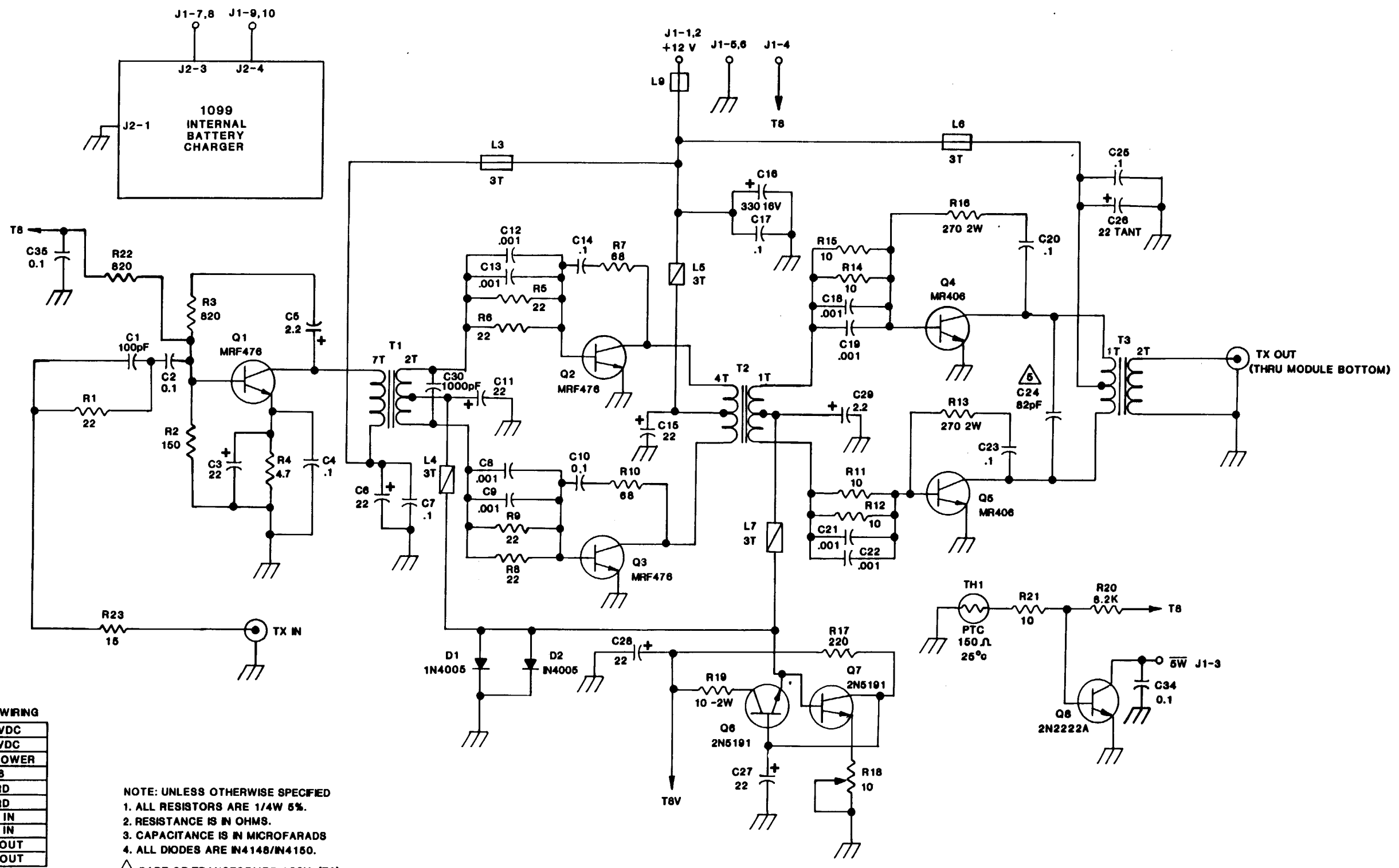


FIGURE 7-3.  
Component Locations, Power-Amplifier Module, M4.



**CONNECTOR WIRING**

J1-1	+ 12 VDC
J1-2	+ 12 VDC
J1-3	LOW POWER
J1-4	T8
J1-5	GRD
J1-6	GRD
J1-7	B.C. IN
J1-8	B.C. IN
J1-9	B.C. OUT
J1-10	B.C. OUT

NOTE: UNLESS OTHERWISE SPECIFIED  
 1. ALL RESISTORS ARE 1/4W 5%.  
 2. RESISTANCE IS IN OHMS.  
 3. CAPACITANCE IS IN MICROFARADS  
 4. ALL DIODES ARE IN4148/IN4150.  
 ⚠ PART OF TRANSFORMER ASSY. (T3).

FIGURE 7-4.  
 Schematic Diagram, Power-Amplifier Module, M4.

**TABLE 7-2.**  
**Parts List, Power-Amplifier Module, M4.**

C1	221101	Capacitor, Mica DM5 100 pF
C2	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C3	241226	Capacitor, Tantalum 22 $\mu$ F
C4	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C5	241020	Capacitor, Tantalum 2.2 $\mu$ F
C6	241226	Capacitor, Tantalum 22 $\mu$ F
C7	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C8,C9	210102	Capacitor, Disc .001 $\mu$ F
C10	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C11	241226	Capacitor, Tantalum 22 $\mu$ F
C12,C13	210102	Capacitor, Disc .001 $\mu$ F
C14	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C15	241226	Capacitor, Tantalum 22 $\mu$ F
C16	231331	Capacitor, Electrolytic 16 V 330 $\mu$ F
C17	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C18,C19	210102	Capacitor, Disc .001 $\mu$ F
C20	275104	Capacitor, Monolithic 50 V $\mu$ F
C21,C22	210102	Capacitor, Disc .001 $\mu$ F
C23	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C24	Not Used	
C25	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C26-C28	241226	Capacitor, Tantalum 22 $\mu$ F
C29	241020	Capacitor, Tantalum 2.2 $\mu$ F
C30	220102	Capacitor, Mica DM15 1000 pF
C31		Not Used.
C32,C33		Not Used
C33-C35	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
D1,D2	320101	Diode 1N4005
L2		Not Used
L3-L5	459032	Inductor, Ferrite shield
L6	459032	Inductor, Ferrite 3 turns
L7	459032	Inductor, Ferrite 3 turns
L8		Not Used
L9	490203	Bead, Ferrite
Q1-Q3	310097	Transistor, MRF476
Q4,Q5	310096	Transistor, MRF406
Q6,Q7	310055	Transistor, NPN 2N5191
Q8	310057	Transistor, NPN PN2222A
R1	124220	Resistor, Film 1/4 W 5% 22 $\Omega$
R2	124151	Resistor, Film 1/4 W 5% 150 $\Omega$
R3	124821	Resistor, Film 1/4 W 5% 820 $\Omega$
R4	124047	Resistor, Film 1/4 W 5% 4.7 $\Omega$
R5,R6	124220	Resistor, Film 1/4 W 5% 22 $\Omega$
R7	124680	Resistor, Film 1/4 W 5% 68 $\Omega$
R8,R9	124151	Resistor, Film 1/4 W 5% 22 $\Omega$
R10	124680	Resistor, Film 1/4 W 5% 68 $\Omega$
R11,R12	124100	Resistor, Film 1/4 W 5% 10 $\Omega$
R13	154271	Resistor, Film 2 W 270 $\Omega$
R14,R15	124100	Resistor, Film 1/4 W 5% 10 $\Omega$
R16	154271	Resistor, Film 2 W 270 $\Omega$
R17	124221	Resistor, Film 1/4 W 5% 220 $\Omega$
R18	170212	Resistor, Trimmer 15 Turns 10 $\Omega$

**TABLE 7-2.**  
**Parts List, Power-Amplifier Module, M4.**

R19	154100	Resistor, Film 2 W 10 $\Omega$
R20	124822	Resistor, Film 1/4 W 5% 8.2 k $\Omega$
R21	124100	Resistor, Film 1/4 W 5% 10 $\Omega$
R22	124821	Resistor, Film 1/4 W 5% 820 $\Omega$
R23	124150	Resistor, Film 1/4 W 5% 15 $\Omega$
T1	PRC1099XT1	Transformer, 7 turns: 2 turns
T2	PRC1099XT2	Transformer, 4 turns: 1 turn
T3	PRC1099XT3	Transformer, 1 turn: 2 turns
TH1	350115	Thermistor, 150 $\Omega$ @ 25 $^{\circ}$ C

## CHAPTER 8

# ANTENNA-TUNER MODULE, M5 - TECHNICAL DESCRIPTION

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### 8-1 DESIGN CONSIDERATIONS

The antenna tuner must match the standard AT271A/U whip antenna and a variety of long wire antennas over the range 2-30 MHz. This poses special design problems in a packset, as the antenna will be very short in relationship to a resonant antenna over most of the frequency range. Additionally, the ground system is extremely poor in the manpack configuration. It is very difficult to maintain an exact match to the antenna, since very small movements by the operator will detune the antenna. The tuner should be fast in operation, have low current drain in the tune mode and no standby current drain. It is also desirable to keep the tune power as low as possible and to retain in memory the tune data for the fixed channel frequencies.

### 8-2 MATCHING NETWORK

The resonant frequency of the whip antenna is approximately 24 MHz. This means that over most of the frequency range the antenna will have a capacitive reactance which can be cancelled by an equivalent series inductance. The tuner uses a binary-sequenced series of inductors to cancel out the reactive component of the antenna. If the antenna has inductive reactance, capacitance is added so that the antenna appears capacitive and the small residual reactance is cancelled by adding series inductance. The internal capacitors will match the whip antenna and most long wire antennas, but on some frequencies the inductive reactance may be very high. The long wire adapter contains a series capacitor to bring the reactance within the tuning range of the network. After the reactance is cancelled, the tuner will present a resistive load between 6 and 400 ohms to the transceiver. A broadband impedance transformer is used to select the closest available matching impedance—12.5, 50 or 200 ohms.

### 8-3 TUNING SYSTEM

A very simple and reliable tuning system is used. Instead of using a VSWR detector, a current detector measures the current flowing to the antenna. The transceiver operates in the low-power (5 W) mode, and a 10-dB attenuator reduces the power to 500 mW. Because the output impedance of the transmitter is 50 ohms (determined by the resistive pad), maximum current will flow when there is a conjugate match or a resistive load of 50 ohms. The system is simple, reliable and accurately determines minimum VSWR.

### 8-4 TUNING RESOLUTION

The tuner typically tunes for a VSWR of less than 1.5:1 but can reach 2:1 if the resistive component falls midway between the impedance taps. In a manpack, the impedance match changes every time the operator moves. Therefore, it is very important to design the final amplifier so that it is very tolerant of mismatched loads. The

PRC1099 final amplifier is capable of a power output of 30-40 W and is able to deliver 20 W into substantial mismatches. At VSWR's of 2:1 there is typically less than 0.5-dB output degradation and, even at 3:1 VSWR there is only about 1-dB performance change.

### 8-5 TUNING PROGRAM

The tuning program is resident in the ROM and is under control of the microprocessor in M7. The tuning program uses proprietary algorithms developed specifically for the PRC1099. When the tune button is pressed the microprocessor checks the frequency and determines which elements should be used. The transmitter is keyed in the low-power mode and the inductors are stepped in a special sequence until a current peak is reached. If no current peak is detected, the antenna is inductive and the capacitors are sequenced in combination with the inductors until a tuning peak is reached. At this point the antenna current is checked. If the current is low, the alternate tap positions are checked; and the tap with the optimum current is selected. The current is then checked; and if the current is low, an incorrect tune will be signaled. It may be possible to operate the transceiver even if an incorrect tune is signaled. The tuner will remain at the setting that achieved the best match. The last tune combination is retained in memory and will be automatically selected each time the channel is changed. The tune information in memory is updated each time the tune button is pressed. The antenna tuner is selected automatically when the whip or long wire adapter is used. A rod on the end of the antenna mount (AB591/U) or long wire adapter activates a microswitch which disconnects the 50-ohm connector.

### 8-6 BLOCK DIAGRAM

A block diagram of the antenna tuner is shown in Figure 8-1. This diagram shows the block functions of the antenna tuner and control circuitry. The module has the following block functions:

1. Binary Sequence Inductors—0.25 to 168  $\mu$ H.
2. Shunt Capacitors—50/100 pF.
3. Series Capacitor—22 pF.
4. Current Detector.
5. Impedance Transformer.
6. Attenuator.
7. Comparator.
8. D/A Decoder.
9. Serial Decoders.
10. Relay Drivers.

### 8-7 BINARY SEQUENCED INDUCTORS

In order to resonate the whip antenna at 2 MHz, an inductance of approximately 168  $\mu$ H is required. It must be possible to vary the inductance from zero to 168  $\mu$ H. The

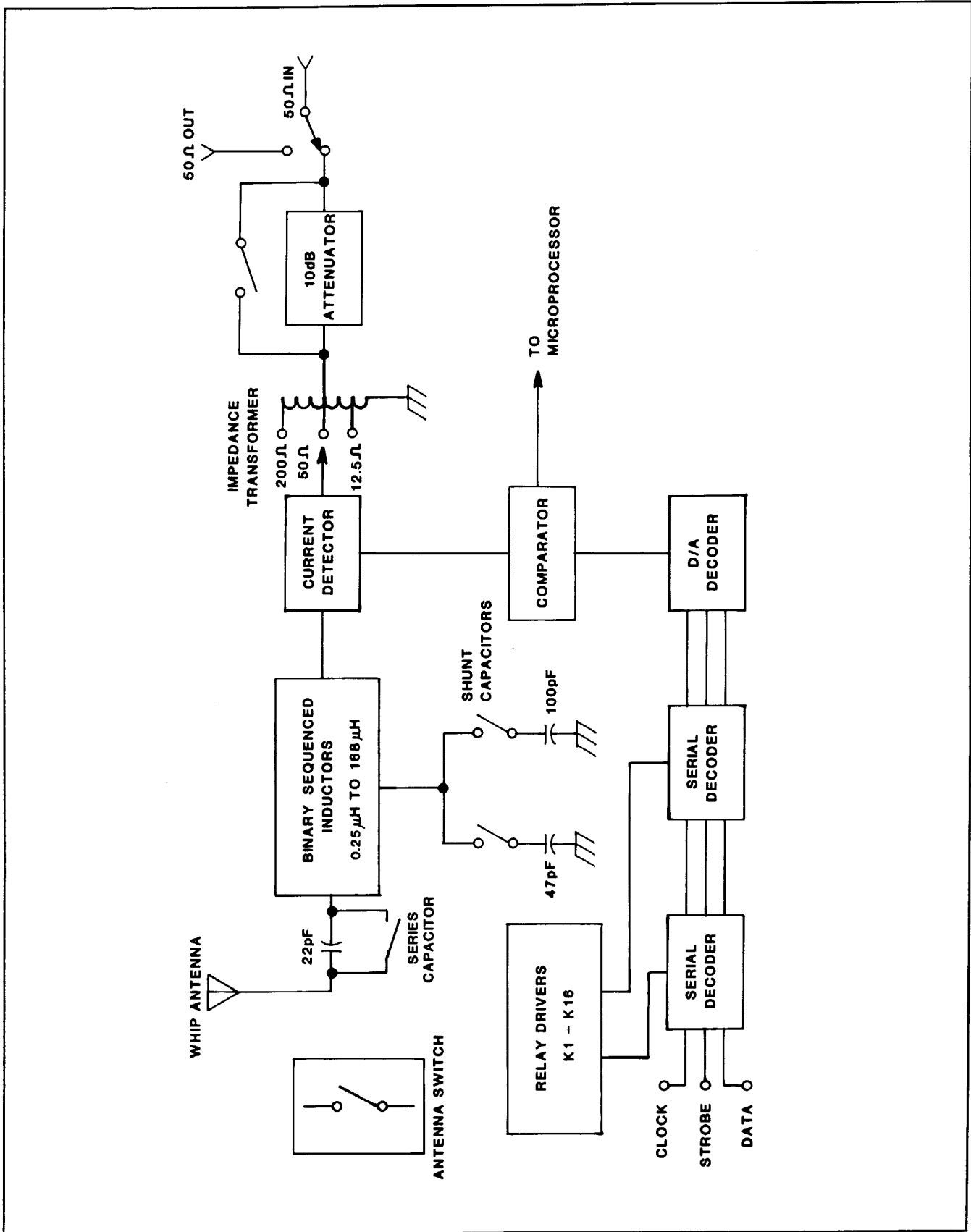


FIGURE 8-1.  
Block Diagram - Antenna Tuner, M5.



RF OUTPUT  
TO ANTENNA

50 OHM RF  
INPUT FROM M1

RF OUTPUT TO  
50 OHM PORT

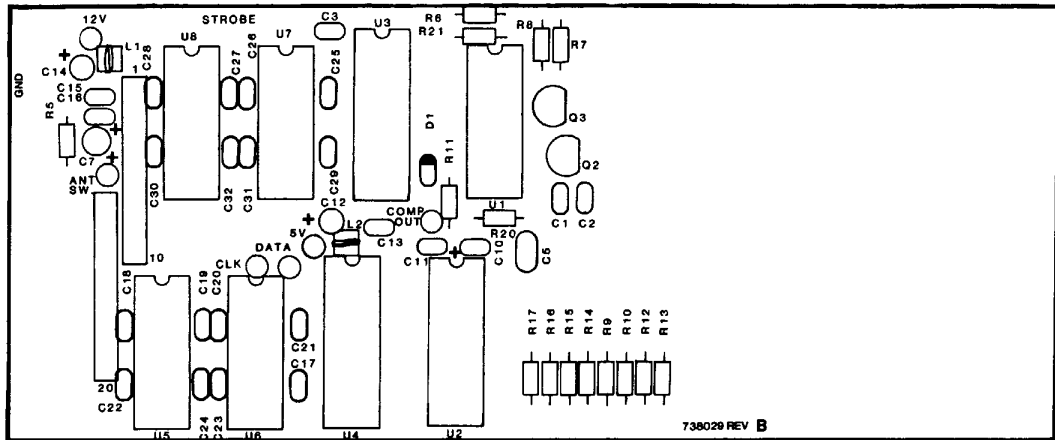
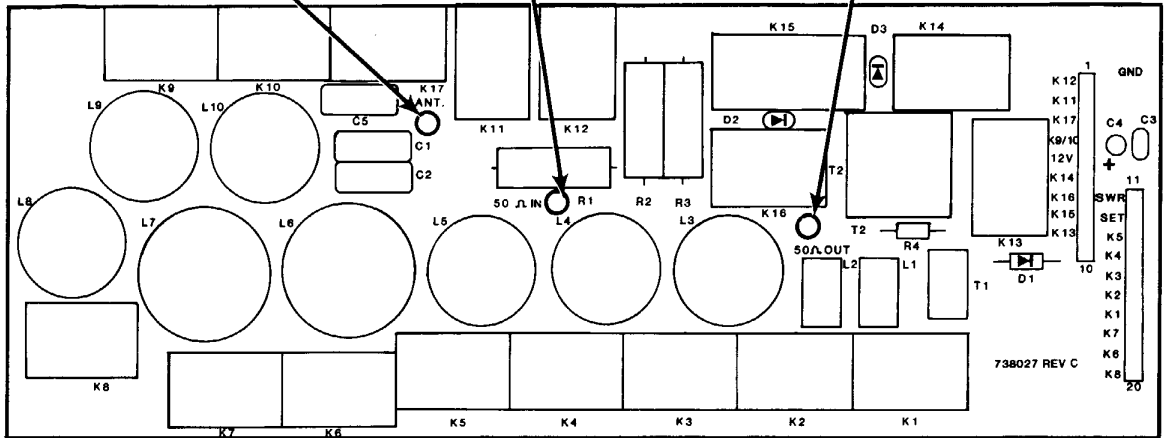


FIGURE 8-2.  
Signal Connections.

**TABLE 8-1.**  
**Specifications, Antenna Tuner, M5.**

<u>Current Drain:</u>													
a. Static:	1.2 mA typical @ 12 V. 5 $\mu$ A typical @ 5 V.												
b. Tuning:	400 mA average @ 12 V. 2000 mA maximum instantaneous @ 12 V. 16 mA average @ 5 V.												
<u>Rated Input Power:</u>													
a. Output $\leq$ 1 kV:	20 W PEP.												
b. Output would exceed 1 kV:	5 W PEP (Power level automatically switched by M7).												
Maximum Output Voltage:	1000 V RF.												
Useable Antennas:													
	<table border="0"> <thead> <tr> <th><u>Range</u></th> <th><u>Antenna</u></th> </tr> </thead> <tbody> <tr> <td>2.0-30 MHz</td> <td>3 m whip</td> </tr> <tr> <td>1.6-30 MHz</td> <td>7 m whip</td> </tr> <tr> <td>5.0-30 MHz</td> <td>1.5 m whip (for very short-range operation)</td> </tr> <tr> <td>1.6-30 MHz</td> <td>7-16 m long wire</td> </tr> <tr> <td>1.6-30 MHz</td> <td>Longer antennas with LWA adaptor</td> </tr> </tbody> </table>	<u>Range</u>	<u>Antenna</u>	2.0-30 MHz	3 m whip	1.6-30 MHz	7 m whip	5.0-30 MHz	1.5 m whip (for very short-range operation)	1.6-30 MHz	7-16 m long wire	1.6-30 MHz	Longer antennas with LWA adaptor
<u>Range</u>	<u>Antenna</u>												
2.0-30 MHz	3 m whip												
1.6-30 MHz	7 m whip												
5.0-30 MHz	1.5 m whip (for very short-range operation)												
1.6-30 MHz	7-16 m long wire												
1.6-30 MHz	Longer antennas with LWA adaptor												
Manual tune time:	1 s typical. 12 s maximum before fault.												
Memory tune time:	20 ms typical.												
Tune indicator:	900 Hz sidetone.												
Fault indicator:	Pulsating tone.												

best solution is a series of inductors, switched in and out of circuit in a binary progression. By starting with L1, a 0.33  $\mu$ H inductor, and doubling the size of each inductor up to 84  $\mu$ H, it is possible to change the inductance in 0.33  $\mu$ H steps from zero up to 168  $\mu$ H and use only 9 inductors. The tuner uses 10 inductors, as it is necessary to use two separate 44  $\mu$ H inductors, L9 and L10, for the final inductance step. This prevents voltage flashover and keeps the size of the inductors compatible with the available space in the module. Each inductor is a toroid using wire and core sizes carefully optimized for maximum Q. It should be noted that very high voltages are generated at maximum inductance when using the whip antenna. In order to prevent flashover and possible RF burns to the operator, the power is automatically reduced when inductors L8, L9, and L10 are in circuit. This keeps the maximum output voltage from exceeding approximately 1000 V.

#### 8-8 SHUNT CAPACITORS

The two shunt capacitors C1 and C2 are used when the antenna exhibits inductive reactance. The capacitors give 50-150 pF in 50-pF steps. The minimum step size that will cause the antenna to appear capacitive is used, and the remaining reactance is cancelled with series inductance. The capacitors are connected between L6 and L7. This

minimizes the effects of stray capacitance and reduces the required voltage rating.

#### 8-9 SERIES CAPACITOR

A series capacitor, C5, is connected between the antenna terminal and the largest binary inductor, L10. It is switched in and out of the network by relay K17. This element is needed in some instances where the antenna impedance is near resonance; it rotates the impedance to a value that can be matched by the rest of the network.

#### 8-10 CURRENT DETECTOR

The current detector uses a saturated transformer directly in line to the series inductors. The transformer is a ferrite toroid, T1, with a single-turn primary and a multi-turn secondary virtually shorted by the 47-ohm resistor R4. The detector output is a voltage proportional to the current flowing in the primary. The RF voltage is rectified by D1.

#### 8-11 IMPEDANCE TRANSFORMER

The impedance transformer is a 2:1 ferrite balun switched by relays K13 and K14. The transformer may be switched out of circuit to provide a 50-ohm match, act as a step-up transformer for a 200-ohm match and act as a step-down transformer for a 12.5-ohm match. With the three impedances available, the transformer will provide a match

of 2:1 or better over the impedance range of 6 ohms to 400 ohms.

#### **8-12 10-DB ATTENUATOR**

The attenuator pad R1/R2/R3 is switched into circuit during the tune mode by the relay K15. The exact attenuation of 9.5 dB has been chosen so that standard-value resistors may be used. The transmitter operates in the low-power mode (5 W) during the tune cycle, and the attenuator reduces the output power to 500 mW. The resistive pad ensures that the transmitter has a true output impedance of 50 ohms, so that maximum output is with a 50-ohm load (a conjugate match). This means that maximum output current to the antenna corresponds with minimum VSWR.

#### **8-13 COMPARATOR**

The comparator U1C is used to compare the output from the current detector and the reference level from the digital to the analog convertor U2. The output from the current detector is amplified by one section of the quad amplifier U1B. The switches Q2 and Q3 switch R7 and R8 to ground. This gives three different gain levels set by the ratio of R21 to R6, R7 or R8.

#### **8-14 D/A DECODER**

The microprocessor can only recognize a high or low output, and it is necessary to provide a reference level to the comparator in order to measure the analog output from the current detector. The output from the decoder is under serial control by the microprocessor and is quantized into 64 steps by output from the decoder. The binary steps are selected by the switching of R12 through R17. Switching R7 and R8 controls the gain of U1A.

#### **8-15 SERIAL DECODER**

The serial decoders U3 and U4 translate the serial data from the microprocessor to 16 different outputs controlling the relay drivers.

#### **8-16 RELAY DRIVERS**

The relay drivers U5, U6, U7 and U8 are 16 NPN transistors contained in four separate 16-pin DIP packages.

There are 14 latching relays in the tuner. These relays have separate coils for latching and unlatching the relay. The relays require short current pulses for latching or unlatching and draw no current in the static condition. Separate drivers are provided to latch each relay; and one transistor, Q1 (driven by one section of U8), is used to unlatch all relays. The microprocessor always unlatches all relays before each switching operation and resets those latched relays that require no change of state, as well as those relays requiring switching. This system means that separate drivers are not required to unlatch each relay.

#### **8-17 SERVICE DATA**

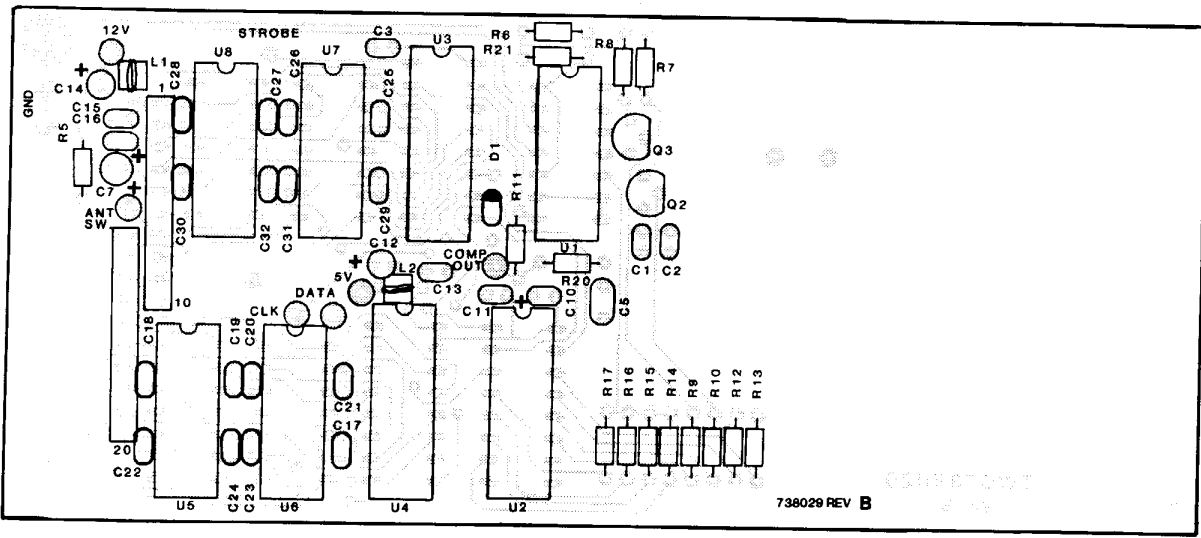
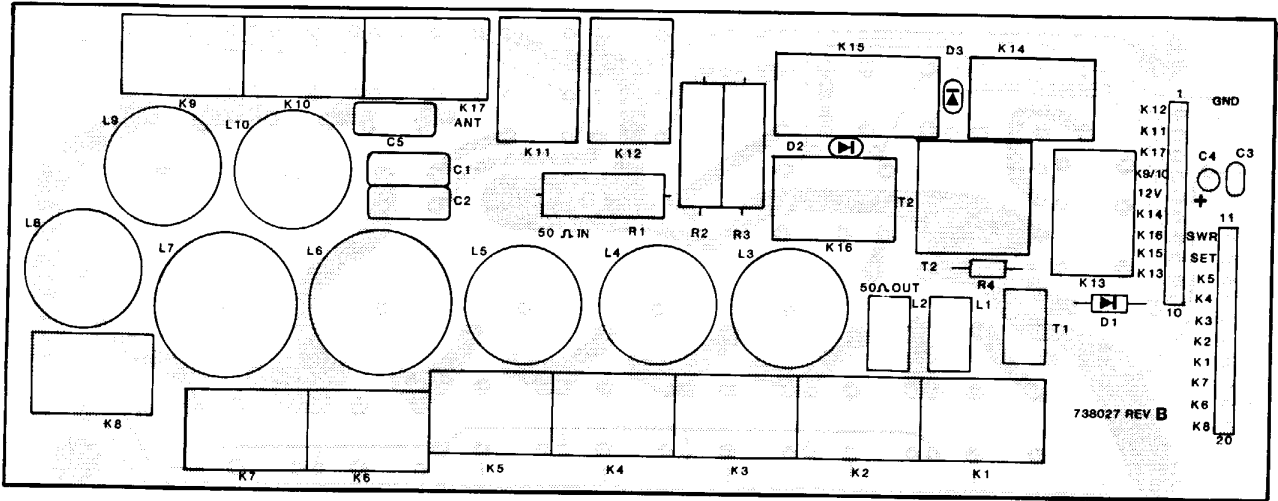
Figure 8-2 is a component location diagram with signal input/output points indicated.

#### **8-18 MODULE INTERCONNECTS**

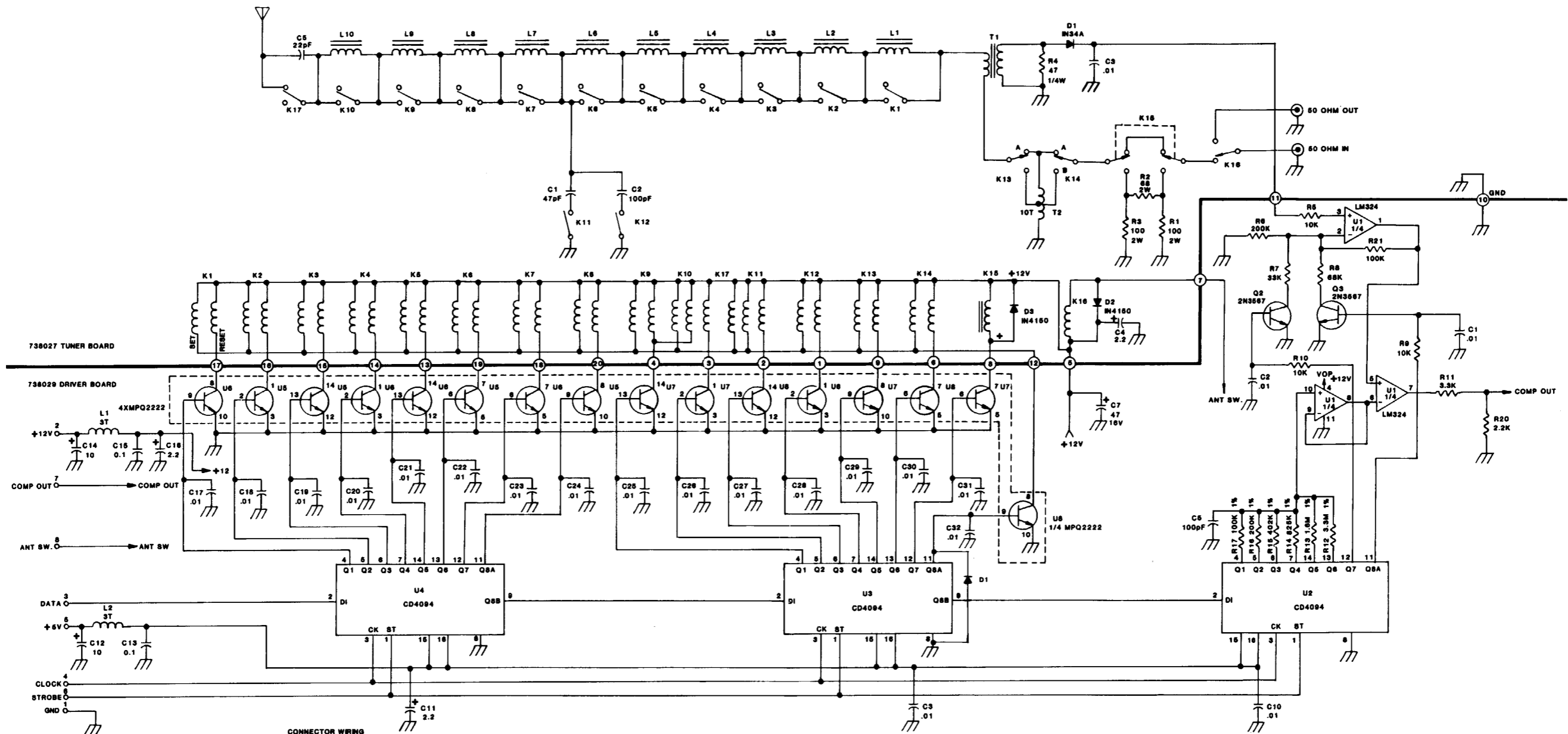
The M5 module has the following interconnections with the transceiver:

##### Connector M5J1

- Pin 1 Ground.
- Pin 2 12 Vdc from power supply.
- Pin 3 DATA. Internal radio data.
- Pin 4 CLOCK. Internal radio clock information.
- Pin 5 5 Vdc from power supply.
- Pin 6 Select. Internal radio select data.
- Pin 7 COMP OUT. This is the comparator output to the processor, used for tuning cycles.
- Pin 8 ANT SWITCH. Used to determine if a whip antenna is installed. 0Vdc with no antenna, 4.8 Vdc with antenna installed.
- Pin 9 No connection.
- Pin 10 No connection.



**FIGURE 8-3.**  
**Component Locations, Tuner Module, M5.**



NOTES: UNLESS OTHERWISE SPECIFIED  
 1. ALL RESISTORS ARE 1/8W 5%.  
 2. RESISTANCE IS IN OHMS.  
 3. CAPACITANCE IS IN MICROFARADS.  
 4. LATCHING RELAYS SHOWN IN RESET POSITION.

CONNECTOR WIRING

J1-1	GRD
J1-2	+12 VDC
J1-3	DATA
J1-4	CLOCK
J1-5	+5 VDC
J1-6	STROBE
J1-7	COMP OUT
J1-8	ANT SW
J1-9	
J1-10	

FIGURE 8-4.  
 Schematic Diagram, Tuner Module, M5.

**TABLE 8-2.**  
**Parts List, Tuner Module, M5. Tuner Board.**

C1	220470	Capacitor, Mica DM15 47 pF
C2	220101	Capacitor, Mica DM15 100 pF
C3	214103	Capacitor, Monolithic 0.01 $\mu$ F
C4	241020	Capacitor, Tantalum 2.2 $\mu$ F
C5	220220	Capacitor, Mica DM15 22 pF
D1	320003	Diode, 1N34A
D2,D3	320002	Diode, 1N4148
K1-K14	540066	Relay, Latchseal
K15	540045	Relay, DPDT 12 Vdc
K16	540056	Relay, SPDT 12 Vdc
K17	540066	Relay, SPDT 12 Vdc
L1	459005	Inductor, Toroid 0.33 $\mu$ H 8 turns
L2	459004	Inductor, Toroid 0.66 $\mu$ H 12 turns
L3	459003	Inductor, Toroid 1.3 $\mu$ H 15 turns
L4	459002	Inductor, Toroid 2.5 $\mu$ H 23 turns
L5	459006	Inductor, Toroid 5.23 $\mu$ H 23 turns
L6	459007	Inductor, Toroid 10.5 $\mu$ H 32 turns
L7	459010	Inductor, Toroid 21 $\mu$ H 42 turns
L8	459008	Inductor, Toroid 70 turns
L9,L10	459118	Inductor, Toroid 74 turns
R1	154101	Resistor, Film 2 W 5% 100 $\Omega$
R2	154680	Resistor, Film 2 W 5% 68 $\Omega$
R3	154101	Resistor, Film 2 W 5% 100 $\Omega$
R4	124470	Resistor, Film 1/4 W 5% 47 $\Omega$
T1	459009	Transformer, 6 turns
T2	459011	Transformer, 10 turns

**TABLE 8-3.**  
**Parts List, Tuner Module, M5. Tuner Driver Board.**

C1-C3	214103	Capacitor, Monolithic 0.01 $\mu$ F
C5	210101	Capacitor, Disc 100 pF
C7	237470	Capacitor, Tantalum 16 V 47 $\mu$ F
C10	214103	Capacitor, Monolithic 0.01 $\mu$ F
C11	241020	Capacitor, Tantalum 2.2 $\mu$ F
C12	241100	Capacitor, Tanatalum 10 $\mu$ F
C13	275104	Capacitor, Monolithic 0.1 $\mu$ F
C14	241100	Capacitor, Tantalum 10 $\mu$ F
C16	241020	Capacitor, Tantalum 2.2 $\mu$ F
C17-C32	214103	Capacitor, Monolithic 0.01 $\mu$ F
D1	320002	Diode, IN4148
L1,L2	459032	Inductor, Ferrite 3 turns
Q2,Q3	310003	Transistor, NPN 2N3567
R5	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R6	1112003	Resistor, Film 1/8 W 1% 200 k $\Omega$
R7	113333	Resistor, Film 1/8 W 5% 33 k $\Omega$
R8	113683	Resistor, Film 1/8 W 5% 68 k $\Omega$
R9	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R10	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R11	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R12	1113304	Resistor, Film 1/8 W 1% 3.3 M $\Omega$
R13	1111604	Resistor, Film 1/8 W 1% 1.6 M $\Omega$
R14	1118253	Resistor, Film 1/8 W 1% 825 k $\Omega$
R15	1114023	Resistor, Film 1/8 W 1% 402 k $\Omega$
R16	1112003	Resistor, Film 1/8 W 1% 200 k $\Omega$
R17	1111003	Resistor, Film 1/8 W 1% 100 k $\Omega$
R20	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R21	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
U1	330030	IC, LM324N
U2-U4	330126	IC, CD4094BE/MC14094BCP
U5-U8	310101	IC, MPQ2222

## CHAPTER 9

# SYNTHESIZER MODULE, M6 - TECHNICAL DESCRIPTION

### 9-1 BLOCK DIAGRAM

A block diagram of the module is shown in Figure 9-1. The module contains the transceiver 5.12-MHz reference oscillator, 10-kHz phase-locked loop synthesizer and 100-Hz phase-locked loop synthesizer. It has the following components:

1. 5.120-MHz reference oscillator.
2. 10-kHz synthesizer, prescaler, and loop filter.
3. 76.6 to 105-MHz VCO.
4. 100-Hz synthesizer, prescaler, and loop filter.
5. 73.34 to 73.35-MHz VCXO.
6. Serial decoder logic.

An exploded view of the 10-kHz synthesizer is shown in Figure 9-2, while the 100-Hz synthesizer is shown in Figure 9-3.

### 9-2 5.120-MHZ REFERENCE OSCILLATOR

The 5.120-MHz reference oscillator is a temperature-compensated crystal oscillator TXCO which provides the reference frequency for both the 100-Hz and 10-kHz synthesizers. The 5.120-MHz signal from the oscillator is sent directly to pin 1 on U3 of the 10-kHz synthesizer. It is then divided by 512 internally in U3 to provide the 10-kHz loop reference signal. The standard TCXO has a stability of 1 ppm from 0 to 50° C. An optional high-stability TCXO is available which has a temperature stability of 1 ppm from -30 to +60° C.

### 9-3 10-KHZ SYNTHESIZER

U3, the 10-kHz synthesizer chip, contains a fully programmable 14-bit reference counter, 7-bit A counter and 10-bit N counter. All counters are programmed serially through a common data input and latched into the appropriate counter latch according to the last data bit entered. Binary control data used to program the counters is sent to U3 from the microprocessor module. The 5.12-MHz reference input on pin 1 is divided down to 10 kHz for the loop reference. This 10-kHz frequency also appears at pin 13 and is routed to U4, the 100-Hz synthesizer chip.

The total divider ratio is expressed by the formula  $NT = 32N + A$ , where  $NT = (\text{L.O. output frequency})/(\text{reference frequency})$ . The output of the programmable divider is compared to the 10-kHz reference frequency in the phase detector. The phase detector output is an error voltage used to correct the VCO frequency and lock it to the reference frequency times NT. This output is a dual output from pins 15 and 16 and goes to the loop filter.

### 9-4 LOOP FILTER

The loop filter establishes the overall loop bandwidth, natural frequency, and damping factor. These parameters effectively determine the synthesizer lock-up time and spurious rejection ratio.

The active filter is used as a charge pump to combine the two phase detector outputs, while additional low-pass filters provide needed reference sideband attenuation. U2 is an operational amplifier used as the active component in the loop filter. R6, R7, R10, R12 and C8, C9, C10, C13, C14, C15 are the passive filter components. The output of the loop filter goes to the VCO circuits.

### 9-5 VCO

Two voltage-controlled oscillators are used to cover the total frequency range. The "VCO Switch Line" coming from the serial decoder U8 automatically switches operation from the low-frequency VCO (76.6-89.99 MHz) to the high-frequency VCO (90-104.99 MHz). An error voltage produced by the phase detector sets the appropriate VCO to the correct L.O. frequency. The output of the VCO goes to the +32/33 prescaler to close the phase locked loop.

Each VCO is a modified Colpitts (Clapp) oscillator using a J310 Field Effect Transistor (FET) as the active element. The operation of the high-frequency oscillator will be described here, with the understanding that the low-frequency oscillator works the same way.

The high-frequency VCO covers 90-104.99 MHz. The frequency determining elements are inductor L108, capacitor C117, and varactor diode D107. L108 is a toroid inductor whose value is set so that its inductance and the capacitance of the varactor enable the VCO to oscillate over the chosen frequency range. The capacitance of D107 is determined by the error voltage from the phase detector. C118 is used as a coupling capacitor, while R114 provides control line isolation between the loop filter and the VCO. C119 and C120 determine the oscillator feedback, while D108 is a gate-clamping diode for controlling the bias of Q106. Q107 is an FET configured as a source follower and acts as a buffer for VCO. D109 and D104 are used to provide isolation between the two VCO's.

The low-frequency VCO performs in the same fashion as the high-frequency one. The only differences are the value of the feedback capacitors (C114 and C115) which are adjusted for the lower frequency range and the value of the tank circuit coil L106, which is set to enable the VCO to oscillate over the 76.6 to 89.99-MHz range.



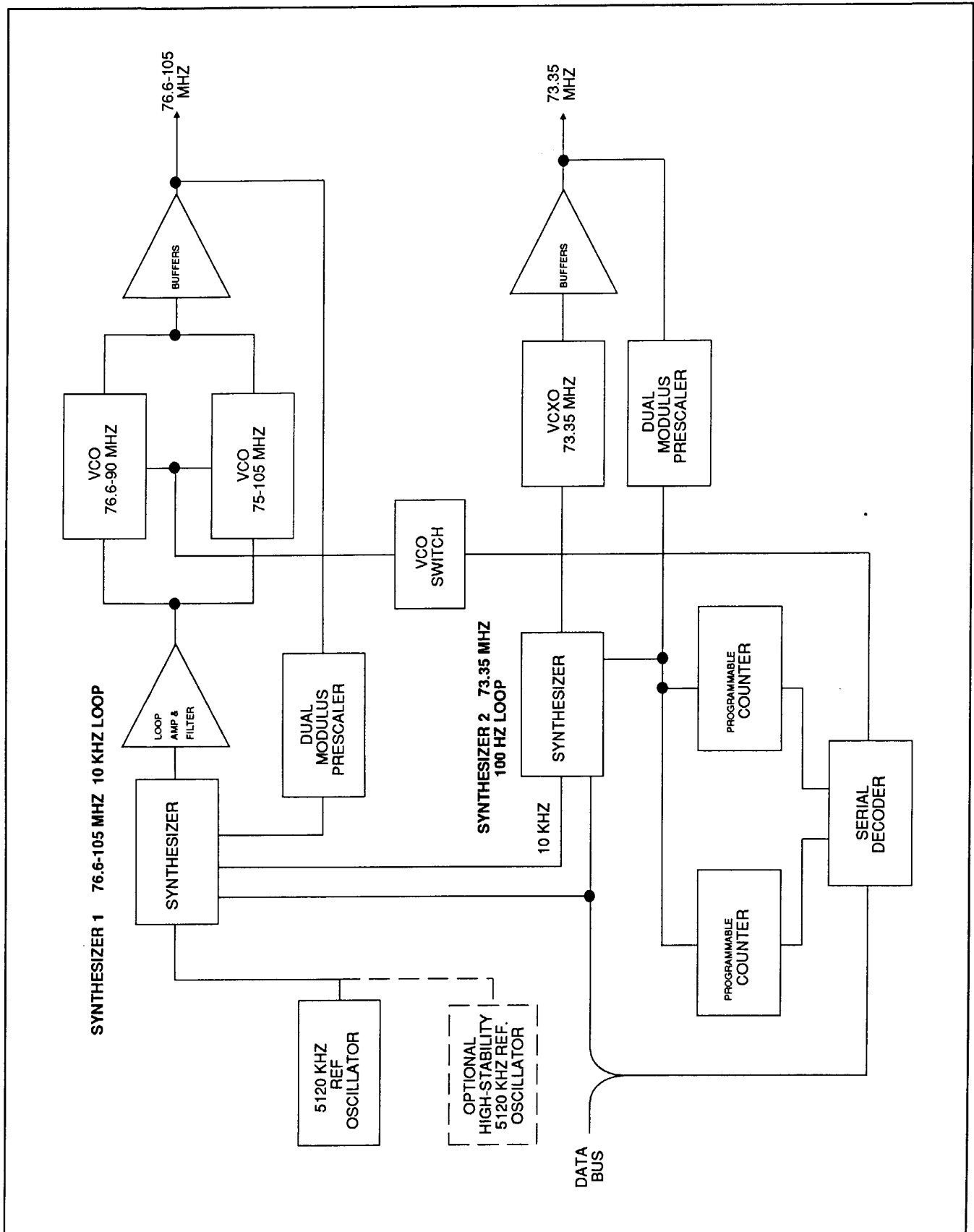
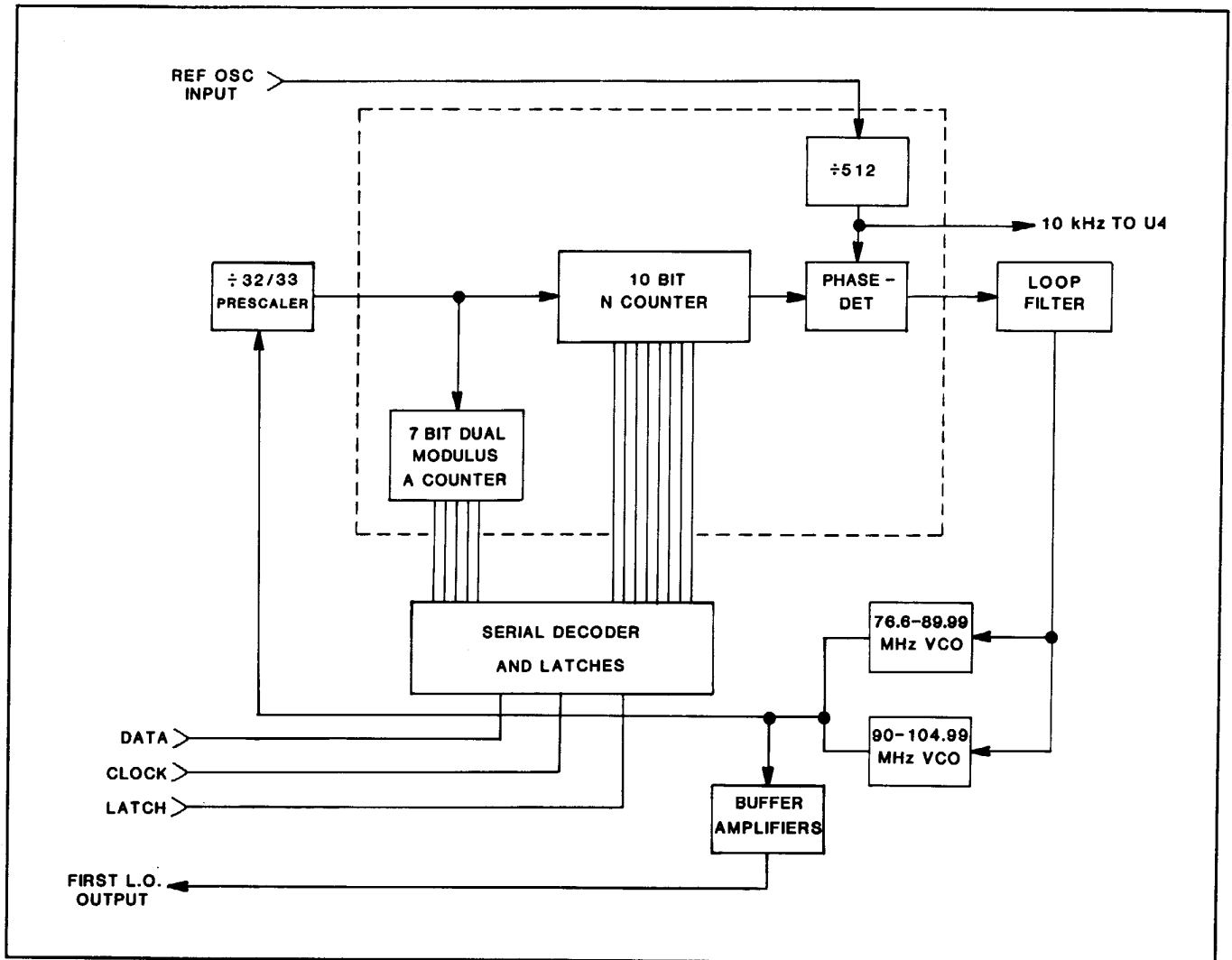


FIGURE 9-1.  
Block Diagram - Synthesizer Module, M6.



**FIGURE 9-2.**  
**10-kHz Synthesizer.**

Regulated 8 V is provided for both VCO's. Transistors Q105, Q108 and Q109 are controlled by the VCO switch line which comes from the decoder U8. When the VCO switch line is "high," Q105 is off and Q108 is biased "on" through Q109.

The supply voltage is then provided to Q106 (the high-frequency oscillator) while the low-frequency VCO is shut off. At frequencies below 90 MHz the VCO control line goes "low," Q105 is biased "on" to provide the dc supply voltage for the low-frequency VCO (Q103) and Q108 is biased off to turn off the high-frequency VCO.

Q111 and Q110 are buffer amplifiers at the output of both VCO's. The purpose of these amplifiers are twofold; first, to amplify the output of the VCO to a level sufficient to drive the mixer, and second, to "buffer" the VCO from any effects of the changing load impedance at the L.O. output. The output of the last buffer amplifier is the local oscillator signal to the first mixer. (Note that the final buffer is contained in the mixer module). The L.O. output

is taken from T101 secondary and goes to the +32/33 prescaler U1.

#### 9-6 +32/33 PRESCALER

U1 is a dual-modulus prescaler which can be programmed to divide by either 32 or 33. Its division ratio is controlled by the number programmed into the dual-modulus A-Counter in the synthesizer chip. As mentioned previously, a prescaler is used to divide the VCO frequency down to a level which can be handled by low-frequency programmable counters. A dual-modulus prescaler provides this performance with no sacrifice in system frequency resolution.

The VCO input is coupled through C19 to pin 5 of U1. The output of U1 is the VCO frequency divided by either 32 or 33 depending on the status of the dual modulus control line. This line comes from pin 12 of the synthesizer chip U3 and goes to pin 1 of the prescaler. When this line is "low," the prescaler divides by 33; and when it is high, the prescaler divides by 32. Whether the line is low or

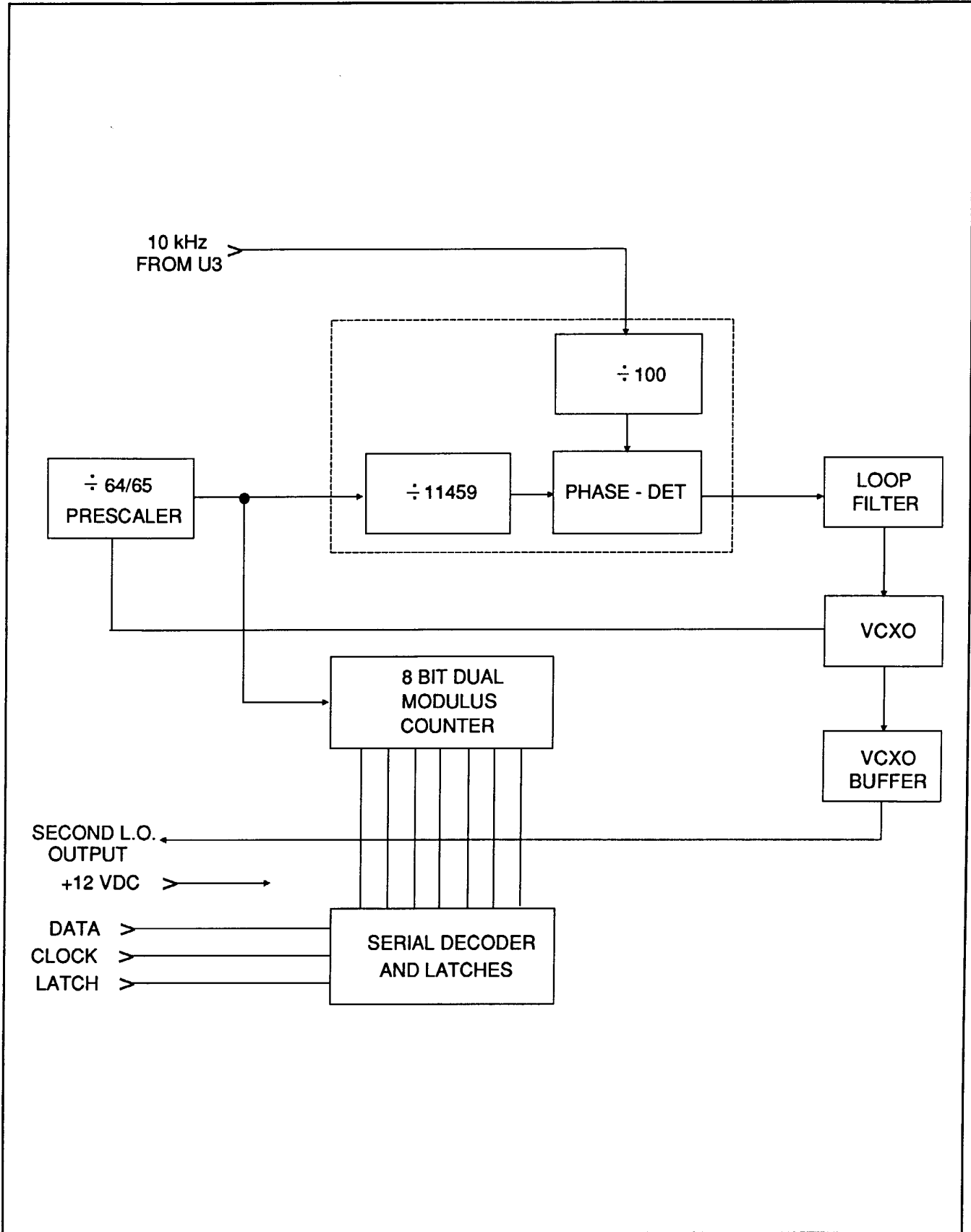


FIGURE 9-3.  
100-Hz Synthesizer.

**TABLE 9-1.**  
**Specifications, Synthesizer Module, M6.**

<b>Oscillators</b>	
Current:	8 Vdc @ 52 mA.
Reference Frequency:	5120 kHz.
Syn. #1:	Fs + 75 MHz in 10 kHz increments; -3 to 0 dBm into 50 $\Omega$ @ 105 MHz.
Syn. #2:	73.3401-73.350 MHz in 100 Hz increments; -7 dBm into 50 $\Omega$ .

high depends on the frequency number programmed into U3. (As described earlier, the line is low and the prescaler is dividing by 33 for the duration of the time the A-Counter in U3 is counting. For the remainder of the count cycle the prescaler divides by 32. This is determined by the  $NT = 32N + A$  algorithm).

The output of the prescaler at pin 3 is coupled through C20 to pin 8 of U3.

**NOTE**

The 7-bit A-Counter acts as a dual-modulus counter programmed to instruct the prescaler when to divide by 33. The 10-bit +N-Counter is the main loop divider. Since the VCO output is determined by:

$$F_{out} = NT \text{ Fref} = NT \times 10 \text{ kHz}$$

and by the technique of dual-modulus prescaling,

$$NT = 32N + A,$$

where

N = binary number programmed into the N-Counter  
A = binary number programmed into the A-Counter

therefore, the output L.O. frequency is determined by  
 $FL.O. = (32N + A) \times 10 \text{ kHz}$ .

**9-7 100-HZ SYNTHESIZER**

The 100-Hz synthesizer chip consists of a programmable reference divider, phase detector, and a 14-bit programmable N-Counter. The 100-Hz reference frequency for the loop is obtained by internally dividing the 10-kHz input at pin 1 of U4 by 100. The N-Counter is fixed to divide by 11459, while the 100 frequency increments (spaced at 100-Hz intervals) are determined solely by the programming of the A-Counter. The output of the N-Counter is compared to the 100-Hz reference frequency in the phase detector. The phase detector output is an error voltage used to set the VCXO frequency to its programmed value and lock it to the reference frequency time NT (where  $NT = 64N + A$  = the total loop value divide ratio).

Pin 5 is the tri-state output of the phase detector. While the loop is unlocked, the output from pin 5 will be a pulsing voltage designed to drive the VCXO in a direction such that  $F_{out} = 100 NT$ . Upon obtaining a locked condi-

tion, the phase detector output goes to a high-impedance state to effectively "hold" the proper control voltage on the varactor diode D101. This control voltage is "updated" every 100 Hz (10 milliseconds) to compensate for any frequency drift and keep the loop locked. The output of U7 from pin 5 goes to the 100-Hz loop filter.

**9-8 LOOP FILTER**

The loop filter is used to establish the correct loop bandwidth, natural frequency and damping factor. Since the phase detector in U4 has a tri-state, single-ended output, the loop filter is a simple, passive, low-pass filter with an additional lag filter to establish the correct loop damping.

C32, C33, R16 and R17 are the components in the loop filter. R16 and C32 determine the loop natural frequency (along with K0, the phase detector gain constant and KV, the VCXO gain constant). It is set to be approximately 10 Hz. R17 and C33 provide the proper damping for the loop. The output of the loop filter goes to the VCXO.

**9-9 VCXO**

A crystal oscillator is used to provide the second L.O. output signal. This oscillator is then "pulled" over a 10-kHz range, with the error voltage produced by U4's phase detector setting the VCXO to the programmed output frequency in 100-Hz increments. The output of the VCXO goes to the +64/65 prescaler and the output buffer amplifier.

The VCXO is a Colpitts oscillator using a series mode fifth overtone 73.365-MHz crystal. Use of a crystal oscillator leads to a highly stable synthesizer with excellent output spectral purity. The oscillator tank circuit is composed of varactor diode D101, capacitor C104, and tunable L102. R101 is used to dampen the crystal and add stability to the oscillator. C105 couples the tank circuit to the base of Q101, the oscillator active element. C106 and C107 are used to set the proper oscillator feedback ratio, while resistors R103 and R102 set the dc bias for the oscillator transistor Q101. The output of the VCXO is coupled via C108 from the emitter of Q101 to buffer amplifier Q102, which is configured as an emitter-follower. This buffer amplifies the VCXO output to the level necessary for the mixer and also buffers the VCXO from any load impedance variations.

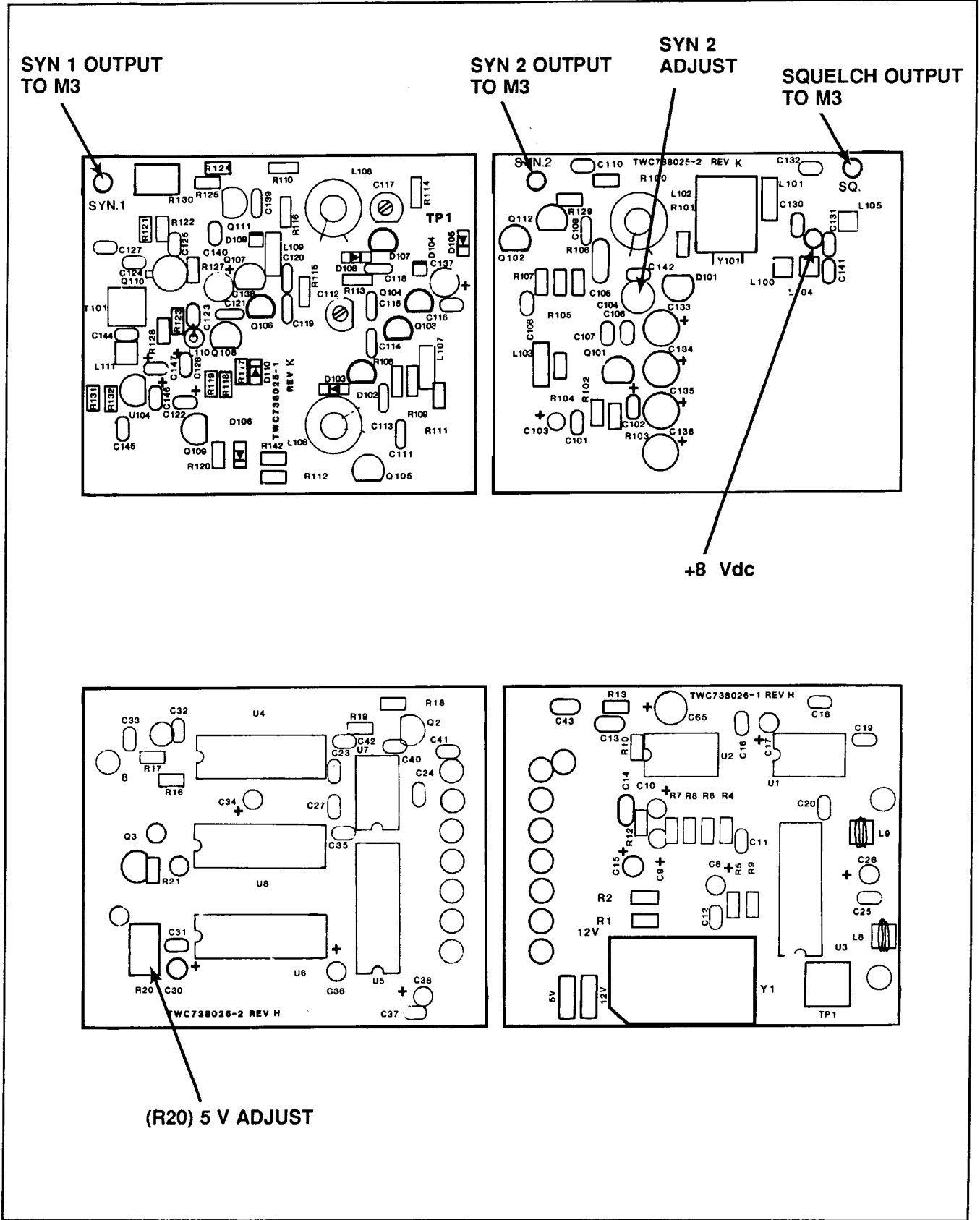


FIGURE 9-4. Signal Connections and Adjustment Points.

The control voltage from the loop filter is coupled to D101 through inductor L101. Tank circuit inductor L102 is set so that the control voltage can "pull" the VCXO frequency down from its crystal controlled series resonant point of 73.365 MHz. The circuit components are set for an operating range of 73.3401-73.350 MHz (corresponding to a control voltage on D101 of approximately 3-5 V). The output of Q102 gives to the +64/65 dual-modulus prescaler, U7.

#### 9-10 +64/65 PRESCALER

U7 is a dual-modulus prescaler which can be programmed to divide by either 64 or 65. Its division ratio is controlled by the number programmed into the dual-modulus A-Counter. It is used to divide the high-frequency VCXO output down to a level which can be handled by the low-frequency CMOS loop counters. The output of the +64/65 prescaler goes to the programmable N-Counter in U4 and to the external A-Counter. The input to U7 comes through C24 to pin 5.

U7 runs off of regulated 5-V dc which is adjusted by R20. The output of U7 is the VCXO frequency divided by either 64 or 65 depending on the status of the dual-modulus control line. This line comes from pin 4 of U5 and goes to pin 1 of the prescaler. The output of U7 goes to pin 6 of U5 in the A-Counter, and through C27 to pin 8 of U4.

#### 9-11 DUAL-MODULUS A-COUNTER

U5 and U6 make up the dual-modulus A-Counter. It is a two-stage binary CMOS down-counter that will count from the number "A" (preset into it by lines A1-A7) down to zero. Remember that "A" is determined by the 100-Hz loop programming algorithm  $NT = 64N + A$ , where  $NT = F_{out}/100$  and  $NT = 11459$ . Therefore, the loop algorithm reduces to  $NT = 733,376 + A$ . This counter will start counting down to zero from whatever number is programmed into it at the start of the overall count cycle. During this period of time, the prescaler will divide by 65. After the A-Counter has reached zero, the prescaler will divide by 64 for the rest of the overall count cycle. Input lines A1-A7 program this counter.

Changing "A" over the range of 25 to 124 effectively changes the VCXO output frequency in 100-Hz steps from 73.3401-73.350 MHz. The end-of-count pulse (U4, pin 3) from the synthesizer is used to enable the A-Counter. When this occurs, the A-Counter starts counting down from "A" to zero at the same time the N-Counter in U4 starts to count down from 11459 to zero. When the A-Counter reaches zero, pin 4 of U5 goes from low to high and accomplishes two things: the A-Counter is inhibited from further counting until it is again preset by the end-of-count pulse from U4; and the prescaler, which had been dividing by 65 during the duration of the A count, will now divide by 64 for the remaining (11459-A) counts in the overall cycle.

#### 9-12 SERIAL DECODER LOGIC

U8 is an 8-bit serial decoder consisting of an 8-bit serial shift register and an 8-bit D-type latch with tri-state parallel outputs. The shift register accepts the serial data from the microprocessor at pin 14 and provides serial data out to U3, the 10-kHz synthesizer, and U4, the 100-Hz synthesizer. The shift register also provides parallel data to the 8-bit latch; seven bits are used to program the A-Counter (U5 and U6) in the 100-Hz loop, while one bit is used (pin 15) to switch between the two VCO's in the 10-kHz loop.

#### 9-13 SERVICE DATA

Figure 9-4 is a component location diagram with the signal input/outputs points and adjustments indicated. The following adjustment points are used:

- 1) R20 used to adjust the 5-volt supply.
- 2) C104. Used to adjust the Syn. 2 VCXO; factory set for loop locking over the required frequency range.

#### 9-14 PRC1099-HS HIGH-STABILITY REFERENCE OPTION

##### 9-14.1 GENERAL

The PRC1099-HS option increases the frequency stability of the 5120-kHz reference oscillator in the PRC1099 HF manpack transceiver. It is required when the transmission of data is anticipated or when extra frequency stability is desired.

##### 9-14.2 TECHNICAL DESCRIPTION

When the PRC1099-HS option is installed, the standard 5120-kHz TCXO is not installed. In place of this, a high-stability TCXO is installed. This high-stability TCXO is powered by 12 volts instead of 5 volts which powers the standard TCXO. The TCXO has a frequency stability of 1 part per million (ppm) from -30 to +60°C and has an aging characteristic of 1 ppm per year.

##### 9-14.3 MAINTENANCE

To adjust for the effects of long-term aging, the standard, and high-stability TCXO are equipped with an internal adjustment which allows for TCXO output frequency adjustment. Adjustment of the TCXO frequency will not normally be necessary in the life of the equipment.

#### 9-15 MODULE INTERCONNECTIONS

The M6 module has the following interconnections with the transceiver:

##### Connector M6J1

- Pin 1 EN 2. Enable 2 is used to enable Synthesizer 2 for data reception.
- Pin 2 No connection.
- Pin 3 8 Vdc from power supply.

Pin 4	DATA. Internal radio processor data.	Pin 9	Ground.
Pin 5	EN 1. Enable 1 is used to enable Synthesizer 1 for data reception.	Pin 10	Ground.
Pin 6	CLOCK. Internal radio clock information.	Pin 11	Ground.
Pin 7	16 Vdc provided from the voltage doubler circuit on the M7A module.	Pin 12	Ground.
Pin 8	SQUELCH. The Squelch signal is passed through to the M3 module.	Pin 13	Ground.
		Pin 14	Ground.
		Pin 15	Ground.

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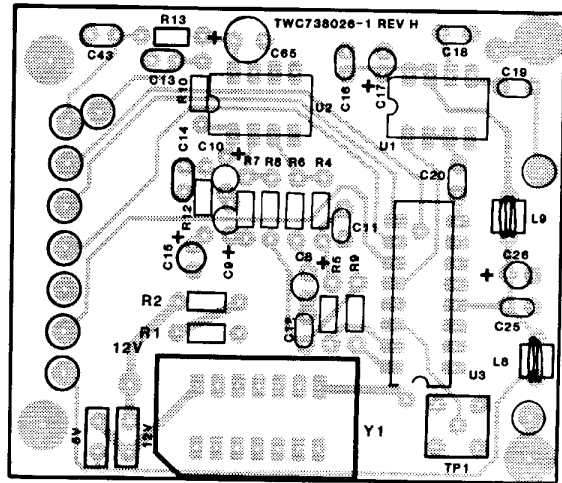
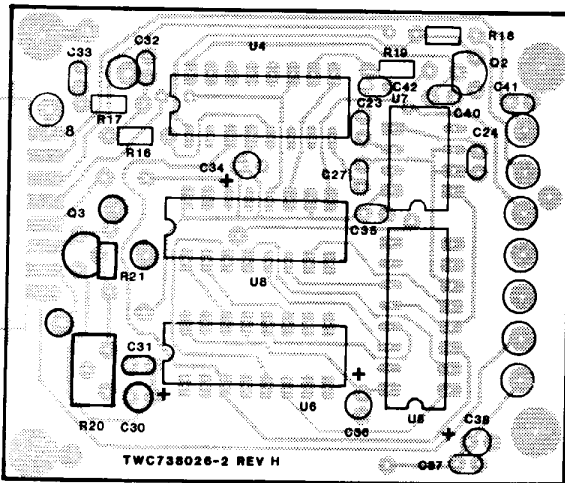
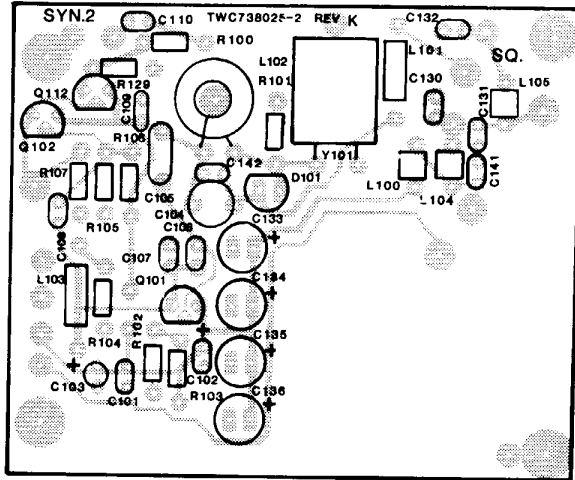
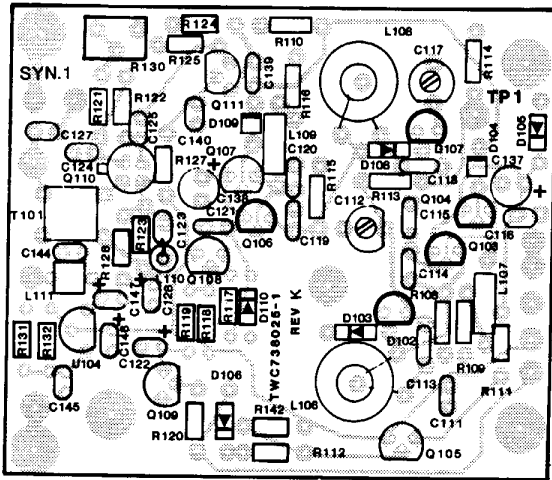
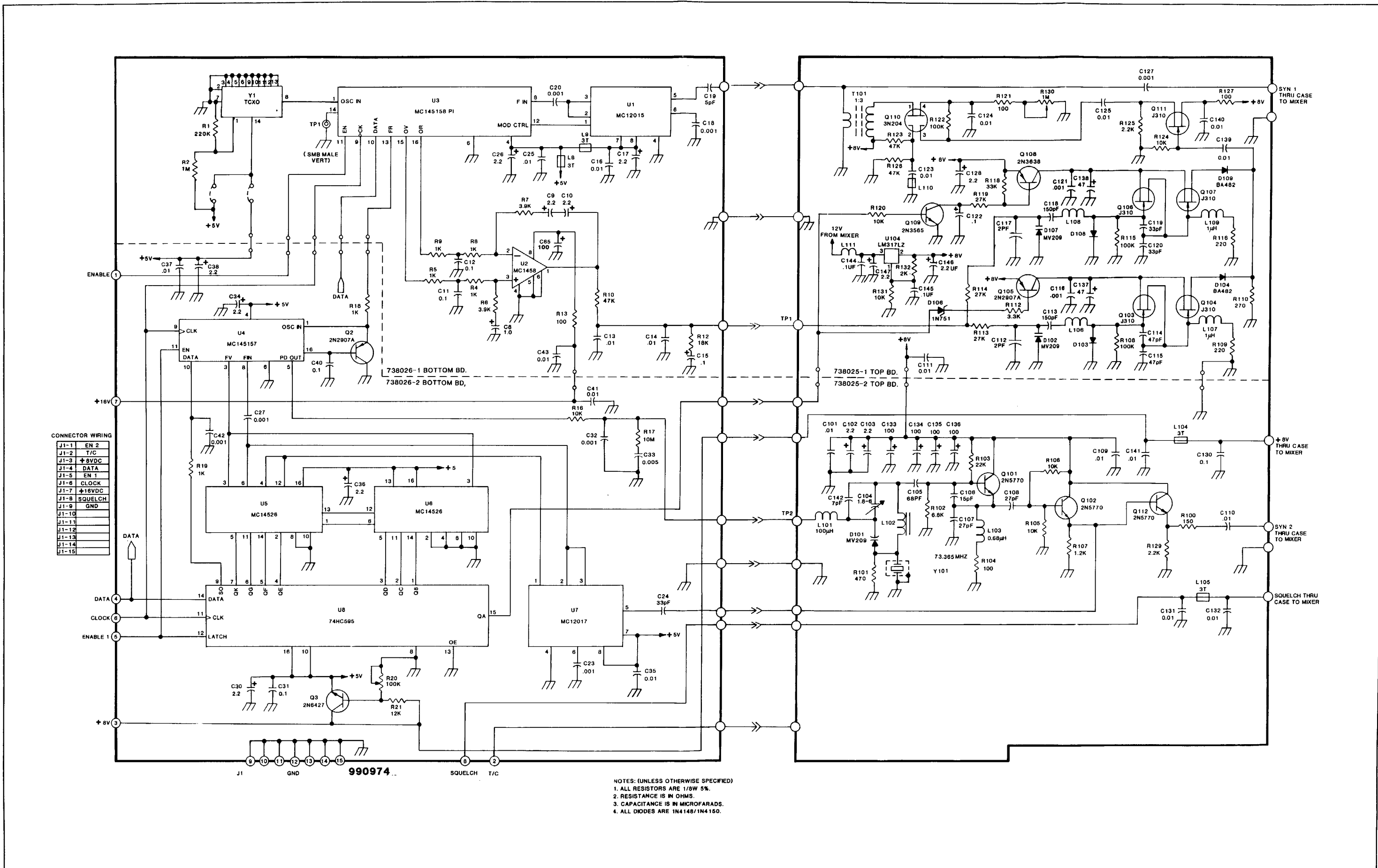


FIGURE 9-5.  
Component Locations, Synthesizer Module, M6.



**FIGURE 9-4.**  
Schematic Diagram, Synthesizer Module, M6.

**TABLE 9-2.**  
**Parts List, Synthesizer Module, M6. Assembly-1 Top Board.**

C111	214103	Capacitor, Monolithic 0.01 $\mu$ F
C112	210020	Capacitor, Disc NPO 2 pF
C113	210151	Capacitor, Disc 150pF
C114,C115	210470	Capacitor, Disc 47 pF
C116	210102	Capacitor, Disc 0.001 $\mu$ F
C117	210020	Capacitor, Disc NPO 2 pF
C118	210151	Capacitor, Disc 150 pF
C119,C120	210330	Capacitor, Disc 33 pF
C121	210102	Capacitor, Disc 0.001 $\mu$ F
C122	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C123-C125	214103	Capacitor, Monolithic 0.01 $\mu$ F
C127	210102	Capacitor, Disc 0.001 $\mu$ F
C128	241020	Capacitor, Tantalum 2.2 $\mu$ F
C137,C138	241476	Capacitor, Tantalum 47 $\mu$ F
C139-C140	214103	Capacitor, Monolithic 0.01 $\mu$ F
C141-C143		Not Used.
C144,C145	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C146,C147	241020	Capacitor, Tantalum 2.2 $\mu$ F
D102	320305A	Diode, MV209
D103	320002	Diode, 1N4148
D104	320005	Diode, Pin BA482
D105		Not Used.
D106	320204	Diode, Zener 1N751
D107	320305A	Diode, MV209
D108	320002	Diode, 1N4148
D109	320005	Diode, Pin BA482
L106	459176	Inductor, Toroid 14 turns
L107	430030	Inductor, Fixed 1.0 $\mu$ H
L108	459142	Inductor, Toroid 12 turns
L109	430030	Inductor, Fiber Washer 1.0 $\mu$ H
L110	490201	Inductor, Ferrite shield
L111	459032	Inductor, Ferrite 3 turns
Q103,Q104	310033	Transistor, FET J310
Q105	310052	Transistor, PNP PN2907A
Q106,Q107	310033	Transistor, FET J310
Q108	310007	Transistor, PNP 2N3638
Q109	310006	Transistor, NPN 2N3565
Q110	310001	Transistor, MFT 3N204
Q111	310033	Transistor, FET J310
R108	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R109	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R110	113271	Resistor, Film 1/8 W 5% 270 $\Omega$
R111		Not Used.
R112	113332	Resistor, Film 1/8 W 5% 3.3 k $\Omega$
R113,R114	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R115	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R116	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R117		Not Used.
R118	113333	Resistor, Film 1/8 W 5% 33 k $\Omega$
R119	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R120	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R121	113101	Resistor, Film 1/8 W 5% 100 $\Omega$

**TABLE 9-2.**  
**Parts List, Synthesizer Module, M6. Assembly-1 Top Board, Continued.**

R122	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R123	113473	Resistor, Film 1/8 W 5% 47 k $\Omega$
R124	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R125	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
R127	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R128	113473	Resistor, Film 1/8 W 5% 47 k $\Omega$
R130	170224	Resistor, Potentiometer 1 k $\Omega$
R131	1111002	Resistor, Film 1/8 W 1% 10 k $\Omega$
R132	1112001	Resistor, Film 1/8 W 1% 2 k $\Omega$
T101	PRC1099XT4	Transformer, 3 turns: 1 turn
U104	330343	IC, LM317LZ

**TABLE 9-3.**  
**Parts List, Synthesizer Module, M6. Assembly-2 Top Board.**

C101	214103	Capacitor, Monolithic 0.01 $\mu$ F
C102,C103	241020	Capacitor, Tantalum 2.2 $\mu$ F
C104	261006	Capacitor, Trimmer 1.8-6 pF
C105	210680	Capacitor Disc NPO 68 pF
C106	210150	Capacitor, Disc NPO 15 pF
C107,C108	210270	Capacitor, Disc NPO 27 pF
C109,C110	214103	Capacitor, Monolithic 0.01 $\mu$ F
C130-C132	214103	Capacitor, Monolithic 0.01 $\mu$ F
C133-C136	237101	Capacitor, Electrolytic 100 $\mu$ F
C141	214103	Capacitor, Monolithic 0.01 $\mu$ F
C142	210050	Capacitor, Disc NPO 5 pF
D101	320305A	Diode, MV209
L100		Not Used.
L101	430014	Inductor, Molded 100 $\mu$ H
L102	459012	Inductor, Toroid 14 turns
L103	430005	Inductor, Fixed 0.68 $\mu$ H
L104,L105	459032	Inductor, Ferrite 3 turns
Q101,Q102	310032	Transistor, NPN 2N5770
Q112	310032	Transistor, NPN 2N5770
R100	113151	Resistor, Film 1/8 W 5% 150 $\Omega$
R101	113471	Resistor, Film 1/8 W 5% 470 $\Omega$
R102	113682	Resistor, Film 1/8 W 5% 6.8 k $\Omega$
R103	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R104	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
R105,R106	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R107	113122	Resistor, Film 1/8 W 5% 1.2 k $\Omega$
R129	113222	Resistor, Film 1/8 W 5% 2.2 k $\Omega$
Y101	360040	Crystal, 73.3650 MHz

**TABLE 9-4.**  
**Parts List, Synthesizer Module, M6. Assembly-1 Bottom Board.**

C1-C7		Not Used.
C8	241010	Capacitor, Tantalum 1.0 $\mu$ F
C9	241020	Capacitor, Tantalum 2.2 $\mu$ F
C10	241020	Capacitor, Tantalum 2.2 $\mu$ F
C11	275104	Capacitor, Monolithic 0.1 $\mu$ F
C13,C14	214103	Capacitor, Monolithic 0.01 $\mu$ F
C15	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C16	214103	Capacitor, Monolithic 0.01 $\mu$ F
C17	241020	Capacitor, Tantalum 2.2 $\mu$ F
C18	210102	Capacitor, Disc 0.001 $\mu$ F
C19	210050	Capacitor, Disc NPO 5 pF
C20	210102	Capacitor, Disc 0.001 $\mu$ F
C25	214103	Capacitor, Monolithic 0.01 $\mu$ F
C26	241020	Capacitor, Tantalum 2.2 $\mu$ F
C39		Not Used.
C43	214103	Capacitor, Monolithic 0.01 $\mu$ F
C65	237101	Capacitor, Electrolytic 16 V 100 $\mu$ F
L1		Not Used.
L8,L9	459032	Inductor, Ferrite 3 turns
Q1		Not Used.
R1	113273	Resistor, Film 1/8 W 5% 27 k $\Omega$
R2	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R3		Not Used.
R4,R5	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R6,R7	113392	Resistor, Film 1/8 W 5% 3.9 k $\Omega$
R8,R9	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R10	113473	Resistor, Film 1/8 W 5% 47 k $\Omega$
R11		Not Used.
R12	113183	Resistor, Film 1/8 W 5% 18 k $\Omega$
R13	113101	Resistor, Film 1/8 W 5% 100 $\Omega$
U1	330105	IC, MC12015P
U2	330019	IC, RC1458CP-1
U3	330272	IC, MC145158P1
Y1		Not Used.
Y2	361078	Crystal, Oscillator, 5.120 MHz TCXO
Y2*	361080	Crystal, Oscillator, High Stability 5.120 MHz TCXO

\* Part of high-stability reference option.

**TABLE 9-5.**  
**Parts List, Synthesizer Module, M6. Assembly-2 Bottom Board.**

C23	210102	Capacitor, Disc .001 $\mu$ F
C24	210330	Capacitor, Disc NPO 33 pF
C27	210102	Capacitor, Disc .001 $\mu$ F
C30	241020	Capacitor, Tantalum 2.2 $\mu$ F
C31	275104	Capacitor, Monolithic 0.1 $\mu$ F
C32	210102	Capacitor, Disc .001 $\mu$ F
C33	254502	Capacitor, Mylar .005 $\mu$ F
C34	241020	Capacitor, Tantalum 2.2 $\mu$ F
C35	214103	Capacitor, Monolithic .01 $\mu$ F
C36	241020	Capacitor, Tantalum 2.2 $\mu$ F
C37	214103	Capacitor, Monolithic .01 $\mu$ F
C38	241020	Capacitor, Tantalum 2.2 $\mu$ F
C40	275104	Capacitor, Monolithic 0.1 $\mu$ F
C41	214103	Capacitor, Monolithic .01 $\mu$ F
C42	210102	Capacitor, Disc .001 $\mu$ F
Q2	310052	Transistor, PNP PN2907A
Q3	310064	Transistor, Darlington 2N6427
R16	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R17	113106	Resistor, Film 1/8 W 5% 10 M $\Omega$
R18,R19	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
R20	170225	Resistor, Trimmer Mini 100 k $\Omega$
R21	113123	Resistor, Film 1/8 W 5% 12 k $\Omega$
U4	330271	IC, MC145157P1
U5,U6	330086	IC, MC14526
U7	330106	IC, MC12017P
U8	330273	IC, 74HC595

# CHAPTER 10

## PROCESSOR MODULE, M7 - TECHNICAL DESCRIPTION

### 10-1 GENERAL DESCRIPTION

The processor module contains a microprocessor and the associated components to perform the control functions in the transceiver. These include the tuning of the synthesizer, harmonic filter selection, antenna-tuner control and driving of the LCD frequency display.

Communication with the external modules is conducted through a serial data bus. Within a piece of digital equipment, it is normal to transfer data in parallel—all bits in a group (byte or word) are sent at the same time. The synthesizer itself requires 49 bits of information; if the data were sent in parallel 49 lines would be required, which would be too expensive and complex for this application. The solution to this problem is serial data transmission, in which each of the bits is sent in turn, in agreed sequence, over a single channel or wire.

The microprocessor operates only during the period required to perform its specific control functions. This gives two important operational advantages. The first is that the processor only draws current during the brief period required to perform the control functions, typically only a few milliseconds. The second advantage is that there is no need to provide extensive shielding to stop noise in the receiver. The processor operates only when controls are changed.

CMOS devices are used throughout the module. Therefore, power drain is very low, especially in standby mode.

### 10-2 M7 BLOCK DIAGRAM

The M7 module contains the processor and also contains connections for the optional TRANSADAPT board. The M7A contains the microprocessor and all the components required to perform all of the radio control functions. A block diagram of the M7A is shown in Figure 10-1. The module has the following block components:

#### M7A

1. Microprocessor
2. Clock Oscillator Circuit
3. Reset Circuit
4. Memory Backup Circuit
5. Power Failure Interrupt
6. Port C Latch
7. Control Bus Latch
8. Input Demultiplexer
9. Wake-up Control
10. CW Tone Oscillator
11. Voltage Regulators
12. Voltage Doubler Oscillator
13. External-Amp PTT Control

### 10-3 MICROPROCESSOR

The microprocessor is combined with the input/output circuits to form a special purpose microcomputer. The theory of operation of the microprocessor is beyond the scope of this manual. Simply stated, the microprocessor controls the operation of the transceiver in response to the control inputs in accordance with the program stored in memory.

The M7A microprocessor is a Motorola MC68HC705C8, which is a member of the M68HC05 family of microcomputers. It features 7744 bytes of internal one-time programmable read-only memory (OTPROM), along with 176 bytes of random access memory (RAM). Having programmable memory inside the microprocessor allows for a much more compact module, as there is no need for an external memory chip. Other features include: A computer operating properly (COP) watchdog timer, an on-chip clock oscillator and 24 bidirectional input/output lines.

The microprocessor operates at a clock frequency of 4.00 MHz and uses an internal oscillator controlled by Y1. Port lines PB0-PB7 drive the control bus, while PA0-PA4 drive the d-mux bus. Ports lines PC0-PC7 are used to drive the port C latch.

### 10-4 CLOCK-OSCILLATOR CIRCUIT

The clock oscillator is internal within the microprocessor, except for the crystal and external trimming capacitors. The frequency is adjusted to 4.000 MHz by C33.

### 10-5 RESET CIRCUIT

In the reset circuit within U3, a voltage detector monitors the +5-volt line, and will generate a reset output to hold the microprocessor's reset line low whenever the +5-volt line is below 4.65 Vdc. An internal monostable multivibrator holds the reset line low for 50 milliseconds after the +5-volt line rises above 4.65 Vdc. This prevents repeated toggling of the reset line.

### 10-6 MEMORY-BACKUP CIRCUIT

Frequency program information entered by the operator is stored in RAM of the microprocessor, which must be preserved at all times. While the processor module is in power-down mode, RAM is backed up by the lithium cell (BT1).

### 10-7 POWER FAILURE INTERRUPT

U3, a microprocessor supervisory chip, will issue a non-maskable interrupt to the processor whenever a power failure occurs. In addition, U3 will also forward bias Q8, which inhibits the operation of Y1. In this manner, both the microprocessor and the oscillator will not be operating on the memory-backup battery.

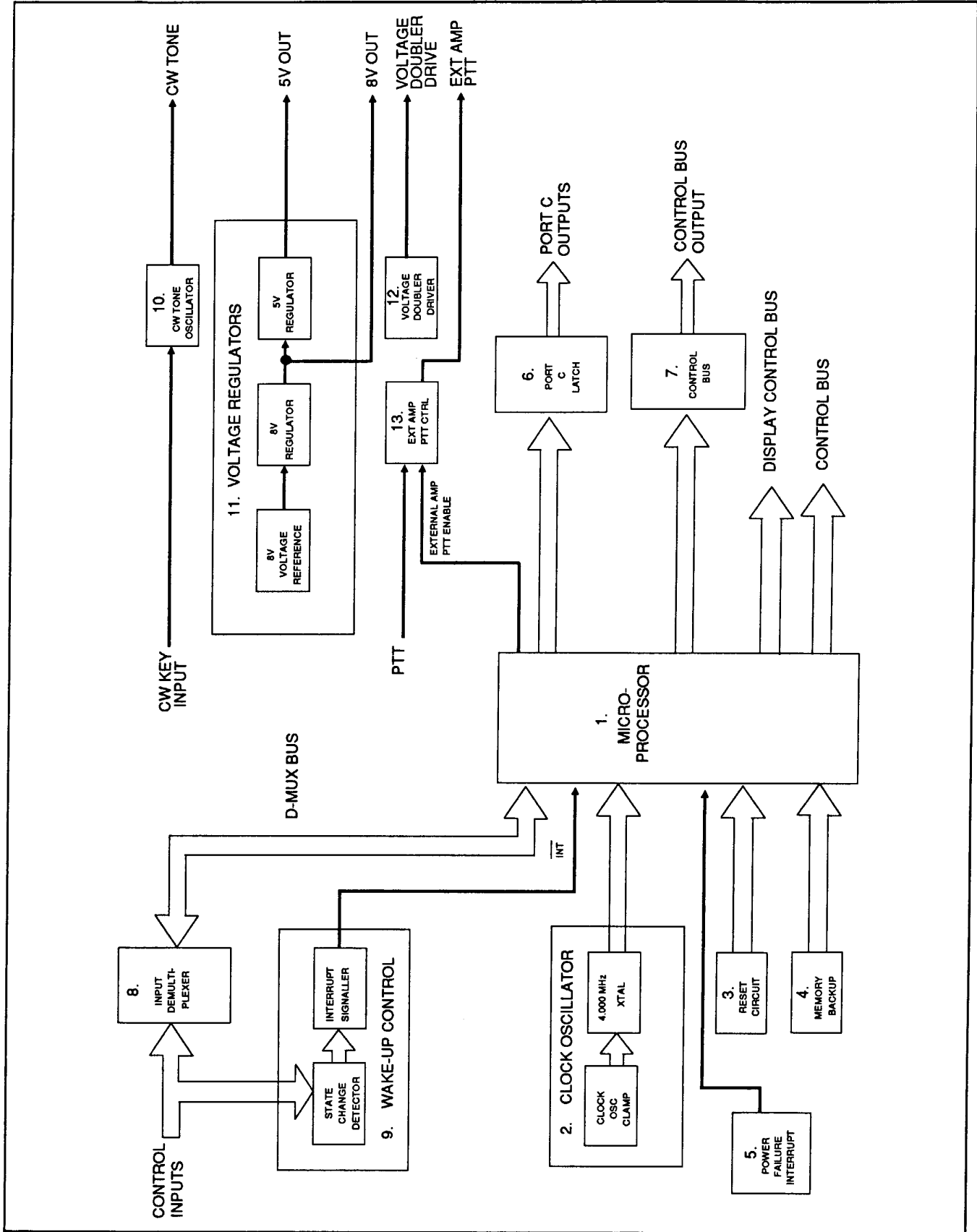


FIGURE 10-1.  
Block Diagram - Processor Module, M7.



**TABLE 10-1.**  
**Specifications, Processor Module, M7.**

<b>Current Drain:</b>	
a. Static:	10 mA typical @ 12 V.
b. Operating:	33 mA typical @ 12 V.
c. Lithium Cell:	2 $\mu$ A typical @ 2.5 V.
<b>Lithium Cell Life:</b>	5 years minimum, 10 years typical.
<b>CW Tone THD:</b>	< 1%.

### 10-8 PORT C LATCH

The port C latch U1 is used to output the mute line, antenna-tuner initiate signal, transmitter, low-power control and the USB/LSB selection signals.

### 10-9 CONTROL BUS LATCH

The control bus latch U2 is used to output the entire control bus. This bus includes: synthesizer select signals, data and clock signals, along with the filter and tuner signals. The control bus latch also outputs the display information to the M8 module.

### 10-10 INPUT DEMULTIPLEXER

The input demultiplexer U12 is used to interface the 16 input lines to the processor module. U12 is an HC14067 analog multiplexer/demultiplexer which has 16 channels and 4 address lines. The processor communicates with the input demultiplexer through the d-mux bus. The 5-line d-mux bus consists of 4 address lines which are connected to PA1-PA4 of the processor and an input line connected to PA0. The processor outputs the desired input channel address through the address lines, and data is read in through the input line.

### 10-11 WAKE-UP CONTROL

The state change detector U9, which represents half of the wake-up control block, monitors the input lines for any change in state of the inputs, which then triggers the interrupt signaller to create an interrupt within the microprocessor. U9 is an MC14531 12-bit parity tree which has 12 inputs, odd/even parity select input and a parity valid output. The interrupt signaller U11 is an MC14528B dual monostable multivibrator. One section of the multivibrator is configured to trigger on the rising edge of the parity tree output and the other on the falling edge. The outputs of the multivibrators drive the interrupt line of the microprocessor, which then brings the processor out of the standby state.

### 10-12 CW TONE OSCILLATOR

Op amp U8 forms a keyed oscillator for the CW function. The oscillation frequency is determined by R23. The output is inherently amplitude stabilized by the limiter stage U8A, which feeds a 20% clipped waveform back into the bandpass filter U8B. The resulting output is very low in distortion, i.e., less than 1%.

The oscillator is keyed by pulling the limiter's inverting input down near ground via Q4. The CW key is attached to the base of Q4 through the tone key input J2-2.

Q4 conducts when the key is open. When the key is closed, correct bias is restored and the oscillator starts smoothly from a zero amplitude to the level where the 20% clipping occurs in the limiter. When the key is opened, the oscillator stops within a few cycles as Q4 saturates.

Thus the keyed envelopes are trapezoidal as desired. It should be noted that the transmitter will reach full output before the oscillator does, at some point where the transmitter gain is enough to reach ALC limits. This means that the attack and decay times will be less than those of the oscillator.

### 10-13 VOLTAGE REGULATORS



The 5-V and 8-V supplies for the entire transceiver are located on the M7 board. U6, a short-circuit-proof 3-terminal regulator provides the +8-V output. Resistors R20, R21, R22 set the output voltage. R22 allows for adjustment of the +8-V output. U4, a short-circuit-proof 3-terminal regulator provides the +5-V output. Resistors R4 and R5 set the +5-V output voltage.

### 10-14 VOLTAGE-DOUBLER DRIVE

U7B and associated components form a 3-kHz square-wave oscillator to provide the voltage-doubler drive signal. This signal is routed to the voltage-doubler circuitry on the junction board to create the 16 V required in the M6 synthesizer module.

### 10-15 EXTERNAL-AMP PTT CONTROL

Transistors Q6, Q7 and associated components form an enable circuit for the external-amplifier PTT line, which is controlled through the PA5 port line from the microprocessor.

### 10-16 PROGRAM OPERATION

Most of the time the microprocessor is in standby mode waiting for a command from any of the inputs. When an input is changed, the state change detector signals the processor to switch to active mode. The processor then polls all the inputs through the input demultiplexer to find

out which input triggered the interrupt. Upon determining the correct input, the processor executes the proper instructions to execute the command(s) determined by the specific input. For example, a change in the channel switch line would wake up the processor, which then gets the new channel frequency data stored in RAM. The new channel data is then sent to the synthesizer, antenna tuner and harmonic filter through the control bus; and the display module data is sent through the display bus.

#### 10-17 CONTROL BUS

The control bus basically consists of 3 signals. The signals are clock, data, and select. The processor places the first data bit on the data line at PB5 of the processor. Then it toggles the clock line (PB7) twice, so that the data is shifted into the selected shift register. This is repeated until all of the data in the data stream is shifted out. The desired select line (PA7, PB0-PB3) is then toggled twice also to latch the shifted data into the desired register. The display has its own interface bus lines, PB4 and PB5, which are display data and display clock respectively. Display bus operation is similar to the control bus, except that no select line is needed since the display is the only device.

#### 10-18 MEMORY-DUMP FEATURE

The PRC1099 is equipped with a Memory-Dump Feature, which allows the operator to erase all frequencies stored in memory (channels MAN through 9) in one quick maneuver. This ability to quickly erase the memory would be very useful to avoid compromising unit frequencies in the event of enemy capture. To erase the frequencies stored in memory, simply hold the WHIP-TUNE button in, hold the DIGIT switch up, and turn the radio from OFF to LO. This will cause the radio to reset all programmed frequencies to 00.0000 MHz.

#### 10-19 BUILT-IN-TEST-EQUIPMENT PROGRAM (BITE) - GENERAL DESCRIPTION

##### 10-19.1 INTRODUCTION

This is a general description of the Built-In-Test-Equipment (BITE) feature of the PRC1099 radio set. BITE is a series of "built-in" tests to enable the radio operator to test various sections of the PRC1099. The BITE software is capable of performing tests to the following sections of the PRC1099:

1. Battery
2. Antenna
3. LCD display
4. Processor RAM
5. Receiver
6. Transmitter
7. Antenna tuner

Section 10-19.2 describes the operation of the PRC1099 BITE program. Sections 10-20.1 through 10-20.12 below give an overview of the BITE program, which describes

each test step in detail, and includes pass or fail indications and areas of required operator interaction.

#### 10-19.2 BITE OPERATION

Before starting BITE, the radio should be configured as follows:

- Power switch set to "off".
- Whip antenna installed (or adapter when using a long wire antenna).
- Handset connected to one of the audio connectors.
- Mode switch set to "USB".
- Volume control set to the "5" position.
- 

The BITE tests are invoked by depressing the WHIP TUNE/STORE button, then at the same time turning the PRC1099's power switch to LO or HI. The WHIP TUNE/STORE button should be depressed for about 1 second after the power switch is switched on. This will start the BITE test which is indicated by 'TEST:01' showing on the display. The BITE program will begin stepping through each test routine, halting if a failure occurs (except with tests requiring operator interaction) and then displaying an error message. When BITE is operating DO NOT depress the PTT switch on the handset, as it may interfere with the BITE tests.

#### 10-20 BITE TEST DESCRIPTIONS

##### 10-20.1 BATTERY TEST

Test 1 includes the testing of the battery pack. BITE tests the battery voltage sensor (D5 of M7) and verifies that the battery voltage meets the minimum level of 11 volts. If the battery voltage is below the minimum level, BITE will fail this portion of the test and will halt displaying the error message 'Err :01' on the LCD display. Upon passing this section, BITE will display 'PASS:01' and then proceed to test 2 (section 10-20.2).

##### 10-20.2 WHIP ANTENNA TEST

Test 2 tests the antenna whip switch and verifies that a whip antenna (or antenna adapter) is installed which is required for the transmitter tests (Tests 7 through 12). If the antenna is not installed, BITE will fail this portion of the test and will halt displaying the error message 'Err :02'. Otherwise, BITE will proceed to test 3 (section 10-20.3) of the BITE test program.

##### 10-20.3 LCD DISPLAY TEST

Test 3 tests the LCD display and verifies that each digit and segment of the display functions properly. BITE tests each digit/segment by performing a "walking 8" test in which the number "8" is first displayed in the left hand most portion of the display and then is "shifted" over 1 digit to the right until it has been through all 6 digit positions. The second portion of the test "shifts" a decimal point in the same manner, which exercises the decimal points of the display. This test requires that the radio operator be present to determine if this portion of the test passes or fails. Since the BITE program cannot detect a

failure during this test, BITE will then proceed to test 4 (section 10-20.4).

**10-20.4 PROCESSOR RAM TEST**

Test 4 tests the RAM (Read Only Memory) within the MC68HC705C8 microprocessor. BITE does a non-destructive memory test which includes the writing and reading of selected test bit patterns to insure the integrity of the battery-backed RAM. BITE will fail this portion of the test upon any read/write cycle failure. Upon failure, BITE will display 'Err :04' and then will halt and exit the BITE test program. If there are no memory test errors detected, BITE will then proceed to test 5 (section 10-20.5).

**10-20.5 USB RECEIVER TEST**

Test 5 tests the receiver circuitry of the PRC1099 in upper sideband mode. This test requires that the radio operator listen in the handset for an audible tone which should be present for at least 2 seconds. The validation of this test is determined by the operator, and therefore no failure message is displayed for this test. Since the BITE program cannot detect a failure during this test, BITE will then continue with test 6 (section 10-20.6).

**10-20.6 LSB RECEIVER TEST**

Test 6 also tests the receiver circuitry of the PRC1099, this time in lower sideband mode. This test requires that the radio operator listen for a tone in the handset which should be present for at least 2 seconds. The validation of this test is determined by the operator, and therefore no failure message is displayed for this test. Since the BITE program cannot detect a failure during this test, BITE will then continue with tests 7-12 (sections 10-20.7 through 10-20.12).

**10-20.7-10-20.12 TRANSMITTER TESTS**

Tests 7 through 12 exercise the transmitter functions of the PRC1099 radio. This section of the BITE program begins by tuning the synthesizer to one of the six test frequencies (USB) in Table 10-2 below.

The transmitter test continues by setting the radio to low-power mode and then attempts to tune the antenna to the current test frequency. The BITE program generates an audible test tone through the handset for 2 seconds, in which the operator should verify. Upon passing this section, the BITE program switches the transmitter to high power for 2 seconds (If the resulting antenna tune setting

includes L8, L9 or L10, the transmitter will stay in low power). The audible test tone should also be present for this portion of the test, which the operator should verify. The BITE program can only fail the antenna-tuning portion of this test, which requires the operator to verify the presence of the test tone during the low/high power sections of these tests. If the antenna-tuning section fails to tune during the transmitter test sequence, the BITE program will display 'Err :xx' (where xx is the current test number)—therefore failing that portion of the BITE program. If the test tone is not present or fades during the low/high power sections of any of the transmitter tests, the current test should be failed.

**10-21 MODULE INTERCONNECTIONS**



The M7A module has the following interconnects with the transceiver:

Connector M7AJ1

- Pin 1 LOW POWER. From the power switch, 0 Vdc in LO or EXT AMP, 5 Vdc in HIGH.
- Pin 2 12 Vdc from the power supply.
- Pin 3 8 Vdc from the power supply.
- Pin 4 5 Vdc from the power supply.
- Pin 5 GROUND.

Connector M7AJ2

- Pin 1 CW TONE. 1.4 V<sub>p-p</sub> CW tone signal in CW transmit.
- Pin 2 TONE KEY. 0 Vdc with CW keyed, .65 Vdc in receive.
- Pin 3 VOLTAGE DOUBLER DRIVE. 12 V<sub>p-p</sub> square wave signal.
- Pin 4 TUNER DET. This is the comparator output of the M5 module, used for tuning cycles.
- Pin 5 ANT SW. Used to determine if a whip antenna is installed. 0 Vdc with no antenna, 4.8 Vdc with antenna.

**TABLE 10-2.  
Transmitter Test Frequencies.**

Test 7	29.9000 MHz
Test 8	19.9000 MHz
Test 9	12.9000 MHz
Test 10	7.9000 MHz
Test 11	4.9000 MHz
Test 12	2.9000 MHz

Connector M7AJ3

- Pin 1 LOW POWER. From the power switch, 0 Vdc in LOW or EXT AMP, 5 Vdc in HIGH.
- Pin 2 CHANNEL SET/TUNE. Normally 5 Vdc. 0 Vdc with WHIP TUNE depressed.
- Pin 3 SLEW DOWN. Normally 5 Vdc. 0 Vdc with TUNE switch down.
- Pin 4 SLEW UP. Normally 5 Vdc. 0 Vdc with TUNE switch up.
- Pin 5 DIGIT DOWN. Normally 5 Vdc. 0 Vdc with DIGIT switch Down.

Connector M7AJ4

- Pin 1 DIGIT UP. Normally 5 Vdc. 0 Vdc with DIGIT switch up.

**Channel**

<u>Switch</u>	<u>Pin 2</u>	<u>Pin 3</u>	<u>Pin 4</u>	<u>Pin 5</u>
Manual	5 Vdc	5 Vdc	5 Vdc	5 Vdc
1	0 Vdc	5 Vdc	5 Vdc	5 Vdc
2	5 Vdc	5 Vdc	5 Vdc	0 Vdc
3	0 Vdc	5 Vdc	5 Vdc	0 Vdc
4	5 Vdc	5 Vdc	0 Vdc	5 Vdc
5	0 Vdc	5 Vdc	0 Vdc	5 Vdc
6	5 Vdc	5 Vdc	0 Vdc	0 Vdc
7	0 Vdc	5 Vdc	0 Vdc	0 Vdc
8	5 Vdc	0 Vdc	5 Vdc	5 Vdc
9	0 Vdc	0 Vdc	5 Vdc	5 Vdc

Connector M7AJ5

- Pin 1 LSB SW. 0 Vdc in LSB.
- Pin 2 No connection.
- Pin 3 EXTERNAL AMP. 0 Vdc in EXT AMP, 5 Vdc in HIGH or LOW.
- Pin 4 AMP PTT. Low impedance to ground with POWER in EXT AMP position, radio keyed. High impedance otherwise.
- Pin 5 PTT. 13.6 Vdc in receive. 0 Vdc in transmit.

Connector M7AJ6

- Pin 1 USB. 0 Vdc with MODE switch in LSB. 5 Vdc otherwise.
- Pin 2 LO POWER. 5 Vdc in LOW POWER or EXT AMP. 0 Vdc in HIGH.
- Pin 3 LSB. 5 Vdc with MODE switch in LSB. 0 Vdc otherwise.

- Pin 4 LO POWER/. Low impedance to ground in HIGH POWER, high impedance otherwise.
- Pin 5 TUNE INITIATE. Initiates a tune cycle in an external tuner with a 45-ms low-going pulse, when the POWER switch in EXT-AMP position, and the WHIP-TUNE button is depressed.
- Pin 6 ATU TUNE. Normally 13.8 Vdc, 0 Vdc with WHIP TUNE depressed.
- Pin 7 No connection.
- Pin 8 MUTE/. Used to mute the receive audio in transmit. 0 Vdc in transmit, 8 Vdc in receive.
- Pin 9 No connection.
- Pin 10 No connection.
- Pin 11 EXTERNAL ENABLE. Used to enable external equipment for data and clock reception.
- Pin 12 No connection.
- Pin 13 CLOCK. Internal radio clock information.
- Pin 14 EN 4. Internal radio select data.
- Pin 15 DATA. Internal radio data.
- Pin 16 EN 3. Internal radio select data.
- Pin 17 DISPLAY CLOCK. Clock information sent to the display.
- Pin 18 EN 2. Internal radio select data.
- Pin 19 DISPLAY DATA. Data information sent to the display.
- Pin 20 EN 1. Internal radio select data.

Connector M7AJ7

- Pin 1 RDI. Received data in, supplied to the processor.
- Pin 2 TDO. Transmitted data out, supplied from the processor.
- Pin 3 No connection.
- Pin 4 No connection.
- Pin 5 No connection.
- Pin 6 No connection.
- Pin 7 No connection.
- Pin 8 No connection.

Pin 9 No connection.

Pin 10 No connection.

Pin 11 No connection.

Pin 12 EN. Enable data to enable the transadapt board.

Pin 13 No connection.

Pin 14 DATA. Internal radio Data information, supplied to the transadapt board.

Pin 15 A2. Used in conjunction with A1 and A0 for selection on the transadapt board.

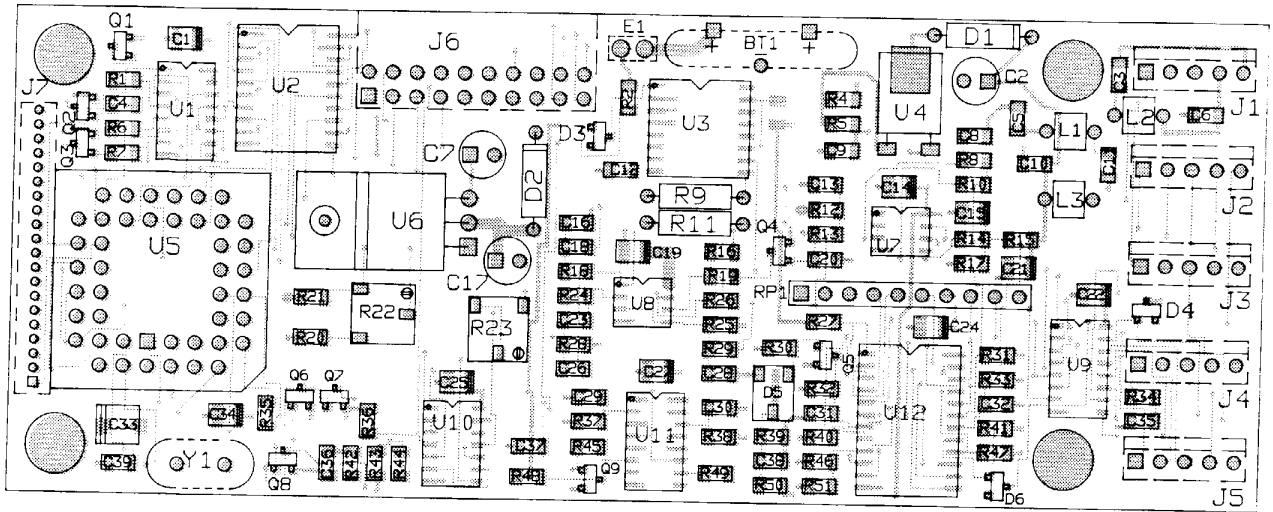
Pin 16 A1. Used in conjunction with A0 and A2 for selection on the transadapt board.

Pin 17 A0. Used in conjunction with A0 and A1 for selection on the transadapt board.

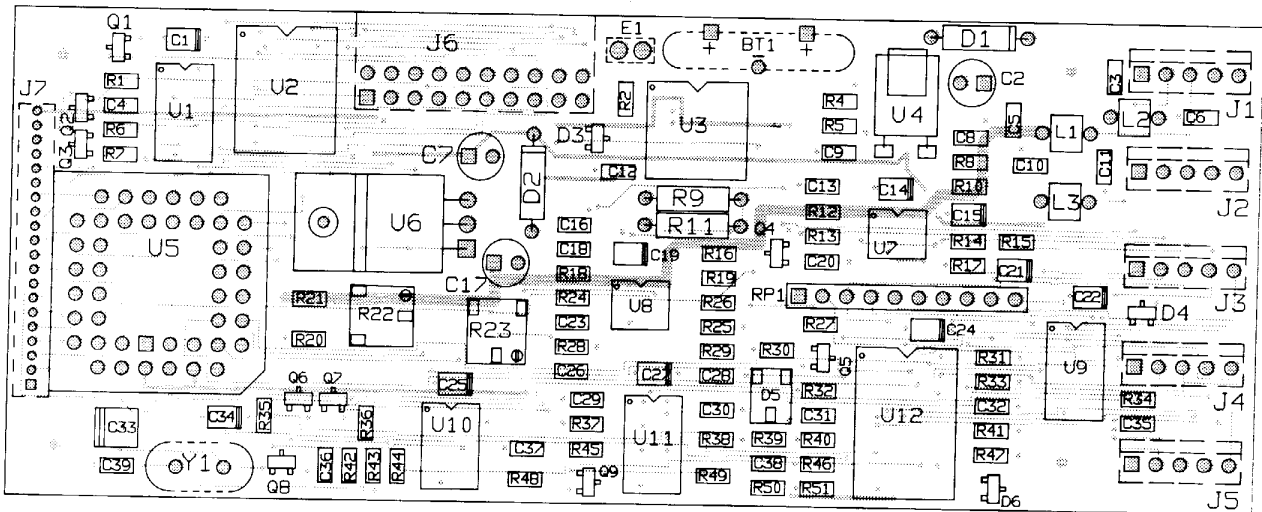
Pin 18 5 Vdc from the power supply.

Pin 19 GROUND.

Pin 20 12 Vdc from the power supply.

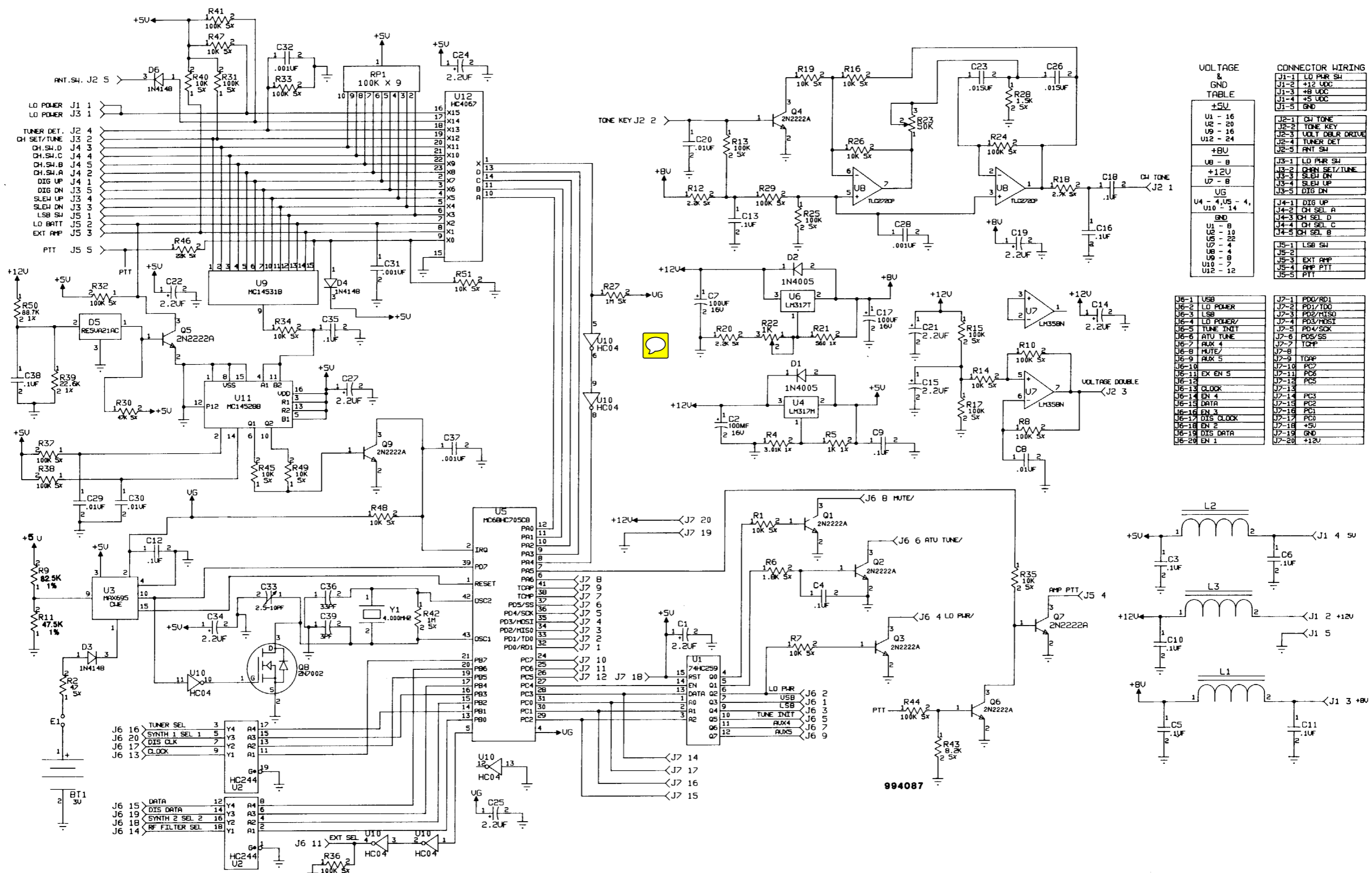


COMPONENT SIDE



CIRCUIT SIDE

FIGURE 10-2.  
Component Locations, Processor Module, M7.



**VOLTAGE TABLE**

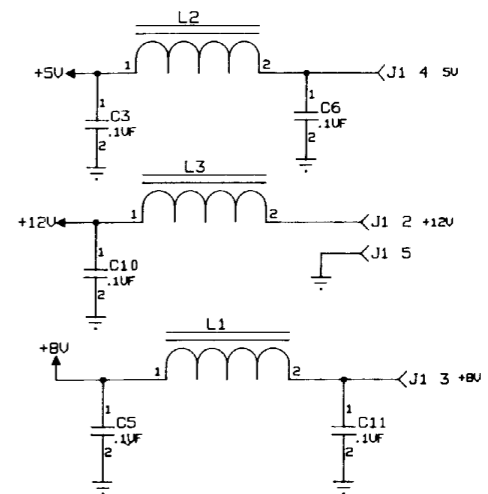
U1 - 16
U9 - 16
U12 - 24
+5U
+BU
UB - 8
+12U
U7 - 8
UG
U4 - 4, U5 - 4, U10 - 14
GND
U1 - 8
U6 - 10
U8 - 22
U6 - 4
U9 - 9
U10 - 7
U12 - 12

**CONNECTOR WIRING**

J1-1	LO PWR SH
J1-2	+12 UCC
J1-3	+8 UCC
J1-4	+5 UCC
J1-5	GND
J2-1	DI TONE
J2-2	TONE KEY
J2-3	VOLT DBLR DRIVE
J2-4	TUNER DET
J2-5	ANT SH
J3-1	LO PWR SH
J3-2	CHN SET/TUNE
J3-3	SELB DN
J3-4	SELB UP
J3-5	DTG DN
J4-1	DTG UP
J4-2	CH SEL A
J4-3	CH SEL D
J4-4	CH SEL C
J4-5	CH SEL B
J5-1	LSB SH
J5-2	PTT
J5-3	EXT AMP
J5-4	AMP PTT
J5-5	PTT

**CONNECTOR WIRING (Continued)**

J6-1	USB
J6-2	LO PWR
J6-3	LSB
J6-4	LO PWR/
J6-5	TUNE INIT
J6-6	ATU TUNE
J6-7	AUX 4
J6-8	MUTE/
J6-9	AUX 5
J6-10	PC7
J6-11	EX EN 5
J6-12	PCS
J6-13	CLOCK
J6-14	EN 4
J6-15	DATA
J6-16	EN 3
J6-17	PCS
J6-18	EN 2
J6-19	DIS DATA
J6-20	EN 1
J7-1	PD0/RD1
J7-2	PD1/TD0
J7-3	PD2/HS0
J7-4	PD3/HOST
J7-5	PD4/SXK
J7-6	PD5/SS
J7-7	TOHP
J7-8	TOHP
J7-9	TOHP
J7-10	PC2
J7-11	PC5
J7-12	PC5
J7-13	PC5
J7-14	PC3
J7-15	PC2
J7-16	PC1
J7-17	PC0
J7-18	+5U
J7-19	GND
J7-20	+12U



**FIGURE 10-3.**  
Schematic Diagram, Processor Module, M7.

**TABLE 10-3.**  
**Parts List, Processor Module, M7.**

BT1	751053	Battery 3V Lithium
C1	022020	Capacitor, SMT, Tantalum 2.2 $\mu$ F
C2	237101	Capacitor, Electrolytic 100 $\mu$ F
C3-C6	021104	Capacitor, SMT 0.1 $\mu$ F
C7	237101	Capacitor, Electrolytic 100 $\mu$ F
C8	021103	Capacitor, SMT 0.01 $\mu$ F
C9-C13	021104	Capacitor, SMT 0.1 $\mu$ F
C14,C15	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C16	021104	Capacitor, SMT 0.1 $\mu$ F
C17	237101	Capacitor, Electrolytic 100 $\mu$ F
C18	021104	Capacitor, SMT 0.1 $\mu$ F
C19	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C20	021103	Capacitor, SMT 0.01 $\mu$ F
C21,C22	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C23	021152	Capacitor, SMT 1500 pF
C24,C25	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C26	021152	Capacitor, SMT 1500 pF
C27	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C28	021102	Capacitor, SMT 0.001 $\mu$ F
C29,C30	021103	Capacitor, SMT 0.01 $\mu$ F
C31,C32	021102	Capacitor, SMT 0.001 $\mu$ F
C33	025002	Capacitor, Trimmer 2-10 pF
C34	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C35	021104	Capacitor, SMT 0.1 $\mu$ F
C36	020330	Capacitor, SMT 33 pF
C37	021102	Capacitor, SMT 0.001 $\mu$ F
C38	021104	Capacitor, SMT 0.1 $\mu$ F
C39	020030	Capacitor, SMT 3 pF
D1,D2	320101	Diode, 1N4005
D3,D4	031002	Diode, SMT BAS16
D5	031003	Diode, SMT RH5VA21AC
D6	031002	Diode, SMT BAS16
L1-L3	459032	Inductor, 3 Turns
Q1-Q7	032004	Transistor, SMT MMBT2222LL
Q8	032005	Transistor, SMT 2N7002
Q9	032004	Transistor, SMT MMBT2222LL
R1	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R2	013471	Resistor, SMT 1/8 W 5% 470 $\Omega$
R3	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R4	003011	Resistor, SMT 1/8 W 1% 3.01 k $\Omega$
R5	001001	Resistor, SMT 1/8 W 1% 1 k $\Omega$
R6	013183	Resistor, SMT 1/8 W 5% 1.8 k $\Omega$
R7	103103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R8	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R9	1118252	Resistor, Film 1/8 W 1% 82.5 k $\Omega$
R10	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R11	1114752	Resistor, Film 1/8 W 1% 47.5 k $\Omega$
R12	013222	Resistor, SMT 1/8 W 5% 2.2 k $\Omega$
R13	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R14	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R15	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R16	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$



**TABLE 10-3.  
Parts List, Processor Module, M7, Continued.**

R17	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R18	013272	Resistor, SMT 1/8 W 5% 2.7 k $\Omega$
R19	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R20	013222	Resistor, SMT 1/8 W 5% 2.2 k $\Omega$
R21	013561	Resistor, SMT 1/8 W 5% 560 $\Omega$
R22	017002	Trimmer Resistor, SMT 10 k $\Omega$
R23	017001	Trimmer Resistor, SMT 50 k $\Omega$
R24,R25	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R26	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R27	013105	Resistor, SMT 1/8 W 5% 1 M $\Omega$
R28	013152	Resistor, SMT 1/8 W 5% 1.5 k $\Omega$
R29	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R30	013473	Resistor, SMT 1/8 W 5% 47 k $\Omega$
R31-R33	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R34,R35	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R36-R38	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R39	002262	Resistor, SMT 1/8 W 1% 22.6 k $\Omega$
R40	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R41	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R42	013105	Resistor, SMT 1/8 W 5% 1 M $\Omega$
R43	013822	Resistor, SMT 1/8 W 5% 8.2 k $\Omega$
R44	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R45	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R46	013223	Resistor, SMT 1/8 W 5% 22 k $\Omega$
R47-R49	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R50	008872	Resistor, SMT 1/8 W 1% 88.7 k $\Omega$
R51	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
RP1	182002	Resistor Pack 9 X 100 k $\Omega$
U1	033018	IC, SMT MC74HC259
U2	033017	IC, SMT MC74HC244
U3	033019	IC, SMT MAX695
U4	033021	IC, SMT LM317
U5	033022	IC, MC68HC705C8
U6	330340	IC, LM317T
U7	033012	IC, SMT LM358D
U8	033015	IC, SMT TLC272
U9	033014	IC, SMT MC14531
U10	033016	IC, SMT MC74HC04
U11	033013	IC, SMT MC14528
U12	033020	IC, SMT 74HC4067
Y1	361067	Crystal 4.000 MHz

**TABLE 10-3.  
Parts List, Processor Module, M7.**

BT1	751053	Battery 3V Lithium
C1	022020	Capacitor, SMT, Tantalum 2.2 $\mu$ F
C2	237101	Capacitor, Electrolytic 100 $\mu$ F
C3-C6	021104	Capacitor, SMT 0.1 $\mu$ F
C7	237101	Capacitor, Electrolytic 100 $\mu$ F
C8	021103	Capacitor, SMT 0.01 $\mu$ F
C9-C13	021104	Capacitor, SMT 0.1 $\mu$ F
C14,C15	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C16	021104	Capacitor, SMT 0.1 $\mu$ F
C17	237101	Capacitor, Electrolytic 100 $\mu$ F
C18	021104	Capacitor, SMT 0.1 $\mu$ F
C19	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C20	021103	Capacitor, SMT 0.01 $\mu$ F
C21,C22	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C23	021152	Capacitor, SMT 1500 pF
C24,C25	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C26	021152	Capacitor, SMT 1500 pF
C27	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C28	021102	Capacitor, SMT 0.001 $\mu$ F
C29,C30	021103	Capacitor, SMT 0.01 $\mu$ F
C31,C32	021102	Capacitor, SMT 0.001 $\mu$ F
C33	025002	Capacitor, Trimmer 2-10 pF
C34	022020	Capacitor, SMT Tantalum 2.2 $\mu$ F
C35	021104	Capacitor, SMT 0.1 $\mu$ F
C36	020330	Capacitor, SMT 33 pF
C37	021102	Capacitor, SMT 0.001 $\mu$ F
C38	021104	Capacitor, SMT 0.1 $\mu$ F
C39	020030	Capacitor, SMT 3 pF
D1,D2	320101	Diode, 1N4005
D3,D4	031002	Diode, SMT BAS16
D5	031003	Diode, SMT RH5VA21AC
D6	031002	Diode, SMT BAS16
L1-L3	459032	Inductor, 3 Turns
Q1-Q7	032004	Transistor, SMT MMBT2222LL
Q8	032005	Transistor, SMT 2N7002
Q9	032004	Transistor, SMT MMBT2222LL
R1	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R2	013471	Resistor, SMT 1/8 W 5% 470 $\Omega$
R3	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R4	003011	Resistor, SMT 1/8 W 1% 3.01 k $\Omega$
R5	001001	Resistor, SMT 1/8 W 1% 1 k $\Omega$
R6	013183	Resistor, SMT 1/8 W 5% 1.8 k $\Omega$
R7	103103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R8	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R9	1118252	Resistor, Film 1/8 W 1% 82.5 k $\Omega$
R10	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R11	1114752	Resistor, Film 1/8 W 1% 47.5 k $\Omega$
R12	013222	Resistor, SMT 1/8 W 5% 2.2 k $\Omega$
R13	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R14	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$
R15	013104	Resistor, SMT 1/8 W 5% 100 k $\Omega$
R16	013103	Resistor, SMT 1/8 W 5% 10 k $\Omega$

# CHAPTER 11

## DISPLAY MODULE, M8 - TECHNICAL DESCRIPTION

### 11-1 GENERAL DESCRIPTION

The LCD (liquid crystal display) is attached to the M8 module. The module also contains two display driver integrated circuits: the backplane signal generator and the backlight generator. The 5 V for these circuits is supplied by the regulators in the processor module.

The display driver circuits are 32-bit, serial-in, parallel-out shift registers, which have the ability to have their outputs complimented (inverted) under control of an external signal. They are CMOS devices and as such draw very little current.

### 11-2 CIRCUIT DESCRIPTION

The supply voltage is 5 V and the current drain is exceptionally low (approximately 5 microamps). The data and clock line provide for the serial inputting of data to the drivers. A total of 64 serial bits must be shifted each time the display is updated.

The LCD requires a backplane signal to operate correctly. This signal must be a good square wave and is provided by the ripple carry counter U3, connected to the backplane. The input Schmitt trigger is connected as an oscillator with the time constant set by R1, R2 and C1. The backplane drive frequency is 100 Hz. This signal, known as the "T/C" (true/complement) line, is connected to the backplane and to the invert control pin of the driver.

To drive the LCD, it is necessary to apply both the backplane signal and the inverted signal to the desired segment. The segments that are off are driven by the noninverted backplane signal. Each output bit which is a zero (0) will follow the backplane signal, and the ones (1) will be inverted so the desired segment is turned on. By shifting in the right combination of data, the right segments will be turned on to display the correct frequency.

The LCD is backlit by an electroluminescent display on the backplane. The power supply is turned on when the mode switch is in the "LITE" position. This grounds the emitter of Q1, which drives the step-up auto trans-

former T1. The 800-Hz drive signal is supplied from the counter U3. The output voltage is 150 V p-p, and care should be taken not to switch on the back light when working on the display. Transistors Q2, Q3 and Q4 provide buffering for the External Select, Data and check signals going to external devices connected to the 14-pin accessory connector.

Channel changes from the optional remote-control handset are decoded by U4 and U5. The channels are switched by means of a resistive divider running off of 8.0 Vdc. The top leg of the divider is R11 on the M8. The bottom legs are in the remote handset and are selected by the handset channel knob. Each of the bottom legs applies a different voltage to the U5-pin 5 input. Inside the U4, this voltage is compared to a reference voltage which is run down a 10-step voltage divider. Each step has its own comparator which is turned on (output low) when the channel voltage is within that comparator window. The reference voltage is derived from the precision 8.0-Vdc line, a reference voltage source in U4, R13 and R14. U6 is a voltage reference set to 1.75 volts by R29. With the reference 8.00 volts on pin 5 and the reference 1.75 volts on pin 4, U4 is completely temperature insensitive.

Resistor pack RP1 is used as pull-ups for the open-collector outputs of U4. These outputs are fed to U5, a CMOS decimal-to-BCD decoder. The four BCD outputs are connected to the channel-select lines of the microprocessor via four isolation diodes. Capacitors have been shunted across two of these BCD outputs to lengthen the time during which there is a change in the output. This ensures proper reading of the channel change by the microprocessor.

### 11-3 MODULE INTERCONNECTIONS

The M8 module has the following interconnections with the transceiver:

#### Connector M8J1

Pin 1 No connection.

**TABLE 11-1.**  
**Specifications, Display Module, M8.**

<u>Current Drain:</u>	
5 V	285 $\mu$ A, Typ.
8 V	2 mA Typ, without Remote Handset (RCH).
	6 mA Typ, with RCH.
12 V	4.5 mA Typ, with Backlight OFF.
	105 mA Typ, with Backlight ON.

Pin 2 5 Vdc from the power supply.

Pin 3 DISPLAY CLOCK. Clock information for the display.

Pin 4 No connection.

Pin 5 DISPLAY DATA. Data information for the display.

Pin 6 GROUND.

Connector M8J2

Pin 1 12 Vdc from the power supply.

Pin 2 LIGHT SWITCH. Normally 5 Vdc, but 0 Vdc with the MODE switch in the LIGHT position.

Connector M8J3

**Channel**

<u>Switch</u>	<u>Pin 1</u>	<u>Pin 2</u>	<u>Pin 3</u>	<u>Pin 4</u>
Manual	5 Vdc	5 Vdc	5 Vdc	5 Vdc
1	0 Vdc	5 Vdc	5 Vdc	5 Vdc
2	5 Vdc	5 Vdc	5 Vdc	0 Vdc

3	0 Vdc	5 Vdc	5 Vdc	0 Vdc
4	5 Vdc	5 Vdc	0 Vdc	5 Vdc
5	0 Vdc	5 Vdc	0 Vdc	5 Vdc
6	5 Vdc	5 Vdc	0 Vdc	0 Vdc
7	0 Vdc	5 Vdc	0 Vdc	0 Vdc
8	5 Vdc	0 Vdc	5 Vdc	5 Vdc
9	0 Vdc	0 Vdc	5 Vdc	5 Vdc

Connector M8J4

Pin 1 No connection.

Pin 2 EXT SEL. Unbuffered external select input.

Pin 3 EXT SEL B. Buffered external select output.

Pin 4 DATA. Unbuffered data input.

Pin 5 DATA B. Buffered data output.

Pin 6 CLOCK. Unbuffered clock input.

Pin 7 CLOCK B. Buffered clock output.

Pin 8 8 Vdc from the power supply.

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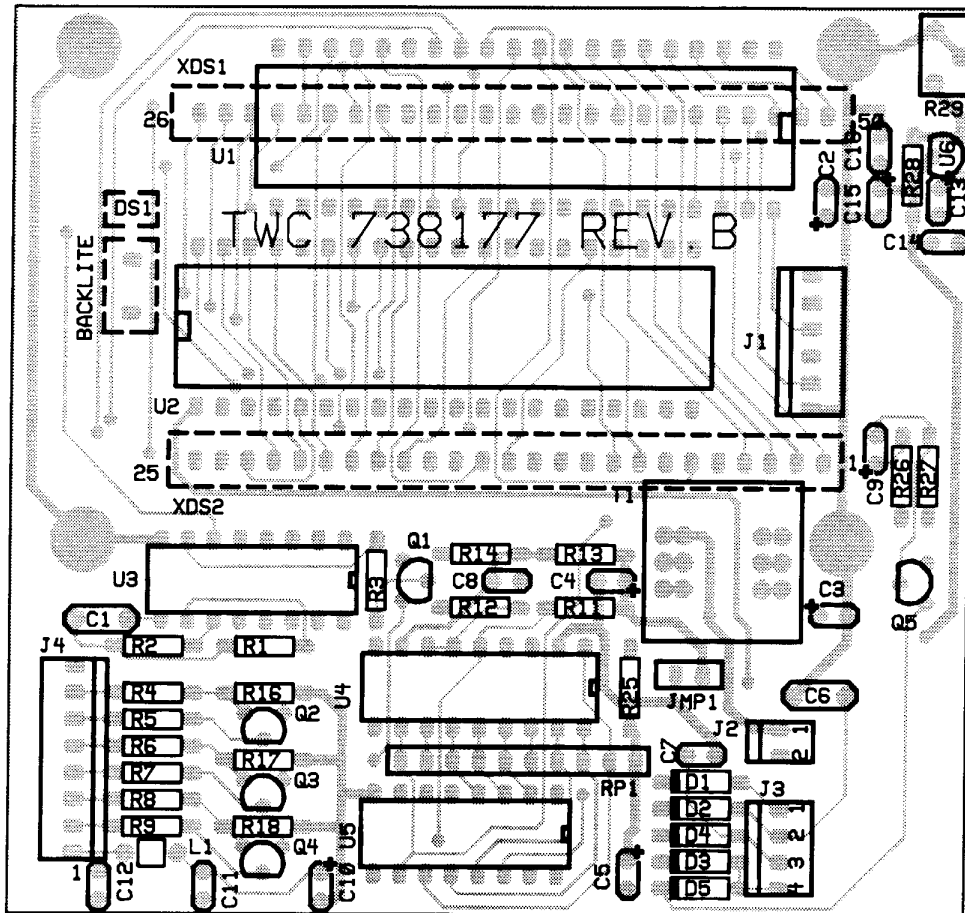
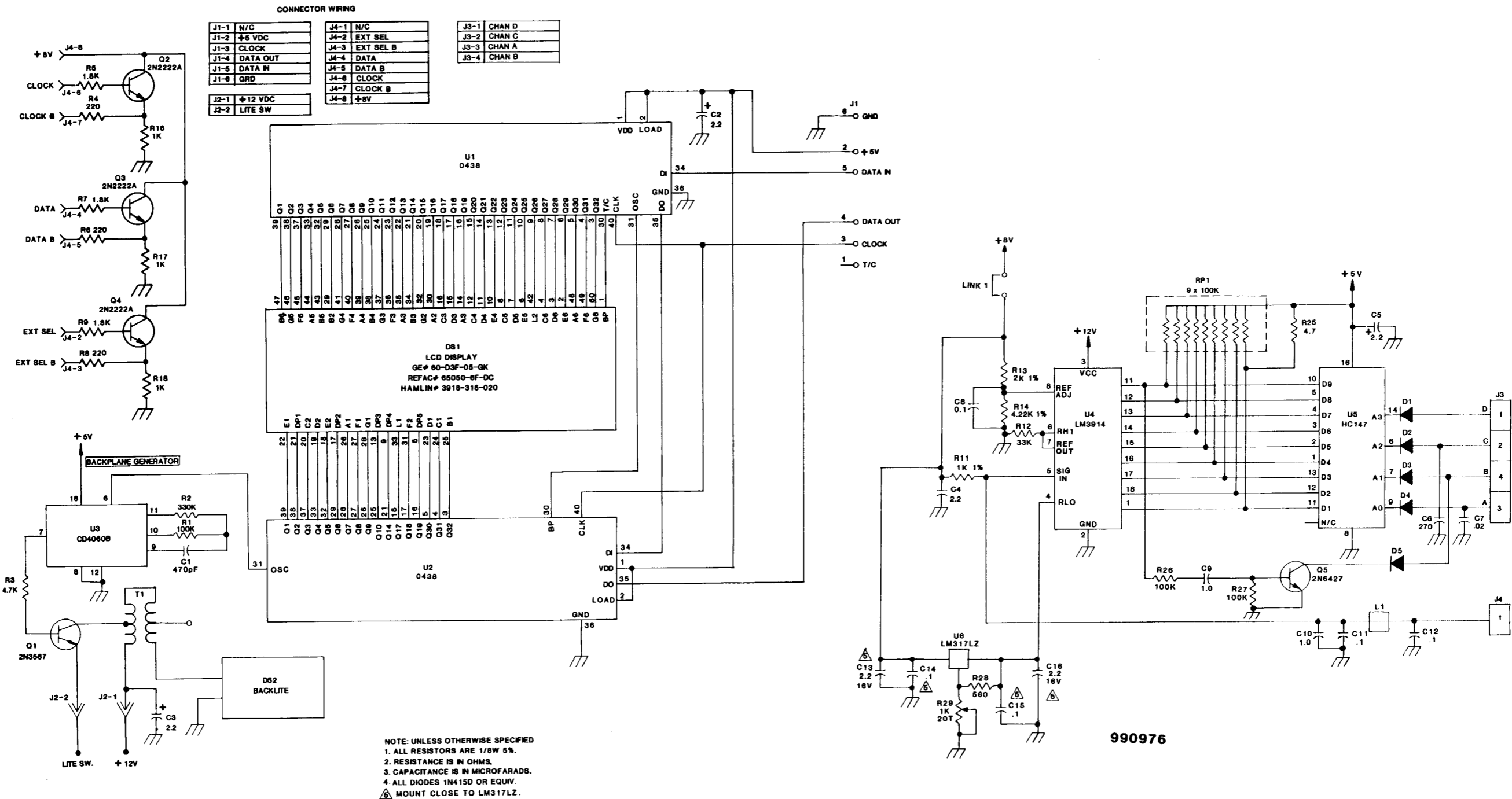


FIGURE 11-1.  
Component Locations, Display Module, M8.



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FIGURE 11-2.  
Schematic Diagram, Display Module, M8.

**TABLE 11-2.  
Parts List, Display Module, M8.**

C1	210471	Capacitor, Disc NPO 500 V 470 pF
C2,C3	241020	Capacitor, Tantalum 2.2 $\mu$ F
C4,C5	241020	Capacitor, Tantalum 2.2 $\mu$ F
C6	210271	Capacitor, Disc NPO 270 pF
C7	254203	Capacitor, Mylar 0.02 $\mu$ F
C8	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C9,C10	241010	Capacitor, Tantalum 1.0 $\mu$ F
C11,C12	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C13	241020	Capacitor, Tantalum 2.2 $\mu$ F
C14,C15	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C16	241020	Capacitor, Tantalum 2.2 $\mu$ F
D1-D5	320002	Diode, 1N4148
DS1	320802	LCD ,6 digit
DS2	392001	Display, luminescent
L1	459032	Inductor, Ferrite 3 turns
Q1	310003	Transistor, NPN 2N3567
Q2-Q4	310057	Transistor, NPN PN2222A
Q5	310064	Transistor, NPN Darlington 2N6427
R1	113104	Resistor, Film 1/8 W 5% 100 $k\Omega$
R2	113334	Resistor, Film 1/8 W 5% 330 $k\Omega$
R3	113472	Resistor, Film 1/8 W 5% 4.7 $k\Omega$
R4	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R5	113182	Resistor, Film 1/8 W 5% 1.8 $k\Omega$
R6	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R7	113182	Resistor, Film 1/8 W 5% 1.8 $k\Omega$
R8	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R9	113182	Resistor, Film 1/8 W 5% 1.8 $k\Omega$
R10		Not Used.
R11	1111001	Resistor, Metal Film 1/8 W 1% 1 $k\Omega$
R12	113333	Resistor, Film 1/8 W 5% 33 $k\Omega$
R13	1112001	Resistor, Film 1/8 W 1% 2 $k\Omega$
R14	1114221	Resistor, Film 1/8 W 1% 4.22 $k\Omega$
R15		Not Used.
R16-R18	113102	Resistor, Film 1/8 W 5% 1 $k\Omega$
R19-R24		Not Used.
R25	113472	Resistor, Film 1/8 W 5% 4.7 $k\Omega$
R26,R27	113104	Resistor, Film 1/8 W 5% 100 $k\Omega$
R28	113561	Resistor, Film 1/8 W 5% 560 $\Omega$
R29	170224	Resistor, Variable 1 $k\Omega$
RP1	182002	Resistor Pak, 100 $k\Omega$
U1,U2	330360	IC, LCD Display Driver
U3	330037	IC, CD 4060 BE
U4*	330055	IC, LM3914N
U5*	330345	IC, MC74HC147
U6	330343	IC, LM317LZ
T1	410019	Transformer, 600- $\Omega$ line to 600- $\Omega$ line

\* Parts fitted when RCH Remote Control Handset option installed.



## CHAPTER 12 CHASSIS/MAINFRAME

### 12-1 GENERAL

This chapter contains information on the mainframe components not covered elsewhere, as well as an overall wiring diagram of the transceiver. Figure 12-1 shows a

top view of the module locations; Figure 12-2 shows the bottom view. The mainframe schematic is depicted in Figure 12-3 and the parts are specified in Table 12-1.

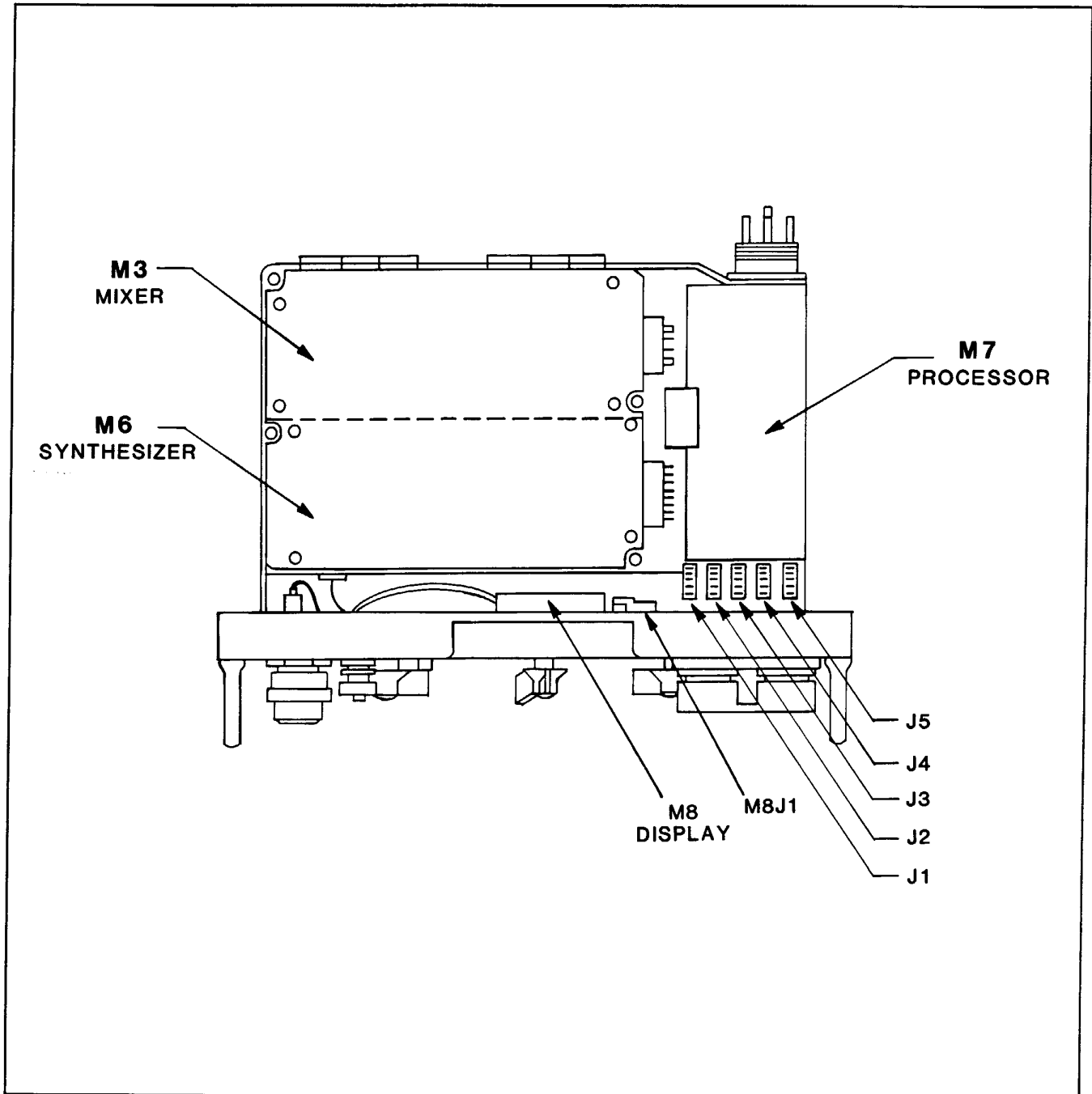
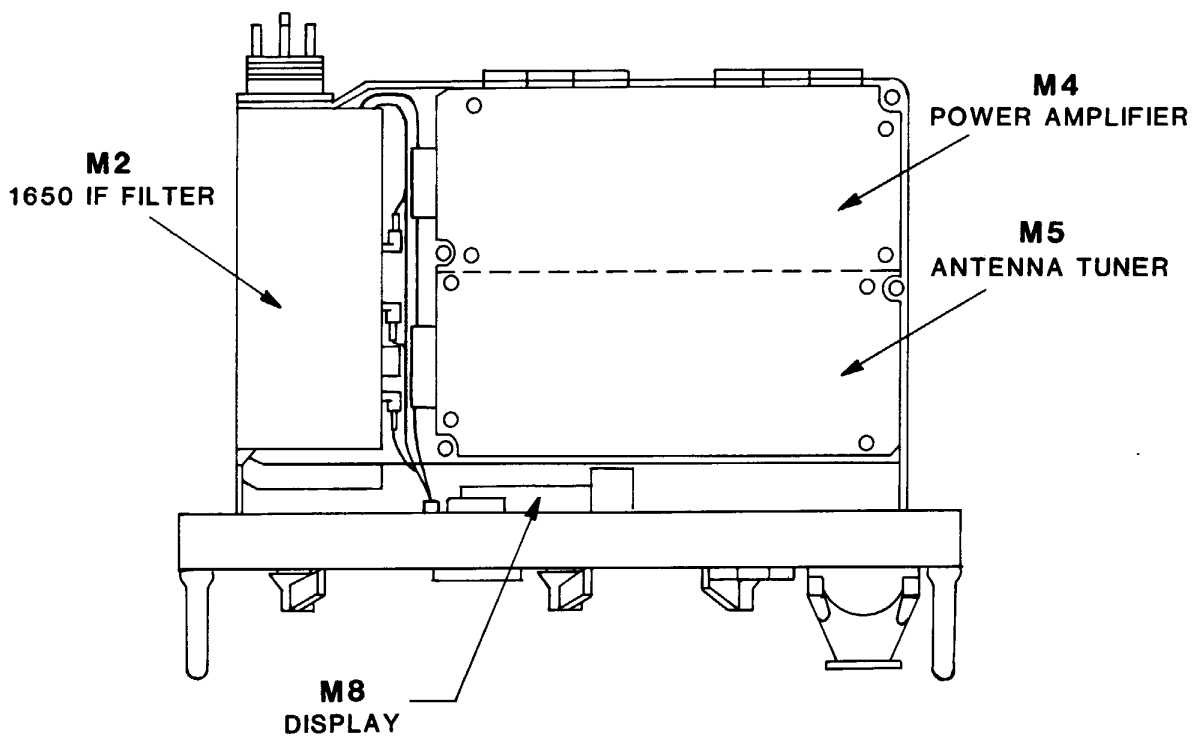
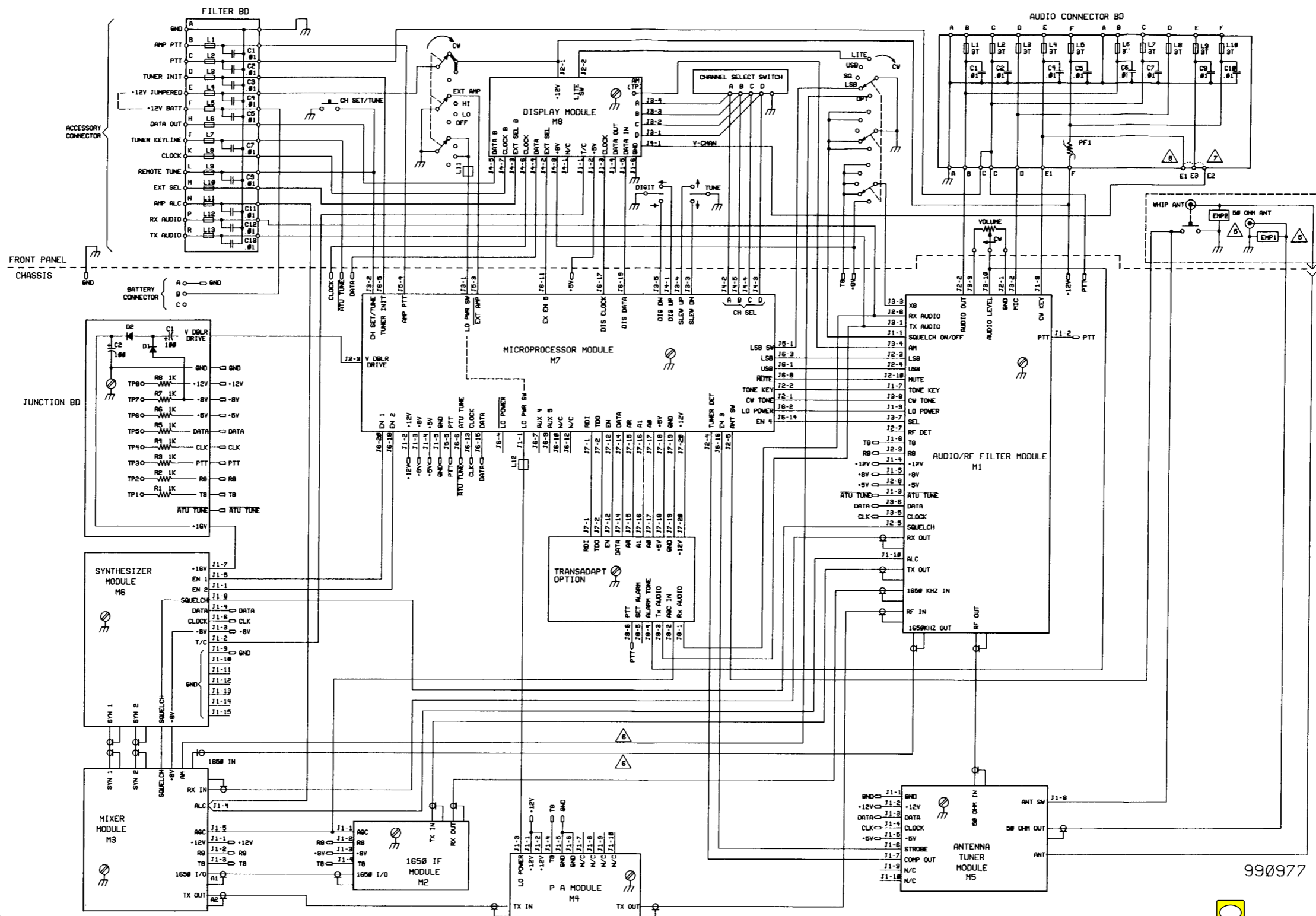


FIGURE 12-1.  
Module Locations, Top View.



**FIGURE 12-2.**  
**Module Locations, Bottom View.**



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- ▲ STANDARD RADIO ONLY - REMOVED FOR OPTIONS
  - ▲ 1099RCH OPTION ONLY
  - ▲ 1099-AHE OPTION ONLY
  - ▲ 1099A NEMP PROTECTION TUBES
  - 4. DIODES ARE 1N4148/1N4150.
  - 3. CAPACITANCE IS IN MICROFARADS.
  - 2. RESISTANCE IS IN OHMS.
  - 1. RESISTORS ARE 1/8W, 5%
- NOTES: UNLESS OTHERWISE SPECIFIED

FIGURE 12-3. Schematic Diagram, Mainframe.

**TABLE 12-1.  
Parts List, Mainframe.**

<b>Filter Board</b>		
C1-C5	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C6		Not Used
C7	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C8		Not Used
C9	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C10		Not Used
C11-C13	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
L1-L13	490201	Bead, Ferrite
<b>Junction Board</b>		
C1,C2	236101	Capacitor, Electrolytic 25 V 100 $\mu$ F
D1,D2	320002	Diode, 1N4148
R1-R8	113102	Resistor, Film 1/8 W 5% 1 k $\Omega$
<b>Audio Connector Board</b>		
C1,C2	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C3		Not Used.
C4-C7	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C8		Not Used.
C9,C10	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
L1-L10	459032	Inductor, Ferrite 3 turns
TH1	350111	Thermistor, 5 $\Omega$ 25 $^{\circ}$ C
<b>Front Panel</b>		
EMP1*	320505	EMP, Surge Protector
EMP2*	320506	SVP, Surge Protector
R1	170015	Resistor, Potentiometer 10 k $\Omega$
SW1	510028	Switch, Channel Select
SW2	530025	Switch, Channel Set/Tune
SW3	532005	Switch, Whip Antenna
SW4	510029	Switch, Digit
SW5	510029	Switch, Tune
SW6	510061	Switch, Mode
SW7	510060	Switch, Power
<b>Harness</b>		
L11	490201	Bead, Ferrite
* PRC1099A Option.		

## CHAPTER 13 TRANSCEIVER INTERNAL OPTIONS

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### 13-0 INTRODUCTION

This section covers optional internal features that can be added to the transceiver at the customer's request. These optional features are listed below.

<u>SECTION</u>	<u>INTERNAL OPTION</u>	<u>DESIGNATION</u>
13-1	Remote-Control Handset	RCH
13-2	High-Stability Option	HS
13-3	Amplitude Modulation Equivalent	AME
13-4	TransAdapt	TRANSADAPT
13-5	Internal Battery Charger	IBC

## 13-1 REMOTE CONTROL HANDSET

### 13-1.1 GENERAL DESCRIPTION

The PRC1099-RCH Remote Handset Option allows the operator to adjust the handset volume and change channels in the radio with controls located on the handset itself. For proper operation, the remote handset must be connected to the right handset connector and the radio channel selector must be in MANUAL. To operate the radio locally simply put the remote channel selector to the "C" or "1/C" position.

### 13-1.2 CIRCUIT DESCRIPTION

Refer to Figure 11-2, page 11-3 for a schematic diagram of the circuit. Channel changes from the optional remote-control handset are decoded by U4 and U5. The channels are switched by means of a resistive divider running off of 8.0 Vdc. The top leg of the divider is R11 on the M8. The bottom legs are in the remote handset and are selected by the handset channel knob. Each of the bottom legs applies a different voltage to the U5-pin 5 input. Inside the U4, this voltage is compared to a reference voltage which is run down a 10-step voltage divider. Each step has its own comparator which is turned on (output low) when the channel voltage is within that comparator window. The reference voltage is derived from the precision 8.0-Vdc line, a reference voltage source in U4, R13 and R14.

Resistor pack RP1 is used as pull-ups for the open-collector outputs of U4. These outputs are fed to U5, a CMOS decimal-to-BCD decoder. The four BCD outputs are connected to the channel-select lines of the microprocessor via four isolation diodes. Capacitors have been shunted across two of these BCD outputs to lengthen the time during which there is a change in the output. This ensures proper reading of the channel change by the microprocessor.

## 13-2 PRC1099-HS HIGH-STABILITY REFERENCE OPTION

### 13-2.1 GENERAL

The PRC1099-HS option increases the frequency stability of the 5120-kHz reference oscillator in the PRC1099 HF manpack transceiver. It is required when the transmission of data is anticipated or when extra frequency stability is desired.

### 13-2.2 TECHNICAL DESCRIPTION

When the PRC1099-HS option is installed, the standard 5120-kHz oscillator (Q1 and the associated components shown in Figure 9-6) are not installed. In place of these components, a Temperature-Controlled Crystal Oscillator (TCXO) is installed in the M6 synthesizer module. The TCXO has a complete temperature-controlled oscillator circuit inside and is powered from the 5-volt supply. The 5-volt supply to the TCXO must be 5 volts  $\pm$  0.10 and is adjusted by R20. The TCXO has a frequency stability of 1 part per million (ppm) and has an aging characteristic of 1 ppm per year.

## 13-2.3 MAINTENANCE

To adjust for the effects of long-term aging, the TCXO is equipped with an internal adjustment which allows for TCXO output frequency adjustment. Adjustment of the TCXO frequency will not normally be necessary in the life of the equipment.

## 13-3 AMPLITUDE MODULATION (AME) OPTION

### 13-3.1 GENERAL DESCRIPTION

The standard PRC1099 is a single-sideband transmitter and uses special circuitry to suppress the carrier and one sideband of a normal AM signal. Being a single-sideband transmitter, the standard PRC1099 is unable to communicate with normal AM radios. The PRC1099AME—Amplitude Modulation Equivalent Option—allows the PRC1099 to communicate with both single-sideband radios as well as AM radios. For operation in AME mode, simply select OPT (option) with the mode selector switch.

### 13-3.2 CIRCUIT DESCRIPTION

Refer to Figure 6-4, page 6-7 for a schematic diagram of the option circuitry. The purpose of this circuit is to inject a 1650-kHz signal from the carrier oscillator directly into the transmit chain at the highest possible level. This is necessary as the carrier level should not be controlled by the ALC circuit, and it is not desirable to pass the carrier through the crystal filter. The carrier is applied to the input of the mixer U1 via the PIN diode attenuator D9/D10. In the off position, D10 is forward biased, which shorts the carrier to ground. D9 is reverse biased. This gives approximately 60 dB of attenuation. When the carrier switch is grounded, D9 is forward biased, and D10 is reverse biased, and the carrier is not attenuated. The carrier level is adjusted by the input potentiometer R73.

## 13-4 TRANSADAPT OPTION

### 13-4.1 TRANSADAPT OPTION FUNCTIONAL DESCRIPTION

The TRANSADAPT option is an advanced selective-calling option for the PRC1099 that is fully compatible with the older TW100/RT100 Selcall/Transcall option. The main difference between TRANSADAPT and Transcall is that the TRANSADAPT system is looking for the first available channel that is clear enough for normal voice-grade communications. This is different from the Transcall method of evaluating all channels, and then selecting the best one. The TRANSADAPT system is approximately 5 times faster than the Transcall system. This means significantly decreased acquisition time and lower current drain for a TRANSADAPT system.

In Mode 1, the transmitting station is stationary on a single channel and can call another station which is either stationary or in a scan mode. In Mode 2, the transmitting station and the receiving station are both scanning, and the transmitting station can call the receiving station in any of the scan channels.

## DEFINITIONS:

### Receive Scan

Receive scan is a fast scan in which the radio is listening for the acquisition call from the transmitting station. Receive scan will remain on each channel for 1 second.

### Acquisition Call

Acquisition call is the call that the transmitting station makes to establish contact with the receiving station.

### Selcall RX Code

The Selcall RX code is a three-digit number entered into the Transadapt board at the factory. This code identifies each radio with its own individual receiver number (001-255). When a station wishes to establish communications with another station, the receiving station's Selcall code must be entered into the transmitting station's radio. In this manner the receiving station only replies to transmissions intended for that station. Refer to Table 13-1 for receive-code switch settings. If the transmitting station wishes to call all the stations, a Selcall code of 000 must be entered as the Selcall number.

## 13-4.2 OPERATION

### Scan Limit Entry Mode

The scan is enabled by switching the channel selector to position 9 and selecting the number of scan channels. To enter the Scan Limit Entry Mode, hold the digit-select paddle up until "SL: X" is displayed. Once the one-digit scan number is displayed, it may be changed using the tune paddle—up for increase, down for decrease. The number displayed will be the number of the channels scanned. For example, if the scan number is 4, then channels 1 to 4 are scanned. Setting the display to "SL: OFF" will turn the scan mode off and regain full use of channel 9 as a regular memory channel. To exit the Scan Limit Entry Mode, release the digit-select paddle.

### Selcall Code Entry Mode

To call a particular station, the transmitting station must know the Selcall code of the station to be called. This code must be entered so that it can be transmitted with the acquisition call. To enter the Selcall Code Entry Mode, hold the digit-select paddle down until "SC: XXX" is displayed. Once the three-digit code is displayed, it may be changed using the tune paddle—up for increase, down for decrease. To exit the Selcall Code Entry Mode, release the digit-select paddle.

Entering the SC code 000 will initiate an "allcall." This will cause a call alarm to sound at any Transadapt station receiving this call. For stations that are in receive scan, this will cause them to go into scan hold and remain on the calling channel for 2 minutes. The scan hold may be terminated at any time by holding the WHIP-TUNE button down for 1 second.

### TRANSADAPT Mode 1 (Selcall Compatible)

To initiate a Mode-1 (Selcall-compatible) calling sequence, in any channel other than channel 9, hold the digit-select paddle down and push the WHIP-TUNE button. The transmitter will then transmit 60 acquisition packets that include the Selcall code entered into memory. If an acknowledgment is received, a fast call alarm will be heard in the handset, signalling communications are established. If no acknowledgment is received, a slow error alarm will be heard in the handset. The calling sequence may be terminated at any time by holding the WHIP-TUNE button down for 1 second.

### TRANSADAPT Mode 2 (Transcall Compatible)

To initiate a Mode-2 (Transcall-compatible) calling sequence on channel 9, hold the digit-select paddle down and push the WHIP-TUNE button. The transmitter will automatically transmit acquisition packets that include the Selcall code entered into memory. The receiver will first listen to ensure the channel is free of excessive noise or other transmissions. In the first part of the call sequence, the transmitter will transmit 2 acquisition packets on each of the scan channels and it will do this on all the scan channels twice. In the second part of the call sequence, the transmitter will send 15 calls on each of the scan channels. If communications are established, then a fast call alarm will be heard in the handset and the radio will go into scan hold and remain on the calling channel for 2 minutes. The 2-minute scan hold will be restarted after each transmission on the calling channel. The scan hold may be terminated at any time by holding the WHIP-TUNE button down for 1 second.

If communications are not established in one complete calling sequence, then a slow error alarm will sound and the radio will return to receiver scan at the original channel. The calling sequence may be terminated at any time by holding the WHIP-TUNE button down for 1 second.

### BIT Error Rate (BER) Entry Mode

To enter the Bit Error Rate Entry Mode, hold the digit-select paddle down until "SC: XXX" is displayed. Simultaneously hold the WHIP-TUNE button down until the "bEr XX" is displayed. Once the two-digit BER number is displayed, it may be changed using the tune paddle—up for increase, down for decrease. The number displayed is the minimum number of bits the TRANSADAPT system will have to receive from another station to determine that a channel is good enough for voice-quality communications. There are a maximum of 80 bits and through field tests it has been determined that 70 acceptable bits out of 80 denotes a channel that is good enough for normal voice-quality communications. This number can be permanently changed if your particular application requires a lesser or better quality channel for communications. To exit the Bit Error Rate Entry Mode, release the WHIP-TUNE button.

### 13-4.3 BLOCK DIAGRAM

A block diagram of the TRANSADAPT board is shown in Figure 13-1. This board contains the receive-code switches along with the modem, filter and decoder circuits.

### 13-4.4 CIRCUIT DESCRIPTION

Refer to Figure 13-3, page 13-11 for the TRANSADAPT schematic diagram. The 1-of-8 decoder U1 decodes the incoming data and address lines to enable the appropriate functions with a logic level 1 output. Once enabled, the data selector U2 will output the receive-code information contained in switch S1 back to the processor. These switch setting determine the receive code for this particular radio.

The PRC1099 TRANSADAPT board utilizes a 300-baud modem, U3, which is compatible with BELL 103 specifications. This modem provides a 300-baud FSK signal for bidirectional transmission between stations. With a transmit-enable signal from U1, U3 translates the incoming transmit data out (TDO) signal into an FSK signal which is amplified to the proper level by Q5 and Q6, and then applied to the transmitter. During receive, the receive audio is applied to the modem, U3, which will translate the FSK signal into data that can be understood by the processor. Q4 and its associated circuitry make up an oscillator used as an alarm-tone generator. The output from Q4 is applied to the audio circuitry so it can be heard by the operator.

### 13-4.5 M2 MODULE MODIFICATIONS

The M2 module is modified when the TRANSADAPT option is installed. These modifications are described below.

1. Remove R19 and C13.
2. Install a 4.7- $\mu$ F tantalum capacitor (P/N 241040) in place of C13.
3. Install a 22-gauge jumper wire in place of R19.

## 13-5 INTERNAL BATTERY CHARGER OPTION

### 13-5.1 GENERAL

The PRC1099 has an internal battery charger which can be used to charge an attached battery from an external power source. The charger is designed to take a 12- to 30-Vdc input and provide a constant current 400-mA output to charge a battery to 13.6 Vdc.

### 13-5.2 OPERATION

A wiring diagram showing the charger connections to the radio is given in Figure 13-3. The following steps must be followed to charge a battery:

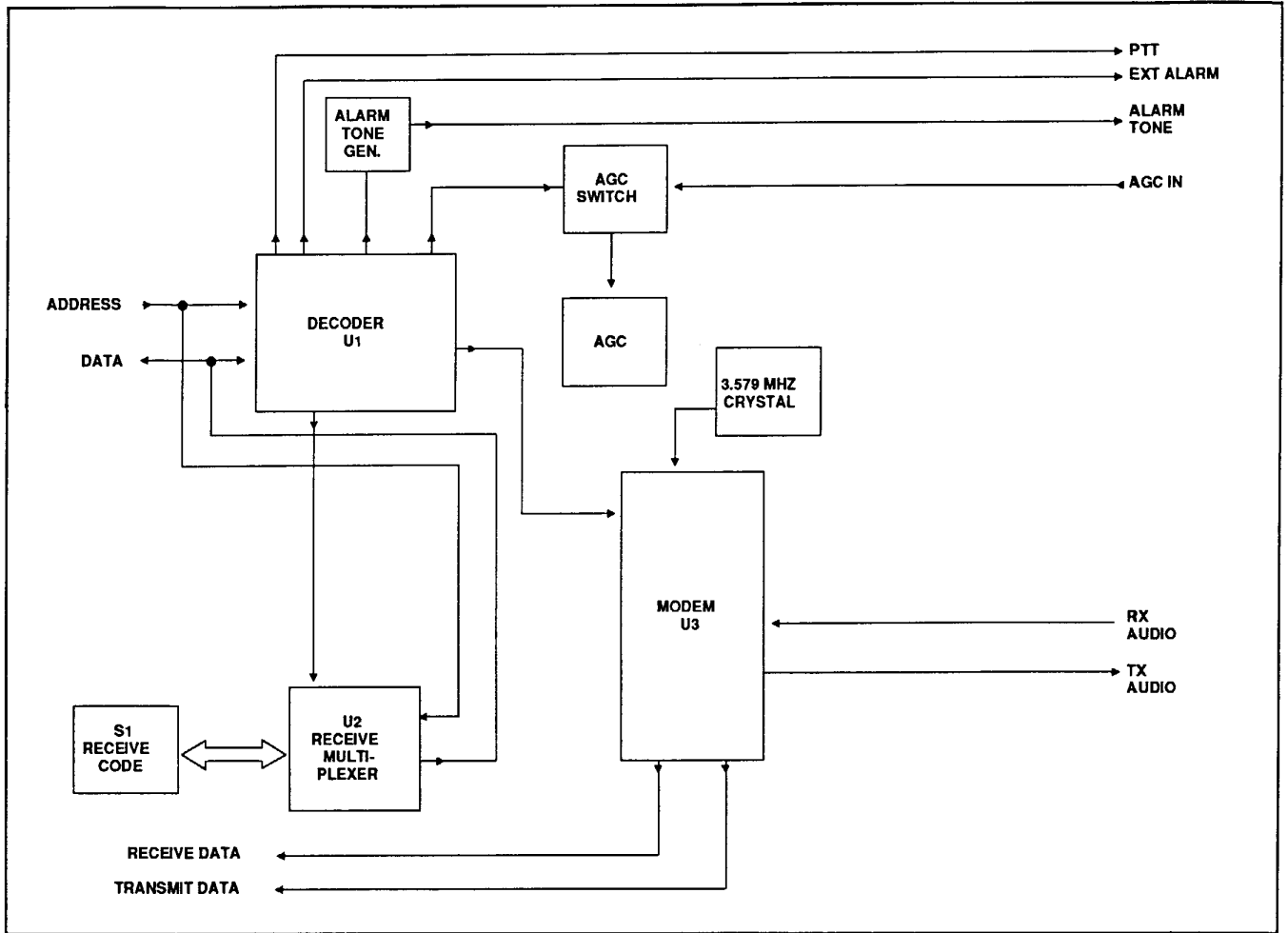
1. The battery must be in the PRC1099 battery box and the box must be attached to the transceiver.
2. A 12- to 30-Vdc power source must be attached to the transceiver accessory connector.
3. The moment the external power source is connected, the timer circuit in the charger automatically resets and the charger is programmed to run for approximately 14 hours.
4. Removing the external power source deactivates the charger.

### 13-5.3 MAINTENANCE

The charger is physically located inside the M4 module in the PRC1099. To access the charger, the M4 top cover must be removed and turned over to expose the charger circuitry which is contained on a PCB mounted to the underside of the cover. Connections to the charger are made through M4J1-7,8 (input voltage) and M4J1-9,10 (output voltage to battery). Inside the module, the wires are routed from the M4J1 connector to the charger PCB J2 connector.

The charger consists of three separate circuits—a timer, current limiter, and buck-boost regulator. These circuits are shown in Figure 13-4 and are all mounted on the same PCB. Table 13-4 is a parts list for the charger.





**FIGURE 13-1.**  
**Block Diagram, TRANSADAPT Option.**

**TABLE 13-1.  
Selcall Conversion Chart.**

<u>TX CODE</u>	<u>RX SWITCHES ON</u>	<u>TX CODE</u>	<u>RX SWITCHES ON</u>
001	2345678	053	2 4 78
002	1 345678	054	1 4 78
003	345678	055	4 78
004	12 45678	056	123 78
005	2 45678	057	23 78
006	1 45678	058	1 3 78
007	45678	059	3 78
008	123 5678	060	12 78
009	23 5678	061	2 78
010	1 3 5678	062	1 78
011	3 5678	063	78
012	12 5678	064	123456 8
013	2 5678	065	23456 8
014	1 5678	066	1 3456 8
015	5678	067	3456 8
016	1234 678	068	12 456 8
017	234 678	069	2 456 8
018	1 34 678	070	1 456 8
019	34 678	071	456 8
020	12 4 678	072	123 56 8
021	2 4 678	073	23 56 8
022	1 4 678	074	1 3 56 8
023	4 678	075	3 56 8
024	123 678	076	12 56 8
025	23 678	077	2 56 8
026	1 3 678	078	1 56 8
027	3 678	079	56 8
028	12 678	080	1234 6 8
029	2 678	081	234 6 8
030	1 678	082	1 34 6 8
031	678	083	34 6 8
032	12345 78	084	12 4 6 8
033	2345 78	085	2 4 6 8
034	1 345 78	086	1 4 6 8
035	345 78	087	4 6 8
036	12 45 78	088	123 6 8
037	2 45 78	089	23 6 8
038	1 45 78	090	1 3 6 8
039	45 78	091	3 6 8
040	123 5 78	092	12 6 8
041	23 5 78	093	2 6 8
042	1 3 5 78	094	1 6 8
043	3 5 78	095	6 8
044	12 5 78	096	12345 8
045	2 5 78	097	2345 8
046	1 5 78	098	1 345 8
047	5 78	099	345 8
048	1234 78	100	12 45 8
049	234 78	101	2 45 8
050	1 34 78	102	1 45 8
051	34 78	103	45 8
052	12 4 78	104	123 5 8

**TABLE 13-1.  
Selcall Conversion Chart, Continued.**

<u>TX CODE</u>	<u>RX SWITCHES ON</u>	<u>TX CODE</u>	<u>RX SWITCHES ON</u>
105	23 5 8	156	12 67
106	1 3 5 8	157	2 67
107	3 5 8	158	1 67
108	12 5 8	159	67
109	2 5 8	160	12345 7
110	1 5 8	161	2345 7
111	5 8	162	1 345 7
112	1234 8	163	345 7
113	234 8	164	12 45 7
114	1 34 8	165	2 45 7
115	34 8	166	1 45 7
116	12 4 8	167	45 7
117	2 4 8	168	123 5 7
118	1 4 8	169	23 5 7
119	4 8	170	1 3 5 7
120	123 8	171	3 5 7
121	23 8	172	12 5 7
122	1 3 8	173	2 5 7
123	3 8	174	1 5 7
124	12 8	175	5 7
125	2 8	176	1234 7
126	1 8	177	234 7
127	8	178	1 34 7
128	1234567	179	34 7
129	234567	180	12 4 7
130	1 34567	181	2 4 7
131	34567	182	1 4 7
132	12 4567	183	4 7
133	2 4567	184	123 7
134	1 4567	185	23 7
135	4567	186	1 3 7
136	123 567	187	3 7
137	23 567	188	12 7
138	1 3 567	189	2 7
139	3 567	190	1 7
140	12 567	191	7
141	2 567	192	123456
142	1 567	193	23456
143	567	194	1 3456
144	1234 67	195	3456
145	234 67	196	12 456
146	1 34 67	197	2 456
147	34 67	198	1 456
148	12 4 67	199	456
149	2 4 67	200	123 56
150	1 4 67	201	23 56
151	4 67	202	1 3 56
152	123 67	203	3 56
153	23 67	204	12 56
154	1 3 67	205	2 56
155	3 67	206	1 56

TABLE 13-1.  
Selcall Conversion Chart, Continued.

<u>TX CODE</u>	<u>RX SWITCHES ON</u>	<u>TX CODE</u>	<u>RX SWITCHES ON</u>
207	56	232	123 5
208	1234 6	233	23 5
209	234 6	234	1 3 5
210	1 34 6	235	3 5
211	34 6	236	12 5
212	12 4 6	237	2 5
213	2 4 6	238	1 5
214	1 4 6	239	5
215	4 6	240	1234
216	123 6	241	234
217	23 6	242	1 34
218	1 3 6	243	34
219	3 6	244	12 4
220	12 6	245	2 4
221	2 6	246	1 4
222	1 6	247	4
223	6	248	123
224	12345	249	23
225	2345	250	1 3
226	1 345	251	3
227	345	252	12
228	12 45	253	2
229	2 45	254	1
230	1 45	255	
231	45		

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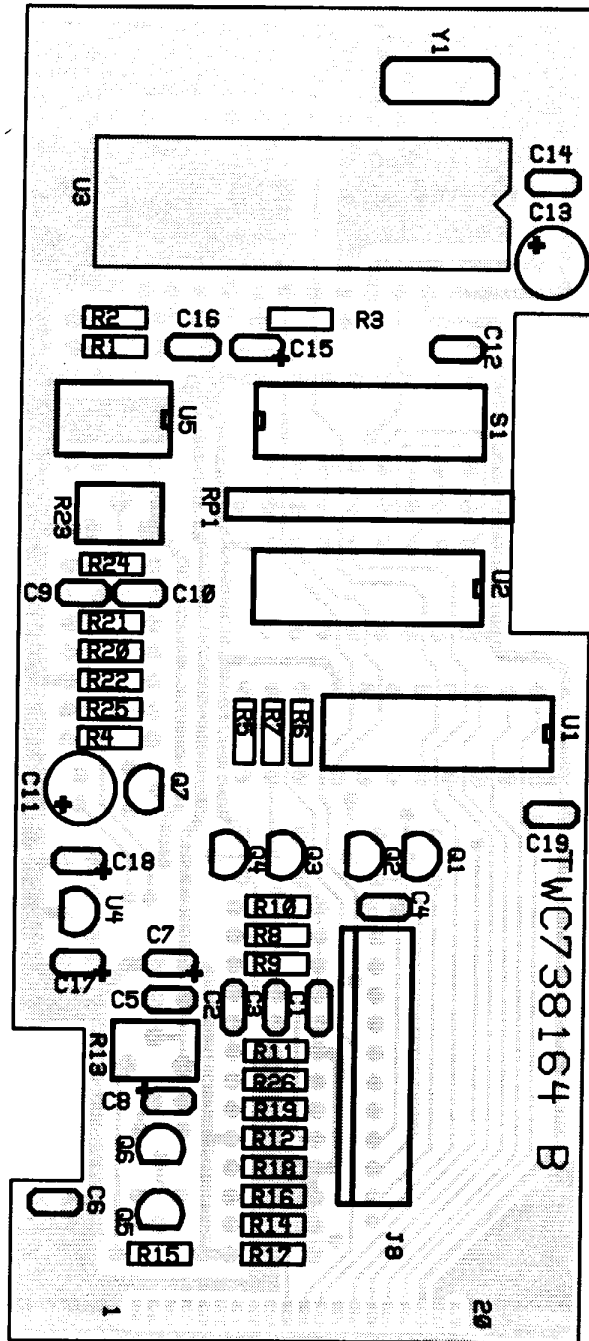
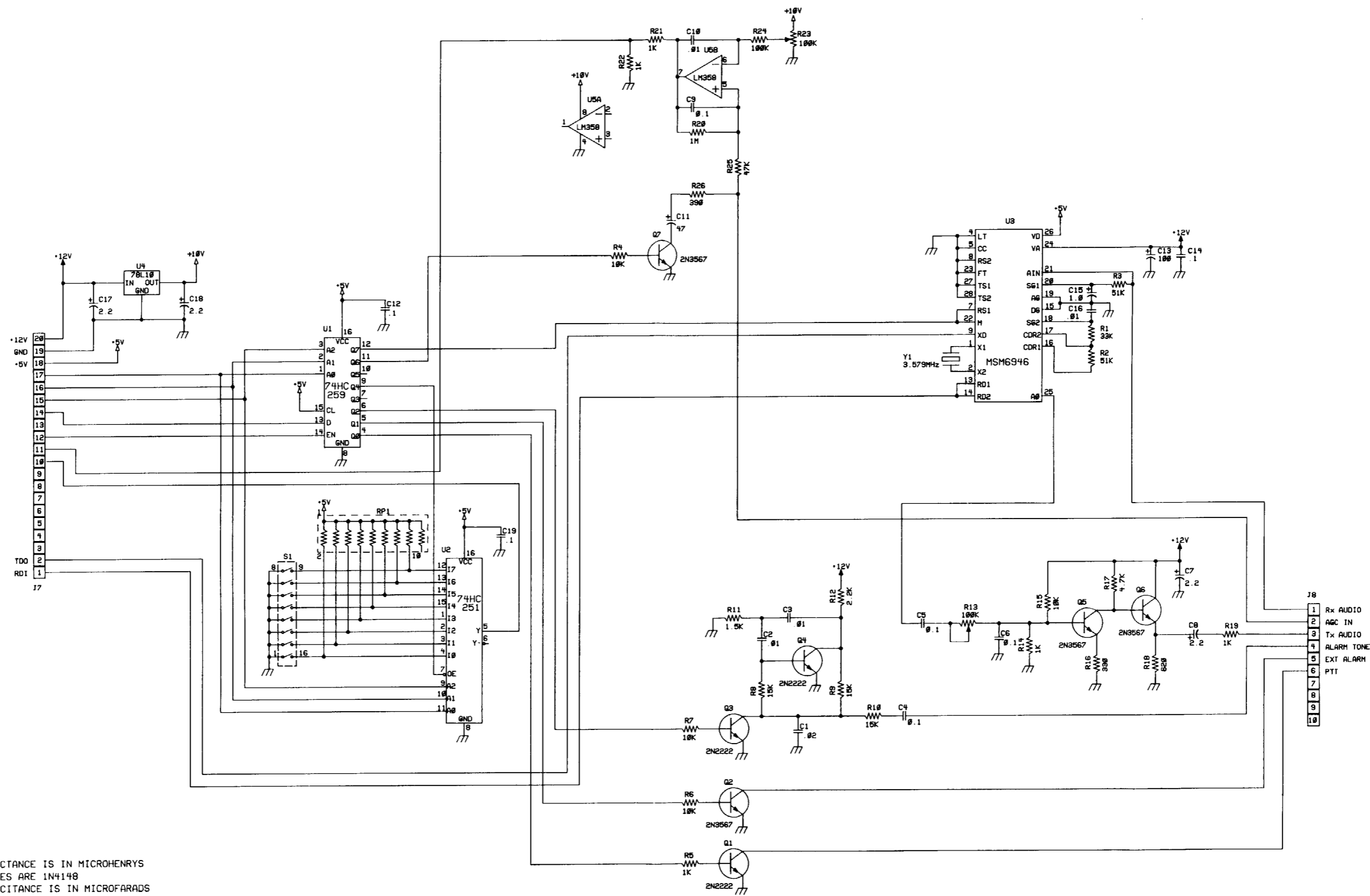


FIGURE 13-2.  
Component Locations, TRANSADAPT Option.



4 INDUCTANCE IS IN MICROHENRYS  
 3 DIODES ARE 1N4148  
 2 CAPACITANCE IS IN MICROFARADS  
 1 RESISTANCE IS IN OHMS  
 NOTES: UNLESS OTHERWISE SPECIFIED

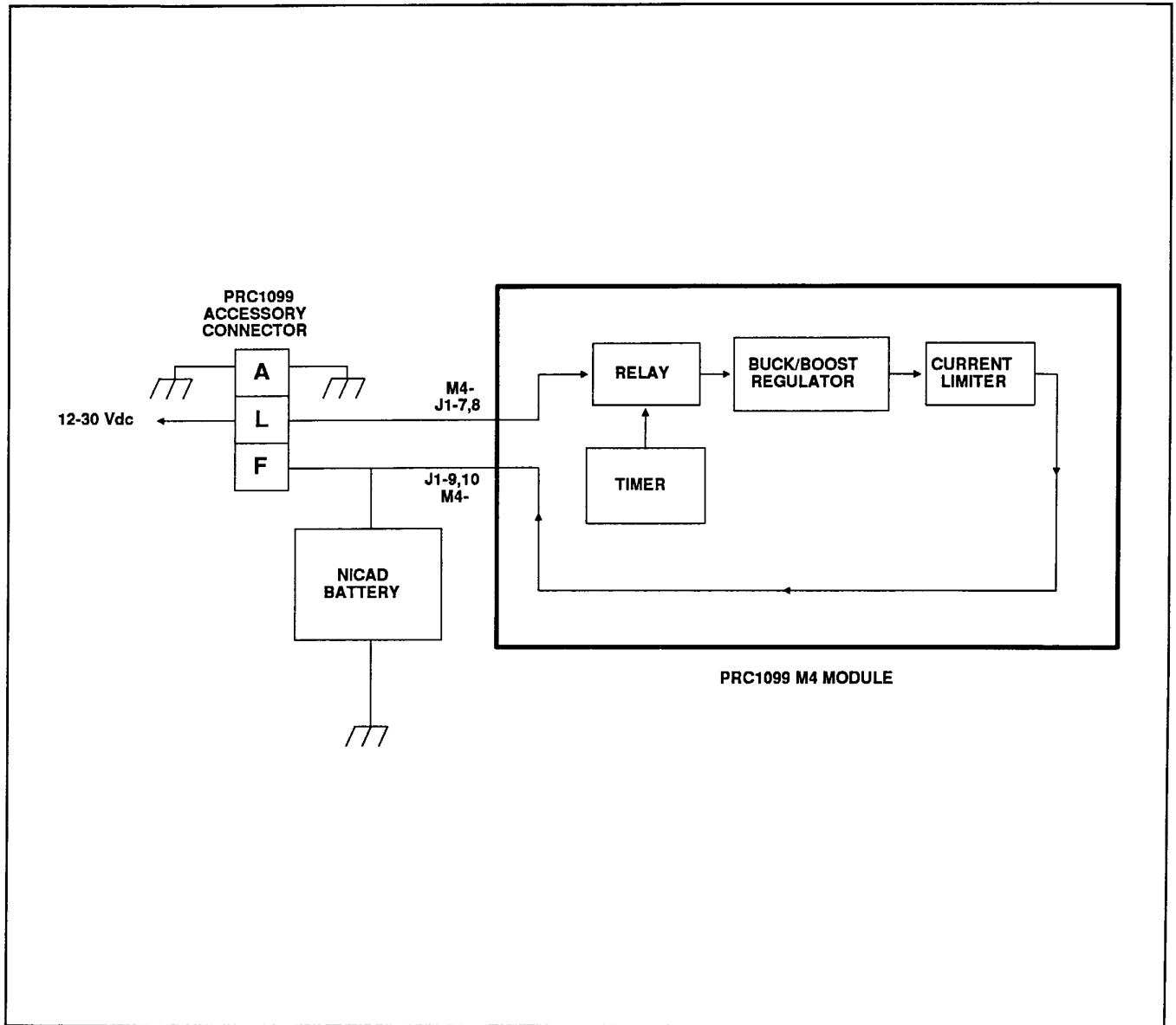
FIGURE 13-3.  
 Schematic Diagram, TRANSADAPT Option.

**TABLE 13-2.**  
**Parts List, TRANSADAPT Option.**

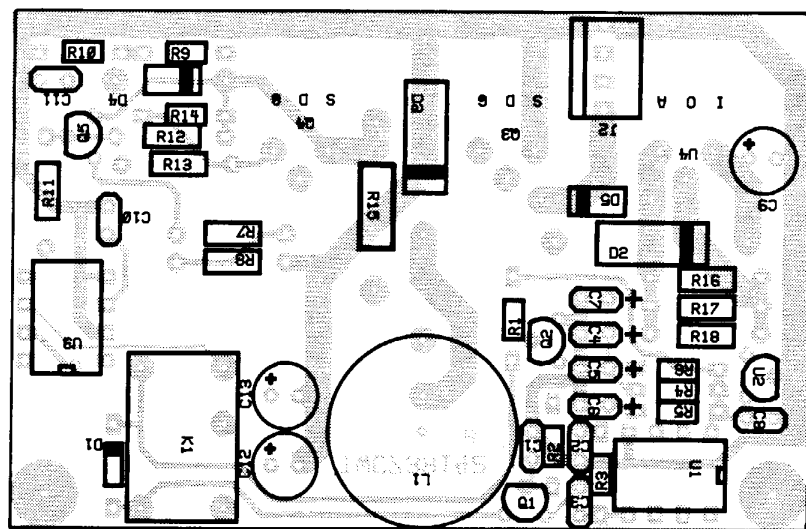
C1	254203	Capacitor, Mylar 0.02 $\mu$ F
C2,C3	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C4-C6	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C7,C8	241020	Capacitor, Tantalum 2.2 $\mu$ F
C9	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C10	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C11	237470	Capacitor, Electrolytic 16 V 47 $\mu$ F
C12	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C13	237101	Capacitor, Electrolytic 16 V 100 $\mu$ F
C14	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C15	241010	Capacitor, Tantalum 1.0 $\mu$ F
C16	214103	Capacitor, Monolithic 50 V 0.01 $\mu$ F
C17,C18	241020	Capacitor, Tantalum 2.2 $\mu$ F
C19	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
J7	614029	Connector, Header 20-pin
J8	610208	Connector, Right Angle 10-pin
Q1	310057	Transistor, NPN PN2222A
Q2	310003	Transistor, NPN 2N3567
Q3,Q4	310057	Transistor, NPN PN2222A
R1	113333	Resistor, Carbon Film 1/8 W 5% 33 k $\Omega$
R2,R3	113513	Resistor, Carbon Film 1/8 W 5% 51 k $\Omega$
R4	113103	Resistor, Carbon Film 1/8 W 5% 10 k $\Omega$
R5	113102	Resistor, Carbon Film 1/8 W 5% 1 k $\Omega$
R6,R7	113103	Resistor, Carbon Film 1/8 W 5% 10 k $\Omega$
R8-R10	113153	Resistor, Carbon Film 1/8 W 5% 15 k $\Omega$
R11	113152	Resistor, Carbon Film 1/8 W 5% 1.5 k $\Omega$
R12	113222	Resistor, Carbon Film 1/8 W 5% 2.2 k $\Omega$
R13	170225	Resistor, Variable 100 k $\Omega$
R14	113102	Resistor, Carbon Film 1/8 W 5% 1 k $\Omega$
R15	113103	Resistor, Carbon Film 1/8 W 5% 10 k $\Omega$
R16	113331	Resistor, Carbon Film 1/8 W 5% 330 $\Omega$
R17	113472	Resistor, Carbon Film 1/8 W 5% 4.7 k $\Omega$
R18	113621	Resistor, Carbon Film 1/8 W 5% 620 $\Omega$
R19	113102	Resistor, Carbon Film 1/8 W 5% 1 k $\Omega$
R20	113105	Resistor, Carbon Film 1/8 W 5% 1 M $\Omega$
R21,R22	113102	Resistor, Carbon Film 1/8 W 5% 1 k $\Omega$
R23	170225	Resistor, Variable 100 k $\Omega$
R24	113104	Resistor, Carbon Film 1/8 W 5% 100 k $\Omega$
R25	113473	Resistor, Carbon Film 1/8 W 5% 47 k $\Omega$
R26	113391	Resistor, Carbon Film 1/8 W 5% 390 $\Omega$
RP1	182002	Resistor Pak 9X 100 k $\Omega$
S1	530010	Switch, SPST
U1	330348	IC, 74HC259N
U2	330349	IC, 74HC251N
U3	330369	IC, MSM6946RS
U4	330300	IC, UA78L10CLP
U5	330081	IC, LM358N
Y1	361081	Crystal, 3.579545



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**FIGURE 13-4.**  
**Wiring Diagram, Internal Battery Charger Option.**



**FIGURE 13-5.**  
**Component Locations, Internal Battery Charger Option.**

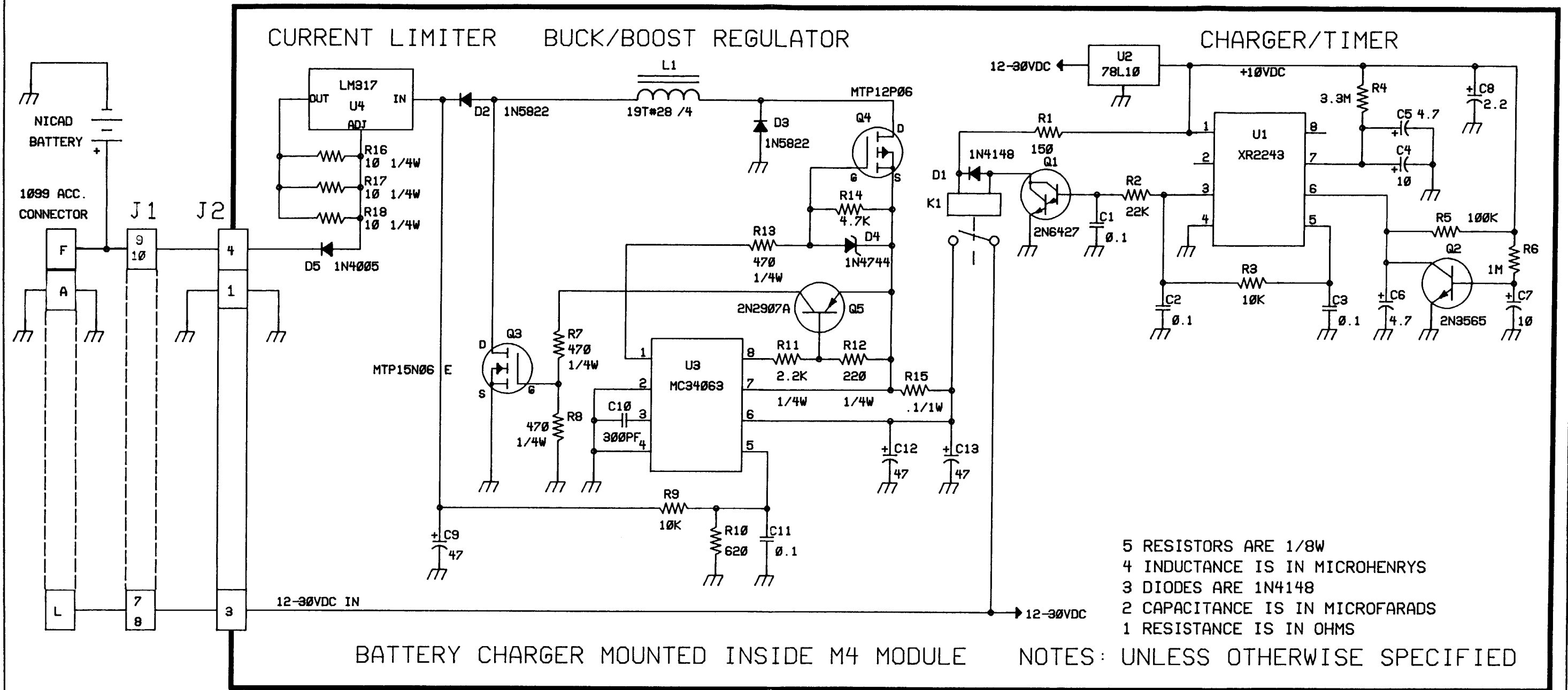


FIGURE 13-6.  
Schematic Diagram, Internal Battery Charger Option.

**TABLE 13-3.**  
**Parts List, Internal Battery Charger.**

C1-C3	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C4	241100	Capacitor, Tantalum 10 $\mu$ F
C5,C6	241040	Capacitor, Tantalum 35 V 4.7 $\mu$ F
C7	241100	Capacitor, Tantalum 10 $\mu$ F
C8	241020	Capacitor, Tantalum 2.2 $\mu$ F
C9	234470	Capacitor, Electrolytic 35 V 47 $\mu$ F
C10	221301	Capacitor, Mica 300 pF
C11	275104	Capacitor, Monolithic 50 V 0.1 $\mu$ F
C12,C13	234470	Capacitor, Electrolytic 35 V 47 $\mu$ F
D1	320002	Diode, 1N4148
D2,D3	320420	Diode, Schottky 1N5822
D4	320205	Diode, Zener 1N4744
D5	320101	Diode, 1N4005
K1	540060	Relay, SPDT 9 Vdc
L1	459158	Inductor, Toroid 19 turns
Q1	310064	Transistor, NPN Darlington 2N6427
Q2	310006	Transistor, NPN 2N3565
Q3	310127	Transistor, NCH MTP15N06E
Q4	310128	Transistor, PCH MTP12P06
Q5	310052	Transistor, PNP PN2907A
R1	113151	Resistor, Film 1/8 W 5% 150 $\Omega$
R2	113223	Resistor, Film 1/8 W 5% 22 k $\Omega$
R3	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R4	113335	Resistor, Film 1/8 W 5% 3.3 M $\Omega$
R5	113104	Resistor, Film 1/8 W 5% 100 k $\Omega$
R6	113105	Resistor, Film 1/8 W 5% 1 M $\Omega$
R7,R8	124471	Resistor, Film 1/4 W 5% 470 $\Omega$
R9	113103	Resistor, Film 1/8 W 5% 10 k $\Omega$
R10	113621	Resistor, Film 1/8 W 5% 620 $\Omega$
R11	124222	Resistor, Film 1/4 W 5% 2.2 k $\Omega$
R12	113221	Resistor, Film 1/8 W 5% 220 $\Omega$
R14	113472	Resistor, Film 1/8 W 5% 4.7 k $\Omega$
R15	144001	Resistor, Film 1 W 5% 0.1 $\Omega$
R16-R18	124100	Resistor, Film 1/4 W 5% 10 $\Omega$
U1	330347	IC, XR2243
U2	330300	IC, UA78L10CLP
U3	330191	IC, MC34063PI
U4	330340	IC, LM317T

# APPENDIX A

## A-1 GENERAL

A basic knowledge of the techniques used in the synthesizer design is necessary for both understanding and troubleshooting these circuits. The transceiver has two completely independent synthesizers, one providing the 76.6 to 104.99-MHz signal for the First Local oscillator and the other providing the 73.3401 to 73.350-MHz signal for the Second Local oscillator. The heart of both synthesizers is a phase-locked loop; a brief analysis of phase-locked loops is given in this section. Another important concept used in the design of the synthesizer is dual-modulus prescaling. The knowledge of this concept is important not only in the understanding of the synthesizer design, but also in the programming of the transceiver radio frequencies.

This section includes a block diagram of the overall synthesizer. The description of the block diagram is shown in relation to the techniques of the phase-locked loop and dual-modulus prescaling in order to give a better understanding of the operation of the synthesizer. An example illustrating the frequency programming of each synthesizer loop demonstrates the mathematical algorithms used and their relationship to the overall frequency conversion scheme.

Also shown in this section is a description of the frequency scheme used in the transceiver. Numerical examples are provided to clearly illustrate this approach. The overall frequency stability of the transceiver is also discussed, and an equation is developed which shows how the stability criterion is established.

## A-2 BLOCK DIAGRAM DESCRIPTION

A block diagram of the synthesizer is shown in Figure A-1. It is composed of two completely independent single-loop digital synthesizers. The 10-kHz Loop uses a VCO phase-locked to a 10-kHz reference frequency. This choice of reference frequency enables using a loop bandwidth high enough for good stability and switching speed, and also low enough for good reference spurious suppression. The 10-kHz Loop is a single-loop synthesizer using no mixing or multiplication, and as such has excellent spectral purity. The 100-Hz Loop uses a VCXO phase-locked to a 100-Hz reference frequency. The very stable crystal oscillator is "pulled" over a 10-kHz range using the 100-Hz PLL. Because of the inherent stability and purity of crystal oscillators, the 100-Hz Loop provides an exceptionally good I.O. signal for the Second Mixers.

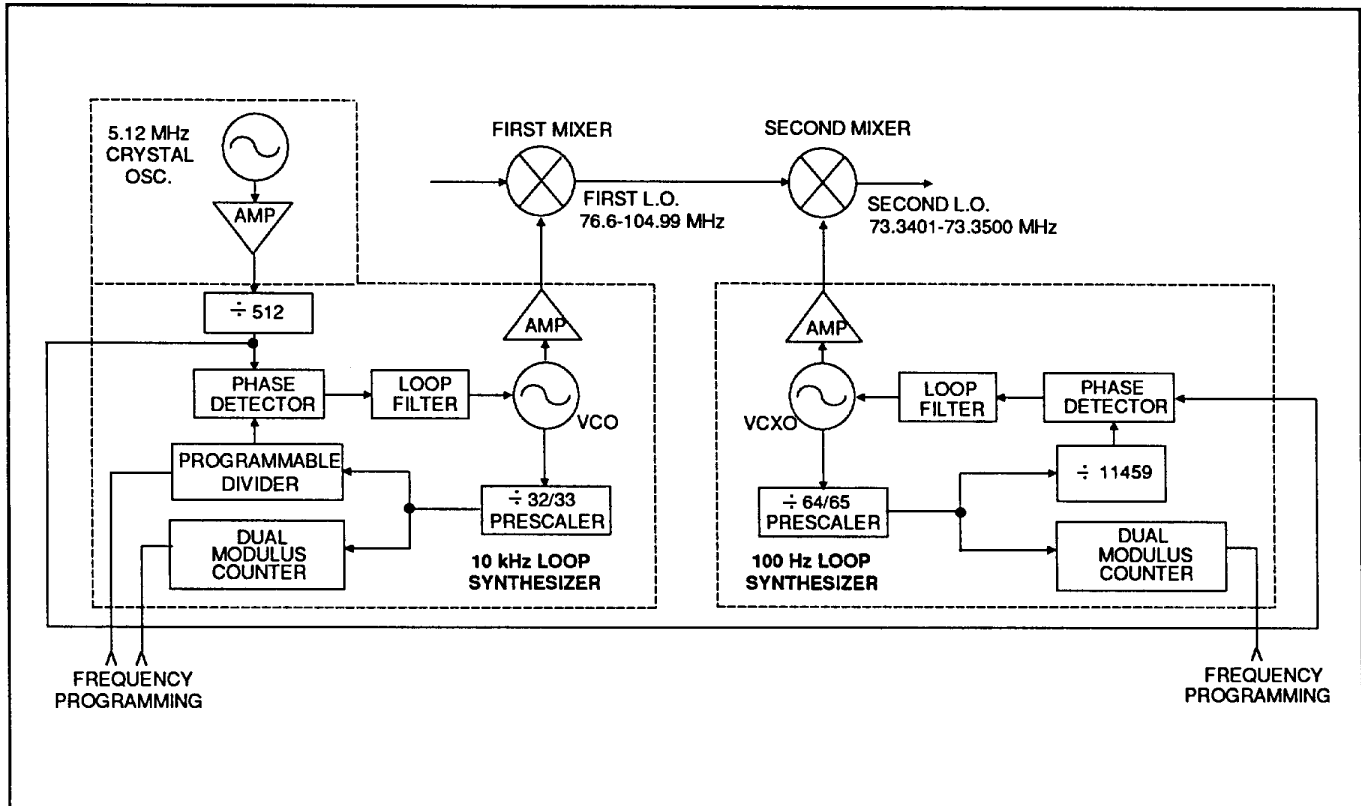


FIGURE A-1.  
Synthesizer Block Diagram.

### A-3 PHASE-LOCKED LOOPS

The heart of each synthesizer is the phase-locked loop (PLL), a simplified diagram of which is depicted in Figure A-2. Referring to this diagram, it is seen that a PLL consists of the following basic elements:

1. A Voltage Controlled Oscillator (VCO).
2. A Phase Detector.
3. A Divider; either fixed (+M) or Variable (+N).
4. A Loop Filter.

The purpose of a PLL is to provide a VCO, which operating alone might be unstable, with the stability and accuracy of a single, highly stable reference frequency. The inputs to the phase detector are a reference frequency (generally a very stable temperature-controlled crystal oscillator), and the VCO output frequency divided by the integers  $N \times M$ . The phase detector dc output controls the VCO frequency, and under proper PLL conditions, will change the VCO frequency (divided by  $M \times N$ ) to equal the reference frequency. The +M is generally a fixed divider called a prescaler, whose purpose is to reduce a high VCO frequency to a lower level that can be handled by standard programmable logic system.

The +N can be either a fixed or a variable divider. When N is variable, it can be programmed externally to change the VCO frequency in discrete steps. The phase detector will electronically tune the VCO each time N is changed

to bring the output of the divider to the same frequency and phase as that of the reference. The loop is locked when  $F_{out} = NMF_{ref}$ .

Once the loop is locked, operation proceeds as follows: If the output frequency increases, the frequency out of the divider will exceed  $F_{ref}$  and the phase detector will react by trying to drive the VCO frequency lower. The tuning voltage to the VCO will decrease as a result and the output frequency will decrease, which counters the initial frequency increase. The loop filter is present to suppress undesired components produced in the phase detector so they don't cause unacceptable FM on the VCO. The loop filter also has an important effect on other types of noise, on acquisition of lock, loop response time, and stability.

In a PLL synthesizer, the error signal driving the VCO changes value only once each reference period; the loop bandwidth, which determines response speed, is set to be approximately one-tenth the reference frequency. This is necessary for stability and for suppression of the reference frequency sidebands. The higher the reference frequency, the faster the loop response time; but the reference frequency also determines the minimum synthesizer channel spacing. For example, if the reference frequency is 10 kHz, the MINIMUM channel spacing is 10 kHz. If the fixed divider M in Figure A-2 is greater than one, the  $F_{out}$  can only be changed in steps of  $MF_{ref}$ . If M is made equal to one, then the channel spacing depends only on  $F_{ref}$ .

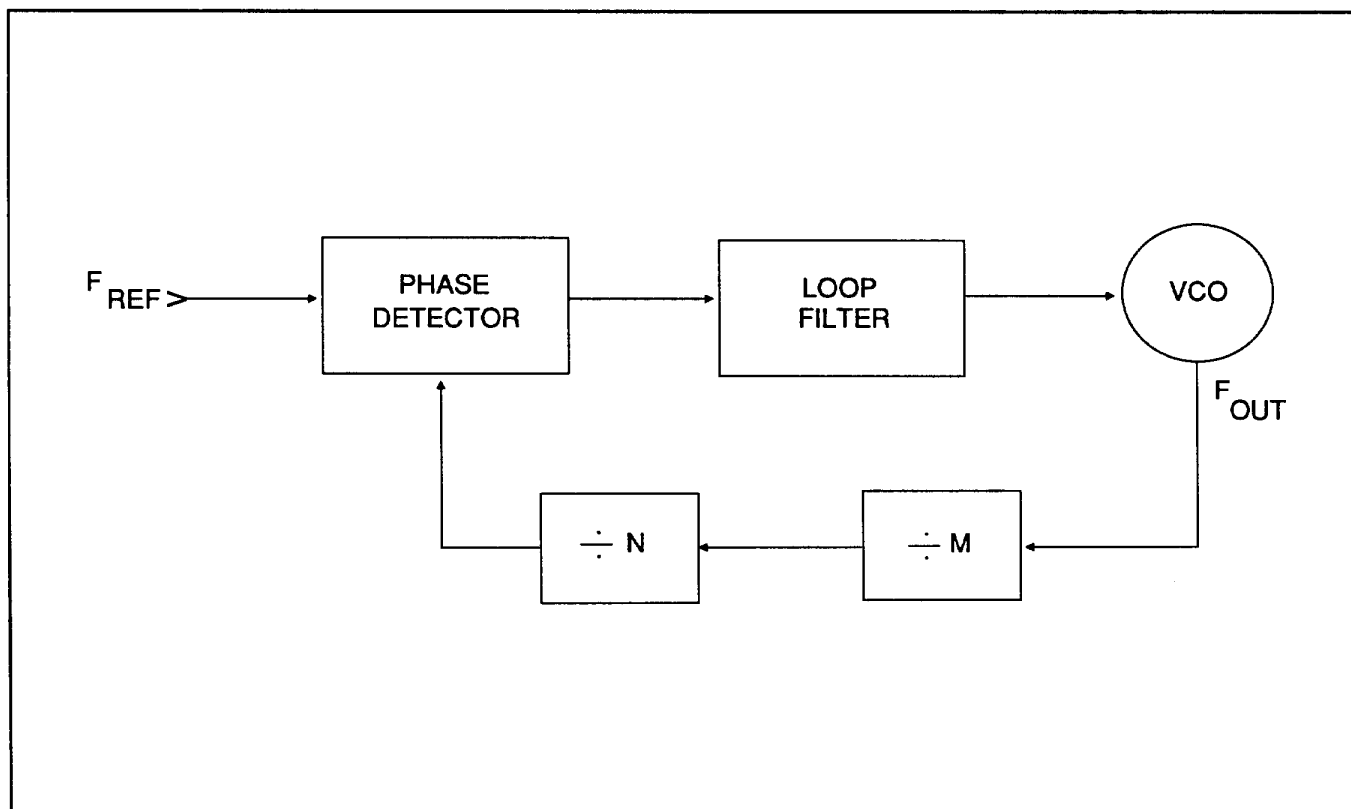


FIGURE A-2.  
Phase-Locked Loop.

In our case, the ultimate channel spacing is 100 Hz. But to make a single-loop synthesizer with a 100-Hz reference covering a 28-MHz range would place severe restrictions on loop response time as well as VCO stability. Thus, the transceiver uses two synthesizers: the 10-kHz Loop covering 76.6-104.99 MHz with 10-kHz channel spacing which provides a loop BW high enough for good response time and stability, and a 100-Hz Loop covering 10 kHz in 100-Hz steps using a high-stability crystal oscillator.

#### A-4 DUAL-MODULUS PRESCALING

CMOS dividers provide not only the lowest power approach, but also the best approach for spectral purity because of their switching response. However, CMOS dividers are restricted in operating speed to below 10 MHz for reliable operation.

With the 10-kHz Loop operating at 76.6-104.99 MHz, and the 100-Hz Loop at 73 MHz, it is clear that some form of prescaling (or +M) is required to reduce the VCO frequency to a level that can be handled by standard CMOS programmable dividers, and still the channel spacing needed for 10-MHz and 100-Hz loops.

The synthesizers solve this problem by using a technique known as dual-modulus prescaling. This approach allows low-frequency CMOS programmable counters to be used as high-frequency programmable counters with speeds of several hundred MHz. This is possible without the sacrifice in channel spacing and performance that would otherwise result if a fixed divider was used for the prescaler (-M). Prescalers are used whose division ratio can be switched between two values to allow effective division at the high prescaler input frequency (VCO output), with the actual programmable dividers operating at the lower output frequency of the prescaler.

Figure A-3 illustrates how a dual-modulus divider system operates. The VCO drives the dual-modulus prescaler (which can divide by P and P+1), which in turn drives two programmable counters in parallel. These two counters are programmed to "A" and "N". The prescaler and the A-counter are connected in such a way that in a complete count cycle, the prescaler divides by P+1 until the A-counter reaches zero and then reverts to a division ratio of P. Both the A-counter and the N-counter start counting at the same time. Therefore, the prescaler divides by P+1 for "A" counts and by P for "N-A" counts. For example, the programmed divide ratio  $N_T$  is:

Therefore, the overall divider system divides by P+1 for as long a count as the A-counter is programmed (A counts), and then divides by P for the remainder of the cycle (N-A counts). The only restriction on the scheme is that the total count cycle (N) be greater than A.

$$N_T = (N-A) P + A(P+1)$$

or

$$N_T = NP + A$$

For example, the 10-kHz Loop Synthesizer (as shown in Figure A-1) uses a +32/33 prescaler (an MC12015 rated at

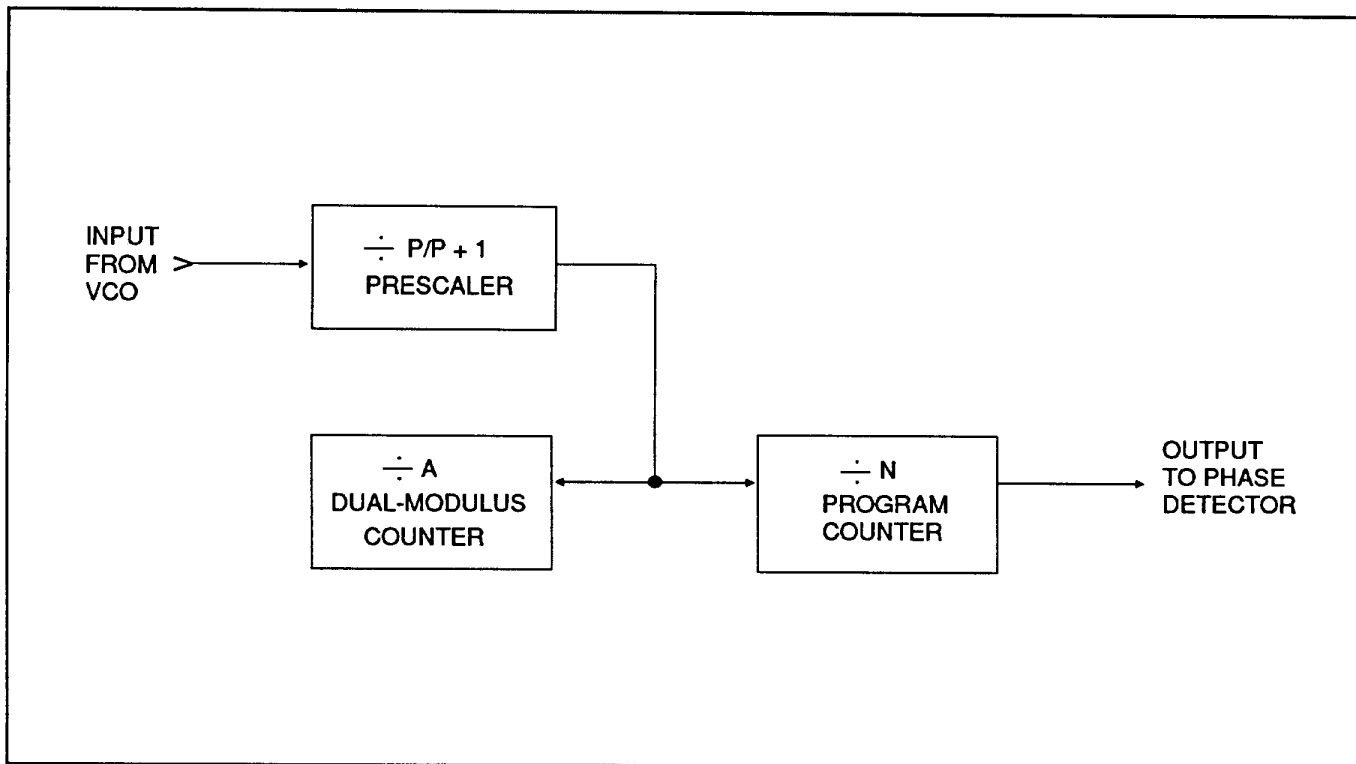


FIGURE A-3.  
Dual-Modulus Prescaler.



200 MHz). The highest VCO frequency is 105 MHz, which when divided by 32 equals 5—well below the 30-MHz MC145158 CMOS counting speed. If the selected channel frequency is 25 MHz, then the VCO frequency is  $25 + 75 = 100$  MHz. The total divide ratio is:  $N_T = F_{out} / F_{ref} = NP + A$ ; or  $N_T 100 \times 10^6 / 10^4 = NP + A$ . Therefore, the total division ratio is 10,000 and with  $P = 32$ , the equation is:

$$10,000 = 32N + A,$$

or  
 $N = 312$ , and  $A = 16$

Then 312 is the number programmed into the N-counter and 16 is the number programmed into the A-counter. The +32/33 prescaler then divides by 33 for 10 counts and 32 for 296 counts to account for the overall division ratio of 10,000.

$$33 \times 16 = 528$$

$$32 \times 296 = 9472$$

$$\therefore 528 + 9472 = 10,000$$

The 100-Hz Loop Synthesizer (Figure A-1) uses a +64/65 prescaler with a frequency limit of 200 MHz. The VCXO frequency is 73.3401-73.3500 MHz. Therefore, the output of the prescaler into the programmable divider is approximately 1 MHz. Since this loop has only 100 discrete frequencies (73.3401-73.350 MHz in 100-Hz steps) all the programming can be done in the dual-modulus counter (set for count from 1-100), while the +N programmable counter has a fixed division ratio of 11459. The total 100-Hz Loop divide ratio is:

$$N_T = 64N + A, \text{ or } N_T = 64 \times 11459 + A$$

which is:

$$N_T = 733376 + A$$

This means that the loop will divide by 65 for "A" counts, and then divide by 64 for (11459-A) counts.

#### A-5 FREQUENCY PROGRAMMING EXAMPLE

To illustrate the concept of dual-modulus prescaling used in the synthesizer, the following example is presented:

##### EXAMPLE:

Let the selected channel frequency be 9,124,200 Hz. The 10-kHz Loop programming then goes as follows:

1. The first L.O. output frequency is:  
 $09.12 + 75.00 = 84.12$  MHz
2. Using the formula developed earlier for the 10-kHz Loop:  
 $N_T = F_{out} / F_{ref} = 84,120,000 / 10,000 = 8412$

3. Therefore, the total division ratio for the 10-kHz Loop is  $N_T = 8412$ .

4. Since  $N_T = 32N + A$ , where "N" is the number programmed into the variable programmable counter, and "A" is the number programmed into the dual modulus counter then,

$$8142 = 32N + A$$

$$\therefore N = 8142 / 32 = 254$$

$$\text{Then, } A = 8142 - 254 \times 32 = 14$$

5. The total 10-kHz Loop counter cycle is then 254, with the loop dividing by 33 for 14 counts and by 32 for  $254 - 14 = 240$  counts. Thus,  $N_T = (33 \times 14 = 462) + (240 \times 32 = 7680) = 8142$ .

6. With the 10-kHz Loop at 84.12 MHz and the channel frequency at 9.1242 MHz, the First IF is 74.9958 MHz (or 4.2 kHz below the center of the 75-MHz IF filter passband). The Second L.O. is then:

$$\text{Second L.O.} = 74.9958 - 1.65 = 73.3458 \text{ MHz}$$

7. 100-Hz Loop programming is done by first looking at the 1-kHz and 100-Hz digits of the channel frequency (in this case, 9.1242 MHz).

- a. Let these two digits be EF. Then  $A = 124 - EF$ .
- b. In this case, the two digits are 42.  
Therefore,  $A = 124 - 42 = 82$ .

8. The dual-modulus frequency formula for the 100-Hz Loop is then applied:

$$N_T = 11459 \times 64 + A$$

$$N_T = 733376 + 82 = 733458$$

9. The output frequency is then  $F_{LO} = F_{ref} \times N$ , or  $F_{LO} = 733,458 \times 100 \text{ Hz} = 73.3458 \text{ MHz}$ , which corresponds with the frequency determined in part 6.

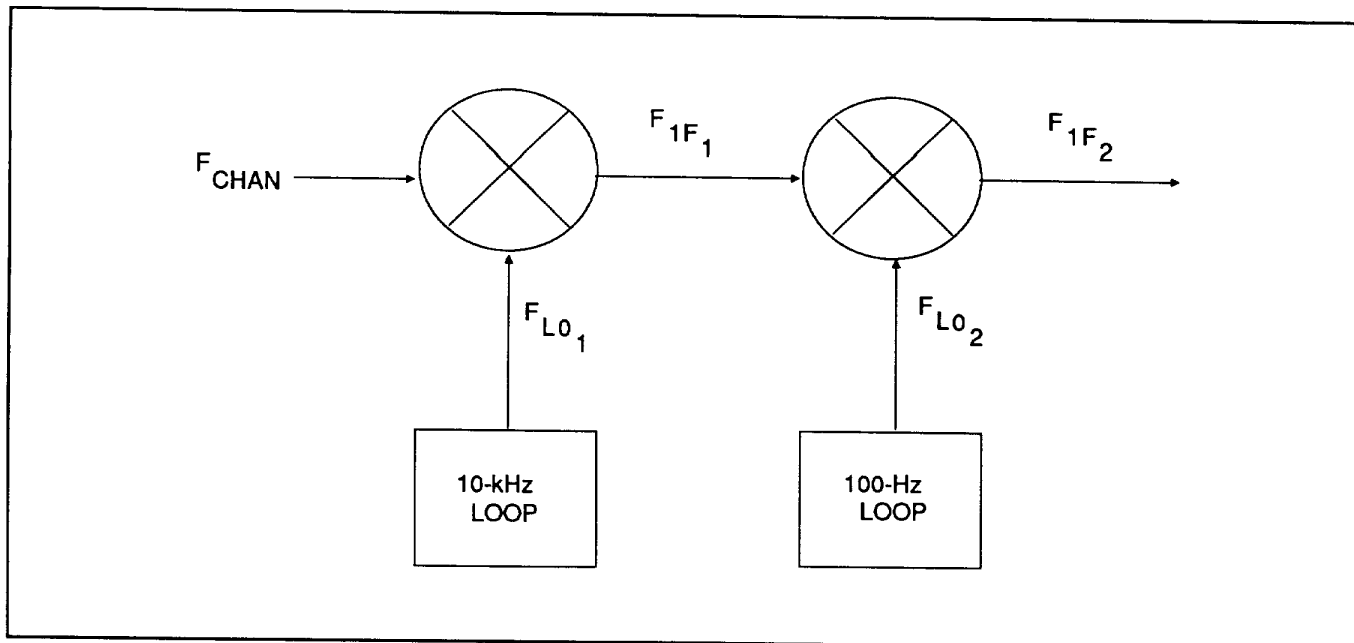
#### A-6 FREQUENCY CONVERSION SCHEME

This simplified diagram in Figure A-4 illustrates the overall frequency scheme.

Frequencies shown are as follows:

$F_{chan}$  = RF channel frequency of the radio; 1.600-29.9999 MHz, selectable in 100-Hz increments resulting in 284,000 available channels.

$F_{LO1}$  = Output of the 10-kHz Loop, a phase-locked loop (PLL) synthesizer generating a 76.60 to 104.99-MHz output in 10-kHz increments.



**FIGURE A-4.**  
Frequency Scheme.

F<sub>1F1</sub> = First IF; varies between 75.000 and 74.9901 MHz depending on the chosen channel frequency.

F<sub>LO2</sub> = Output of the 100-Hz Loop, a PLL synthesizer operating from 73.3401-73.350 MHz in the 100-Hz increments.

F<sub>1F2</sub> = Second IF; fixed at 1.65 MHz.

#### A-7 EXAMPLES OF OSCILLATOR FREQUENCIES

Table A-1 shows the oscillator injection frequencies for a few sample channel RF frequencies. Note that the first IF frequency is not fixed at 75.00 MHz but varies over a 10-kHz range depending on the selected channel frequency. This is accomplished as follows:

$$f_{LO1} = f_{chan} + 75.00 \text{ MHz}^*$$

1. The first IF is always:

$$F_{IF1} = F_{LO1} - f_{chan}$$

2. The second IF is always fixed at 1.65 MHz. Therefore, the second L.O. is:

$$F_{LO2} = F_{IF2} - 1.650 \text{ MHz}$$

#### \*NOTE

Only the first four digits of the channel frequency are used in determining F<sub>LO1</sub>.

#### EXAMPLE:

$f_{chan} = 2,000,000 \text{ Hz}$ , and

$f_{chan} = 2,005,900 \text{ Hz}$

Both result in  $F_{LO1} = 2.00 + 75.00 = 77.00 \text{ MHz}$  (remember that the first digit is always the 10-MHz digit; therefore, the first four digits of 2,000,000 Hz are 02.00).

#### A-8 FREQUENCY STABILITY

Since both local oscillators are locked to a single reference frequency, the frequency errors in the two oscillators due to a change in reference frequency will tend to cancel each other. Therefore, the overall radio frequency error due to a shift in the reference is proportional to the difference in the two L.O. frequencies. The following is the equation for overall system frequency shift due to a shift in the reference frequency:

$$f_{\text{system}} = \frac{F_{LO1} - F_{LO2}}{F_{\text{ref}}} (f_{\text{ref}})$$

where:

$f_{\text{system}}$  = System Frequency Shift

F<sub>LO1</sub> = first L.O.

F<sub>LO2</sub> = second L.O.

$f_{\text{ref}}$  = 5.120 MHz

$f_{\text{ref}}$  = drift in F<sub>ref</sub> from 5.120 MHz

The transceiver's reference oscillator uses a 5.120-MHz crystal oscillator. Stabilities in the order of ±5 ppm can be achieved in this fashion. This translates into a 25.6-Hz drift in reference frequency over the specified -30°C to +55°C temperature range. The total frequency drift of the radio is then:

At 2 MHz:

$$f_{\text{system}} = \frac{77 - 73.35}{5.12} \times 25.6 = 18.25 \text{ Hz}$$

At 30 MHz:

$$f_{\text{system}} = \frac{105 - 73.35}{5.12} \times 25.6 = 158.25 \text{ Hz}$$

**TABLE A-1.**  
**Example Frequencies.**

<b>Fchan</b>	<b>FLO1</b>	<b>FIF1</b>	<b>FLO2</b>	<b>FIF2</b>
2.0000	77.0000	75.0000	73.3500	1.6500
2.0001	77.0000	74.9999	73.3499	1.6500
2.0099	77.0000	75.9901	73.3401	1.6500
2.0100	77.0100	75.0000	73.3500	1.6500
3.0000	78.0000	75.0000	73.3500	1.6500
29.9999	104.9900	74.9901	73.3401	1.6500

**NOTE**

As F<sub>chan</sub> goes through 10-kHz (e.g. from 2.000-2.0099), F<sub>LO1</sub> remains the same frequency (77.0000 MHz), and F<sub>LO2</sub> makes one hundred 100-Hz steps (from 73.3500 to 73.3401).

## APPENDIX B OPTIONAL ACCESSORY EQUIPMENT

### B-1 General

This Appendix contains a list of optional accessory items for radio set PRC1099 in Table B-1. It also includes instructions for using the major accessory items with the PRC1099.

b. Description, column 2.

The item name and military part number (if used) are included in this column. Accessories are grouped in categories to assist in locating items of interest.

### B-2 Explanation of Columns

An explanation of columns in Table B-1 is given below.

c. Unit of issue, column 3.

The unit used as a basis of issue (e.g. ea, pr, ft, yd etc) is located in this column.

a. Stock number, column 1.

The manufacturer's stock number for the item is indicated in this column.

d. Quantity used in (or with) unit, column 4.

The quantity of items used per radio/system is indicated in this column.

**TABLE B-1.  
Optional Accessory Equipment.**

(1)	(2)	(3)	(4)
TWC STOCK NUMBER	DESCRIPTION	UNIT OF ISSUE	QTY USED PER UNIT
	<b><u>BATTERIES</u></b>		
BB-LA6:	Sealed lead-calcium rechargeable battery (6 Ah).	ea	1
BA6598/U:	BA6598/U high-capacity lithium battery (14 Ah).	ea	1
BB-NC4:	"D"-cell battery cassette for dry batteries or "D" nicad cells. NOTE: Only usable at 5-W power level with "D" dry batteries. Cassette only does not include batteries.	ea	1
	<b><u>BATTERY CHARGERS/POWER SUPPLIES</u></b>		
PRC-PS:	Power supply//battery charger for sealed lead-calcium battery pack. Will operate radio while charging internal battery. Automatic rapid/taper charge characteristic; 115/230-Vac input. Separate charger circuit charges spare battery.	ea	1
PRC-BC4:	Multiple battery charger. 115/230-Vac, 24-Vdc input power. Charges up to 4 BB-LA6 lead-calcium battery packs simultaneously. Automatic rapid/taper charge characteristic. Individual charge status indicators.	ea	1
PRC-SPU-10:	Solar power generator for charging sealed lead-calcium battery pack. Portable, rugged unit can supply 10-W output.	ea	1
PRC-HC-30:	Portable hand-crank generator used for charging nicad or lead-calcium batteries. Rugged, compact unit that can supply 30-W output.	ea	1
PRC-HC-8:	Portable hand-crank generator used for charging nicad or lead-calcium batteries. Rugged, compact unit that can supply 8-W output.	ea	1

**TABLE B-1.  
Optional Accessory Equipment, Continued.**

(1)	(2)	(3)	(4)
TWC STOCK NUMBER	DESCRIPTION	UNIT OF ISSUE	QTY USED PER UNIT
	<p><b><u>POWER CABLES</u></b></p>		
PRC-CA12V:	12-V power cable allows operation of radio from 12-V source. Allows charging of lead-calcium BB-LA6 battery pack on radio direct from 12-V vehicle charging system. 12-V systems only—no lithium or dry battery charging.	ea	1
	<p><b><u>CARRYING ACCESSORIES</u></b></p>		
ST-138:	Standard military carrying harness with shoulder straps, frame, and securing straps for PRC1099.	ea	1
CW-503:	Accessory carrying bag. For PRC1099 antennas and handset. Attaches to ST-138 carrying harness.	ea	1
	<p><b><u>AUDIO ACCESSORIES</u></b></p> <p>All PRC1099 audio accessories are terminated with twist-lock mil-spec connectors. Audio accessories which have color coding may only be connected to the front-panel 6-pin audio connector with the matching color code. If one of the front-panel audio connectors is not color coded, that connector accepts noncolor-coded audio accessories. The appropriate audio connector (left (L) or right (R)) is shown here next to "Qty Used Per Unit."</p>		
RCH	RCH remote-control handset. Allows remote PTT, Earphone Volume and Channel Select Control Non-noise cancelling.	ea	1 (R)
H-250/U:	H-250/U military handset. Noise-cancelling.	ea	1 (L,R)
H-189/U:	H-189/U military handset. Nonnoise-cancelling.	ea	1 (L,R)
H-80/U:	M-80/U ruggedized hand microphone.	ea	1 (L,R)
H3M:	Headset-boom microphone. Single earphone low profile—will fit under GI Kevlar helmet with clip-on push-to-talk switch.	ea	1 (L,R)
H-140/U:	H-140/U ruggedized headphones with 5-pin mil-spec connector.	ea	1 (L,R)
KYR:	Morse key with 36-in cord and 5-pin mil-spec connector.	ea	1 (L)
LS-R:	Loudspeaker, allows loudspeaker monitoring of PRC1099 radio.	ea	1 (L,R)

**TABLE B-1.  
Optional Accessory Equipment, Continued.**

(1)	(2)	(3)	(4)
TWC STOCK NUMBER	DESCRIPTION	UNIT OF ISSUE	QTY USED PER UNIT
	<p align="center"><b><u>ENCRYPTION AND CODED SIGNALLING ACCESSORIES</u></b></p> <p>Note the possibility of color-coded connectors, as described under "Audio Accessories."</p>		
PRC-SELCALL	PRC-SELCALL. high-speed selective-calling unit with internal modem.	ea	1 (L)
	<p align="center"><b><u>MANPACK AND LONG-RANGE ANTENNAS</u></b></p>		
AT-271A/U- AB-591/U:	AT-271A/U 3-m folding whip antenna with AB-591/U flexible antenna base.	ea	1
ATD:	Adjustable stainless steel tape halfwave dipole with 45 ft RG-58/CU feedline.	ea	1
ALD:	Lightweight tactical dipole kit with 30 ft RG-58/CU feedline and erection lines.	ea	1
ALW:	Ruggedized longwire antenna kit. Includes 100 ft antenna wire on bobbin insulator, hang-up cord and counterpoise/ground stake. Longwire adapter for whip antenna socket also provided.	ea	1
AGK:	Grounding kit—2 wire braided 50 ft each, counterpoise/ground stake to enhance efficiency with short antennas.	ea	1
AAW:	Whip adapter and feedwire used for direct connection of PRC1099 to either RA-MAS and RA-PAS. Not required when external automatic antenna tuner is used.	ea	1
RA-MAS:	Mobile antenna system, comprised of 120-16 4.8-m, 4-section fiberglass military whip, 120-43 mobile base, and RMB mobile mounting bracket. Requires antenna tuner.	ea	1
RA-MSS:	Mobile antenna system. As above except includes 4245 locking rigidized spring base for heavy duty use.	ea	1
RA-PAS:	9.6 m (32 ft) fiberglass ruggedized-type whip with flange base, side feed.	ea	1
ABB100A:	Broadband folded loop dipole 2-30 MHz, 45.7 m long. Optimized for 2-10 MHz performance. Supplied with 15 m RG-213/U coaxial cable feedline. For semi-permanent applications (mast required).	ea	1

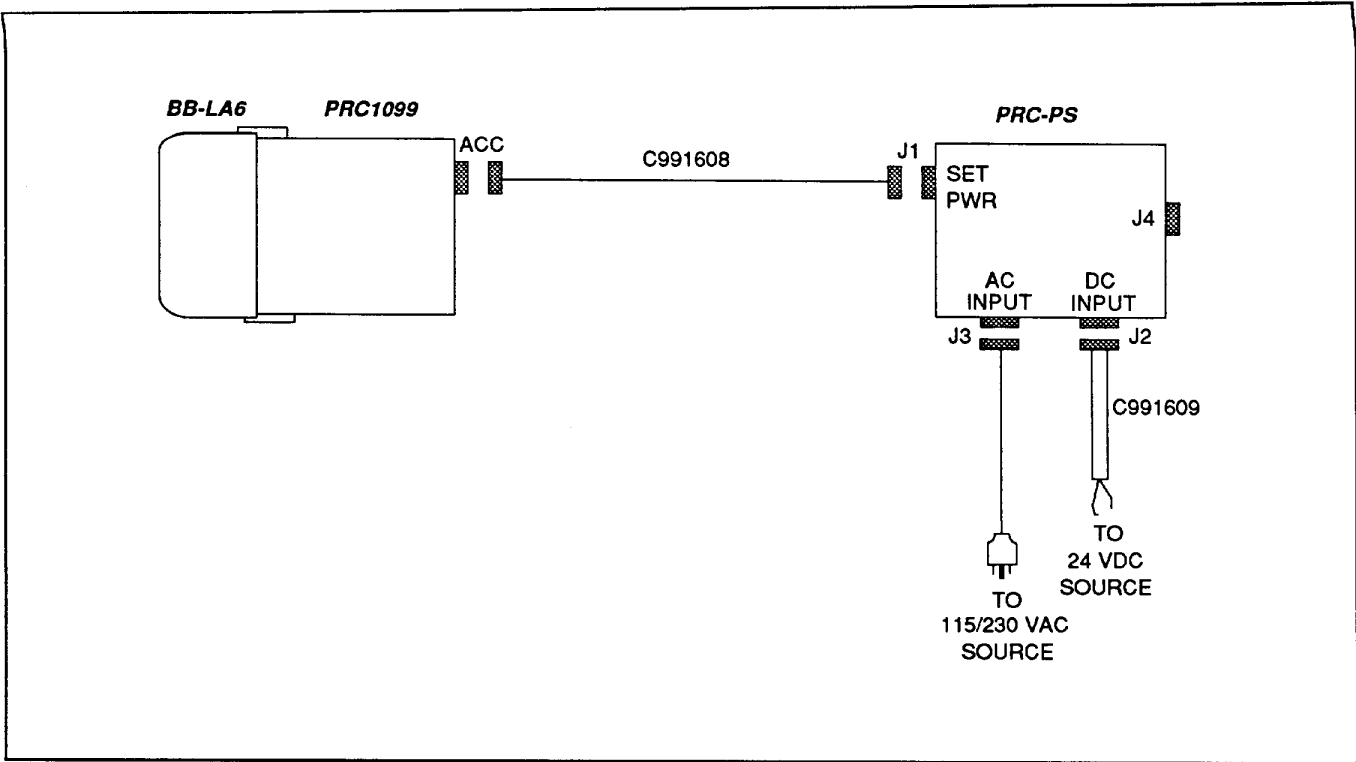
**TABLE B-1.  
Optional Accessory Equipment, Continued.**

(1)	(2)	(3)	(4)
TWC STOCK NUMBER	DESCRIPTION	UNIT OF ISSUE	QTY USED PER UNIT
	<b><u>MANPACK AND LONG-RANGE ANTENNAS (Continued)</u></b>		
ABB100B:	Broadband folded loop dipole 2-30 MHz. Short model 27.4 m long. Supplied with 15 m RG213/U coaxial cable feedline. For semi-permanent applications (mast required).	ea	1
AMX:	Portable antenna mast kit for ABB100 and ABB1000 series antennas. Includes 48 ft of mast sections, guy rings, dacron rope guys, guy stakes, mast base, raising halyard rope and pully supplied in canvas carrying bag with guy hammer.	ea	1
	<b><u>AMPLIFIERS AND POWER SUPPLIES</u></b>		
RA100-12:	100-W RF power amplifier 1.6-30 MHz. Ruggedized package compatible with MT-1099 vehicle adapter mount and PRC1099 manpack transceiver. Transceiver operates from nominal 12-Vdc power source. Order C991575 RF cable and C991585 control cable separately.	ea	1
RA100-24:	100-W RF power amplifier 1.6-30 MHz. Same as RA100-12, except operates from nominal 24-Vdc power source. Order C991575 RF cable and C991585 control cable separately (Figure B-9).	ea	1
RA400-99:	400-W RF power amplifier. 1.6-30 MHz medium power tactical amplifier for PRC1099 manpack transceiver. Designed for continuous duty applications. Fully immersible. Order C991510 RF cable and C991509 control cable separately (Figure B-10).	ea	1
RA1000-99:	1000-W RF power amplifier 1.6-30 MHz base station or mobile high-power amplifier for PRC1099 manpack. Requires 100-W RA100 amplifier as a driver unit. Designed for continuous duty applications in a rugged tactical environment. Order RF and control cables separately (Figure B-11).	ea	1
UPS100-12:	115/230-Vac power supply for RA100-12. Also supplies power for PRC1099 driver unit.	ea	1
UPS100-28:	115/230-Vac power supply for RA100-28. Also supplies power for PRC1099 driver unit.	ea	1
UPS500:	115/230-V power supply for RA400-99. Also supplies power for PRC1099 driver unit.	ea	1
UPS1000:	115/230-V power supply for RA1000-99. Also supplies power for PRC1099 driver unit.	ea	1

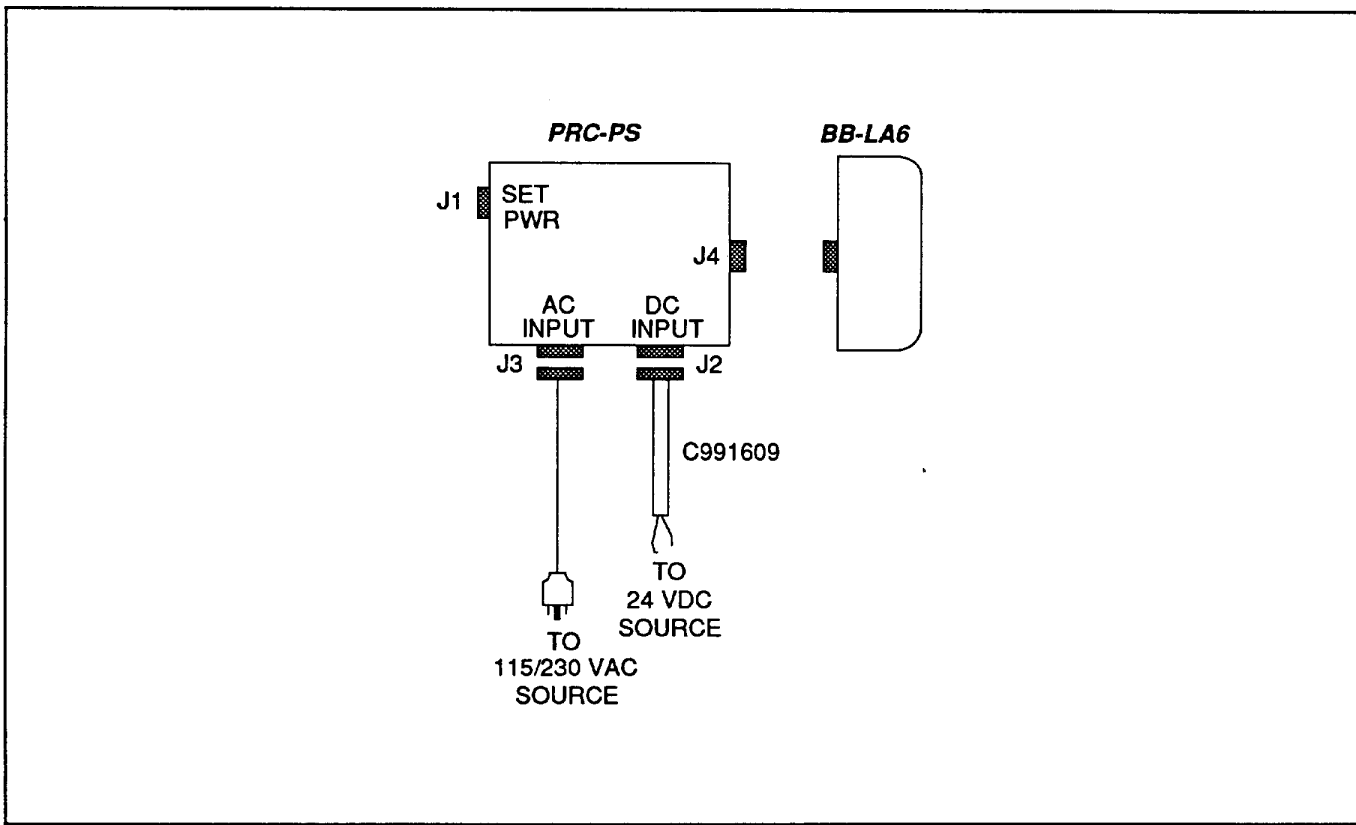
**TABLE B-1.  
Optional Accessory Equipment, Continued.**

(1)	(2)	(3)	(4)
TWC STOCK NUMBER	DESCRIPTION	UNIT OF ISSUE	QTY USED PER UNIT
	<b><u>ANTENNA TUNERS</u></b> (Supplied less interface cables. Order cables as indicated).		
RAT20	25-W automatic digital antenna tuner—used with PRC1099 to locate the radiating antenna away from the radio operator. May be used with dipoles, longwires, NVIS, and other antennas.	ea	1
RAT100-99:	125-W automatic digital antenna tuner—used with RA100 amplifiers for mobile, marine, fixed and portable installation using whip and long-wire antennas. Order cables separately. (Fig. B-9).	ea	1
RAT400-99:	Automatic digital antenna tuner 400 W used with RA400-99 amplifier. For mobile (3-30 MHz) and marine, fixed or portable (2-30 MHz) installations. Provides automatic high-speed (digital) tuning on receipt of actuation signal from PRC1099 transceiver. Operates with whip and longwire antennas. Order cables separately (Figure B-10).	ea	1
RAT1000-99:	1000-W automatic digital antenna tuner. Same as RAT400-99 with additional cooling fan. Order cables separately (Figure B-11).	ea	1
	<b><u>SHOCK MOUNTS</u></b>		
RA100-SM:	Shock mount for RA100 amplifier.	ea	1
RA400-SM:	Shock mount for RA400 amplifier.	ea	1
RA1000-SM:	Shock mount for RA1000 amplifier.	ea	1
RAT100-SM:	Shock mount for RAT100 tuner.	ea	1
RAT400-SM	Shock mount for RAT400 tuner.	ea	1
RAT1000-SM	Shock mount for RAT1000 tuner.	ea	1
	<b><u>VEHICLE MOUNTS</u></b>		
MT-1099-24	Vehicle adapter with integral shock mount for installation of PRC1099 into 24-V vehicles. Unit provides power conditioning and surge/reverse polarity protection plus loudspeaker audio and interface to accessory RA100 power amplifier. Mounting dimensions identical with U.S. standard MT-1029/VRC vehicle mount. Order C991580 power cable separately.	ea	1
MT-1099-12	Vehicle adapter same as MT-1099-24 except for 12-V vehicles.	ea	1





**FIGURE B-1.**  
**Operation of PRC-PS into PRC1099.**



**FIGURE B-2.**  
**Operation of PRC-PS into Separate Battery.**

### **B-3 Installation and Use of Optional Accessory Items**

This section covers the installation and use of the PRC1099 with the following accessories:

1. PRC-PS
2. PRC-BC4
3. PRC-HC-30
4. PRC-SPU-10
5. RA100
6. RA400
7. RA1000
8. MT-1099

### **B-4 Battery Charging Using the PRC-PS Power Supply/Charger**

a. The PRC-PS can charge a battery while it is attached to the radio set, and it can also operate the radio set while charging its battery. Operation is as follows:

1. Attach the transceiver with its battery to the PRC-PS as shown in Figure B-1.

2. Attach the PRC-PS to an appropriate power source, either:

- i) 115/230 Vac, or
- ii) 24 Vdc

3. Turn the transceiver on if both battery charging and radio operation is desired; leave the transceiver off if only battery charging is needed.

4. Turn the PRC-PS on and note the LED indicators:

i) If the battery is not connected, not connected properly or is shorted, the "fault" LED will come on.

ii) The "charging" LED will come on during a normal charge cycle.

iii) The "ready" LED will come on when the battery is fully charged.

b. The PRC-PS can also charge another battery connected to it through a battery connector in the rear of the unit.

1. Attach a BB-LA6 to the PRC-PS as shown in Figure B-2.

2. Attach the PRC-PS to an appropriate power source.

3. Turn the PRC-PS on and note the LED indicators:

i) If the battery is not connected, not connected properly or is shorted, the "fault" LED will come on.

ii) The "charging" LED will come on during a normal charge cycle.

iii) The "ready" LED will come on when the battery is fully charged.

### **B-5 Battery Charging using the PRC-BC4**

a. Charging up to four BB-LA6 sealed lead-calcium battery packs at the same time is done as follows:

1. Attach the PRC-BC4 to an appropriate power source, either:

- i) 115/230 Vac, or
- ii) 24 Vdc

2. Attach the PRC-BC4 to the battery packs to be charged (Figure B-3).

3. Turn the PRC-BC4 on and note the LED indicators:

i) The "fault" LED will come on if the battery is not connected, not connected properly, or is shorted.

ii) The "charging" LED will come on during a normal charge cycle.

iii) The "ready" LED will come on when the battery is fully charged.

### **B-6 Battery Charging Using the PRC-HC-30 Hand Crank Generator**

a) The standard method of battery charging using the PRC-HC-30 is shown in Figure B-4.

1. Attach the BB-LA6 battery needing charging to the PRC1099.

2. Attach the PRC-HC-30 to the PRC1099 transceiver.

3. Mount the PRC-HC-30 for convenient cranking.

4. Begin operating the PRC-HC-30 by rotating its handles.

b. If it is necessary to charge a battery directly from the PRC-HC-30 (Figure B-5):

1. Attach the BB-LA6 to the PRC-HC-30 as shown.

2. Mount the PRC-HC-30 for convenient cranking.

3. Begin operating the PRC-HC-30 by rotating its handles.

### **B-7 Battery Charging Using the PRC-SPU-10 Solar Power Generator**

a. The standard method of battery charging using the PRC-SPU-10 is shown in Figure B-6.

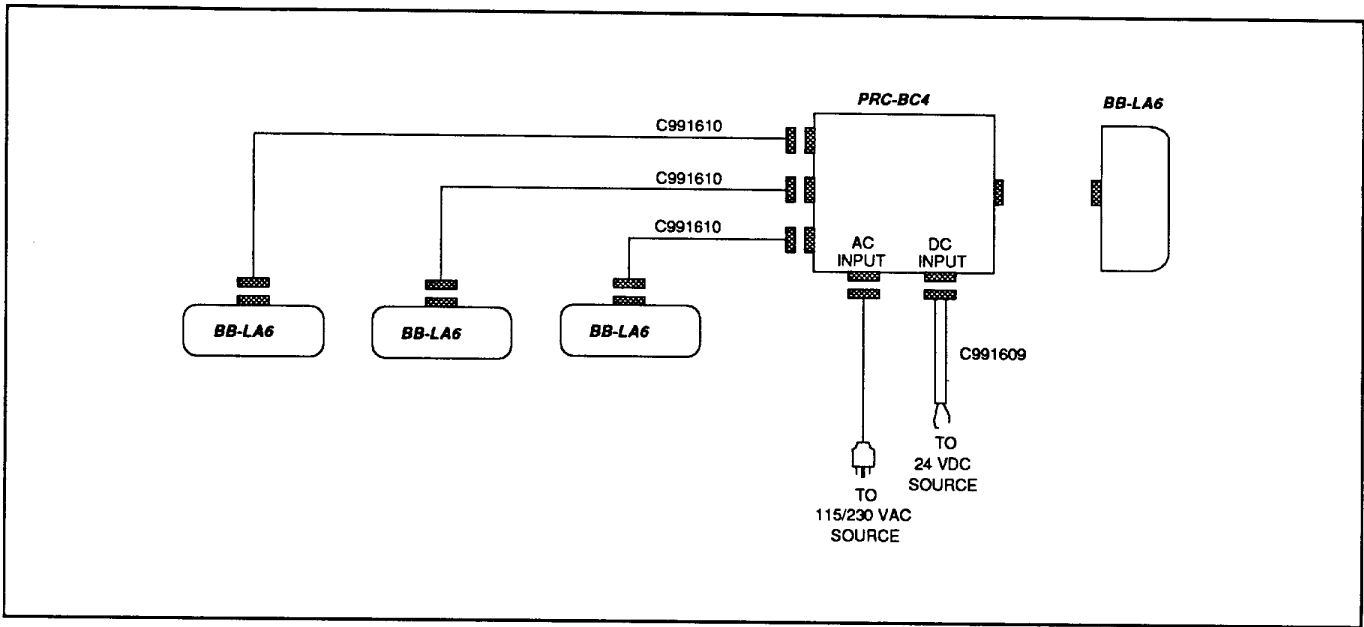
1. Unfold the PRC-SPU-10 and orient it for maximum exposure to the sun.

2. Attach the battery needing charging to the PRC1099.

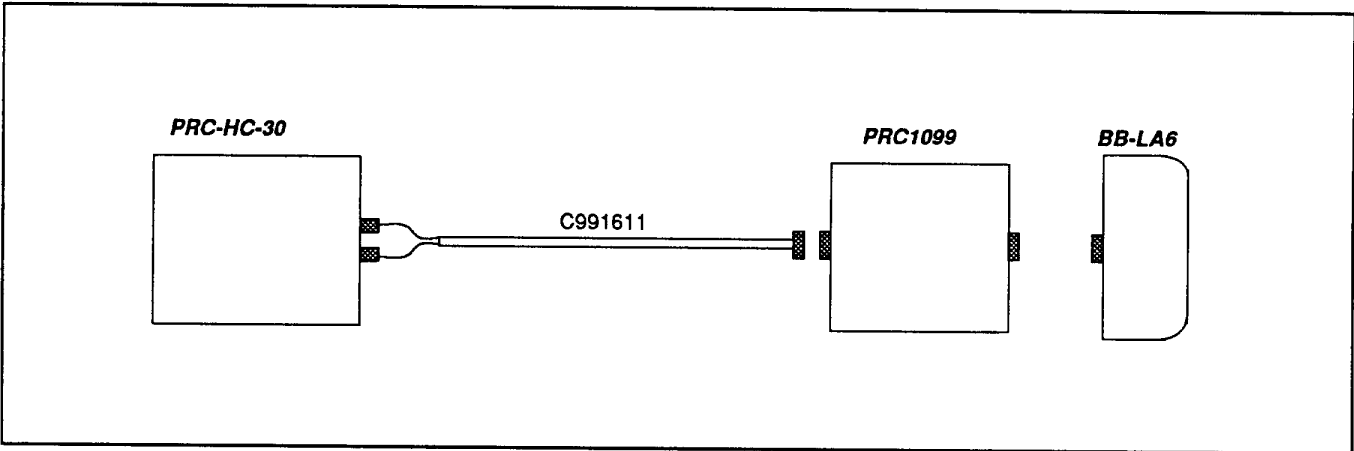
3. Attach the PRC-SPU-10 to the PRC1099 transceiver.

b. If it is necessary to charge a battery directly from the PRC-SPU-10 (Figure B-7):

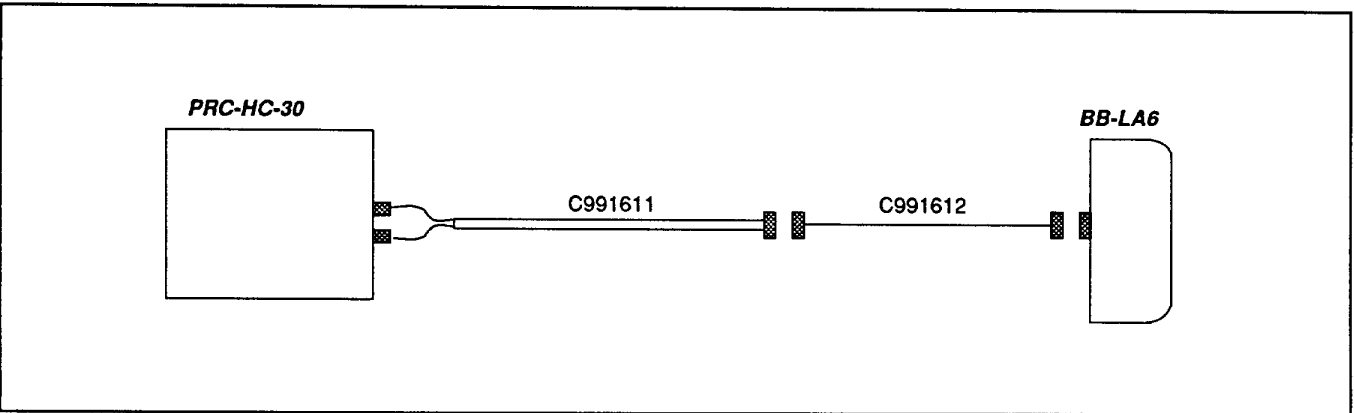
1. Unfold the PRC-SPU-10 and orient it for maximum exposure to the sun.



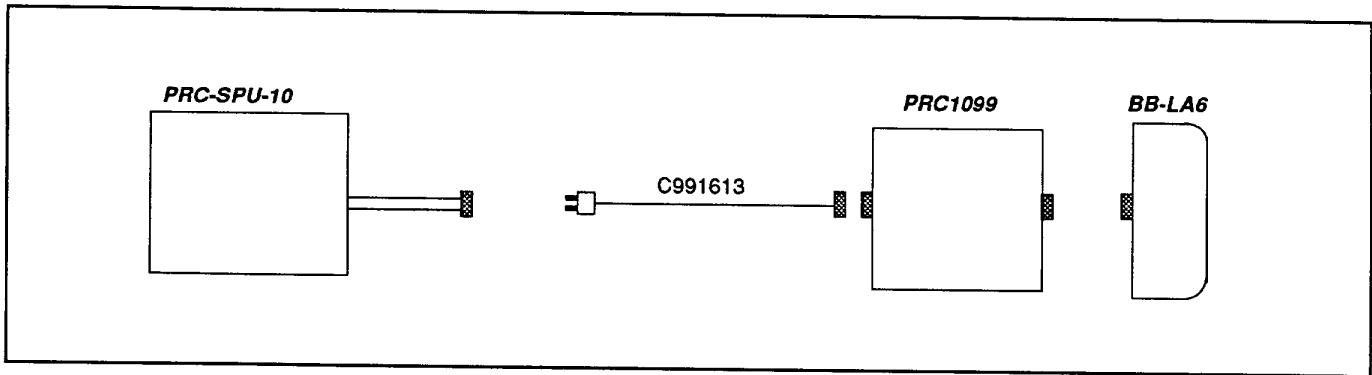
**FIGURE B-3.**  
**Operation of PRC-BC4 with Batteries.**



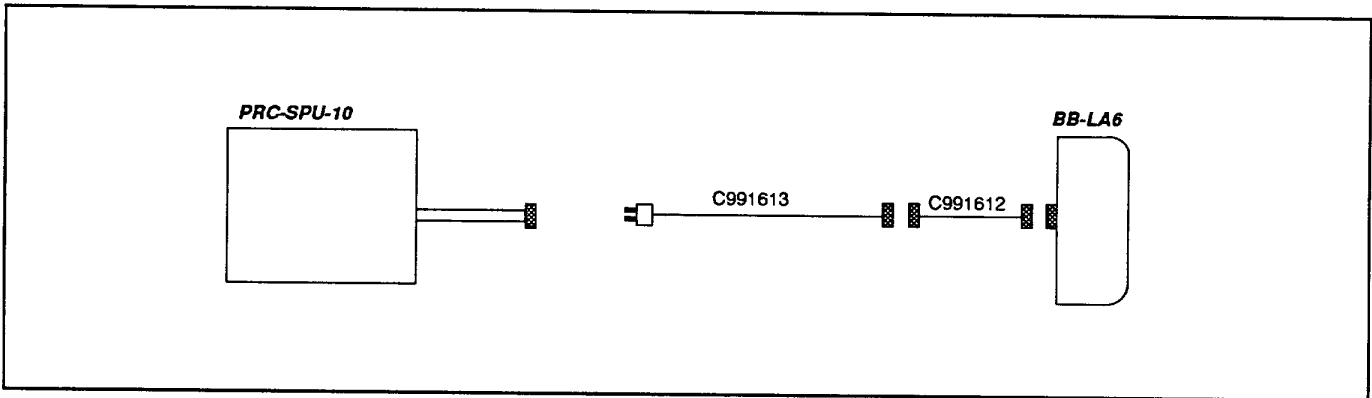
**FIGURE B-4.**  
**Battery Charging Using the PRC-HC-30 and PRC1099.**



**FIGURE B-5.**  
**Battery Charging Using the PRC-HC-30 Directly.**



**FIGURE B-6.**  
Battery Charging Using the PRC-SPU-10 and PRC1099.



**FIGURE B-7.**  
Battery Charging Using the PRC-SPU-10 Directly.

2. Attach the BB-LA6 to be charged to the PRC-SPU-10.

### B-8 Mobile 20-W System Operation

- a. The PRC1099 can be used in a mobile configuration as shown in Figure B-8.

#### NOTE

This system can be used with either 12- or 24-V vehicles; the only difference is that 12-V vehicle installations must use the MT-1099-12 mount while 24-V vehicle installations must use the MT-1099-24 mount. Everything else, including cabling, is the same.

1. The radio set must have its battery box attached.
2. Slide the PRC1099 into the MT-1099 mount and clamp it in place.
3. Attach the correct cables as indicated in Figure B-8.

### B-9 Mobile 100-W System Operation

- a. The PRC1099 can be used in a mobile configuration with the RA100 power amplifier as shown in Figure B-9.

#### NOTE

As in the 20-W mobile system, 12- or 24-V operation is possible in this configuration also. It is necessary to make

sure the RA100 as well as the MT-1099 is the proper 12- or 24-V model.

1. Attach the battery box to the PRC1099.
2. Slide the PRC1099 into the MT-1099 mount and clamp in place.
3. Attach the RA100 amplifier to the MT-1099 mount.
4. Attach the RAT100 automatic antenna tuner to its shock mount, then mount to the vehicle immediately next to the vehicular antenna.
5. Hook up the correct cables as shown in Figure B-9.

### B-10 Mobile 400-W System Operation

- a. The PRC1099 can be used in a mobile configuration with the RA400 power amplifier as shown in Figure B-10.

#### NOTE

This system can only be used in a 24-V vehicle.

1. Attach the battery box to the PRC1099.
2. Slide the PRC1099 into the MT-1099-24 mount and clamp in place.

3. Attach the RA400 amplifier to its shock mount, and mount to the vehicle.
4. Attach the RAT400 ATU to its shock mount, and then mount to the vehicle immediately next to the antenna.
5. Hook up the correct cables as shown in Figure B-10.

2. Slide the PRC1099 into the MT-1099-24 mount and clamp in place.
3. Attach the RA100-24 amplifier to its shock mount, and mount to the vehicle.
4. Attach the RA1000 amplifier to its shock mount, and mount to the vehicle.

### B-11 Mobile 1000-W System Operation

- a. The PRC1099 can be used in a mobile configuration with the RA1000 power amplifier as shown in Figure B-11.

#### NOTE

This system can only be used in a 24-V vehicle.

1. Attach the battery box to the PRC1099.

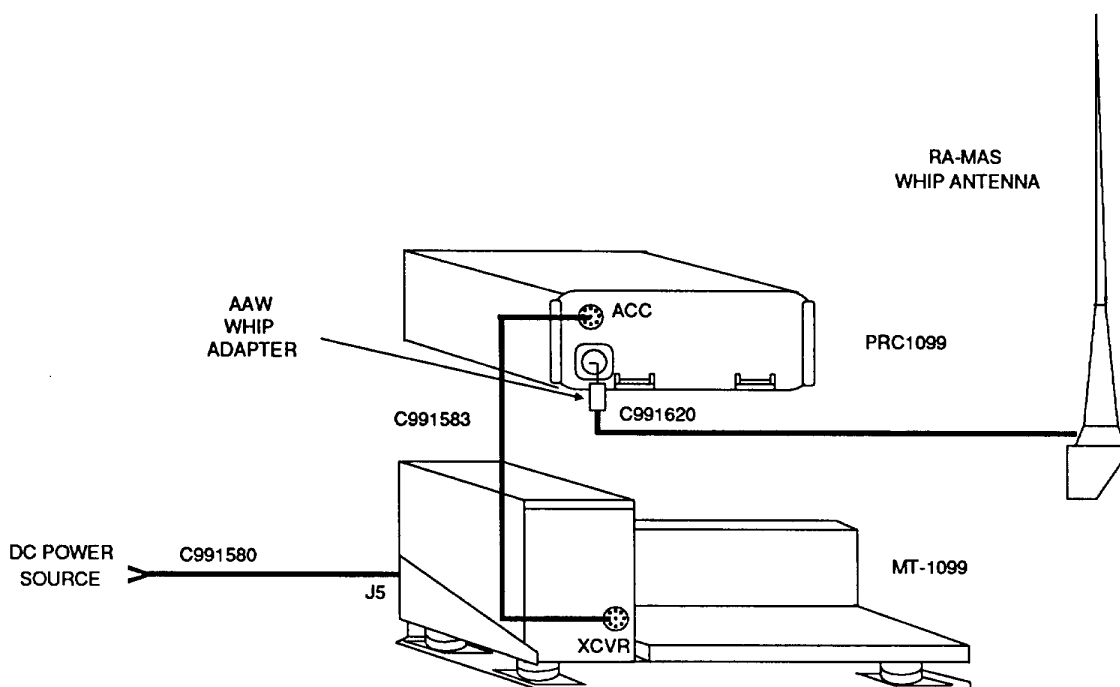
5. Attach the RAT1000 ATU to its shock mount, and the mount to the vehicle immediately next to the antenna.

6. Hook up the correct cables as shown in Figure B-11.

### B-12 Fixed/Portable Station Systems

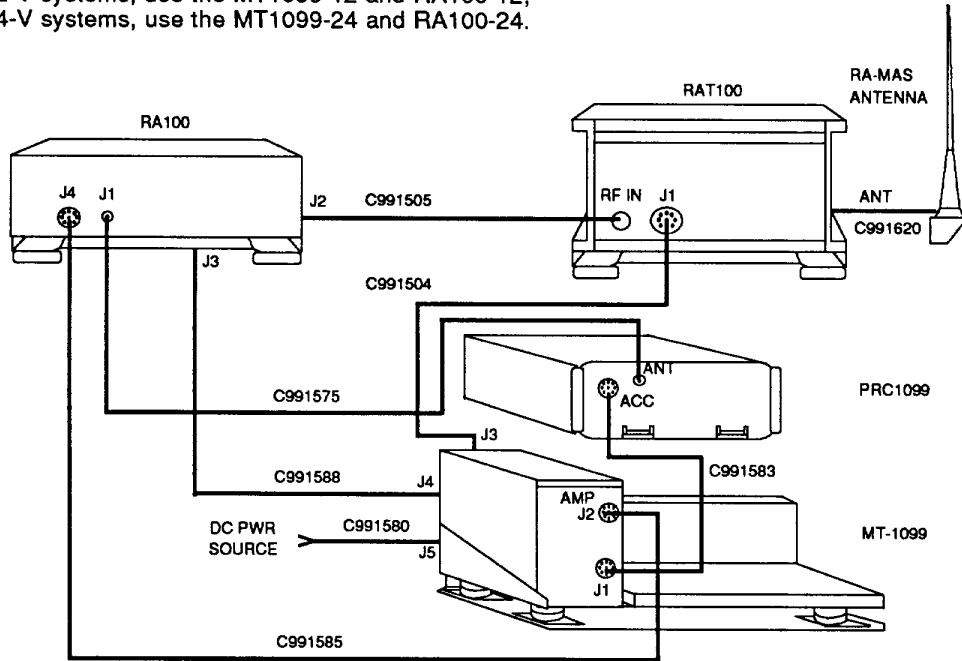
- a. All of the systems previously described can also be

**NOTE:** For 12-V vehicles, use the MT1099-12;  
For 24-V vehicles, use the MT1099-24.

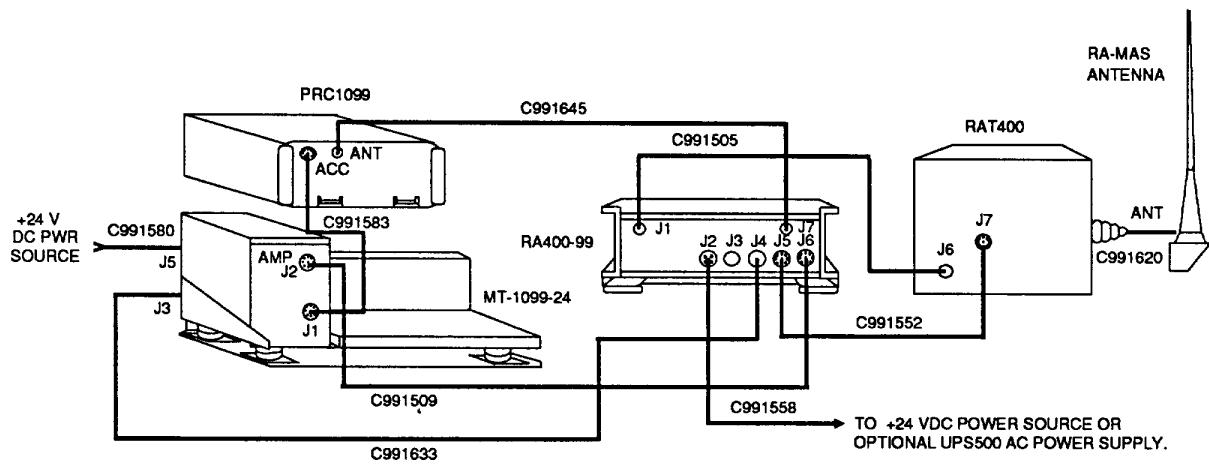


**FIGURE B-8.**  
**Mobile 20-W System.**

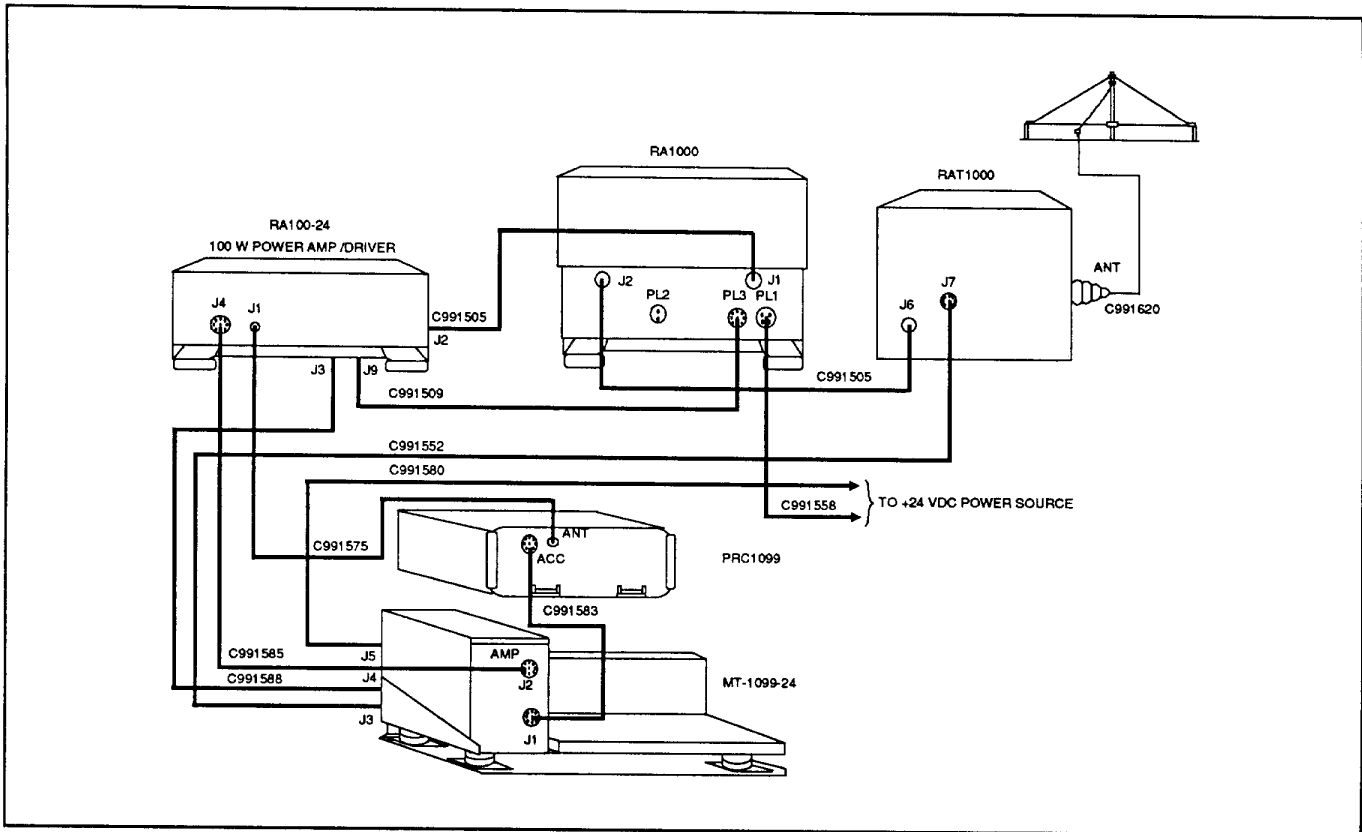
**NOTE:** For 12-V systems, use the MT1099-12 and RA100-12;  
For 24-V systems, use the MT1099-24 and RA100-24.



**FIGURE B-9.**  
**Mobile 100-W System.**



**FIGURE B-10.**  
**Mobile 400-W System.**



**FIGURE B-11.**  
**Mobile 1000-W System.**

used in fixed or portable stations. In these cases the external power must be obtained from ac power sources instead of vehicular supplies.

1. 100-W systems can use the UPS100-12 (for 12-V operation) or UPS100-24 (for 24-V operation) as the primary power source.

Referring to Figure B-9, cable C991580 going between the vehicular power source and the MT-1099 must be replaced with cable C991614. This cable connects the MT-1099 to the UPS100.

2. 400-W systems can use the UPS100 and cable C991614 to power the MT-1099, and also use the UPS500 power supply as the primary power source for the RA400.

Referring to Figure B-10, cable C991580 going between the vehicular power source and the MT-1099 must be replaced with cable C991614; this cable connects the MT-1099 to the UPS100.

Also in Figure B-10, cable C991558 going between the vehicle power source and the RA400 must be replaced with cable C991508; this cable connects the RA400 to the UPS500.

3. 1000-W systems can use the UPS100 and cable C991614 to power the MT-1099, and also use the UPS1000 power supply as the primary power source for the RA1000.

Referring to Figure B-11, cable C991580 going between the vehicular power source and the MT-1099 must be replaced with cable C991614; this cable connects the MT-1099 to the UPS100.

Also in Figure B-11, cable C991558 going between the vehicular power source and the RA1000 must be replaced with cable C991508; this cable connects the RA1000 to the UPS1000.

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**NOTES**

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