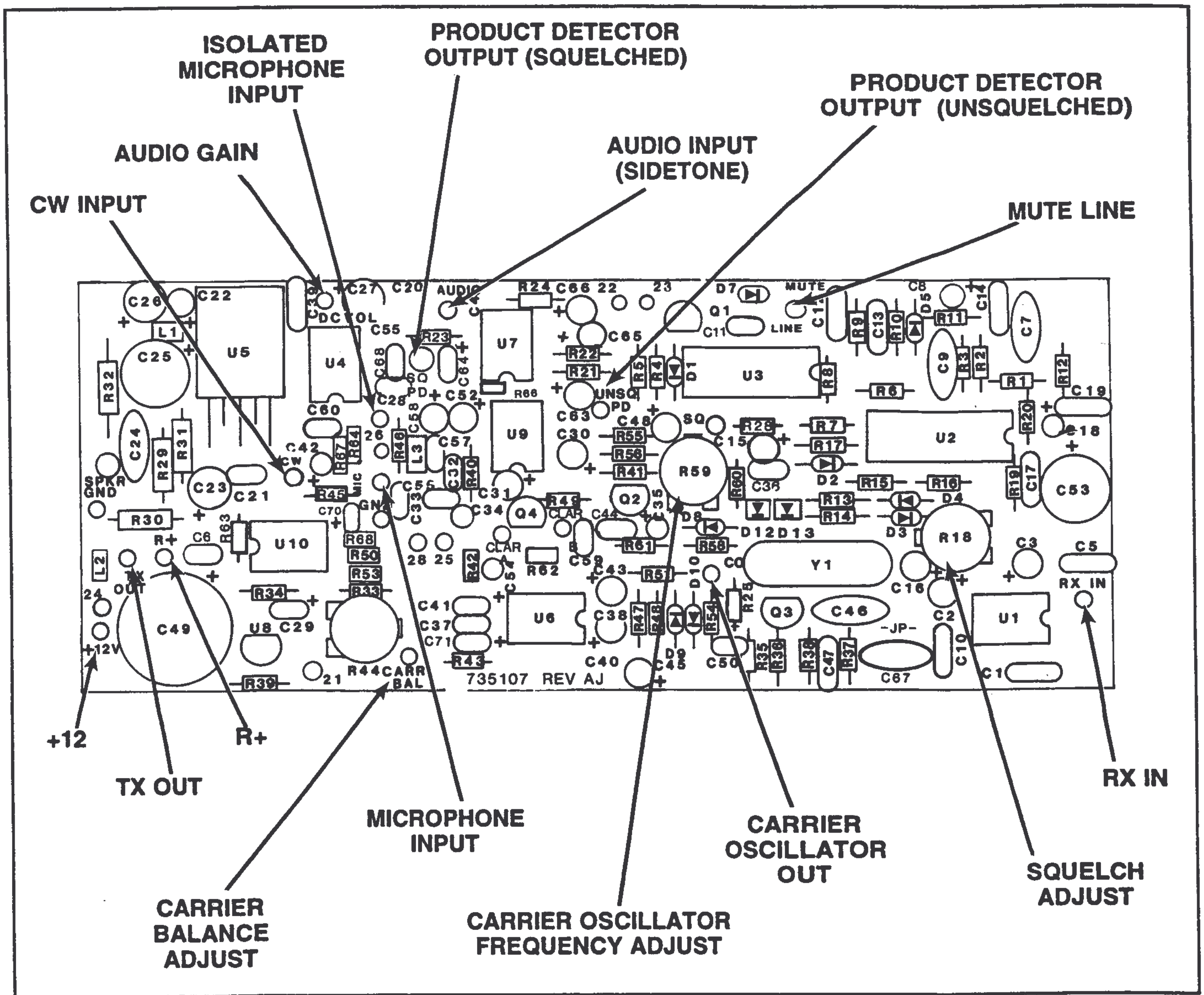


FIGURE 10.1-1.
Adjustment Points.

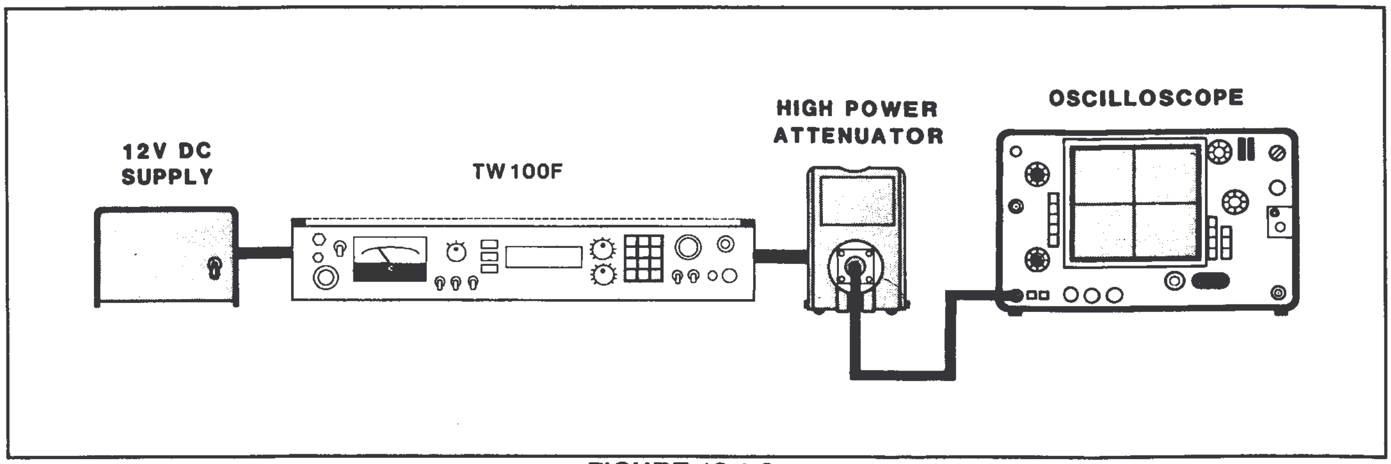


FIGURE 10.1-2.
Carrier Balance Adjustment.

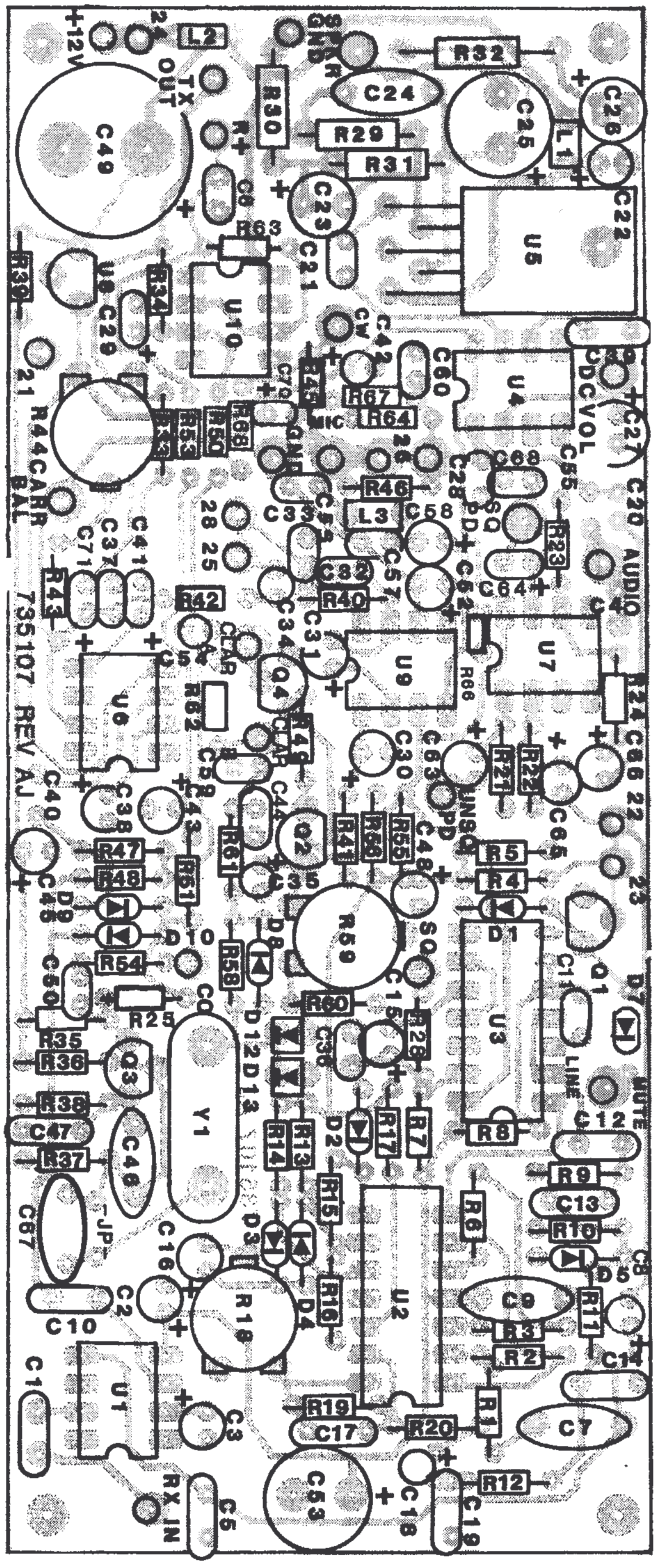
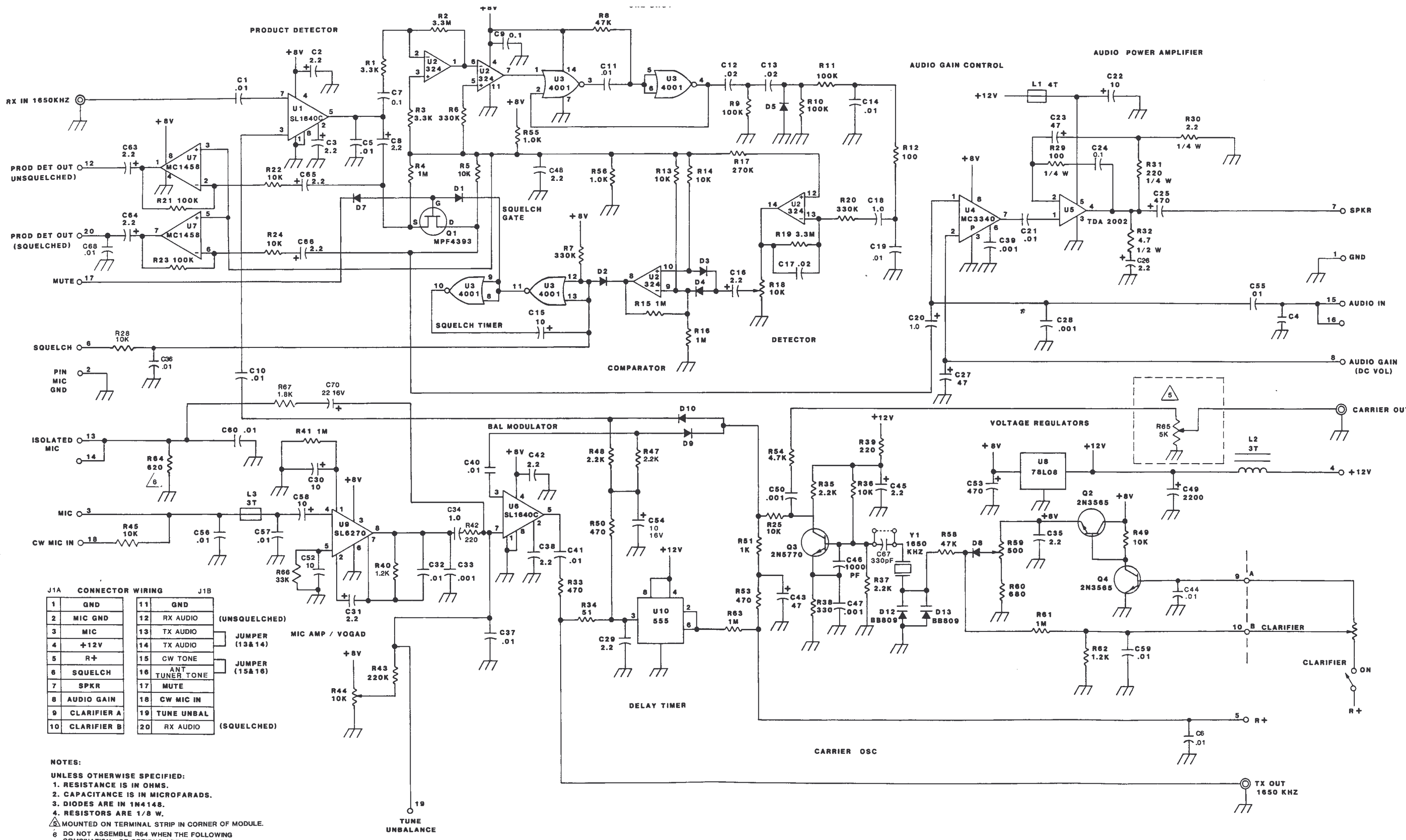


FIGURE 10.1-3.
Component Locations, Audio Module, M1.



J1A	CONNECTOR WIRING	J1B	
1	GND	11	GND
2	MIC GND	12	RX AUDIO (UNSQUELCHED)
3	MIC	13	TX AUDIO
4	+12V	14	TX AUDIO
5	R+	15	CW TONE
6	SQUELCH	16	ANT TUNER TONE
7	SPKR	17	MUTE
8	AUDIO GAIN	18	CW MIC IN
9	CLARIFIER A	19	TUNE UNBAL
10	CLARIFIER B	20	RX AUDIO (SQUELCHED)

NOTES:

UNLESS OTHERWISE SPECIFIED:

1. RESISTANCE IS IN OHMS.
2. CAPACITANCE IS IN MICROFARADS.
3. DIODES ARE IN 1N4148.
4. RESISTORS ARE 1/8 W.
5. MOUNTED ON TERMINAL STRIP IN CORNER OF MODULE.
6. DO NOT ASSEMBLE R64 WHEN THE FOLLOWING COMBINATION OF OPTIONS ARE USED TOGETHER: REMOTE CONTROL, SELCALL, AND TRANSCAL.

TABLE 10.1-3. Parts List, Audio Module, M1.

C1	214103	Capacitor, Monolithic 50 V 0.01 µF
C2,C3	241020	Capacitor, Tantalum 2.2 µF
C4-C6	214103	Capacitor, Monolithic 50 V 0.01 µF
C7	210104	Capacitor, Disc 0.1 µF
C8	241020	Capacitor, Tantalum 2.2 µF
C9	210104	Capacitor, Disc 0.1 µF
C10,C11	214103	Capacitor, Monolithic 50 V 0.01 µF
C12,C13	254203	Capacitor, Mylar 10% 0.02 µF
C14	254103	Capacitor, Mylar 0.01 µF
C15	231100	Capacitor, Electrolytic 16 V 10 µF
C16	241020	Capacitor, Tantalum 2.2 µF
C17	254203	Capacitor, Mylar 10% 0.02 µF
C18	241010	Capacitor, Tantalum 1 µF
C19	254103	Capacitor, Mylar 0.01 µF
C20	241010	Capacitor, Tantalum 1 µF
C21	214103	Capacitor, Monolithic 50 V 0.01 µF
C22	231100	Capacitor, Electrolytic 16 V 10 µF
C23	231500	Capacitor, Electrolytic 16 V 47 µF
C24	210104	Capacitor, Disc 0.1 µF
C25	231471	Capacitor, Electrolytic 16 V 470 µF
C26	241020	Capacitor, Tantalum 2.2 µF
C27	231500	Capacitor, Electrolytic 16 V 47 µF
C28	210102	Capacitor, Disc 0.001 µF
C29	241020	Capacitor, Tantalum 2.2 µF
C30	231100	Capacitor, Electrolytic 16 V 10 µF
C31	241020	Capacitor, Tantalum 2.2 µF
C32	214103	Capacitor, Monolithic 50 V 0.01 µF
C33	210102	Capacitor, Disc 0.001 µF
C34	230010	Capacitor, Electrolytic 50 V 1 µF
C35	241020	Capacitor, Tantalum 2.2 µF
C36,C37	214103	Capacitor, Monolithic 50 V 0.01 µF
C38	241020	Capacitor, Tantalum 2.2 µF
C39	210102	Capacitor, Disc 0.001 µF
C40,C41	214103	Capacitor, Monolithic 50 V 0.01 µF
C42	241020	Capacitor, Tantalum 2.2 µF
C43	231500	Capacitor, Electrolytic 16 V 47 µF
C44	214103	Capacitor, Monolithic 50 V 0.01 µF
C45	241020	Capacitor, Tantalum 2.2 µF
C46	220102	Capacitor, Mica DM15 1000 pF
C47	210102	Capacitor, Disc 0.001 µF
C48	241020	Capacitor, Tantalum 2.2 µF
C49	231222	Capacitor, Electrolytic 16 V 2200 µF
C50	210102	Capacitor, Disc 0.001 µF
C51	254153	Capacitor, Mylar 100 V 0.015 µF
C52	231100	Capacitor, Electrolytic 16 V 10 µF
C53	231471	Capacitor, Electrolytic 16 V 470 µF
C54	241010	Capacitor, Tantalum 1 µF
C55-C57	214103	Capacitor, Monolithic 50 V 0.01 µF
C58	231100	Capacitor, Electrolytic 16 V 10 µF
C59,C60	214103	Capacitor, Monolithic 50 V 0.01 µF
C61,C62		Not Used.
C63-C66	241020	Capacitor, Tantalum 2.2 µF
C67	220331	Capacitor, Mica 330 pF
C68	214103	Capacitor, Monolithic 50 V 0.01 µF
C69		Not Used.
C70	241020	Capacitor, Tantalum 2.2 µF

TABLE 10.1-3. Parts List, Audio Module, M1, Continued.

D1-D5	320002	Diode, 1N4148
D6		Not Used.
D7-D10	320002	Diode, 1N4148
D11		Not Used.
D12,D13	320307	Diode, BB809
L1	450131	Inductor, Ferrite
L2,L3	450132	Inductor, Ferrite
Q1	310046	Transistor, FET MPF4393
Q2	310006	Transistor, NPN 2N3565
Q3	310032	Transistor, NPN 2N5770
Q4	310006	Transistor, NPN 2N3565
R1	113332	Resistor, Film 1/8W 5% 3.3 kΩ
R2	113335	Resistor, Film 1/8W 5% 3.3 MΩ
R3	113332	Resistor, Film 1/8W 5% 3.3 kΩ
R4	113105	Resistor, Film 1/8W 5% 1 MΩ
R5	113103	Resistor, Film 1/8W 5% 10 kΩ
R6,R7	113334	Resistor, Film 1/8W 5% 330 kΩ
R8	113473	Resistor, Film 1/8W 5% 47 kΩ
R9-R12	113104	Resistor. Film 1/8W 5% 100 kΩ
R13,R14	113103	Resistor, Film 1/8W 5% 10 kΩ
R15,R16	113105	Resistor, Film 1/8W 5% 1 MΩ
R17	113274	Resistor, Film 1/8W 5% 270 kΩ
R18	170114	Resistor, Trimmer 10 kΩ
R19	113335	Resistor, Film 1/8W 5% 3.3 MΩ
R20	113334	Resistor, Film 1/8W 5% 330 kΩ
R21	113104	Resistor, Film 1/8W 5% 100 kΩ
R22	113103	Resistor, Film 1/8W 5% 10 kΩ
R23	113104	Resistor, Film 1/8W 5% 100 kΩ
R24,R25	113103	Resistor, Film 1/8W 5% 10 kΩ
R26,R27		Not Used.
R28	113103	Resistor, Film 1/4W 5% 10 kΩ
R29	124101	Resistor, Film 1/4W 5% 100 Ω
R30	124020	Resistor, Film 1/4W 5% 2.2 Ω
R31	124221	Resistor, Film 1/4W 5% 220 Ω
R32	133047	Resistor, Comp 1/2W 5% 4.7 Ω
R33	113471	Resistor, Film 1/8W 5% 470 Ω
R34	113510	Resistor, Film 1/8W 5% 51 Ω
R35	113222	Resistor, Film 1/8W 5% 2.2 kΩ
R36	113103	Resistor, Film 1/8W 5% 10 kΩ
R37	113222	Resistor, Film 1/8W 5% 2.2 kΩ
R38	113331	Resistor, Film 1/8W 5% 330 Ω
R39	113221	Resistor, Film 1/8W 5% 220 Ω
R40	113122	Resistor, Film 1/8W 5% 1.2 kΩ
R41	113105	Resistor, Film 1/8W 5% 1 MΩ
R42	113221	Resistor, Film 1/8W 5% 220 Ω
R43	113224	Resistor, Film 1/8W 5% 220 kΩ
R44	170114	Resistor, Trimmer 10 kΩ
R45	113103	Resistor, Film 1/8W 5% 10 kΩ
R46		Not Used.
R47,R48	113222	Resistor, Film 1/8W 5% 2.2 kΩ
R49	113103	Resistor, Film 1/8W 5% 10 kΩ
R50	113471	Resistor, Film 1/8W 5% 470 Ω
R51	113102	Resistor, Film 1/8W 5% 1 kΩ

TABLE 10.1-3. Parts List, Audio Module, M1, Continued.

R52		Not Used.
R53	113471	Resistor, Film 1/8W 5% 470 Ω
R54	113472	Resistor, Film 1/8W 5% 4.7 kΩ
R55,R56	113102	Resistor, Film 1/8W 5% 1 kΩ
R57		Not Used.
R58	113473	Resistor, Film 1/8W 5% 47 kΩ
R59	170110	Resistor, Trimmer 500 Ω
R60	113681	Resistor, Film 1/8W 5% 680 Ω
R61	113105	Resistor, Film 1/8W 5% 1 MΩ
R62	113122	Resistor, Film 1/8W 5% 1.2 kΩ
R63	113105	Resistor, Film 1/8W 5% 1 MΩ
R64	113621	Resistor, Film 1/8W 5% 620 Ω
R65	170111	Resistor, Trimmer 5 kΩ
R66	113333	Resistor, Film 1/8W 5% 33 kΩ
R67	113182	Resistor, Film 1/8 W 5% 1.8 kΩ
U1	330036	IC, SL1640C
U2	330030	IC, LM324N
U3	330054	IC, CD4001
U4	330159	IC, MC3340P
U5	330043	IC, TDA2002-H
U6	330036	IC, SL1640C
U7	330019	IC, RC1458CP-1
U8	330018	IC, 78L08
U9	330029	IC, SL6270CDP
U10	330094	IC, NE555N Timer
Y1	360021	Crystal, 1650 kHz

10.2 1650-kHz IF MODULE, M2

The M2 module contains the 1650-kHz crystal filter and IF amplifiers. Depending on the requirement, provision is made for both USB and LSB filters. Diode switching is used to switch between transmit and receive circuits and also between USB and LSB filters. The receive input comes in at 1650kHz from M3, is filtered and then amplified before going on to M1. The transmit input comes from M1, also at 1650 kHz, is filtered and amplified and goes out to M3. All circuitry is on PCB 735101, which is contained in a die-cast box located immediately to the right of module M1 in the transceiver.

10.2.1 TECHNICAL CIRCUIT DESCRIPTION

10.2.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Receive Input. 1650-kHz signal from M3 at varying amplitudes. PCB pin is at right front of board while the module SMA connector is at the right front of the box.

b) Receive Output. 1650-kHz signal at approximately 6 mV to M1. PCB pin is at left rear of board and module SMA connector is at left rear of box.

c) Transmit Input. 1650-kHz DSB signal from M1 at approximately 5 mV. PCB pin is at left front of board and module SMA connector is at left front of box.

d) Transmit Output. 1650-kHz signal to M3 at approximately 13 mV. PCB pin is at right rear of PCB and module SMA connector is at right rear of box.

DC Connections

Pin 1. Ground.

Pin 2. T+.

Pin 3. +12 Vdc.

Pin 4. FSK line from mode switch to change R/T time constants; ground in FSK mode.

Pin 5. USB/LSB control line from mode switch. Open for USB, ground for LSB.

Pin 7. R+.

Pin 8. PTT line. +11 Vdc in receive, ground in transmit.

Pin 9. ALC line from M7. 0 V when output power is below ALC threshold (as set on M7), approximately 0.6 V when in ALC.

Pin 10. AGC line. 4 Vdc when receive signal is below AGC "knee" or transmit output power is below ALC threshold; decreases toward 0 Vdc in proportion to signals above threshold.

10.2.1.2 CIRCUIT DESCRIPTION

The filter and the first amplifier stage in this module are used in both the transmit and receive modes. The diode gates D10 and D11 switch the filter input from transmit to receive. In the transmit mode D11 is switched on by a dc voltage from M1. In the receive mode D10 is switched on by the R+ voltage through R24. The ground return for D10 is made through R23 back to the T+ line.

The 6-pole crystal filter is a Chebishev design providing high selectivity in the receive mode. In the transmit mode, the double-sideband signal from M1 is filtered to remove the unwanted sideband. Provision is made to fit filters for upper sideband (USB) and lower sideband (LSB). When the optional LSB filter is fitted, the filters are switched by D4 and D9 at the input and D6/D5 and D8/D7 at the output. The switching voltage for the USB filter is controlled by Q6. When the mode switch is open (USB), Q6 is forward biased by R35 and the transistor conducts. The mode switch is grounded in the LSB mode. This forward biases the PNP transistor Q5, applying the switching voltage for the LSB filter. At the same time the base of Q6 is grounded, which removes the switching voltage from the passband of the USB filter. It should be noted that the sidebands are inverted in the conversion process and the outputs from the IF modules are inverted. The USB filter is 1647.300-1649.700 kHz and the LSB filter is 1650.300-1652.700 Hz.

The first IF amplifier stage Q1 is a dual-gate MOSFET. The gain of Q1 is controlled by the voltage on gate 2. To give adequate gain control the voltage on gate 2 must be capable of going negative with respect to gate 1. The control voltage cannot fall below zero, therefore, gate 1 of Q2 is biased positive by the voltage divider R10/R9. This means that when gate 2 is at zero, it will be negative with respect to gate 1. The gain of Q1 is stabilized by the source degeneration provided by R6/C10. The output from Q1 is transformer coupled by L3 to the transmit gain control R2 and to the base of second IF amplifier Q2, which is used only in the receive mode. The output from Q2 is transformer coupled through L4 to module M1. R14 is shunted by R27 and C25 to provide degeneration and proper ac gain.

The AGC system uses a two-stage amplifier Q3 and Q4 to control the gain of Q1 and the 75-MHz IF amplifier in module M3. Q3 is an emitter-follower IF amplifier driving the AGC rectifier D1/D2. Q4 is a dc amplifier with collector voltage set at approximately 4 V by the voltage divider R19/R21. As the base of Q4 is forward biased, the voltage on the collector falls, which reduces the gain of the IF amplifier(s). The emitter follower Q3 and the high dc gain of Q4 ensure a "stiff" drive source and a very rapid attack time. For SSB operation, transmission gate U2A is switched on in the receive mode by the bias on the open PTT line. This grounds the negative end of C21 and provides the slow release time constant required for SSB operation. In the transmit mode transmission gate U2B closes, which grounds the negative end of C23 and provides the correct ALC time constant. When a fast switching mode is desired, input pin 4 is grounded, which opens U2A and provides a fast time constant; U2C is turned on by R+ in the receive mode, which puts C2 in the circuit alone for FSK or SITOR operation. In the transmit mode, the ALC control voltage from the VSWR bridge in M7 is applied to Q4 and controls the gain of Q2.

The receiver is switched off in the transmit mode by biasing off Q2 with a voltage on the emitter applied through the timer U1. The time delay circuit R29/C26 delays switch on of Q2 when the transceiver returns to the receive mode. The switching delay of approximately 10 ms prevents any transients reaching the audio through IF circuits and gives low-noise switching characteristics. D12 prevents the switching delay when going from receive to transmit.

10.2.2 ADJUSTMENT PROCEDURE

Figure 10.2-1 shows M2 adjustment points. To adjust L3 and L4, turn the transceiver to receive mode and set L3 and L4 for maximum output.

To reset the transmit gain control, initially set R2 to the 2 o'clock position. Final adjustment is made after the ALC control on Module 7 has been adjusted. R2 is then adjusted so that the voltage on the ALC/AGC line, measured at pin 10 of the connector, drops approximately 1 V on voice peaks.

The crystal filters are factory aligned and sealed, and therefore do not normally need adjustment. However, if it is necessary to realign a filter, the following procedure should be followed.

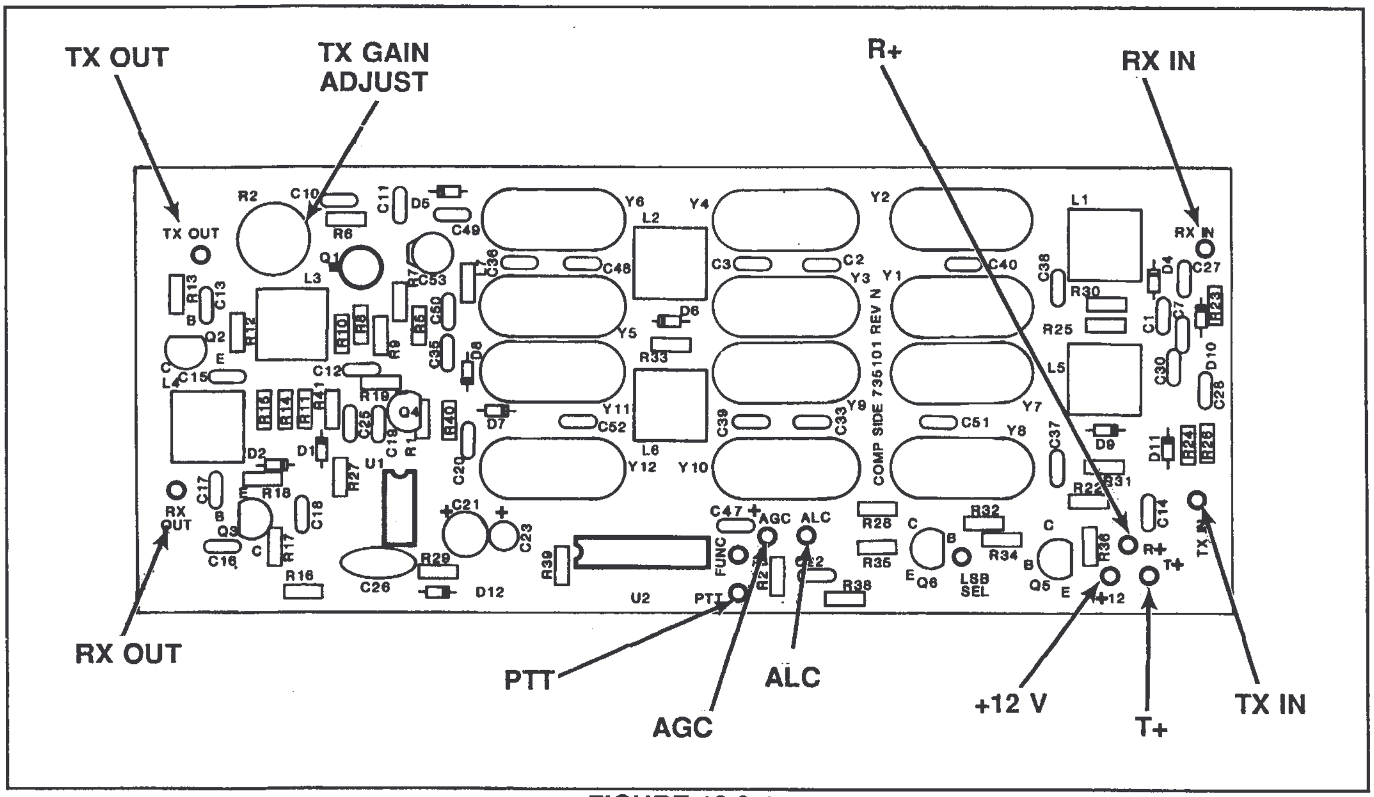


FIGURE 10.2-1.
Adjustment Points.

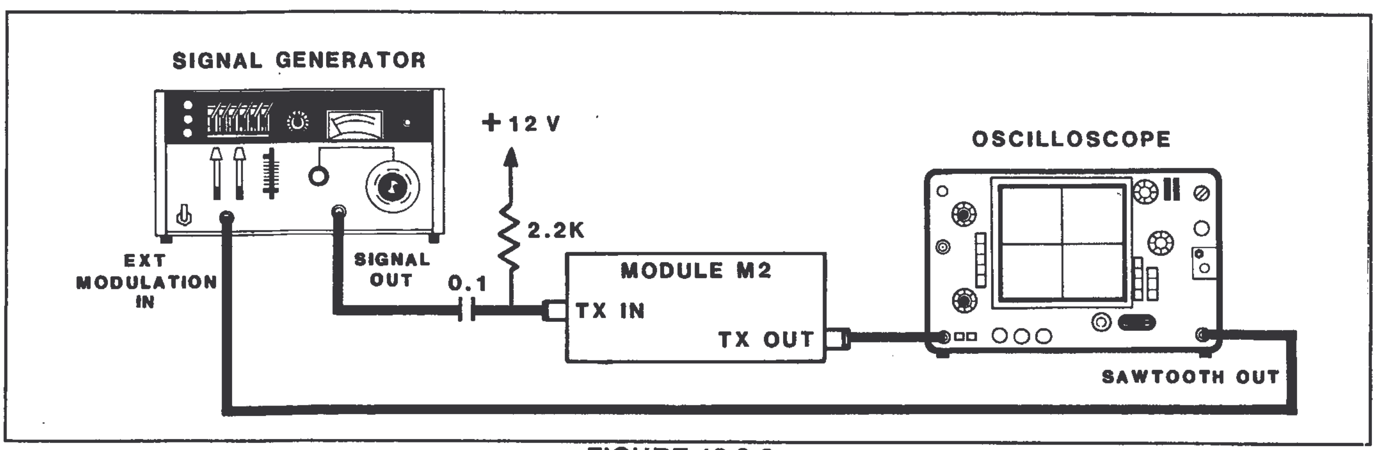


FIGURE 10.2-2.
Filter Alignment.

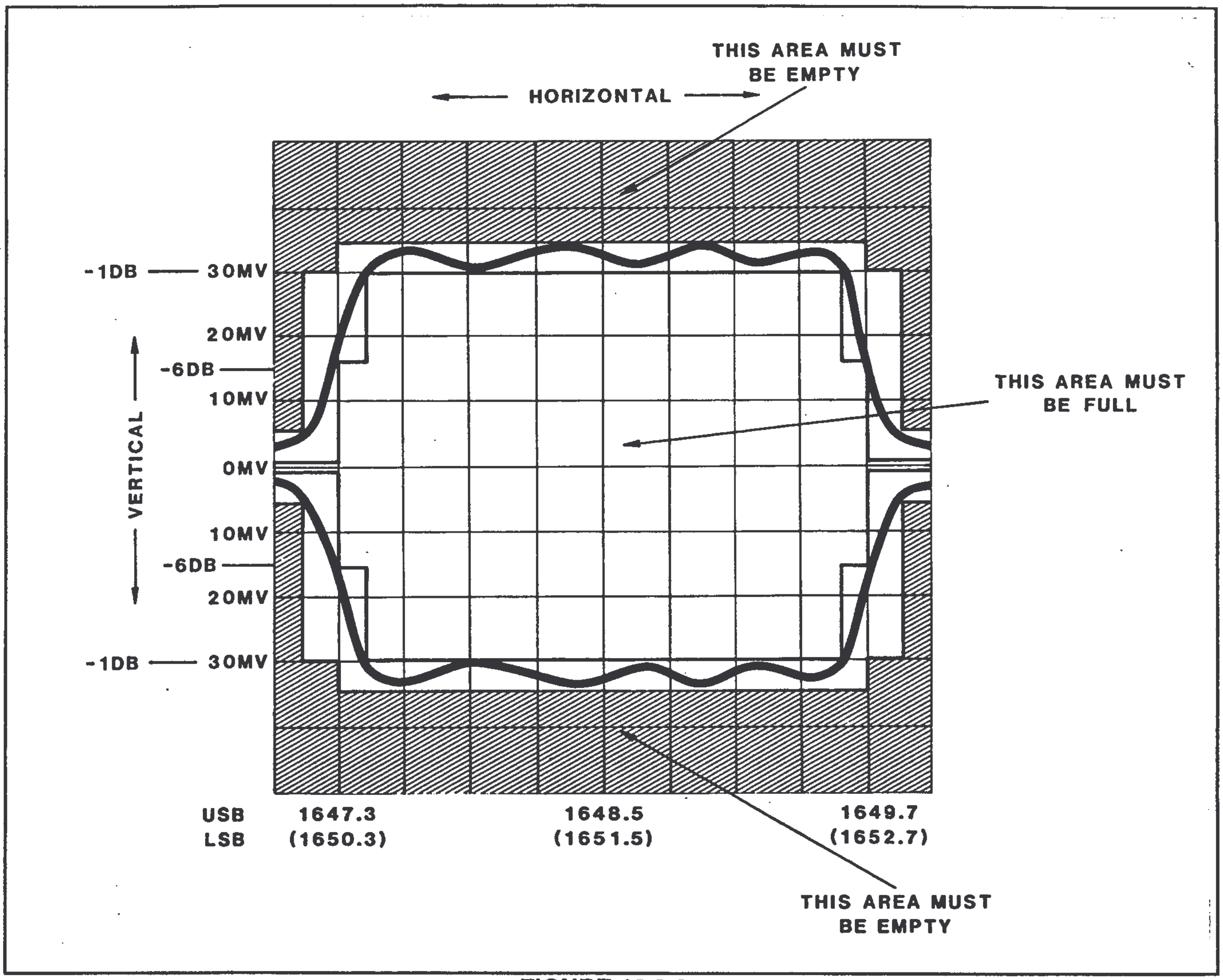


FIGURE 10.2-3.
Waveform.

It is necessary to use a narrowband sweep generator and oscilloscope to align the crystal filters.

Figure 10.2-2 illustrates the correct connections for filter alignment using an RF signal generator.

10.2.2.1 EQUIPMENT ADJUSTMENTS

1. Module M2 is in transmit mode.
2. Set oscilloscope for .1, X1, 10 mS or slower sweep.
3. Ground scope probe lead to PC board.
4. Set generator for 3-kHz sweep, -50 dBm.
5. Apply 12 V to pins 2 and 3, ground pins 1, 7, and 8.
6. Adjust L1 and L2 for the flattest possible response. See Figure 10.2-3.
7. Set scope for .02, X1, and generator to -60 dBm.
8. Apply +12 to pins 3, 7 and 8. Ground pins 1 and 2.
9. Adjust L3 and L4 for maximum amplitude. Amplitude should be 300-mV pp min. If not adjusting, reduce to -60 dBm.

When the equipment has been correctly adjusted, the filter passband will be displayed on the oscilloscope. Adjust L1 and L2 until the filter ripple is minimized. The adjustments will have considerable interaction and several adjustments may be necessary to achieve correct alignment. If LSB is fitted, the procedure should be repeated by turning L5 and L6 in the LSB mode.

NOTE

As a starting point, adjust the upper frequency (1649.7 or 1652.7) 6-dB point for maximum level using L1 or L5 as required.

Then adjust L2 or L6 as required for -6 dB at this frequency. From this point then carefully adjust both coils for best ripple.

10.2.3 SPECIFICATIONS

Table 10.2-1 lists the specifications for the 1650-kHz IF Module, M2.

TABLE 10.2-1.
Specifications, 1650-kHz IF Module, M2.

TRANSMIT	
Current Drain:	40 mA.
Input:	1649 kHz -33 dBm 5 mV RMS.
Output:	1649 kHz -25 dBm 13 mV RMS.
System Gain:	+8 dB.
RECEIVE	
Current Drain:	40 mA.
Input:	1649 kHz -77 dBm 30 mV RMS.
Output:	1649 kHz -23 dBm 16 µV RMS.
System Gain:	+54 dB.

10.2.4 VOLTAGE CHART

Table 10.2-2 defines the relevant voltages for the 1650-kHz IF Module, M2.

10.2.5 SERVICING

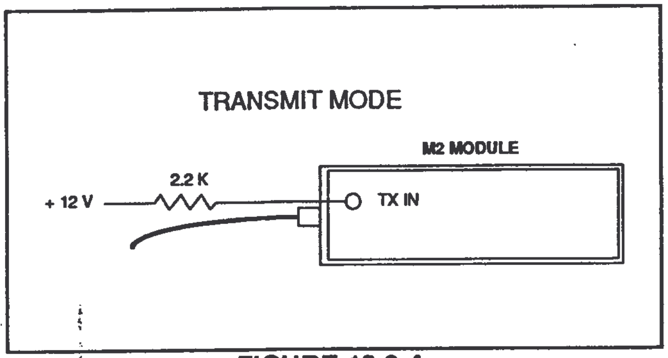


FIGURE 10.2-4.
Diode Switch Connection.

NOTE

The diode switch D11, at the input to the module, will not operate without external control provided by module M1. If the module is to be tested with the TX INPUT disconnected, make the connections as shown in Figure 10.2-4 to turn on the diode switch.

If the module does not operate, check the AGC voltage at pin 10 of the connector. The voltage should be approximately 4 V when the AGC or ALC is not operating. If there is no voltage present, check that there is no external short on the AGC line and that there is no voltage on the ALC input, pin 7. The AGC system is negative going and the voltage reduces as the received signal increases or the ALC action increases.

The complete IF module is used in the receive mode; and if the module does not operate in transmit, the fault must be external to the module. The second IF stage Q2 operates only in the receive mode and if the module is operating only in the transmit mode, the problem is probably in this stage.

It is best to check the operation of the filter in the transmit mode. The high gain of the module in the receive mode makes it difficult to make accurate readings, and it is possible for the test equipment to introduce phase selection feedback which causes passband ripple. Problems in the filter will be indicated by severe ripple in the passband and excessive filter loss. The most likely causes are a defective crystal or transformer (L1/L2 USB or L5/L6 LSB). The transformers are easily checked for dc continuity of the windings. Specialized test equipment is required for testing the filter crystals, and it is usually best to check a suspect crystal by replacement. Crystals usually fail due to a defective holder or crystal fracture. This means that the removal of the faulty crystal will be indicated by only a minor change in the filter performance.

Dual gate MOSFET's do exhibit a wide spread in characteristics. If the gain is low in both the transmit and receive modes, the problem may be low gain in Q1. This stage should be checked by substitution even though the operating voltages appear normal.

The filter switching may be checked by measuring the voltage across the filter switching diodes. In the USB mode, the anode voltages at D4 and D5 should be 0.7 V and D6 should be 1.4 V. In the LSB mode, D7 and D9 should be 0.7 V and D8 should be 1.4 V. No voltages should be present on the switching diodes in the non-operating filter.

TABLE 10.2-2.
Voltage Chart, 1650-kHz IF Module, M2.

	RX	TX
Q1		
Gate 1:	0.8 V	0.8 V
Gate 2:	3.8 V	3.8 V
Source:	2.2 V	2.2 V
Drain:	11.0 V	11.0 V
Q2 (Rx)		
Emitter:	0.8 V	
Base:	1.4 V	
Collector:	11.0 V	
Q3 (Rx)		
Emitter:	9.0 V	
Base:	9.6 V (use high impedance meter)	
Collector:	11.0 V	
Q4		
Emitter:	0.0 V	0.0 V
Base:	0.0V (no ALC/AGC)	
Collector:	4.0 V	4.0 V
Q5		
Emitter:	12.0 V	12.0 V
Base:	12.0 V (USB)	11.4 V (LSB)
Collector:	0.0 V	12.0 V (LSB)
Q6		
Emitter:	11.0 V (USB)	0.0 V (LSB)
Base:	11.6 V (USB)	0.0 V (LSB)
Collector:	12.0 V	12.0 V

	RX	TX
U1		
Pin 1	0.0 V	0.0 V
Pin 2	11.0 V	0.0 V
Pin 3	0.0 V	10.0 V
Pin 4	12.0 V	12.0 V
Pin 5	7.8 V	7.8 V
Pin 6	11.0 V	0.0 V
Pin 7	0.0 V	0.0 V
Pin 8	12.0 V	12.0 V
U2		
Pin 1	0.0 V	0.0 V
Pin 2	0.0 V	0.0 V
Pin 3	0.0 V	0.0 V
Pin 4	0.0 V	0.0 V
Pin 5	0.4 V	11.6 V
Pin 6	0.0 V	0.0 V
Pin 7	0.0 V	0.0 V
Pin 8	0.0 V	0.0 V
Pin 9	0.0 V	0.0 V
Pin 10	0.0 V	0.0 V
Pin 11	0.0 V	0.0 V
Pin 12	0.0 V	0.0 V
Pin 13	11.0 V	0.0 V
Pin 14	12.0 V	12.0 V

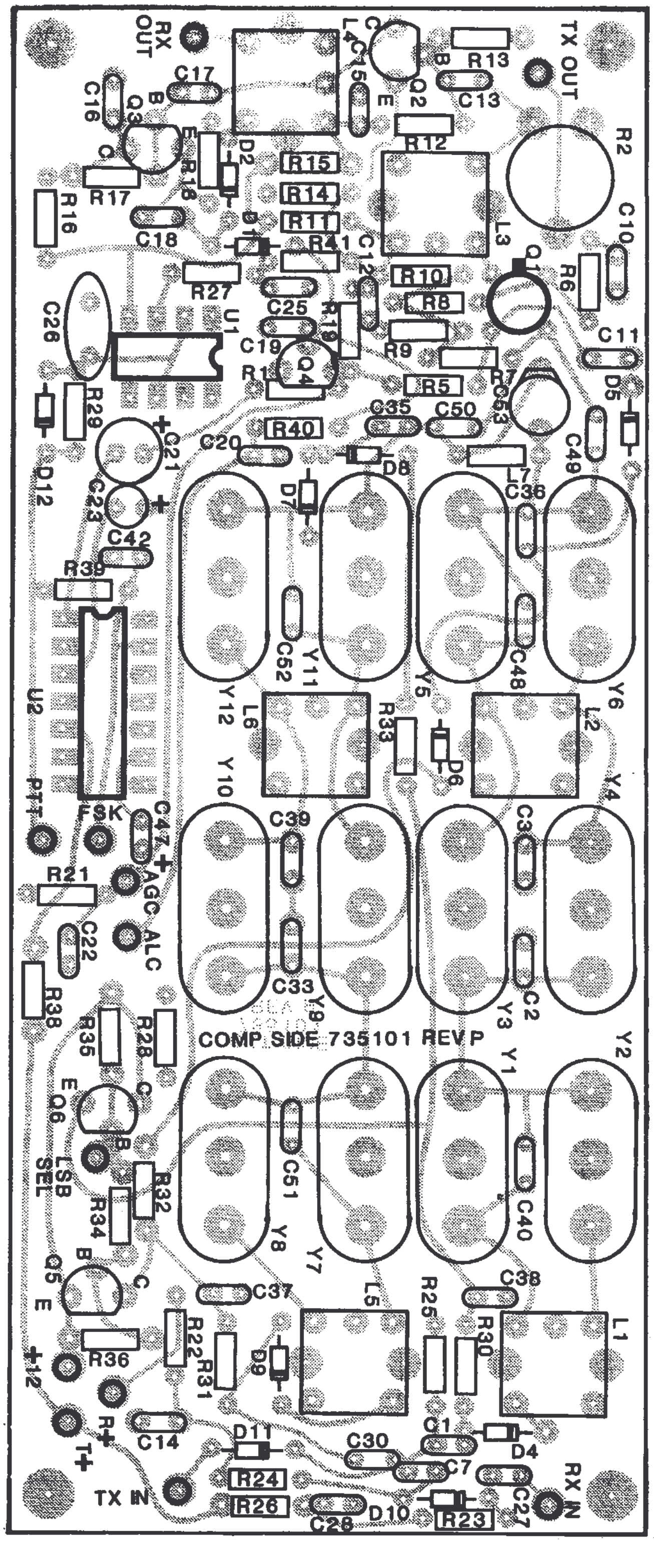
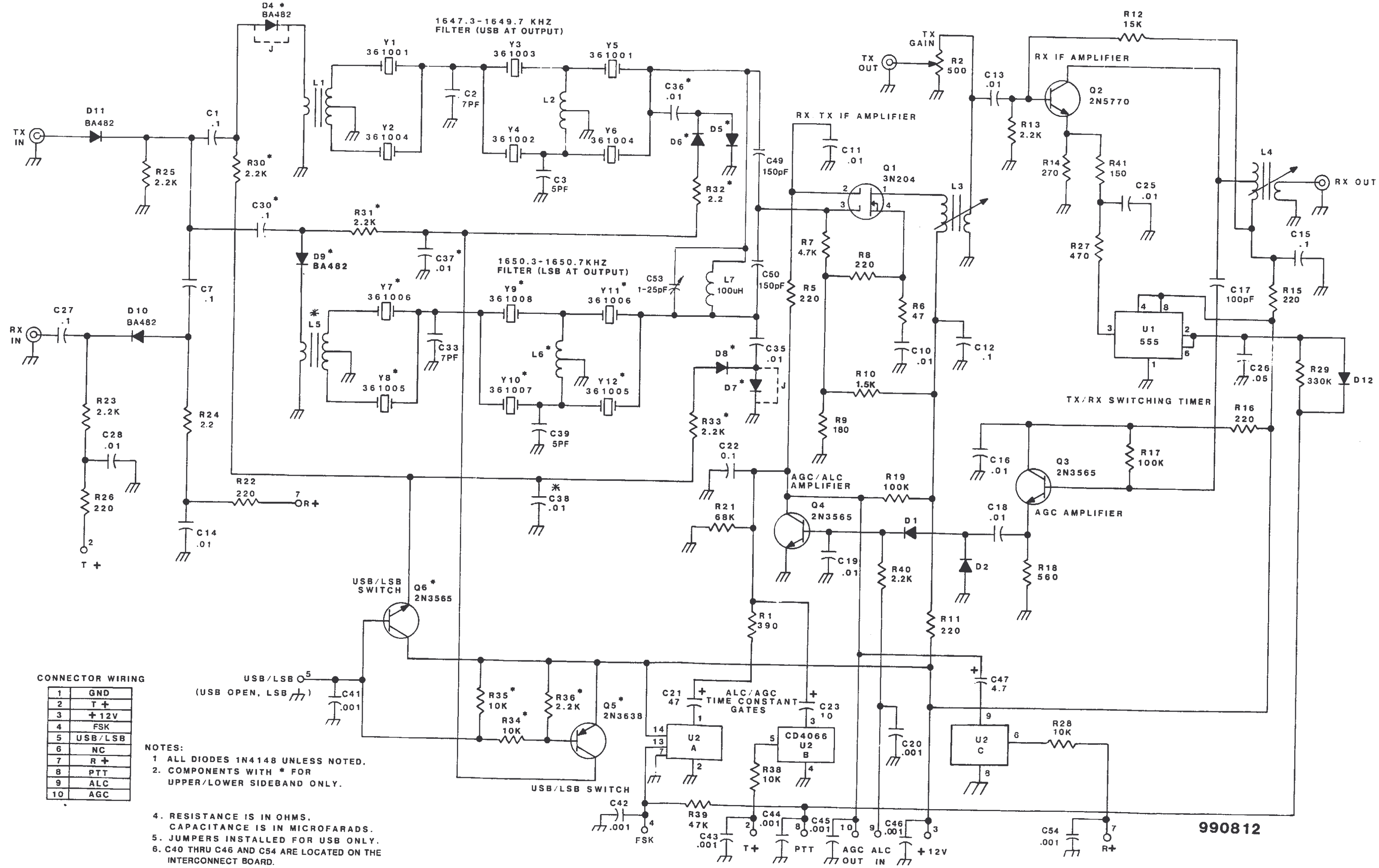


FIGURE 10.2-5.
Component Locations, 1650-kHz IF Module, M2.



CONNECTOR WIRING

1	GND
2	T +
3	+ 12V
4	FSK
5	USB/LSB
6	NC
7	R +
8	PTT
9	ALC
10	AGC

NOTES:
1. ALL DIODES 1N4148 UNLESS NOTED.
2. COMPONENTS WITH * FOR UPPER/LOWER SIDEBAND ONLY.
4. RESISTANCE IS IN OHMS. CAPACITANCE IS IN MICROFARADS.
5. JUMPERS INSTALLED FOR USB ONLY.
6. C40 THRU C46 AND C54 ARE LOCATED ON THE INTERCONNECT BOARD.

990812

TABLE 10.2-3.
Parts List, 1650-kHz IF Module, M2.

C1	275104	Capacitor, Monolithic 50 V 0.1 µF
C2	210070	Capacitor, Disc NPO 7 pF
C3	210050	Capacitor, Disc NPO 5 pF
C4-C6		Not Used.
C7	275104	Capacitor, Monolithic 50 V 0.1 µF
C8, C9		Not Used.
C10, C11	214103	Capacitor, Monolithic 50 V 0.01 µF
C12	275104	Capacitor, Monolithic 50 V 0.1 µF
C13, C14	214103	Capacitor, Monolithic 50 V 0.01 µF
C15	275104	Capacitor, Monolithic 50 V 0.1 µF
C16	214103	Capacitor, Monolithic 50 V 0.01 µF
C17	210101	Capacitor, Disc NPO 100 pF
C18, C19	214103	Capacitor, Monolithic 50 V 0.01 µF
C20	210102	Capacitor, Disc 0.001 µF
C21	231500	Capacitor, Electrolytic 47 µF
C22	275104	Capacitor, Monolithic 50 V 0.1 µF
C23	231100	Capacitor, Electrolytic 10 µF
C24		Not Used.
C25	214103	Capacitor, Monolithic 50 V 0.01 µF
C26	254503	Capacitor, Mylar 0.05 µF
C27	275104	Capacitor, Monolithic 50 V 0.1 µF
C28	214103	Capacitor, Monolithic 50 V 0.01 µF
C29		Not Used.
C30*	275104	Capacitor, Monolithic 50 V 0.1 µF
C31,C32		Not Used.
C33	210070	Capacitor, Disc NPO 7 pF
C34		Not Used.
C35	214103	Capacitor, Monolithic 50 V 0.01 µF
C36*-C38*	214103	Capacitor, Monolithic 50 V 0.01 µF
C39	210050	Capacitor, Disc NPO 5 pF
C40		Not Used.
C41-C46	210102	Capacitor, Disc 0.001 µF
C47	241040	Capacitor, Tantalum 16 V 4.7 µF
C48		Not Used.
C49,C50	221151	Capacitor, Mica DM5 150 pF
C51,C52		Not Used.
C53	261250	Capacitor, Trimmer 1-25 pF
C54	210102	Capacitor, Disc 25 V 0.001µF
D1, D2	320002	Diode, 1N4148
D3		Not Used.
D4* **	320005	Diode, PIN BA482
D5*, D6*	320002	Diode, 1N4148
D7* **	320002	Diode, 1N4148
D8*	320002	Diode, 1N4148
D9*	320005	Diode, PIN BA482
D10, D11	320005	Diode, PIN BA482
D12	320002	Diode, 1N4148
L1-L4	420018	Inductor, IF 1650 kHz
L5*, L6*	420018	Inductor, IF 1650 kHz
L7	430014	Inductor, Molded 100 µH
Q1	310001	Transistor, MFT 3N204
Q2	310032	Transistor, NPN 2N5770
Q3, Q4	310006	Transistor, NPN 2N3565

TABLE 10.2-3.
Parts List, 1650-kHz IF Module, M2, Continued.

Q5*	310007	Transistor, PNP 2N3638
Q6*	310006	Transistor, NPN 2N3565
R1	113391	Resistor, Film 1/8 W 5% 390 Ω
R2	170110	Resistor, Trimmer 500 Ω
R3, R4		Not Used.
R5	113221	Resistor, Film 1/8 W 5% 220 Ω
R6	113470	Resistor, Film 1/8 W 5% 47 Ω
R7	113472	Resistor, Film 1/8 W 5% 4.7 kΩ
R8	113221	Resistor, Film 1/8 W 5% 220 Ω
R9	113181	Resistor, Film 1/8 W 5% 180 Ω
R10	113152	Resistor, Film 1/8 W 5% 15 kΩ
R11	113221	Resistor, Film 1/8 W 5% 220 Ω
R12	113153	Resistor, Film 1/8 W 5% 15 kΩ
R13	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R14	113271	Resistor, 1/8 W 270 Ω
R15, R16	113221	Resistor, Film 1/8 W 5% 220 Ω
R17	113104	Resistor, Film 1/8 W 5% 100 kΩ
R18	113561	Resistor, Film 1/8 W 5% 560 Ω
R19	113104	Resistor, Film 1/8 W 5% 100 kΩ
R20		Not Used.
R21	113683	Resistor, Film 1/8 W 5% 68 kΩ
R22	113221	Resistor, Film 1/8 W 5% 220 Ω
R23-R25	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R26	113221	Resistor, Film 1/8 W 5% 220 Ω
R27	113471	Resistor, Film 1/8 W 5% 470 Ω
R28	113103	Resistor, Film 1/8 W 5% 10 kΩ
R29	113334	Resistor, Film 1/8 W 5% 330 kΩ
R30*-R33*	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R34*, R35*	113103	Resistor, Film 1/8 W 5% 10 kΩ
R36*	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R37		Not Used.
R38	113103	Resistor, Film 1/8 W 5% 10 kΩ
R39	113473	Resistor, Film 1/8 W 5% 47 kΩ
R40	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R41	113151	Resistor, Film 1/8 W 5% 150 Ω
U1	330094	IC, NE555N
U2	330074	IC, CD4066BE
Y1	361001	Crystal, Filter USB2
Y2	361004	Crystal, Filter USB1
Y3	361003	Crystal, Filter USB1
Y4	361002	Crystal, Filter USB2
Y5	361001	Crystal, Filter USB2
Y6	361004	Crystal, Filter USB1
Y7*	361006	Crystal, Filter LSB1
Y8*	361005	Crystal, Filter LSB2
Y9*	361008	Crystal, Filter LSB2
Y10*	361007	Crystal, Filter LSB1
Y11*	361006	Crystal, Filter LSB1
Y12*	361005	Crystal, Filter LSB2

* Parts used on lower sideband only.
** Install jumper for upper sideband only.

10.3 75-MHz MIXERS MODULE, M3

The M3 module contains both the transmit and receive mixers and 75-MHz amplifiers. The receive path has the signal coming in at 75 MHz, being amplified and down-converted to 1650 kHz before going on to the M2 module. The transmit signal comes in at 1650 kHz, is up-converted to 75 MHz, and then amplified before going on to the M4 module. All circuitry is on PCB 735106, which is contained in a die-cast box located in the center of the transceiver between modules M2 and M4.

10.3.1 TECHNICAL CIRCUIT DESCRIPTION

10.3.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Receive Input. 75-MHz signal at varying amplitudes from M4. PCB pin is at right rear of board while module SMA is at the right rear of box, on top.

b) Receive Output. 1650-kHz signal at varying amplitudes to M2. PCB pin is at left front of board and module SMA is at left front of box.

c) Transmit Input. 1650-kHz signal at 25 mV from M2. PCB pin is at left rear (second from edge) of board and module SMA connector is at left rear of box, on top.

d) Transmit Output. 75-MHz signal at 30 mV to M4. PCB pin is at right front of PCB and SMA connector is at right front of box.

e) Carrier Oscillator Input. 1650-kHz signal from M1 at approximately 200 mV. PCB pin is at left rear of board (next to edge) and SMA connector is at lower left rear of box.

f) Local Oscillator Input. 73.340- to 73.350-MHz input at 300 mV from M5. PCB pin is at center rear of board and SMA connector is at lower right rear of box.

DC Connections

Pin 3. AM control line from the mode switch. Ground indicates AM mode while an open indicates any other mode.

Pin 5. T+.

Pin 7. R+.

Pin 9. +12 V dc.

Pin 10. AGC line (see M2, pin 10).

10.3.1.2 CIRCUIT DESCRIPTION—RECEIVE

The input to this module is the 75-MHz output from the HF mixers & driver module (M4). This signal has already been filtered and has a 3-dB bandwidth of 30 kHz. A matching network C16/L4/C17 applies the signal to gate 1 of Q2, a dual gate MOSFET. The full gain of Q2 is not required and R20 introduces a deliberate input mismatch. Dual gate MOSFET's have excellent AGC characteristics when the voltage to gate 2 is controlled. To achieve the full range of control, gate 2 must go negative with respect to gate 1. This is achieved by the voltage divider R21/23, which holds gate 1 above ground. This means that when gate 2 is at ground potential, it is negative with respect to gate 1. The output from Q2 is matched into the mixer through the Pi network C21/L6/C22.

The mixer stage is a high-performance junction FET, Q3. The signal is applied to the gate and the oscillator is applied to the source. The oscillator signal comes from M5, the second loop of the synthesizer, and covers the range 73.340-73.350 MHz in 100-Hz steps. This is necessary as the output from the HF mixers & driver covers the frequency range in 10-kHz increments. The 1650-kHz output from the mixer is coupled to the next module through L7. The resistor R26 across the primary corrects for a 50 ohm output termination.

10.3.1.3 CIRCUIT DESCRIPTION—TRANSMIT

The input to this module is the 1650-kHz SSB signal from the 1650-kHz IF module (M2). The signal is applied directly to the balanced mixer U1. This integrated circuit uses a quad amplifier driven by differential dual current sources, giving excellent suppression of unwanted products. R8 is a potentiometer used to balance the offset current at the differential inputs and is used to ensure the best possible balance of the oscillator signal at the output. The oscillator injection is applied from the second loop of the synthesizer and covers the range 73.340-73.350 kHz. This gives an output signal 74.990-75.000 MHz.

The output from the mixer is coupled through a ferrite transformer L1 to Q1, a grounded-gate, low-distortion, FET amplifier. The output is matched to the HF mixers & driver module through the Pi network C12/L3/C13.

10.3.1.4 CIRCUIT DESCRIPTION—CARRIER SWITCH

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 U2 via the PIN diode attenuator D1/D2. In the off position, D2 is forward biased, which shorts the carrier to ground. D1 is reversed biased. This gives approximately 60 dB of attenuation. When the carrier switch is grounded, D1 is forward biased, and D2 is reverse biased, and the carrier is not attenuated. The carrier level is adjusted by the input potentiometer R1. D3/R32/C32 provide a low-impedance path to ground when the A3A option switch is included. The ratios have been chosen to provide a pilot carrier level of -16 dB.

10.3.2 ADJUSTMENT PROCEDURE

10.3.2.1 TRANSMITTER

Adjust L3 for maximum transmitter output.

10.3.2.2 RECEIVER

No adjustments are required. L4, L6 and L7 are low Q and the adjustment is not critical. They are adjusted for maximum output during factory alignment.

10.3.2.3 CARRIER LEVEL

Adjust R1 in the transmit mode for an unmodulated power output in AM mode of 25 W at the high open-loop gain frequency of the transceiver.

10.3.2.4 MIXER BALANCE

This adjustment is not required unless U1 is replaced. Connect a sensitive millivoltmeter to the transmitter output and disconnect the transmit input to the module. Any residual output is in the 73.350 oscillator leakage. Adjust R8 for lowest output (approximately -40 dBm, 2 mV RMS).

10.3.3 SPECIFICATIONS

Table 10.3-1 lists the specifications for the 75-MHz Mixers Module, M3.

10.3.4 VOLTAGE CHART

Table 10.3-2 defines the relevant voltages for the 75-MHz Mixers Module, M3.

10.3.5 SERVICING

First check that the oscillator input level and frequency are correct. Incorrect oscillator injection level or the wrong frequency will prevent correct operation of the module.

Use a signal generator and RF millivoltmeter to measure the gain of the system as shown in the diagrams, Figure 10.3-2 and Figure 10.3-3.

If the system gain is incorrect, check the voltages at the integrated circuit and transistors. U1 is best checked by substitution. Component or device failures are usually indicated by voltages differing substantially from the chart. Remember the AGC voltage must be present for correct operation in the receive mode.

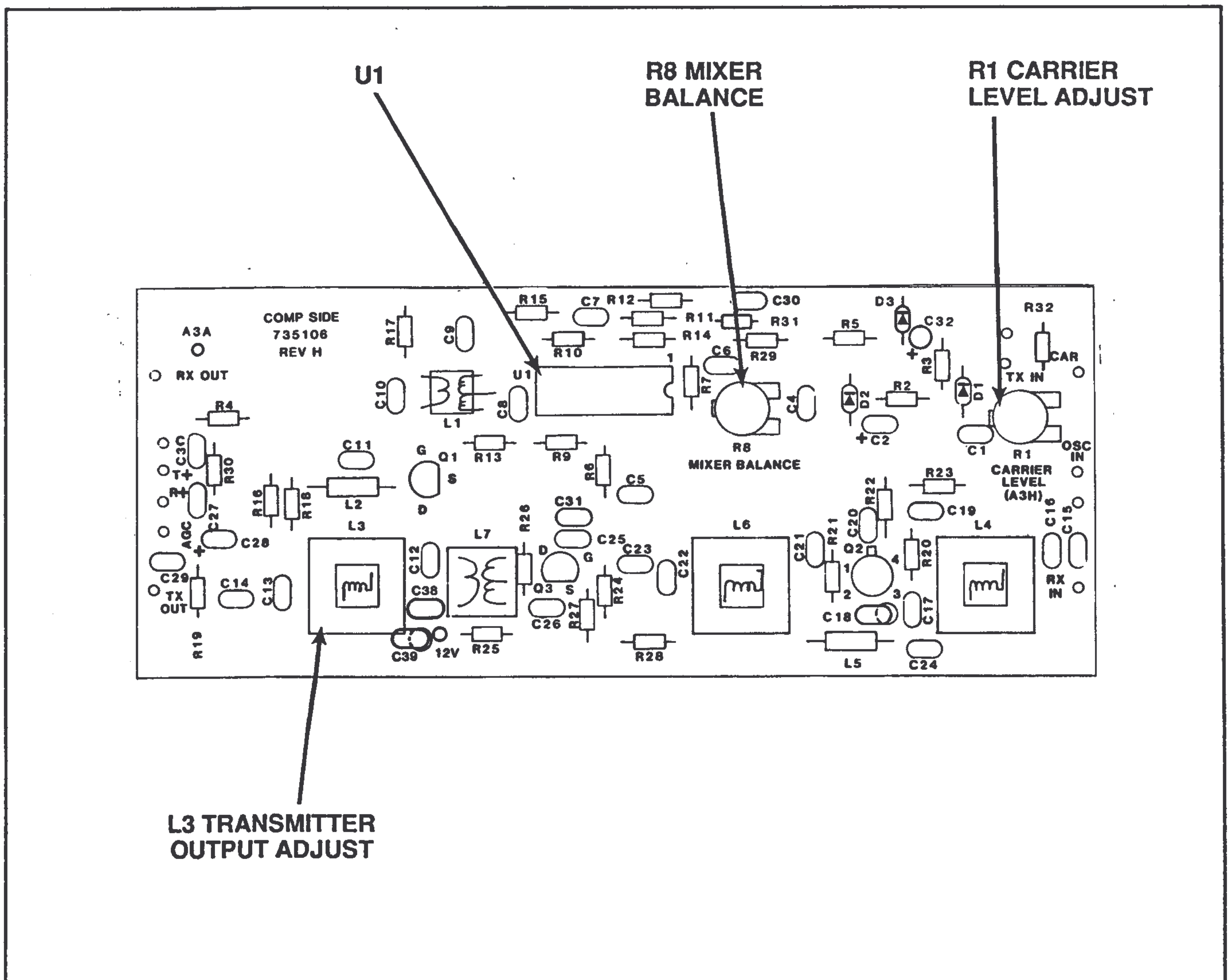


FIGURE 10.3-1.
Adjustment Points.

TABLE 10.3-1.
Specifications, 75-MHz Mixers Module, M3.

TRANSMIT	
Current:	24 mA.
Input:	1650 kHz, -18 dBm (25 mV RMS).
Output:	75 MHz, -17 dBm (30 mV RMS).
System Gain:	1 dB.
Oscillator Injection Level:	300 mV RMS.
Oscillator Level at Output:	-35 dBm.
Carrier Level ON:	-6 dB relative PEP.
Carrier Level OFF:	-60 dB relative PEP.
Carrier Input Level:	200 mV RMS.
RECEIVE	
Current:	10 mA.
Input:	75 MHz.
Output:	1650 kHz.
System Gain:	20 dB.
Oscillator Injection Level:	300 mV RMS.
OSCILLATOR	
Frequency:	73.3401-73.350 MHz in 100 Hz steps.
Level:	300 mV RMS.

TABLE 10.3-2.
Voltage Chart, 75-MHz Mixers Module, M3.

U1 (Tx)	
Pin 1	3.7 V
Pin 2	3.0 V
Pin 3	3.0 V
Pin 4	3.7 V
Pin 5	1.2 V
Pin 6	11.1 V
Pin 8	6.7 V
Pin 10	6.7 V
Pin 12	11.1 V
Q1 (Tx)	
Source:	1.7 V
Gate:	0.0 V
Drain:	10.2 V
Q2 (Rx)	
Source (4):	2.1 V
Gate 1 (2):	4.0 V*
Gate 2 (3):	1.5 V
Drain (1):	11.3 V
Q3 (Rx)	
Source:	3.8 V
Gate:	0.0 V
Drain:	11.6 V

*AGC not operating.

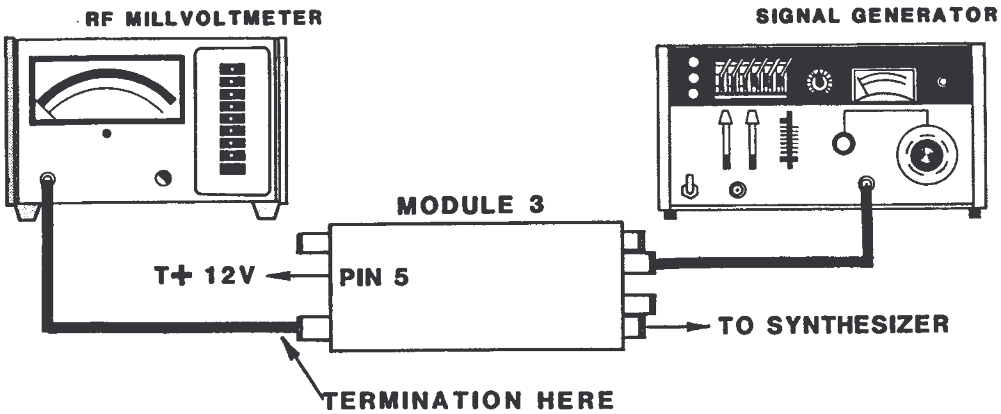


FIGURE 10.3-2.
Transmit Gain Measurement.

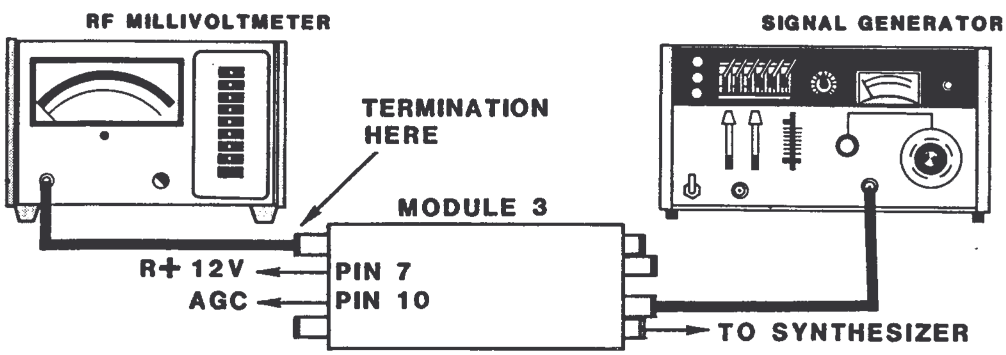


FIGURE 10.3-3.
Receive Gain Measurement.

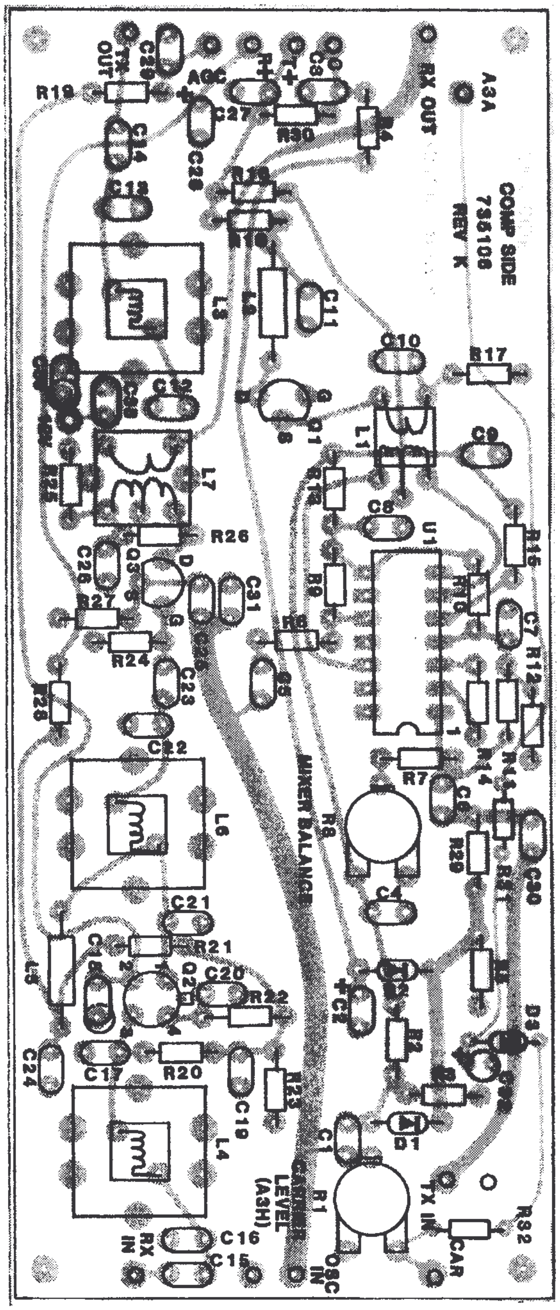
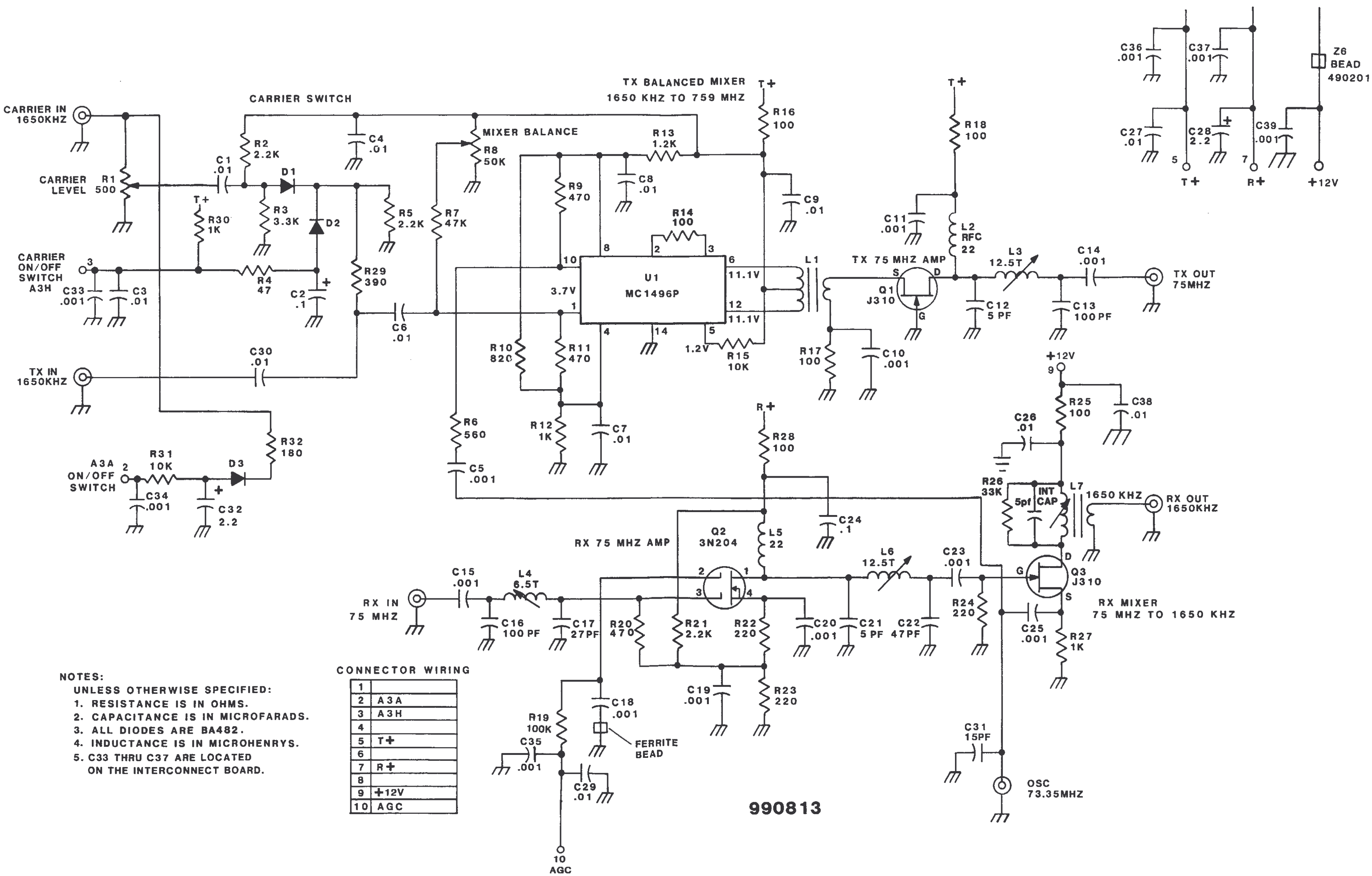


FIGURE 10.3-4.
Component Locations, 75-MHz Mixers Module, M3.



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. RESISTANCE IS IN OHMS.
2. CAPACITANCE IS IN MICROFARADS.
3. ALL DIODES ARE BA482.
4. INDUCTANCE IS IN MICROHENRYS.
5. C33 THRU C37 ARE LOCATED ON THE INTERCONNECT BOARD.

CONNECTOR WIRING

1	
2	A3A
3	A3H
4	
5	T+
6	
7	R+
8	
9	+12V
10	AGC

990813

TABLE 10.3-3.
Parts List, 75-MHz Mixers Module, M3.

C1	214103	Capacitor, Monolithic 50 V 0.01 μF
C2	241001	Capacitor, Tantalum 0.1 μF
C3, C4	214103	Capacitor, Monolithic 50 V 0.01 μF
C5	210102	Capacitor, Disc 0.001 μF
C6-C9	214103	Capacitor, Monolithic 50 V 0.01 μF
C10, C11	210102	Capacitor, Disc 0.001 μF
C12	210050	Capacitor, Disc NPO 5 pF
C13	210101	Capacitor, Disc NPO 100 pF
C14, C15	210102	Capacitor, Disc 0.001 μF
C16	210101	Capacitor, Disc NPO 100 pF
C17	210270	Capacitor, Disc NPO 27 pF
C18-C20	210102	Capacitor, Disc 0.001 μF
C21	210050	Capacitor, Disc NPO 5 pF
C22	210470	Capacitor, Disc NPO 47 pF
C23	210102	Capacitor, Disc 0.001 μF
C24	275104	Capacitor, Monolithic 50 V 0.1 μF
C25	210102	Capacitor, Disc 0.001 μ
C26, C27	214103	Capacitor, Monolithic 50 V 0.01 μF
C28	241020	Capacitor, Tantalum 2.2 μF
C29, C30	214103	Capacitor, Monolithic 50 V 0.01 μF
C31	210150	Capacitor, Disc NPO 15 pF
C32	241020	Capacitor, Tantalum 2.2 μF
C33-C37	210102	Capacitor, Disc 0.001 μF
C38	214103	Capacitor, Monolithic 50 V 0.01 μF
C39	210102	Capacitor, Disc 0.001 μF
D1-D3	320005	Diode, PIN BA482
L1	451109	Inductor, Variable
L2	430021	Inductor, Fixed 22 μH
L3	490109	Inductor, Variable 12.5 turns
L4	490114	Inductor, Variable 6.5 turns
L5	430021	Inductor, Fixed 22 μH
L6	490109	Inductor, Variable 12.5 turns
L7	420018	Inductor, Variable 1650 kHz
Q1	310033	Transistor, FET J310
Q2	310001	Transistor, MFT 3N204
Q3	310033	Transistor, FET J310
R1	170110	Resistor, Trimmer 500 Ω
R2	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R3	113332	Resistor, Film 1/8 W 5% 3.3 kΩ
R4	113470	Resistor, Film 1/8 W 5% 47 Ω
R5	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R6	113561	Resistor, Film 1/8 W 5% 560 Ω
R7	113473	Resistor, Film 1/8 W 5% 47 kΩ
R8	170109	Resistor, Trimmer 50 kΩ
R9	113471	Resistor, Film 1/8 W 5% 470 Ω
R10	113821	Resistor, Film 1/8 W 5% 820 Ω
R11	113471	Resistor, Film 1/8 W 5% 470 Ω
R12	113102	Resistor, Film 1/8 W 5% 1 kΩ
R13	113122	Resistor, Film 1/8 W 5% 1.2 kΩ
R14	113101	Resistor, Film 1/8 W 5% 100 Ω
R15	113103	Resistor, Film 1/8 W 5% 10 kΩ
R16-R18	113101	Resistor, Film 1/8 W 5% 100 Ω

TABLE 10.3-3.
Parts List, 75-MHz Mixers Module, M3, Continued.

R19	113221	Resistor, Film 1/8 W 5% 220 Ω
R20	113471	Resistor, Film 1/8 W 5% 470 Ω
R21	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R22-R24	113221	Resistor, Film 1/8 W 5% 220 Ω
R25	113101	Resistor, Film 1/8 W 5% 100 Ω
R26	113333	Resistor, Film 1/8 W 5% 33 kΩ
R27	113102	Resistor, Film 1/8 W 5% 1 kΩ
R28	113101	Resistor, Film 1/8 W 5% 100 Ω
R29	113391	Resistor, Film 1/8 W 5% 390 Ω
R30	113102	Resistor, Film 1/8 W 5% 1 kΩ
R31	113103	Resistor, Film 1/8 W 5% 10 kΩ
R32	113181	Resistor, Film 1/8 W 5% 180 Ω
U1	330006	IC, MC1496P
Z1-Z6	490201	Bead, Ferrite

10.4 HF MIXER & DRIVER MODULE, M4

The M4 module contains the HF transmit and receive mixers, the 75-MHz amplifier and monolithic filter and the transmit driver amplifiers. Receive input is at the channel frequency from M7; it is up converted to 75-MHz, filtered and sent out to the M3 module. The transmit signal comes in at 75-MHz, is amplified and filtered, then down converted to the channel frequency. It is then amplified and sent to the RF power module, M10. All circuitry is located on PCB 735103 which is contained in the die-cast box between M3 and M5.

10.4.1 TECHNICAL CIRCUIT DESCRIPTION

10.4.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Receive Input. Channel frequency at varying amplitudes from M7. PCB pin at right front of board and module SMA connector is at right front of box.
b) Receive Output. 75-MHz signal to M3. PCB pin at left rear of board and SMA connector at left rear of box.
c) Transmit Input. 75-MHz signal from M3 at 30mV. PCB pin at center front of board and SMA connector at left front of box.
d) Transmit Output. Channel frequency signal at approximately 800 mV to M10. PCB pin at right rear of board and SMA connector at center rear of box.
e) Local Oscillator Input. 76.6 to 104.99-MHz input from M6 at 700 mV. PCB in right center of board and SMA connector at right rear of box.

DC Connections

Pin 3. +12 Vdc.
Pin 5. R+.
Pin 7. T+.

10.4.1.2 CIRCUIT DESCRIPTION - RECEIVE

The input to this module is the filtered input from the antenna. The low-pass filters on M7 attenuate the frequencies above the cutoff on the filter selected, and a further high-pass filter on M7 attenuates the frequencies below 1.6 MHz. The low-pass filter C29, L10, C30 attenuates all frequencies above 30 MHz. This virtually eliminates spurious responses from image frequencies, which fall in the range 151.6-180 MHz, and the first IF frequency, 75 MHz.

The incoming signal is applied to the input of a "high-reliability" precision double-balanced mixer U1. This mixer has a high intercept point and gives the receiver front end an outstanding dynamic range. The output from M6, the 10-kHz loop of the synthesizer, is applied to the oscillator port of the mixer. The synthesizer output is 76.6-104.99 MHz, which produces an IF frequency of 75 MHz.

The mixer output is applied to the base of Q1 through the forward-biased PIN diode D1. This diode is reverse-biased in the transmit mode to isolate the receiver mixer from the 75-MHz IF amplifier Q1. This stage uses a large, low-noise transistor with a high intercept point. The stage uses collector-base feedback and emitter degeneration to provide linearity and a wide range resistive 50-ohm termination for the mixer. The 75-MHz IF amplifier does not degrade the dynamic range of the mixer.

The 75-MHz filter is a high-performance, 4-pole, monolithic design with a bandwidth of 30 kHz. This permits the use of 10-kHz steps in the first loop of the synthesizer. The filter is matched to Q1 by the Pi network C6/L2/C7. The output Pi network C8/L3/C9 provides a 50-ohm output from the filter. The PIN diodes D3 and D5 provide a two-stage switch to provide complete isolation in the transmit mode. D3 is forward biased in the receive mode and D5 is open circuit. In the transmit mode, D3 is open circuit and D5 shorts the signal to ground.

10.4.1.3 CIRCUIT DESCRIPTION - TRANSMIT

The 75-MHz input from M3 is applied through the forward-biased PIN diode switch D2, to the IF amplifier Q1. It will be noted that Q1 and the 75-MHz crystal filter FL1 are used in both the transmit and receive modes.

The amplified 75-MHz IF signal is applied, through the forward-biased PIN diode switch D4, to the IF port of the double-balanced mixer U2. The output from the 10-kHz loop of the synthesizer is applied to the oscillator port of U2. The synthesizer oscillator covers the range 76.6-104.99 MHz, which gives an output frequency range of 1.6-30 MHz. The levels are carefully controlled and a high-level mixer is used to give exceptional spectral purity over the entire HF range.

The low-level transmit signals can be amplified to approximately 100 mW in the three-stage broadband amplifier. Q2 and Q3 are grounded gate low-distortion junction field-effect transistors. Q2 provides a broadband resistive 50-ohm termination to U2. The two stages are transformer coupled using broadband ferrite transformers. The push-pull output stages Q4 and Q5 use Class A bipolar transistors with collector-base feedback. The broadband output transformer L7 provides a 50-ohm output. The network L4, R12, and C15, is a gain-leveling network. It should be noted that the gain of the three-stage amplifier has been compensated, in conjunction with the RF power amplifier module M10, to provide substantially level gain over the entire frequency range of the transmitter.

The output spectrum from U2 includes the image frequencies 151.6-180 MHz. The three-stage broadband amplifier has very low gain at these frequencies. Any residual image output is further attenuated by the low-pass filter C24, L9, C25.

10.4.2 ADJUSTMENT PROCEDURE

No routine alignment is required during the service life of the transceiver. The inductors L2 and L3 are sealed after factory alignment of the crystal filter. The alignment procedure is described in case physical damage should occur to L2 and L3. Do not attempt alignment without the correct equipment. It is unlikely that there will be any perceptible change in performance even if FL1 is replaced. The correct procedure is as follows:

1. Set signal generator to 75 MHz. Switch to external RF mode.

2. Connect the external FM input to the sawtooth output from the oscilloscope. On some oscilloscopes, this may necessitate making an internal connection to the deflection plates.

3. Adjust the deviation to approximately 50 kHz.

4. Connect a 75-MHz oscilloscope to the "RX OUT" terminal on the module. Make sure that the oscilloscope provides a 50-ohm termination or use a 50-ohm, 60- or 10-dB, attenuator.

5. Adjust the gain of the oscilloscope and output of the signal generator until the RF envelope is nearly full screen.

6. Center the signal so that the passband is centered in the oscilloscope screen and adjust the deviation as required.

7. Carefully adjust L2 and L3 until there is minimum ripple on the passband. The ripple should be less than 1 dB.

10.4.3 SPECIFICATIONS

Table 10.4-1 lists the specifications for the HF Mixers & Drive Module, M4.

10.4.4 VOLTAGE CHART

Table 10.4-2 defines the relevant voltages for the HF Mixers & Drive Module, M4.

10.4.5 SERVICING

First check that the oscillator input level and frequency are correct. Incorrect oscillator injection level or the wrong frequency will prevent correct operation of the module.

Check that the diode switches are operating correctly. When forward biased, the anode will be .7 V higher than the cathode. When reverse biased, the cathode will be at higher potential than the anode. The banded end of the diode is the cathode.

Use a signal generator and RF millivoltmeter to measure the gain on the system as shown in the Figures 10.4-2 and 10.4-3.

If the system gain is incorrect, check the voltages on the transistors and make sure the diode switches are correctly biased.

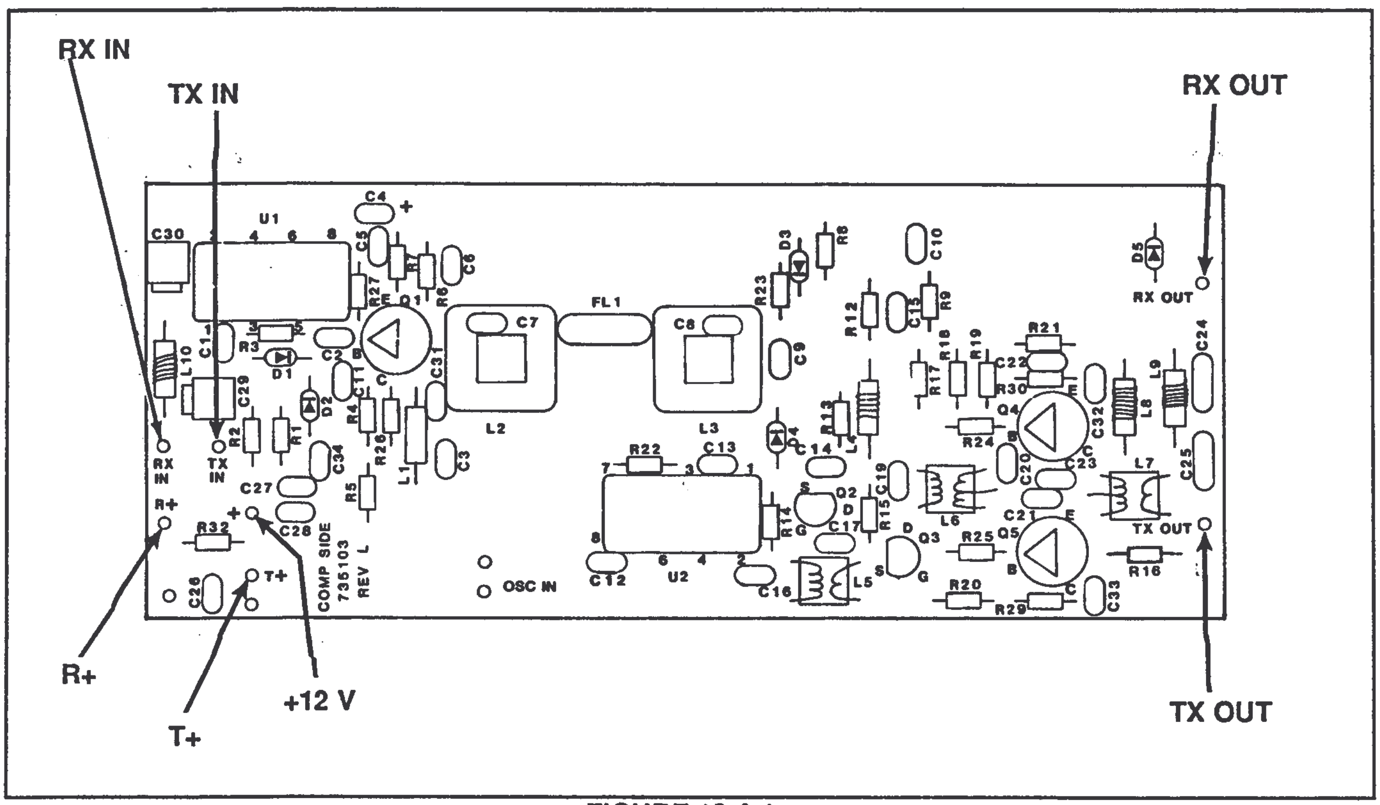


FIGURE 10.4-1.
Adjustment Points.

TABLE 10.4-1.
Specifications, HF Mixers & Driver Module, M4.

TRANSMIT	
Current:	220 mA.
Input:	75 MHz, -17 dBm (30-mV RMS).
Output:	Signal frequency 0 to +20 dBm (0.22-2.2 V, RMS).
System Gain:	*36 dB.
Oscillator Injection Level:	700-mV RMS at pin 8 U2.
*Measured at 30 MHz, varies with signal frequency.	
RECEIVE	
Current:	52 mA.
Input:	Signal frequency -7 dBm (100-mV RMS).
Output:	75 MHz, 0 dBm (220-mV RMS).
System Gain:	+7 dB.
Oscillator Injection Level:	700-mV RMS at pin 8 U1.
OSCILLATOR	
Frequency:	76.6-104.99 MHz (Fs=1.6-30 MHz).
Level:	+10 dBm at M4 input.

TABLE 10.4-2.
Voltage Chart, HF Mixers & Driver Module, M4.

	RX	TX
Q1		
Emitter:	1.2 V	1.2 V
Base:	1.8 V	1.8 V
Collector:	11.4 V	11.4 V
Q2 (Tx)		
Source:		2.0 V
Gate:		0.0 V
Drain:		11.5 V
Q3 (Tx)		
Source:		2.0 V
Gate:		0.0 V
Drain:		11.5 V
Q4 (Tx)		
Emitter:		7.0 V
Base:		1.3 V
Collector:		12.0 V

	RX	TX
Q5 (Tx)		
Emitter:		7.0 V
Base:		1.3 V
Collector:		12.0 V
D1	Forward biased	Reverse biased
D2	Reverse biased	Forward biased
D3	Forward biased	Reverse biased
D4	Reverse biased	Forward biased
D5	No bias	Forward biased
D6	Forward biased	Reverse biased
D7	Reverse biased	Forward biased

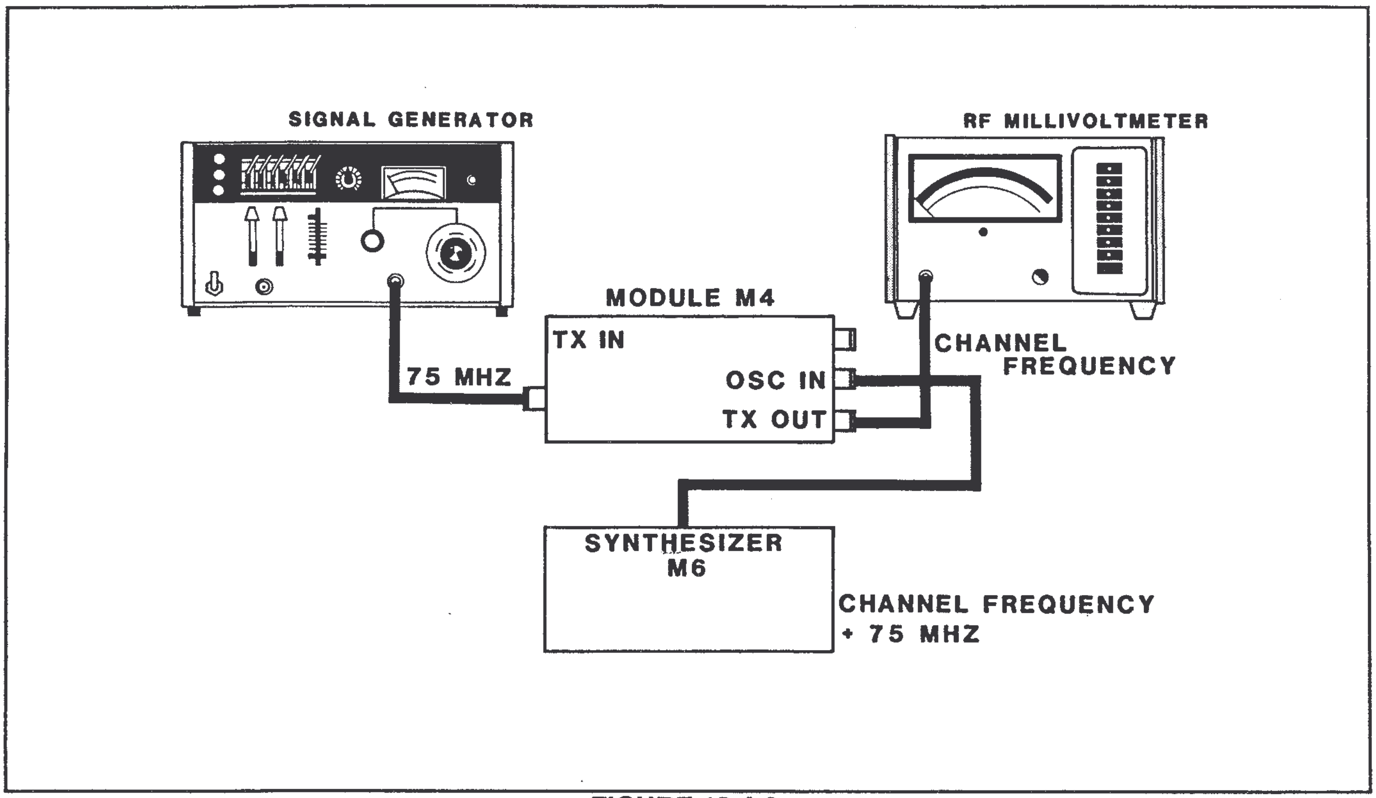


FIGURE 10.4-2.
Transmit Gain Measurement.

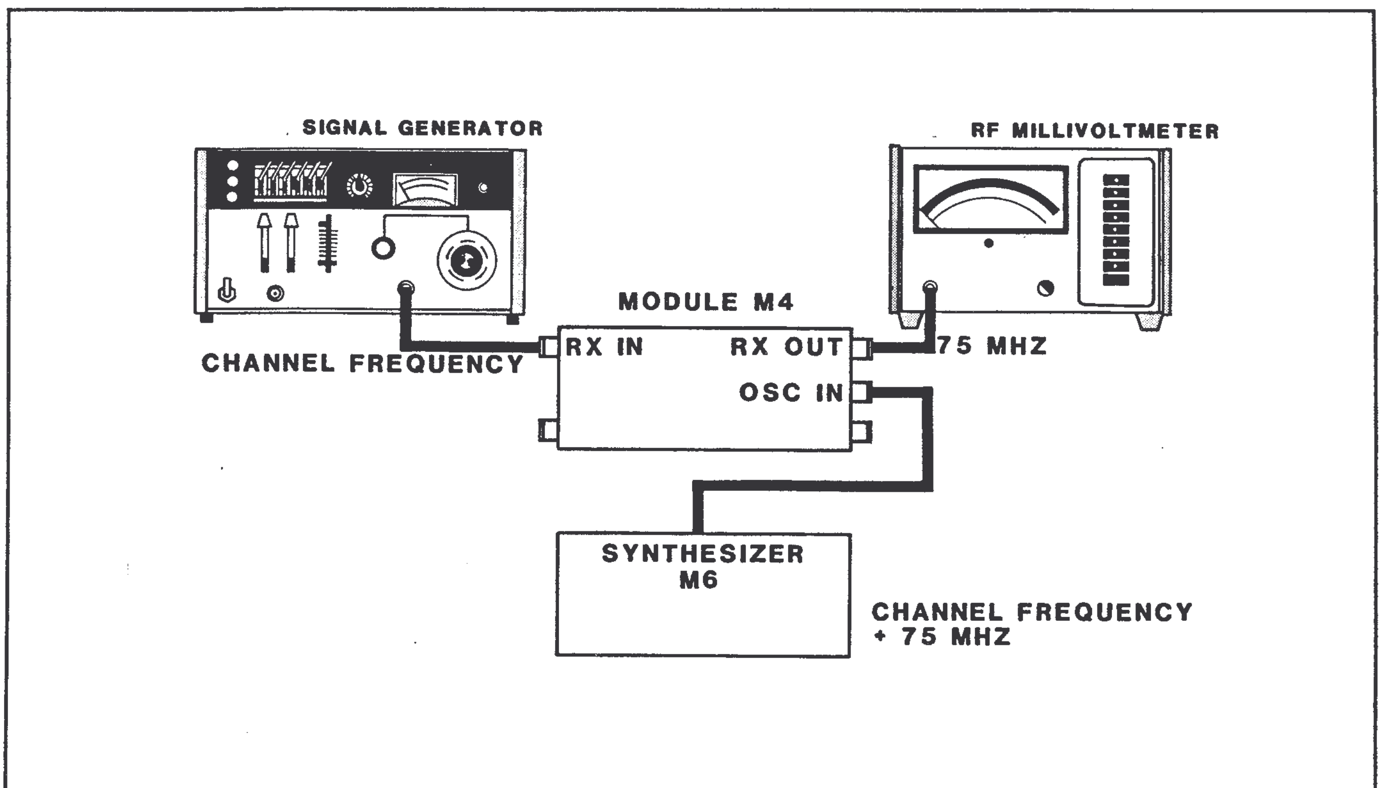


FIGURE 10.4-3.
Receive Gain Measurement.

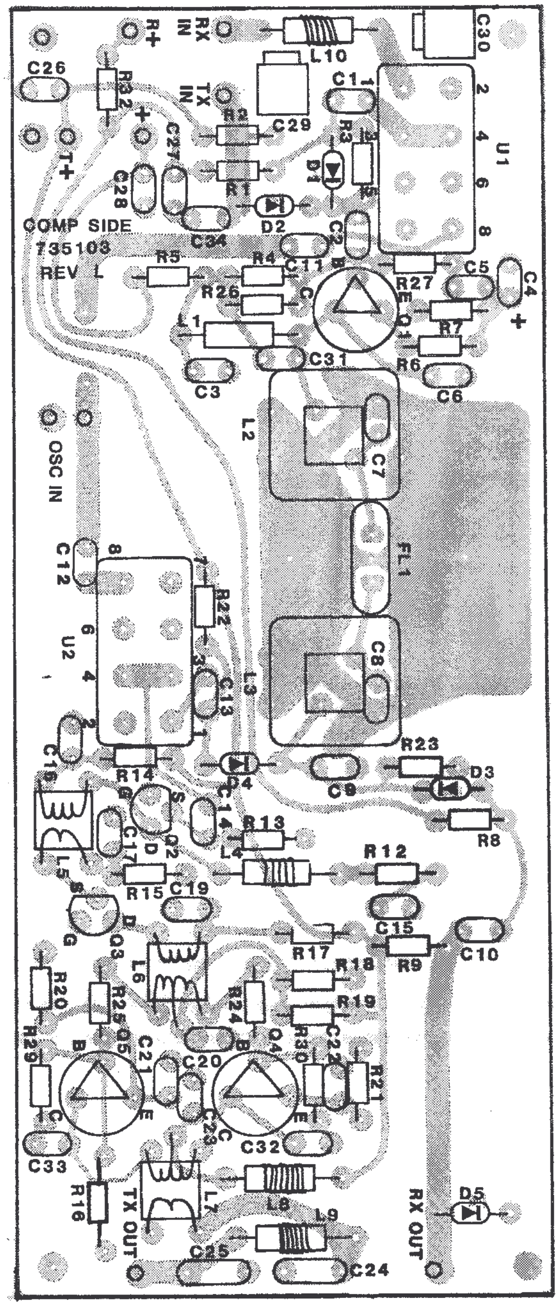
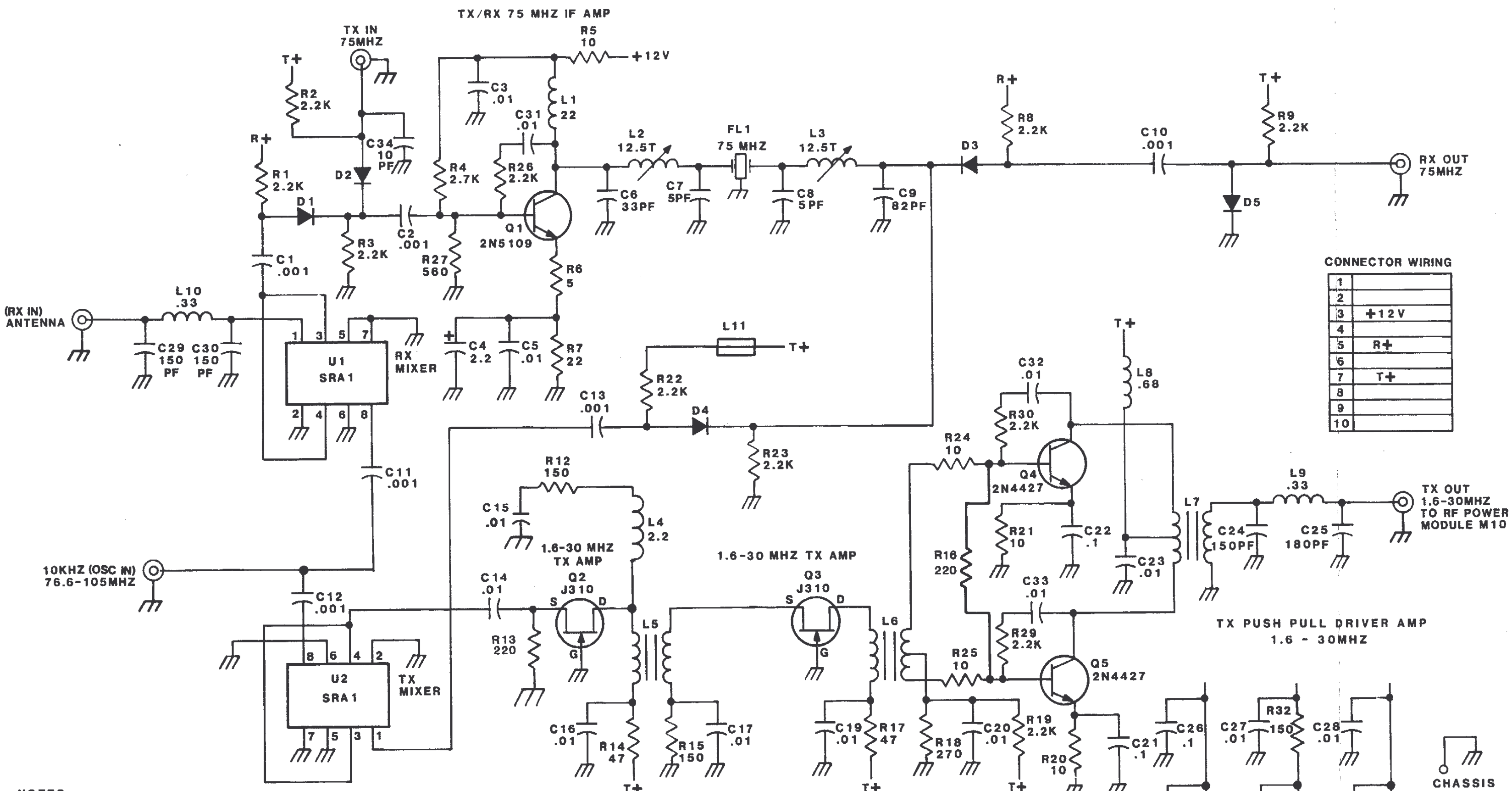


FIGURE 10.4-4.
Component Locations, HF Mixers & Driver Module, M4.



CONNECTOR WIRING

1	
2	
3	+12V
4	
5	R+
6	
7	T+
8	
9	
10	

NOTES:
UNLESS OTHERWISE SPECIFIED:
1. RESISTANCE IS IN OHMS.
2. CAPACITANCE IS IN MICROFARADS.
3. ALL DIODES ARE MPN3500
4. INDUCTANCE IS IN MICROHENRYS.
5. C36 THRU C38 ARE LOCATED ON THE INTERCONNECT BOARD.

TABLE 10.4-3.
Parts List, HF Mixers & Driver, M4.

C1, C2	210102	Capacitor, Disc 0.001 μF
C3	214103	Capacitor, Monolithic 50 V 0.01 μF
C4	241020	Capacitor, Tantalum 2.2 μF
C5	214103	Capacitor, Monolithic 50 V 0.01 μF
C6	210330	Capacitor, Disc NPO 33 pF
C7, C8	210050	Capacitor, Disc NPO 5 pF
C9	210820	Capacitor, Disc NPO 82 pF
C10-C13	210102	Capacitor, Disc 0.001 μF
C14-C17	214103	Capacitor, Monolithic 50 V 0.01 μF
C18		Not Used.
C19, C20	214103	Capacitor, Monolithic 50 V 0.01 μF
C21, C22	274104	Capacitor, Monolithic 0.1 μF
C23	214103	Capacitor, Monolithic 50 V 0.01 μF
C24	220151	Capacitor, Mica DM15 150 pF
C25	220181	Capacitor, Mica DM15 180 pF
C26	275104	Capacitor, Monolithic 50 V 0.1 μF
C27-C28	214103	Capacitor, Monolithic 50 V 0.01 μF
C29, C30	227151	Capacitor, MC Mica 150 pF
C31-C33	214103	Capacitor, Monolithic 50 V 0.01 μF
C34	210100	Capacitor, Disc 10 pF
C35		Not Used.
C36-C38	210102	Capacitor, Disc 0.001 μF
D1-D5	320005	Diode, PIN BA482
FL1	370007	Crystal, Filter 75 MHz
L1	430021	Inductor, Fixed 22 μH
L2, L3	490109	Inductor, Variable 12.5 turns
L4	430031	Inductor, Fixed Molded 2.2 μH
L5	451112	Inductor, Variable
L6	451113	Inductor, Variable
L7	451114	Inductor, Variable
L8	430005	Inductor, Fixed 0.68 μH
L9, L10	430012	Inductor, Fixed 0.33 μH
L11	490203	Inductor, Bead
Q1	310059	Transistor, 2N5109
Q2, Q3	310033	Transistor, FET J310
Q4, Q5	310011	Transistor, NPN 2N4427
R1-R3	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R4	113272	Resistor, Film 1/8 W 5% 2.7 kΩ
R5	113100	Resistor, Film 1/8 W 5% 10 Ω
R6	113050	Resistor, Film 1/8 W 5% 5 Ω
R7	113220	Resistor, Film 1/8 W 5% 22 Ω
R8, R9	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R10, R11		Not Used.
R12	113151	Resistor, Film 1/8 W 5% 150 Ω
R13	113221	Resistor, Film 1/8 W 5% 220 Ω
R14	113470	Resistor, Film 1/8 W 5% 47 Ω
R15	113151	Resistor, Film 1/8 W 5% 150 Ω
R16	113221	Resistor, Film 1/8 W 5% 220 Ω
R17	113470	Resistor, Film 1/8 W 5% 47 Ω
R18	113271	Resistor, Film 1/8 W 5% 270 Ω
R19	113222	Resistor, Film 1/8 W 5% 2.2 kΩ

TABLE 10.4-3.
Parts List, HF Mixers & Driver, M4, Continued.

R20, R21	113100	Resistor, Film 1/8 W 5% 10 Ω
R22, R23	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R24, R25	113100	Resistor, Film 1/8 W 5% 10 Ω
R26	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R27	113561	Resistor, Film 1/8 W 5% 560 Ω
R28		Not Used.
R29, R30	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R31		Not Used.
R32	113151	Resistor, Film 1/8 W 5% 150 Ω
U1, U2	380006	Mixer

10.5 100-Hz SYNTHESIZER, M5

The M5 module contains the 5.120-MHz reference oscillator and 73.34 to 73.35MHz (in 100-Hz steps) synthesizer. All circuitry is contained on PCB 735105, which is located in the top die-cast box on the far right of the transceiver.

10.5.1 TECHNICAL CIRCUIT DESCRIPTION

10.5.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Local oscillator output to M3; 73.3401-73.3500-MHz in 100-Hz steps at 1.2 V. PCB pin at rear of board and SMA connector at rear of box.

b) Reference oscillator output to M6; 5.120-MHz signal at 2.8 V. PCB pin near front of board and SMA connector on front of box.

DC Connections

Pin 2. +12 Vdc.
Pin 4. A1. Least significant binary bit from M9.
Pin 5. A2.
Pin 6. A3.
Pin 7. A4.
Pin 8. A5.
Pin 9. A6.
Pin 10. A7. Most significant binary bit from M7.

10.5.1.2 100-Hz SYNTHESIZER BLOCK DIAGRAM

A block diagram of the 100-Hz synthesizer is shown in Figure 10.5-1. Like the 10-kHz synthesizer, this is a completely self-contained single-loop digital synthesizer. It is used to generate the second L.O. signal (73.3401-73.350 MHz in 100-Hz steps). It has the following block components:

1. Voltage-Controlled Crystal Oscillator (VCXO).
2. Buffer amplifier.
3. ÷64/65 prescaler
4. ÷A-counter
5. Synthesizer (MC145151)
6. Loop filter.
7. 5.120-MHz reference oscillator.

NOTE

This synthesizer, like the 10-kHz synthesizer, uses a phase-locked loop and dual-modulus prescaling to generate the 73.3401- to 73.350-MHz local oscillator output signal. For those unfamiliar with these concepts, a description of them is given in Appendix B of this manual.

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 the MC145151 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.

Buffer Amplifier. The buffer amplifier amplifies the VCXO output to the level necessary to drive the second mixer. It also "buffers" the VCXO from any effects of changing load impedance of the L.O. output.

÷64/65 Prescaler. This 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 the MC145151 synthesizer chip and to the external ÷A-counter.

÷A-Counter. This is a two-stage CMOS counter used to tell the prescaler when to divide by 65. 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.

Synthesizer. The MC145151 synthesizer chip consists of a selectable reference divider, phase detector, and a 14-bit programmable ÷N-counter. 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 multiplied by N_T (where $N_T = 64N + A$ = the total loop value divide ratio). The reference frequency oscillator (5.210 MHz) is divided down by 25 in a fixed CMOS divider before going into the selectable divider in the MC145151 where it is divided down to 100 Hz.

Loop Filter. The loop filter is used to establish the correct loop bandwidth, natural frequency, and damping factor. Since the phase detector in the MC145151 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.

5.120-MHz Reference Oscillator. The 5.120-MHz reference oscillator is a crystal controlled oscillator which provides the reference frequency for both the 100-Hz and 10-kHz synthesizers. The 5.120-MHz signal from the oscillator is an output sent externally to the 10-kHz synthesizer. It is then divided by 25 in a fixed divider before going to the MC145151 as the 100-Hz loop reference signal.

10.5.1.3 DETAIL DESCRIPTION

A schematic of the 100-Hz synthesizer is shown in Figure 10.5-6. The VCXO is a Colpitts oscillator using a series mode fifth overtone 73.365-MHz crystal. Use of a crystal

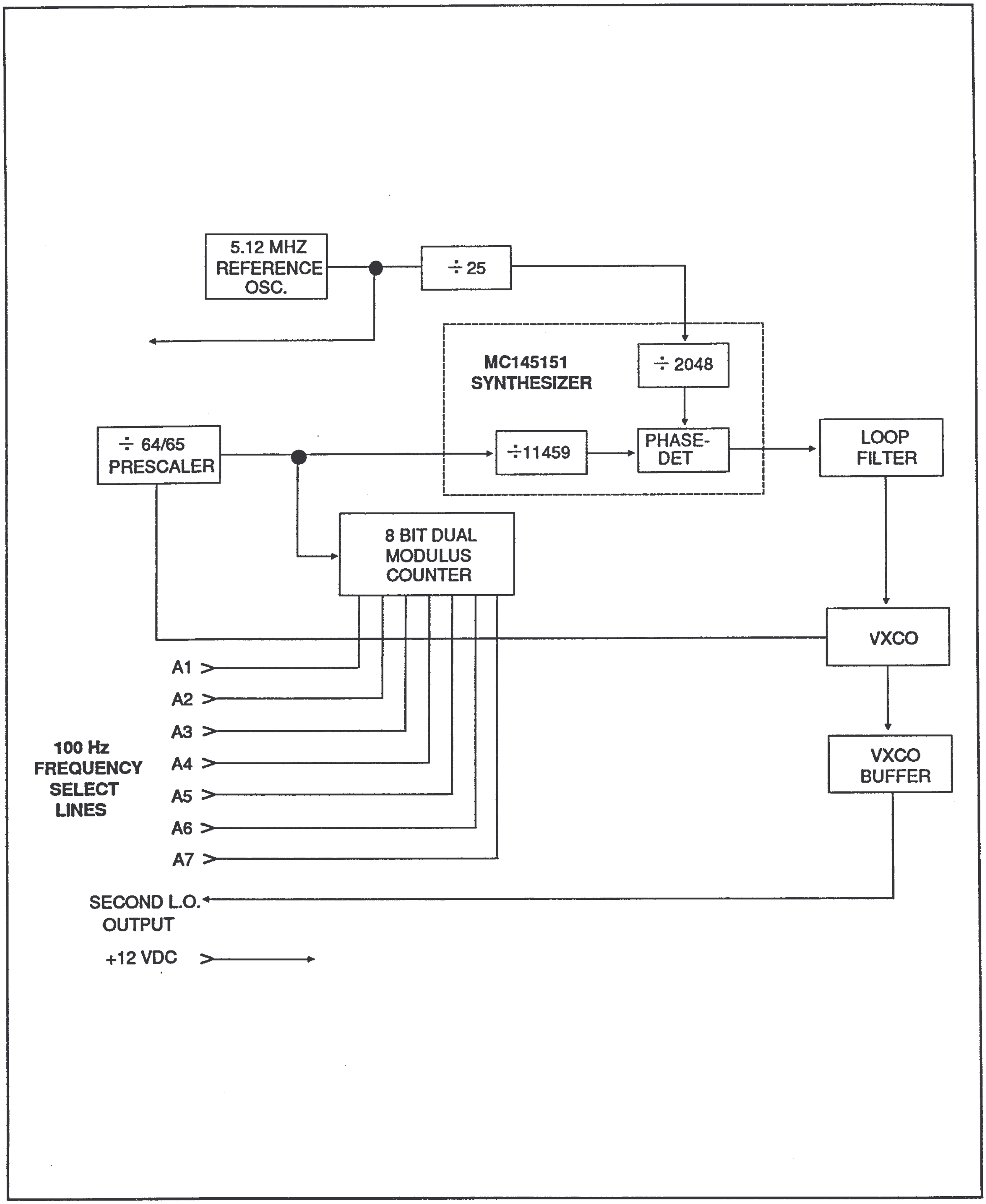


FIGURE 10.5-1.
100-Hz Loop Synthesizer.

oscillator leads to a highly stable synthesizer with excellent output spectral purity. The oscillator tank circuit is composed of varactor diode D1, capacitor C35, and tunable inductor L1. R5 is used to dampen the crystal and add stability to the oscillator. C8 couples the tank circuit to the base of Q1, the oscillator active element. C9 and C10 are used to set the proper oscillator feedback ratio, while resistors R3 and R4 set the dc bias for oscillator transistor Q1. The output of the VCXO is coupled via C4 from the emitter of Q1 to buffer amplifier Q2 which is configured as an emitter-follower.

The control voltage from the loop filter is coupled to D1 thru inductor L5. Tank circuit inductor L1 is adjusted 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 D1 of approximately 3-5 V).

The output of Q2 is coupled thru C11 to pin 5 of U1, the ÷64/65 prescaler, and thru C12 to the output buffer Q3. C28, C29 and L6 make up a single section low-pass filter between the buffer amplifier Q3 and the second L.O. output to the second mixer.

Regulated 8 Vdc is provided for the VCXO and its buffers by U6. The input 12 V to the regulator (and to the other circuits of the module) is filtered by C31, C14 and L3.

U1 is the ÷64/65 prescaler. It runs off of regulated 5 V dc from regulator U9. The output of U1 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 U2 and goes to pin 1 of the prescaler. The output of U1 goes to pin 6 of U2 in the ÷A-counter, and through C15 to pin 1 of U5.

U2 and U3 make up the dual-modulus ÷A-counter. It is a two-stage binary CMOS downcounter 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 $N_T = 64N + A$, where $N_T = F_{out}/100$ and $N_T = 11459$. Therefore, the loop algorithm reduces to $N_T = 733{,}376 + A$.

NOTE

The characteristics of the loop dictate that it always counts one more than the number "A" programmed into it. Therefore, to correctly program this loop, one must enter into the ÷A-counter a number which is less than the number "A" found in the algorithm $N_T = 733{,}376 + A$.

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 (although the entered count is one less, or 24-123). The end-of-count pulse (U5, pin 10) 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 the MC145151 starts to count down from 11459 to zero. When the ÷A-counter reaches zero, pin 4 of U2 goes from low to high accomplishing two things: The ÷A-counter is inhibited from further counting until it is again preset by the end-of-count pulse from U5; and the prescaler, which had been dividing by 65 during the duration of the A count, now will divide by 64 for the remaining (11459-A) counts in the overall cycle.

Both U2 and U3 run off of 5 Vdc provided by regulator U9.

The output of the ÷64/65 prescaler goes to pin 1 of U5, the MC145151 synthesizer chip. It runs off of regulated 8 Vdc from U10. Pins 5, 6 and 7 are programmed to set the fixed 2048 ratio for the reference frequency input of pin 27. Pins 11-25 are programmed to set the ÷11459 ratio for the ÷N-counter. Pin 4 is the tri-state output of the phase detector. While the loop is unlocked, the output from pin 4 will be a pulsing voltage designed to drive the VCXO in a direction such that $F_{out} = 100\ N_T$. Upon obtaining a locked condition, the phase detector output goes to a high-impedance state to effectively "hold" the proper control voltage on the varactor diode D1. This control voltage is "updated" every 100 Hz (10 milliseconds) to compensate for any frequency drift and keep the loop locked.

C5, C6, R1 and R2 are the components in the loop filter. R1 and C6 determine the loop natural frequency (along with K_o, the phase detector gain constant and K_v, the VCXO gain constant). It is set to be approximately 10 Hz. R2 and C5 provide the proper damping for the loop.

The 5.120-MHz reference oscillator is a modified Colpitts oscillator designed for reliable oscillation and good frequency stability. C19, the top leg of the capacitor frequency divider, is connected directly across the base emitter junction of Q4. The high capacitance effectively swamps the transistor and isolates the crystal from the transistor. C21 is a precision trimmer used for adjustment of the oscillator frequency. R23 and R24 provide dc bias for Q4. An emitter follower, Q5, is used to buffer and isolate the oscillator output.

Stability of the 5.120-MHz output is enhanced by the use of a high-stability crystal oven for the 5.120-MHz crystal. A high-grade oven provides accurate temperature control of the crystal over the specified radio temperature range.

10.5.2 ADJUSTMENT PROCEDURE

10.5.2.1 REFERENCE OSCILLATOR

The alignment procedure for the reference oscillator is:

1. Turn the power on and let the module warm up for at least one minute.
2. Adjust C21 until the reference oscillator output (as measured at the output coaxial connector) frequency reads 5.120000 MHz.

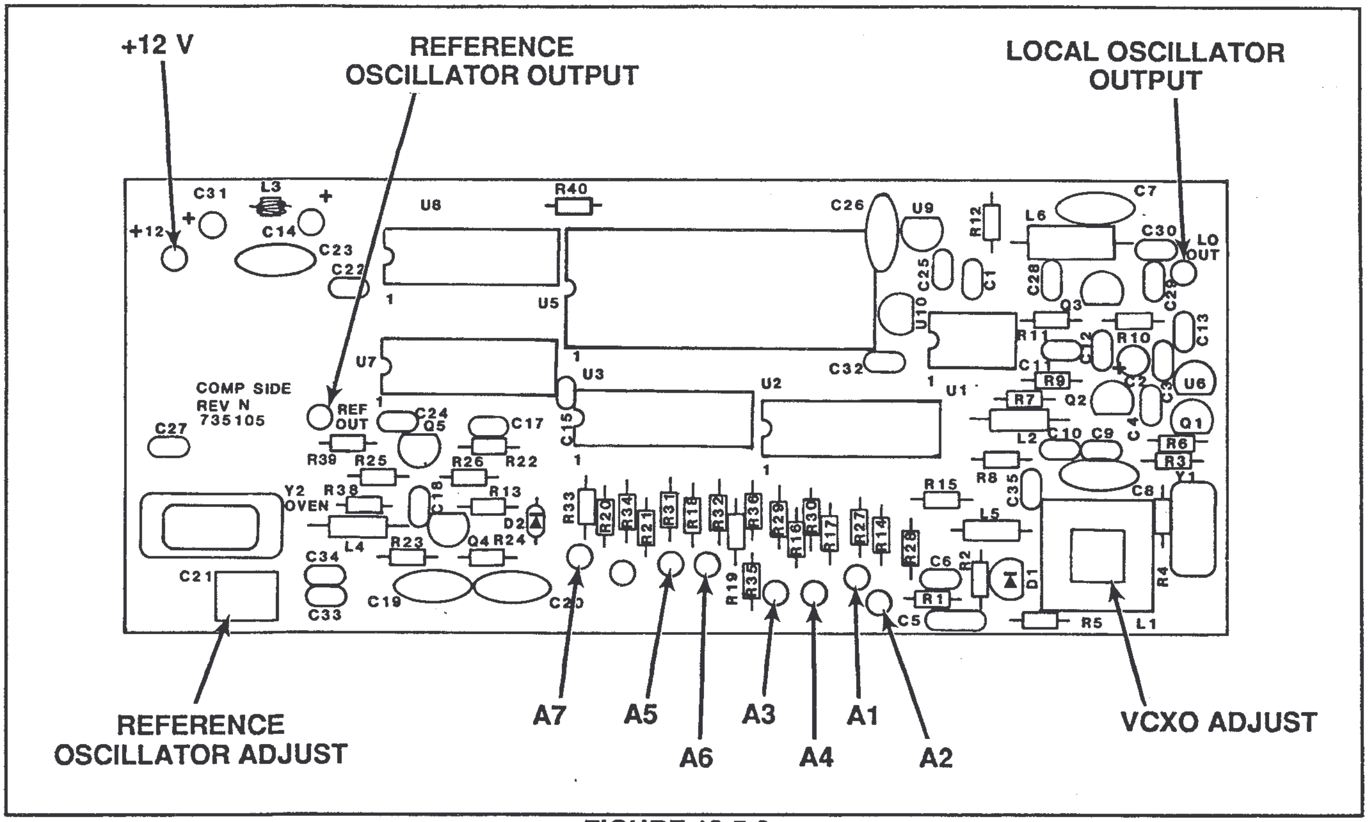


FIGURE 10.5-2.
Adjustment Points.

10.5.2.2 VCXO

The alignment procedure for the VCXO is as follows:

1. Program the +A-counter for a frequency of 73.3376 MHz. This corresponds to all "A" inputs being 0 (open circuit).

2. Temporarily ground pin 5 of U5. Adjust the ferrite slug in inductor L1 until the output frequency is 73.356 MHz. Remove the ground on U5, pin 5 and verify that the output frequency reads 73.3376 MHz.

3. Program the +A-Counter for a frequency of 73.350 MHz. This corresponds to:

A1 = 1	A4 = 1	A7 = 1
A2 = 1	A5 = 1	
A3 = 0	A6 = 1	

4. Verify that the output frequency is 73.350 MHz.

10.5.3 SPECIFICATIONS

Table 10.5-1 lists the specifications for the 100-Hz synthesizer module.

10.5.4 VOLTAGE CHART

Table 10.5-2 defines the important dc voltage levels for the 100-Hz synthesizer, while Table 10.5-3 gives relevant ac voltage levels.

10.5.5 SERVICING

Under normal conditions, servicing of the 100-Hz synthesizer module should not be required. The module has been completely aligned and tested at the factory prior to installation in the radio. However, should a system problem arise which is traceable to this module, the following step-by-step troubleshooting procedure is recommended.

First, determine the major failure symptom. It should be one of the following:

1. No oscillator output.
2. Low oscillator output—loop locked.
3. Synthesizer loop not locking (indicated by output frequency not corresponding to that programmed.)

Second, after determining the overall failure mode, consult the detailed troubleshooting procedures described in this section.

NOTE

In order to facilitate troubleshooting, use should be made of the module schematic (Figure 10.5-6) and component location diagram (Figure 10.5-5) located in this section in order to find the parts or test points called out in the text.

Third, a basic understanding of the operation of a phase-locked loop (PLL) and its programming is essential to quick and efficient troubleshooting of this module. There-

TABLE 10.5-1.
100-Hz Loop Specifications.

Power Requirements:	+12 Vdc @ 150 mA (steady state), 400 mA (warm up).
<u>Inputs</u> Program Lines (A1-A7):	0 V = logic "0." +5 V = logic "1."
<u>Outputs</u> Reference Oscillator:	5.120 MHz, ±5 Hz; 2.8 V, RMS.
Second L.O.:	73.3401-73.350 MHz in 100-Hz steps; 1.2 V RMS, into 50 ohms.

quick and efficient troubleshooting of this module. Therefore, before attempting to correct any module defect, Appendix B should be read.

Fourth, the voltage level charts (Table 10.5-2 and 10.5-3) have been prepared to aid in the diagnostic procedures. These will prove to be an invaluable reference (along with common sense) in troubleshooting this module.

10.5.5.1 MODULE FAILURE SYMPTOMS

No Oscillator Output. Under normal conditions the VCXO will oscillate even with no voltage applied to the control line. Therefore, there is probably a problem in the VCXO chain.

First check the VCXO coil L1 to see if the ferrite slug is broken, missing, or not aligned properly (if not broken or otherwise damaged, the problem probably lies elsewhere since this was carefully aligned at the factory).

Using either a VTVM or high-frequency oscilloscope, trace the ac voltages from the output back to the VCXO using Table 10.5-3 as a reference. This should isolate the problem to a particular stage in the chain.

Use the dc voltage chart in Table 10.5-2 to isolate the problem to the component level once the area where the oscillator signal is picked up and found.

If the VCXO itself is not working, check the regulator U6 to see that it is functioning properly. Check the collector voltage on Q1. Then check for a defective component or broken wire in the VCXO.

Low Oscillator Output (Loop Locked). If the phase-locked loop is locked (i.e., stable and correct output frequency) but the output level is low, then the problem is in the VCXO amplifier chain. Follow the procedure outlined in the preceding steps to isolate the problem.

Synthesizer Loop Not Locking. This happens when the VCXO output frequency does not correspond to the frequency that is programmed into the synthesizer. Pin 28 of U5 will provide an accurate indication of this. When the loop is locked, the output of this line will be a low 100-200 nanosecond pulse appearing once every 100 Hz. In an unlocked condition, this line will appear to be pulsing between ground and 8 Vdc in a random condition. Check the VCXO to see that it is operating properly as determined by the voltage charts in Table 10.5-2 and 10.5-3.

Check the reference oscillator. Trace its path back from U5, pin 27, (where its frequency should be 204.8 kHz) to the oscillator itself. The output of the oscillator at the emitter of Q5 should be 5.120000 MHz at 2.8 V RMS. U7 and U8 divide this by 25, which makes the input to U5, pin 27, a frequency of 204.8 kHz. If the problem is in this area, use Table 10.5-2 and 10.5-3 to isolate the problem.

Check the MC145151 internal reference frequency divider ratio. Measure the dc voltage on pins 5, 6 and 7 of U5. Pins 5 and 7 should read 8 Vdc and pin 6 should be zero.

Check the programming of the ÷N-Counter in the MC145151. It should be:

MC145151 Pin Nos. 10,13,14,15,16,19,22 should read 0 V.

MC145151, Pin Nos. 11,12,17,18,23,24,25 should read 8 V.

This corresponds to a fixed divide ratio of 11459.

Check the output of the ÷64/65 prescaler at U5, pin 1. It should be a 5 V, peak-to-peak square wave. Check the input to the prescaler at U1, pin 5. It can be as low as 100 mV RMS, and still provide reliable prescaler operation.

TABLE 10.5-2.
100-Hz Loop Dc Voltages.

Q1	Emitter:	1.9 V	**U3 (Cont.)**		
	Base:	2.1 V		Pin 8	0.0 V
	Collector:	8.0 V		Pin 11	5.0 V (logic "1") 0.0 V (logic "0")
Q2	Emitter:	3.9 V		Pin 13	5.0 V
	Base:	4.4 V		Pin 14	5.0 V (logic "1") 0.0 V (logic "0")
	Collector:	8.0 V		Pin 16	5.0 V
Q3	Emitter:	2.3 V			
	Base:	3.3 V	**U5**	Pin 1	3.5 V
	Collector:	8.0 V		Pin 2	0.0 V
				Pin 3	8.0 V
Q4	Emitter:	4.0 V		Pin 5	8.0 V
	Base:	4.6 V		Pin 6	0.0 V
	Collector:	8.0 V		Pin 7	8.0 V
				Pin 11	8.0 V
Q5	Emitter:	3.2 V		Pin 12	8.0 V
	Base:	3.5 V		Pin 13	0.0 V
	Collector:	8.0 V		Pin 14	0.0 V
				Pin 15	0.0 V
U1	Pin 1	5.0 V		Pin 16	0.0 V
	Pin 2	1.9 V		Pin 17	8.0 V
	Pin 3	1.9 V		Pin 18	8.0 V
	Pin 4	0.0 V		Pin 19	0.0 V
	Pin 5	3.6 V		Pin 20	0.0 V
	Pin 6	3.6 V		Pin 22	0.0 V
	Pin 7	5.0 V		Pin 23	8.0 V
	Pin 8	5.0 V		Pin 24	8.0 V
				Pin 25	8.0 V
U2	Pin 2	5.0 V (logic "1") 0.0 V (logic "0")	**U7**	Pin 2	0.0 V
	Pin 5	5.0 V (logic "1") 0.0 V (logic "0")		Pin 5	0.0 V
	Pin 8	0.0 V		Pin 8	0.0 V
	Pin 11	5.0 V (logic "1") 0.0 V (logic "0")		Pin 11	0.0 V
				Pin 14	12.0 V
	Pin 14	5.0 V (logic "1") 0.0 V (logic "0")		Pin 16	12.0 V
	Pin 16	5.0 V	**U8**	Pin 2	0.0 V
				Pin 5	0.0 V
				Pin 8	0.0 V
U3	Pin 2	5.0 V (logic "1") 0.0 V (logic "0")		Pin 11	12.0 V
				Pin 13	12.0 V
	Pin 5	5.0 V (logic "1") 0.0 V (logic "0")		Pin 14	0.0 V
				Pin 16	12.0 V

TABLE 10.5-3.
100-Hz Synthesizer Ac Voltages.

Q1	Emitter:	1.25 V, RMS	Q3	Pin 5:	0.5 V, RMS
Q2	Emitter:	1.25 V, RMS	Q4	Collector:	2.8 V, RMS
Q3	Emitter:	0.5 V, RMS	Q5	Emitter:	2.8 V, RMS

Check the operation of the ÷A-counter (U2, U3). Look at counter inputs A1-A7 to verify the proper programming.

A-Number	Pin	Binary Count
A1	U2-5	1
A2	U2-11	2
A3	U2-14	4
A4	U2-2	8
A5	U3-5	16
A6	U3-11	32
A7	U3-14	64

NOTE

The 100-Hz synthesizer is programmed by the algorithm:

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

$$= 733{,}376 + A$$

As was previously described, if the 1-kHz digit of the selected channel frequency = E, and the 100-Hz digit = F, then the programmed "A" = 123 - EF.

As an example, if the selected channel frequency is 15.0125 MHz, then:

$E = 2$, $F = 5$, and $EF = 25$
$\therefore A = 123 - 25 = 98$

and the ÷A-counter should be programmed for the binary number 98.

Check U2, pin 4, the dual modulus control line to the ÷64/65 prescaler. This line should be at 5 Vdc whenever the prescaler is dividing by 64 and at 0 V when the prescaler is dividing by 65. If the ÷A-counter is programmed for A = 0, then the line is high for the duration of the count cycle, except the internally programmed "one" count, which shows up as an initial 1 microsecond low-going pulse. If the ÷A-counter is programmed for any number A = 1 thru 100, then this line is low at the beginning of the count cycle, remaining low until the ÷A-counter has counted down from "A" to zero. At this time, the time goes high and remains so until the ÷N-counter in the MC145151 has counted the rest of its programmed 11459 counts.

Figure 10.5-4 shows the waveforms that are present when the loop is locked. Since the reference frequency is 100 MHz, the length of each count cycle is 1/100 Hz or 10 milliseconds. The length of each count in the cycle is $10^{-2}/11459 = .87$ microseconds. Therefore:

If A = 0, the control line is low for .87 microseconds.

If A = 1, the line is low for 1.74 microseconds and high high for (11459-2) x .87 microseconds.

If A = 2, the line is low for 2.61 microseconds and high for (11459-3) x .87 microseconds.

"A" can be any number from 24-123.

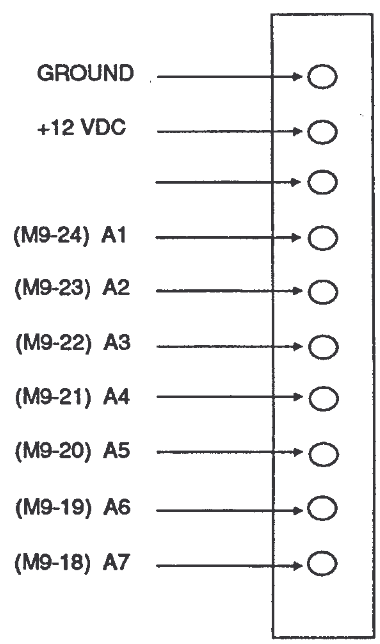
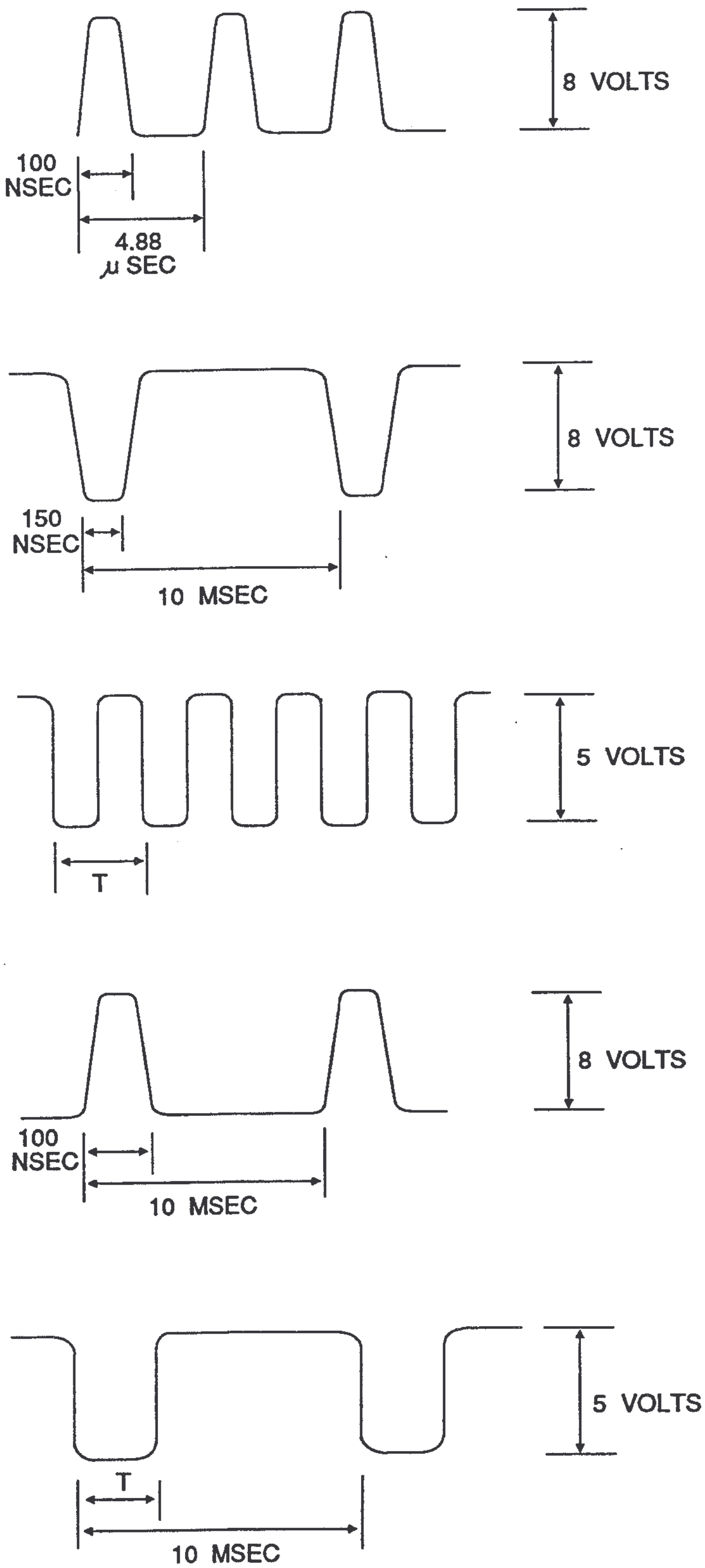


FIGURE 10.5-3.
Minor Loop I/O.



a) Reference frequency input to U5, pin 27: 204.8 MHz.

b) Lock detect at U5, pin 28.

c) ÷64/65 prescaler outputs at U5, pin 1:

$$T = \frac{64}{f_{vcxo}} \text{ secs.}$$

d) End-of-count line at U5, pin 10.

e) Dual-modulus control line at U2, pin 4:

$$T = \frac{A \times 10^{-2}}{11459} \text{ secs.}$$

FIGURE 10.5-4.
100-Hz Loop Waveforms.

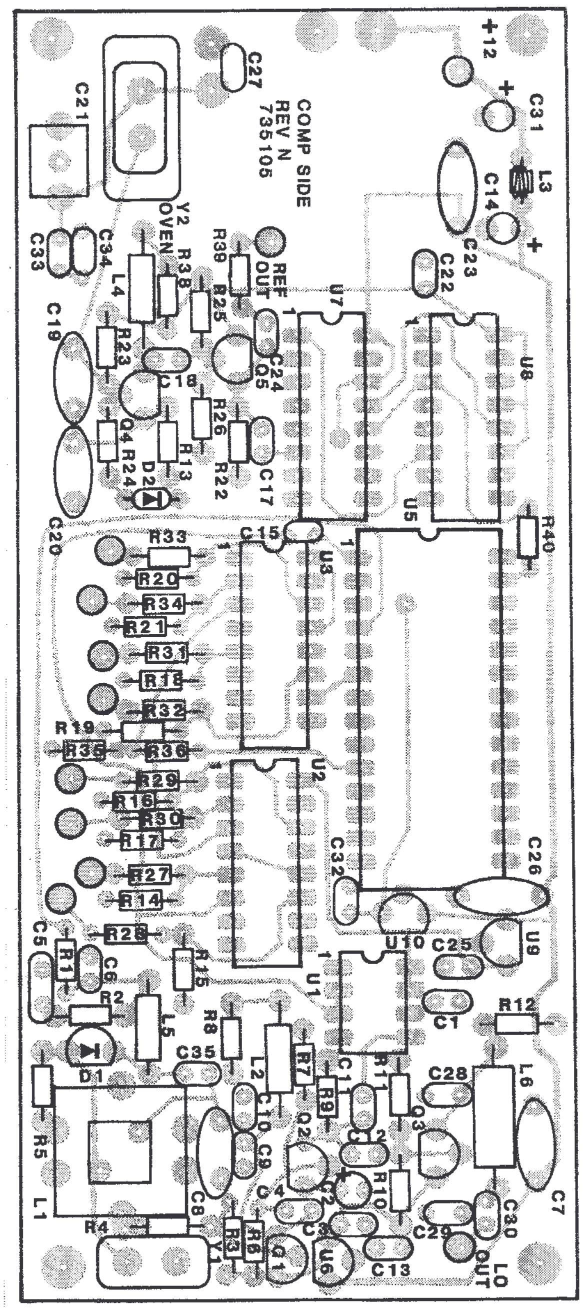
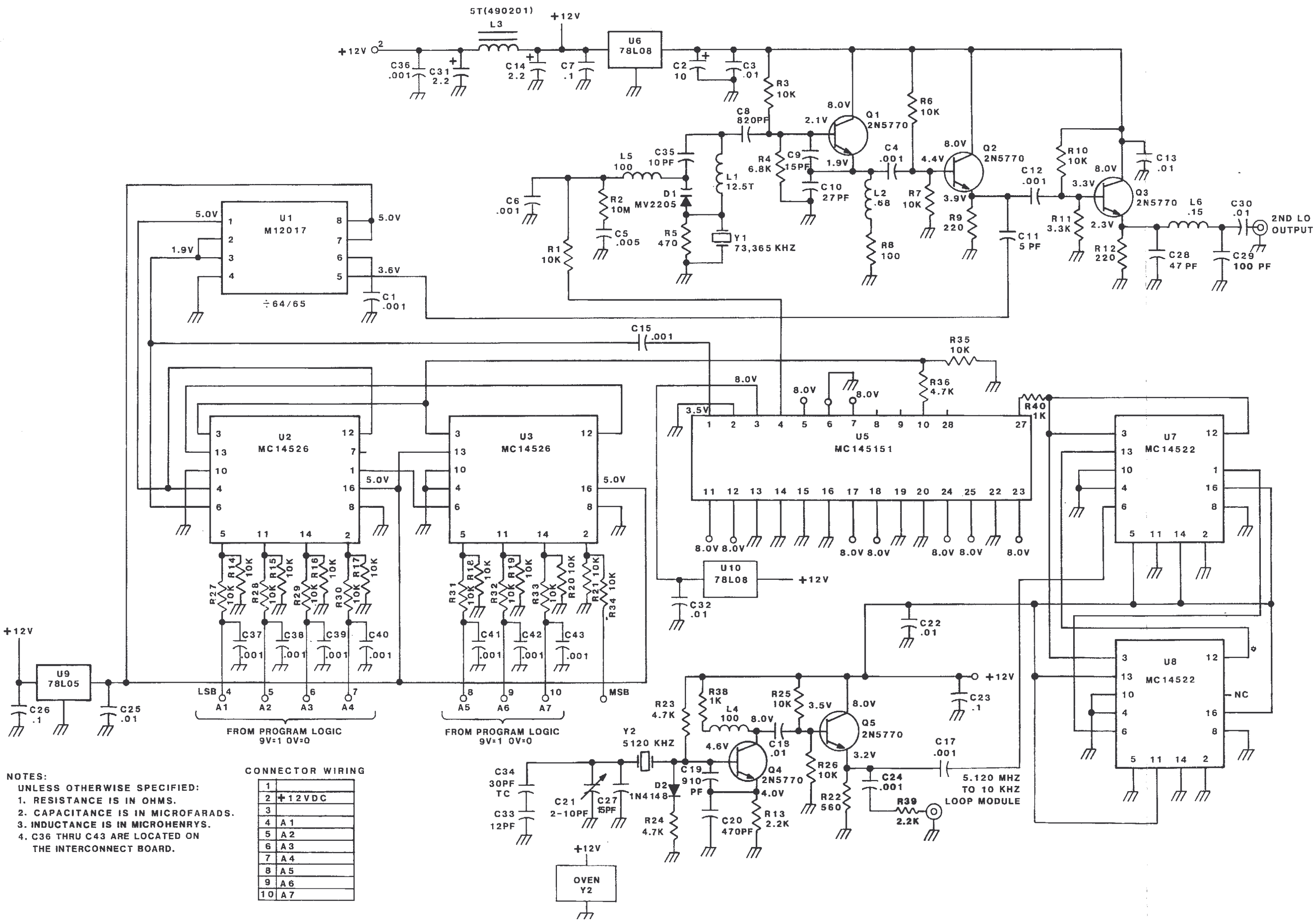


FIGURE 10.5-5.
Component Locations,100-Hz Loop Synthesizer, M5.



NOTES:
UNLESS OTHERWISE SPECIFIED:
1. RESISTANCE IS IN OHMS.
2. CAPACITANCE IS IN MICROFARADS.
3. INDUCTANCE IS IN MICROHENRYS.
4. C36 THRU C43 ARE LOCATED ON THE INTERCONNECT BOARD.

CONNECTOR WIRING

1	
2	+12VDC
3	
4	A1
5	A2
6	A3
7	A4
8	A5
9	A6
10	A7

TABLE 10.5-4.
Parts List, 100-Hz Synthesizer, M5.

C1	210102	Capacitor, Disc 0.001 µF
C2	231100	Capacitor, Electrolytic 16 V 10 µF
C3	214103	Capacitor, Monolithic 50 V 0.01 µF
C4	210102	Capacitor, Disc 0.001 µF
C5	210502	Capacitor, Disc 0.005 µF
C6	210102	Capacitor, Disc 0.001 µF
C7	210104	Capacitor, Disc 0.1 µF
C8	220821	Capacitor, Mica DM15 820 pF
C9	210150	Capacitor, Disc NPO 15 pF
C10	210270	Capacitor, Disc NPO 27 pF
C11	210050	Capacitor, Disc NPO 5 pF
C12	210102	Capacitor, Disc 0.001 µF
C13	214103	Capacitor, Monolithic 50 V 0.01 µF
C14	241020	Capacitor, Tantalum 2.2 µF
C15	210102	Capacitor, Disc 0.001 µF
C16		Not Used.
C17	210102	Capacitor, Disc 0.001 µF
C18	214103	Capacitor, Monolithic 50 V 0.01 µF
C19	220911	Capacitor, Mica DM15 910 pF
C20	220471	Capacitor, Mica DM15 470 pF
C21	260100	Capacitor, Trimmer Film 2-10 pF
C22	214103	Capacitor, Monolithic 50 V 0.01 µF
C23	210104	Capacitor, Disc 0.1 µF
C24	210102	Capacitor, Disc 0.001 µF
C25	214103	Capacitor, Monolithic 50 V 0.01 µF
C26	210104	Capacitor, Disc 0.1 µF
C27	210150	Capacitor, Disc NPO 15 pF
C28	210470	Capacitor, Disc NPO 47 pF
C29	210101	Capacitor, Disc NPO 100 pF
C30	214103	Capacitor, Monolithic 50 V 0.01 µF
C31	241020	Capacitor, Tantalum 2.2 µF
C32	214103	Capacitor, Monolithic 50 V 0.01 µF
C33	210120	Capacitor, Disc NPO 12 pF
C34	213300	Capacitor, Disc NPO 30 pF
C35	210100	Capacitor, Disc NPO 10 pF
C36-C43	210102	Capacitor, Disc 0.001 µF
D1	320301	Diode, Varactor MV2105
D2	320002	Diode, 1N4148
L1	490109	Inductor, Variable 12.5 turns
L2	430005	Inductor, Fixed 0.68 µH
L3	459215	Inductor, Variable 5 turns
L4, L5	430014	Inductor, Molded 100 µH
L6	430011	Inductor, Fixed 0.15 µH
Q1-Q5	310032	Transistor, NPN 2N5770
R1	113103	Resistor, Film 1/8 W 5% 10 kΩ
R2	113106	Resistor, Film 1/8 W 5% 10 MΩ
R3	113103	Resistor, Film 1/8 W 5% 10 kΩ
R4	113682	Resistor, Film 1/8 W 5% 6.8 kΩ
R5	113471	Resistor, Film 1/8 W 5% 470 Ω
R6, R7	113103	Resistor, Film 1/8 W 5% 10 kΩ
R8	113101	Resistor, Film 1/8 W 5% 100 Ω
R9	113221	Resistor, Film 1/8 W 5% 220 Ω

TABLE 10.5-4.
Parts List, 100-Hz Synthesizer, M5, Continued.

R10	113103	Resistor, Film 1/8 W 5% 10 kΩ
R11	113332	Resistor, Film 1/8 W 5% 3.3 kΩ
R12	113221	Resistor, Film 1/8 W 5% 220 Ω
R13	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R14-R21	113103	Resistor, Film 1/8 W 5% 10 kΩ
R22	113561	Resistor, Film 1/8 W 5% 560 Ω
R23, R24	113472	Resistor, Film 1/8 W 5% 4.7 kΩ
R25-R35	113103	Resistor, Film 1/8 W 5% 10 kΩ
R36	113472	Resistor, Film 1/8 W 5% 4.7 kΩ
R37		Not Used.
R38	113102	Resistor, Film 1/8 W 5% 1.0 kΩ
R39	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R40	113102	Resistor, Film 1/8 W 5% 1 kΩ
U1	330106	IC, MC12017P
U2, U3	330086	IC, MC14526
U4		Not Used.
U5	330087	IC, MC145151
U6	330018	IC, 78L08
U7, U8	330088	IC, MC14522
U9	330025	IC, 78L05
U10	330018	IC, 78L08
Y1	360040	Crystal, 73,365.000 kHz
Y2	360030	Crystal, 5,120.000 kHz

10.6 10-kHz SYNTHESIZER, M6

The M6 module contains the complete 76.6 to 104.99-MHz (in 10-kHz steps) synthesizer. All circuitry is on PCB 735104, which is contained in the die-cast box between M4 and the right side of the transceiver (under M5).

10.6.1 TECHNICAL DESCRIPTION

10.6.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Local oscillator output to M4; 76.60 to 104.99-MHz signal at 1.2 V. PCB pin at left rear of board and SMA connector is at rear of box.

b) Reference oscillator input from M5; 5.120 MHz at 2.8 V. PCB pin at front of board and SMA connector is at front of box.

DC Connections (All lines come from M9 except +12 Vdc)

Pin 1. VCO switch line; low-signal calls up 76.6- to 89.99-MHz VCO and high-signal calls up 90- to 104.99-MHz VCO.
Pin 2. N4.
Pin 8. A5.
Pin 9. +12 Vdc.
Pin 10. A2.
Pin 11. N3.
Pin 12. N2.
Pin 13. N1.
Pin 14. N5.
Pin 15. N6.
Pin 16. N7.
Pin 17. N8. (Most significant bit.)
Pin 18. A4.
Pin 19. A1. (Least significant bit.)
Pin 20. A3.

10.6.1.2 BLOCK DIAGRAM ANALYSIS

A block diagram of the 10-kHz loop synthesizer is shown in Figure 10.6-1. This is a completely self-contained single loop digital synthesizer used to generate the first L.O. signal (76.6-104.99 MHz in 10-kHz steps). It has the following components:

1. Voltage-Controlled Oscillator (VCO).
2. Buffer amplifiers.
3. ÷32/33 prescaler.
4. Synthesizer (MC145152).
5. Loop filter.

NOTE

This synthesizer uses a phase-locked loop and dual modulus prescaling to generate the 76.6- to 104.99-MHz local oscillator output signal. It is important to have at least a basic understanding of these techniques in order to service the synthesizer properly. For this reason, a description of them is included in Appendix B.

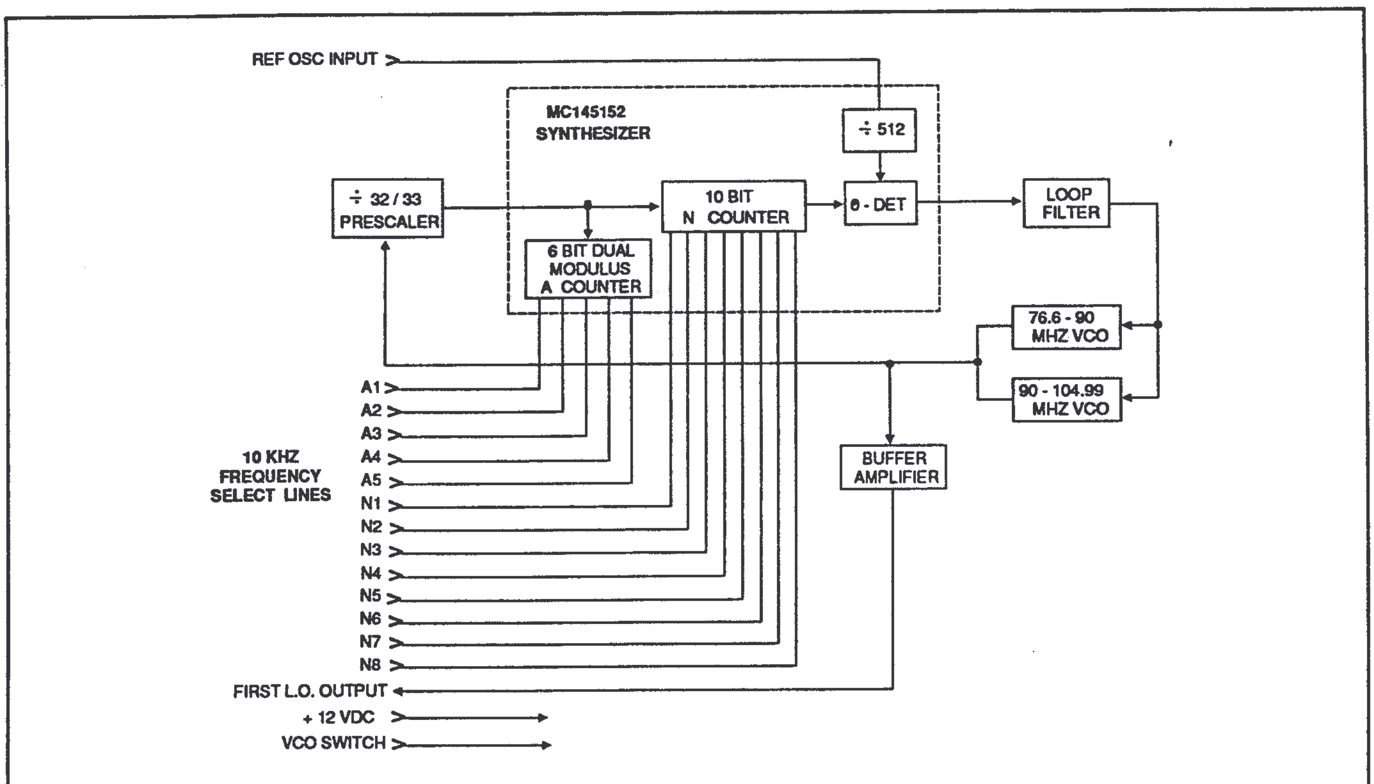


FIGURE 10.6-1.
10-kHz Loop Synthesizer.

VCO. Two voltage-controlled oscillators are used to cover the total frequency range. The "VCO switch line" coming from the programming board 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 two places, the ÷32/33 prescaler to close the phase-locked loop and the buffer amplifiers.

Buffer Amplifiers. The purpose of these amplifiers are twofold; first, to amplify the output of the VCO to a level sufficient to drive the first mixer, and second, to "buffer" the VCO from any effects of changing load impedance at the L.O. output. The output of the last buffer amplifier is the local oscillator signal to the first mixer.

÷32/33 Prescaler. This 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 output of the ÷32/33 prescaler goes to the synthesizer chip.

Synthesizer. The synthesizer chip consists of a selectable reference divider, phase detector, 10-bit programmable ÷N-counter, and 6-bit ÷A-counter. Input lines A1-A5 and N1-N8 come from the programming board and provide the binary number used to program the two counters for setting the desired L.O. frequency. Lines A1-A5 program the dual modulus ÷A-counter while lines N1-N8 program the programmable ÷N-counter.

The total divider ratio is expressed by the formula $N_T = 32N + A$, where N_T = (L.O. output frequency)/(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 N_T. The reference frequency oscillator (5.120 MHz) goes into a selectable divider in the synthesizer chip where it is divided down to 10 kHz.

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.

10.6.1.3 DETAILED DESCRIPTION

A schematic of the 10-kHz loop synthesizer is shown in Figure 10.6-6. The heart of the synthesizer is the VCO. Two identical VCO's are used in the synthesizer; each is a modified Colpitts (Clapp) oscillator using a 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 L1 and varactor diode D1. L1 is a 9.5-turn air coil whose inductance and the capacitance of the varactor enable the VCO to oscillate over the chosen frequency range. The capacitance of D1 is determined by the error voltage from the phase detector. C5 is used as a coupling capacitor, while R28 provides control-line isolation between the loop filter and the VCO. C1 and C2 determine the oscillator feedback, while D2 is a gate-clamping diode for controlling the bias of Q1. Q2 is an FET configured as a source follower and acts as a buffer for the VCO. D5 and D6 are used to provide isolation between the two VCO's. R5 and C3 are used to decouple the supply voltage for the VCO.

The low-frequency VCO performs in the same fashion as the high-frequency one. The only differences in the two are the value of the feedback capacitors (C6 and C7) which are adjusted for the lower frequency range and the value of the tank circuit coil L3, which is set to enable the VCO to oscillate over the 76.6 to 89.99-MHz range.

Regulated 8 V is provided for both VCO's by U1. Transistors Q11, Q5, and Q6 are controlled by the VCO switch line which comes from the programming board. The VCO switch line is filtered by R27, C29 and C21 at the input to Q5. When the VCO switch line is "high," Q5 is off and Q6 is biased "on" through R7 and R6. In this case the supply voltage is provided to Q1 (the high-frequency oscillator) while the low-frequency VCO is shut off. At frequencies below 90 MHz the VCO control line goes "low", Q5 is biased "on" to provide the dc supply voltage for the low-frequency VCO (Q3) and Q6 is biased off to turn off the high-frequency VCO.

The output from the low-frequency VCO (through D6) or the high-frequency VCO (through D5) goes to the base of Q7, the first of the output buffer amplifiers. Q7, Q8 and Q9 act as output buffers for the L.O. signal. Q8 is a transformer-coupled wideband ac amplifier, while Q9 is another transformer-coupled amplifier which provides excellent isolation to load impedance variations. The output from Q9 goes to a low-pass harmonic filter composed of L6, L7, C39, C40 and C41, and is then ac coupled through C67 to the synthesizer output, where it becomes the first L.O. signal and goes to the HF mixer module.

Q12 is an emitter-follower used for further isolation between the VCO and the prescaler. C22 couples the output of Q12 to pin 5 at U5. U5 is a ÷32/33 prescaler. It runs off of +5 Vdc provided by regulator U3. The output of U5 is a VCO frequency divided by either 32 or 33 depending on the status of the dual-modulus control line. This line comes from pin 9 of the MC145152 synthesizer chip 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 high depends on the frequency number programmed into the MC145152. (As described earlier, the line is low and the prescaler is dividing by 33 for the duration of the time the ÷A-Counter in the MC145152 is counting. For the remainder of the count cycle the prescaler divides by 32. This is determined by the $N_T = 32N + A$ algorithm.)

The output of the prescaler at pin 3 is coupled thru C25 to pin 1 of the MC145152 synthesizer chip. The MC145152 contains the ÷N programmable divider, the ÷A dual-modulus counter, the phase detector and the selectable-modulus reference-frequency divider. The latter is set to divide by a fixed 512 ratio to convert the incoming reference frequency of 5.12 MHz (pin 27) to the loop reference of 10 kHz.

The 6 bit ÷A-counter acts as a dual-modulus counter programmed to instruct the prescaler when to divide by 33. Input lines A1-A5 (pins 21 thru 25) are programmed with a binary number from 0-31. The 10 bit ÷N-counter is the main loop divider. It is programmed by input lines N1-N8 (pins 11-18). Since the VCO output is determined by:

$$F_{out} = N_T F_{ref} = N_T \times 10 \text{ kHz}$$

and by the technique of dual-modulus prescaling,

$$N_T = 32N + A,$$

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 $F_{L.O.} = (32N + A) \times 10$ kHz. An example of this is as follows:

1. The divide ratio is 7700 (determined by the selected channel frequency).

2. $F_{out} = 7700 \times 10$ kHz = 77.00 MHz

3. $7700 = 32N + A$
   $\therefore = 240, A = 20$

4. ∴N is programmed with binary 240 with the input lines as follows:

   Least Significant Bit
   (LSB) N1 = 0
   N2 = 0
   N3 = 0
   N4 = 0 = 240
   N5 = 1
   N6 = 1
   N7 = 1
   (MSB) N8 = 1
   Most Significant Bit

5. ∴A is programmed with binary 20 as follows:

   Least Significant Bit
   (LSB) A1 = 0
   A2 = 0
   A3 = 1 = 20
   A4 = 0
   (MSB) A5 = 1
   Most Significant Bit

TABLE 10.6-1.
Programming Chart

Function	Pin	Binary Bit	N_T=7660	N_T=8192	N_T=10499
N10	20	16384	0	0	0
N9	19	8192	0	1	1
N8	18	4096	1	0	0
N7	17	2048	1	0	1
N6	16	1024	1	0	0
N5	15	512	0	0	0
N4	14	256	1	0	1
N3	13	128	1	0	0
N2	12	64	1	0	0
N1	11	32	1	0	0
A5	25	16	0	0	0
A4	24	8	1	0	0
A3	22	4	1	0	0
A2	21	2	0	0	1
A1	23	1	0	0	1

Actually, the "N" and "A" counters do not have to be programmed individually since the primary division modulus is 32, an integer power of "2". When this occurs, then the ÷N-counter and ÷A-counter can be taken together to form one "N+A" counter with its MSB being the MSB of the ÷N-counter and its LSB being the LSB of the ÷A-counter. Therefore, the 10-kHz loop can be pro-grammed directly by converting the overall divide ratio, NT, into binary and inputting it on lines A1-A5, N1-N8.

The programming chart, Table 10.6-1 shows how this works. As the channel frequency goes from 1.6 to 29.9999 MHz, the L.O. goes from 76.6 to 104.99 MHz. Since the overall divide ratio, NT, equals the L.O./100000, NT goes from 7660 to 10499. As Table 10.6-1 indicates, over this range N10, the "16384" binary bit is always equal to zero; and N9, the "8192" bit, and N8, the "4096" binary bit are always opposite. Therefore, it is not necessary to have an input line for N10 and N9. N10 is always zero and N9 is programmed in the module by inverting N8 (in the transistor Q10).

All other 10-kHz loop synthesizer frequencies are programmed in the same fashion. The output covers 76.6-104.99 MHz in 10-kHz increments and, therefore, the total programming of the two counters goes from N = 239 - 328 and A = 0 - 31.

∴ The total count cycle (N) goes from 239 to 328 while the prescaler divides by 33 during A parts of N and then divides by 32 for (N-A) parts.

The loop filter determines the overall natural frequency and damping factor of the PLL. These in turn are instrumental in determining the synthesizer response time, close-in noise suppression, and reference-frequency sideband rejection. The loop filter is a second-order active filter composed by U4, R13-18, and C13-16. The natural frequency is determined by the loop gain constants KO (the voltage change per unit phase difference of the phase detector), KV (the frequency change per unit voltage of the VCO), and the filter components R13, R15 and C15. The outputs from pin 7 and pin 8 of the MC145152 are combined in U4 to provide the error voltage for the VCO. R10, R11, C17 and C28 provide additional filtering of the reference sidebands, while R12 and C18 provide suppression to close-in noise sidebands. The output of the loop filter is a tri-state error voltage which is fed to the VCO varactor. Initially when the loop is unlocked the output is a filtered pulse whose amplitude is corrected once every reference frequency cycle (10 kHz), which tends to drive the VCO toward the programmed frequency. When the loop is locked, the output is a dc voltage corresponding to that necessary to hold the VCO varactor to the proper capacitance for programmed oscillator frequency.

10.6.2 ADJUSTMENT PROCEDURE

10.6.2.1 HARMONIC FILTER

The ferrite slugs in L6 and L7 should be adjusted until each is approximately one turn above the top of the coil form.

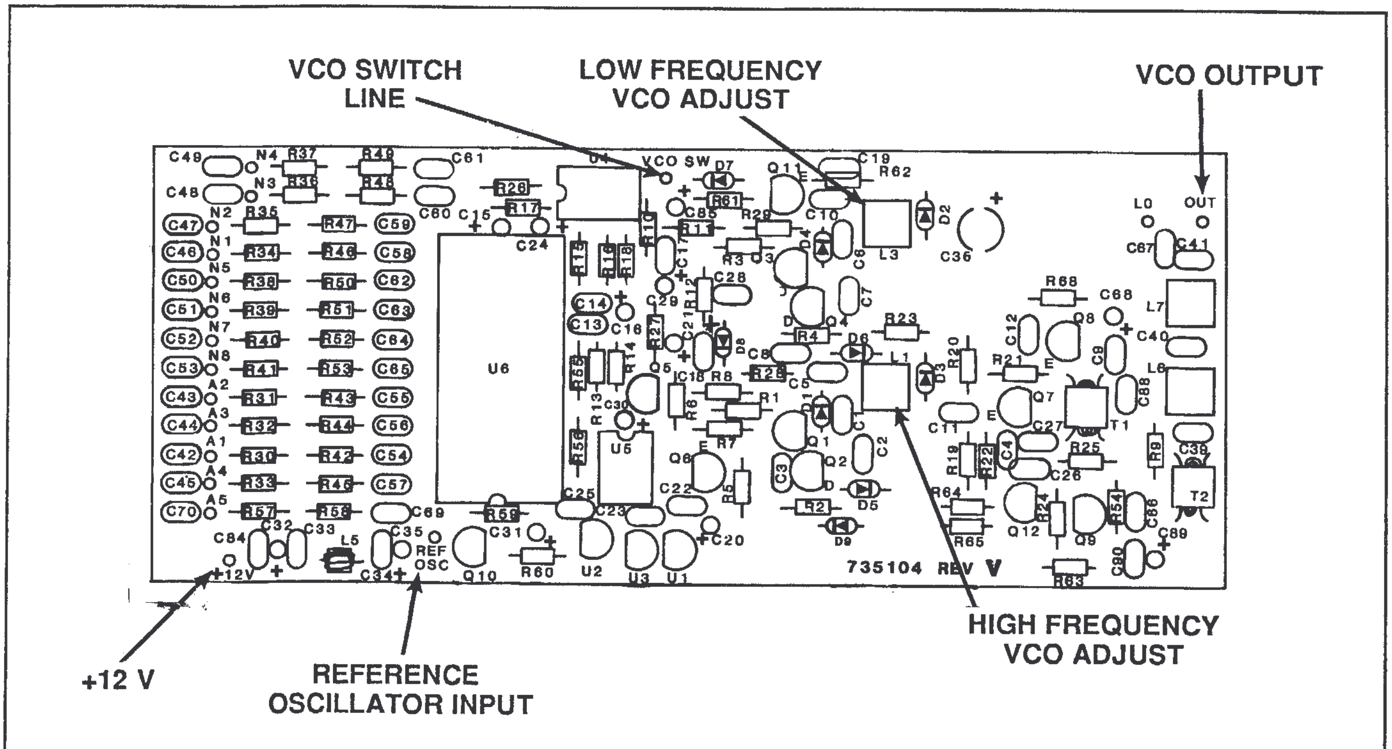


FIGURE 10.6-2.
Adjustment Points.

TABLE 10.6-2.
Major Loop Specifications.

Power Requirements	+12 Vdc at 80 mA.
Input	
Reference Oscillator	5.12 MHz, ±5 Hz; 2.8 V, RMS.
VCO Switch Line	0 V = low-frequency VCO, +12 V = high-frequency VCO.
Program Lines (N1-N8, A1-A5)	+0 V = logic "0," +8 V = logic "1."
Output	
Frequency	76.6-104.99 MHz in 10-kHz steps.
Level	1.2 V, RMS, into 50 ohms.
Harmonics	40 dB.
Spurious	70 dB.

10.6.3 SPECIFICATIONS

Table 10.6-2 lists the specifications for the 10-kHz loop synthesizer module.

10.6.4 VOLTAGE CHART

Table 10.6-3 defines the important dc voltage levels for the 10-kHz loop, while Table 10.6-4 defines important ac voltage levels.

10.6.5 SERVICING

Under normal operating conditions, servicing of the 10-kHz loop synthesizer should not be required. All modules have been aligned and completely tested at the factory prior to installation in complete radios. Therefore, since the VCO and harmonic filter coils are presumed to be properly set, any failure traced to this module is probably a component failure, broken wire or burnt-out trace.

If a problem is found to exist in this module, the symptoms will probably be one of the following:

1. No L.O. output.
2. Loop locked but L.O. output low.
3. Loop not locking.

During the troubleshooting procedure that follows, use should be made of the schematic (Figure 10.6-6) and component location diagram (Figure 10.6-5), located in this section, to find the parts or test points called out in the text. Figure 10.6-3 shows the orientation of the incoming I/O lines in the 10-kHz module connector.

10.6.5.1 NO L.O. OUTPUT

Under normal conditions both VCO's will oscillate even if there is no voltage applied to the control line. Therefore, if there is no output at all, the problem has to lie in the VCO chain.

1. Using either a VTVM or high-frequency oscilloscope, check the ac voltage at the base of Q7. If a voltage of approximately 0.7 V RMS is present the oscillator is working, and the problem is in one of the buffer stages—Q7, 8 or 9. Trace the ac signal through this signal path using the voltage in Table 10.6-4 as a guide. Once the area is located where the ac signal stops, the problem can be quickly isolated by checking the appropriate dc voltage levels as given in Table 10.6-3. If there is no ac voltage at Q7-base, the problem is back in the oscillator. Go to step 2.

2. Check the output of U1 (Q5-collector or Q6-emitter). It should be 8 Vdc. If it is not, the regulator is defective or it is not getting +12 V.

3. If 8-Vdc is present, check Q5-base to see which VCO is selected. If the voltage at Q5-base is less than 3 V, go to step 4. If it is greater than 6 V, go to step 5.

4. The problem is in the high-frequency oscillator section (Q1, Q2). Check the voltages using Table 10.6-3 to isolate the problem.

5. The problem is in the low-frequency oscillator section (Q3, Q4). Check the appropriate voltage levels.

10.6.5.2 LOOP LOCKED BUT L.O. OUTPUT LOW

The problem is most likely in the buffer amplifier chain (Q7, 8 or 9), but a check should be made at Q7-base to verify this. The proper level is about 0.7-V RMS. If the level is less than this, the problem is back in the oscillator and the procedure outlined in Section 10.6.6.1 (1 and 2) should be followed.

10.6.5.3 LOOP NOT LOCKING

The only things other than a defective component, wire or trace that could cause the loop to not lock are:

No reference oscillator input.
MC145152 divider programmed with an invalid number.

1. Therefore, the first thing to do is check pin 27 of U6. The reference oscillator should be an 8-V, peak-to-peak

TABLE 10.6-3.
10-kHz Loop Dc Voltage Levels.

	DC Level with VCO Switch Line = "low"	DC Level with VCO Switch Line = "high"
VCO		
Switch Line	0.0 V	8.7 V
Q1		
Source:	0.0 V	1.1 V
Drain:	0.0 V	6.7 V
Q2		
Source:	0.0 V	2.9 V
Q3		
Source:	0.8 V	0.4 V
Drain:	6.8 V	0.0 V
Q4		
Source:	2.4 V	0.0 V
Drain	6.8 V	0.0 V
Q5		
Emitter:	8.0 V	8.0 V
Base:	0.0 V	8.6 V
Collector	7.8 V	0.0 V
Q6		
Emitter	8.0 V	8.0 V
Base:	10.0 V	7.4 V
Collector:	0.0 V	7.8 V
Q7		
Emitter:	0.7 V	0.7 V
Base:	1.4 V	1.4 V
Collector:	2.4 V	2.4 V
Q8		
Emitter:	2.5 V	2.5 V
Base:	3.3 V	3.3 V
Collector:	7.5 V	7.5 V
Q9		
Emitter:	1.4 V	1.4 V
Base:	2.0 V	2.0 V
Collector:	7.8 V	7.8 V

	DC Level with VCO Switch Line = "low"	DC Level with VCO Switch Line = "high"
Q10		
Emitter:	0.0 V	
Base:	0.0 V (N8 = 0)	
	0.7 V (N8 = 1)	
Collector:	8.0 V (N8 = 0)	
	0.0 V (N8 = 1)	
Q11		
Emitter:	0.0 V	0.0 V
Base:	0.0 V	0.7 V
Collector:	12.0 V	0.0 V
Q12		
Emitter:	0.0 V	0.0 V
Base:	0.5 V	0.5 V
Collector:	0.64 V	0.64 V
U4		
Pin 8	12.0 V	12.0 V
Pin 1		
77MHz		2.8 V
90MHz	2.5 V	9.6 V
105MHz	10.4 V	
U5		
Pin 8	5.0 V	5.0 V
U6		
Pin 3	8.0 V	8.0 V
Pin 4	0.0 V	0.0 V
Pin 5	0.0 V	0.0 V
Pin 6	8.0 V	8.0 V
Pin 10	0.0 V	0.0 V
Pins 11-18	7.0 V (logic "1")	7.0 V (logic "0")
	1.0 V (logic "0")	1.0 V (logic "0")
Pin 19	0.0 V	0.0 V
Pin 20	8.0 V	8.0 V
Pins 21-24	7.0 V (logic "1")	7.0 V (logic "1")
	1.0 V (logic "0")	1.0 V (logic "0")
Pin 25	0.0V	0.0V

signal at a frequency of 5.120 MHz. If the signal is not present, check the wiring to the connector, then the RF cable bringing the signal into the box.

2. If the reference signal is proper, then the programming should be checked. It is possible to program the MC145152 divider wrong such that an output frequency is selected which the VCO cannot cover.

In other words, if the low-frequency VCO is selected (VCO Switch Line = low), then the divider must be programmed for frequencies of 77-89.99 MHz. If the VCO Switch Line is high, then programming should be for the 90- to 104.99-MHz high-frequency oscillator.

NOTE

Programming of the synthesizer is described in Section 10.6.1.3. Table 10.6-5 summarizes the programming re-

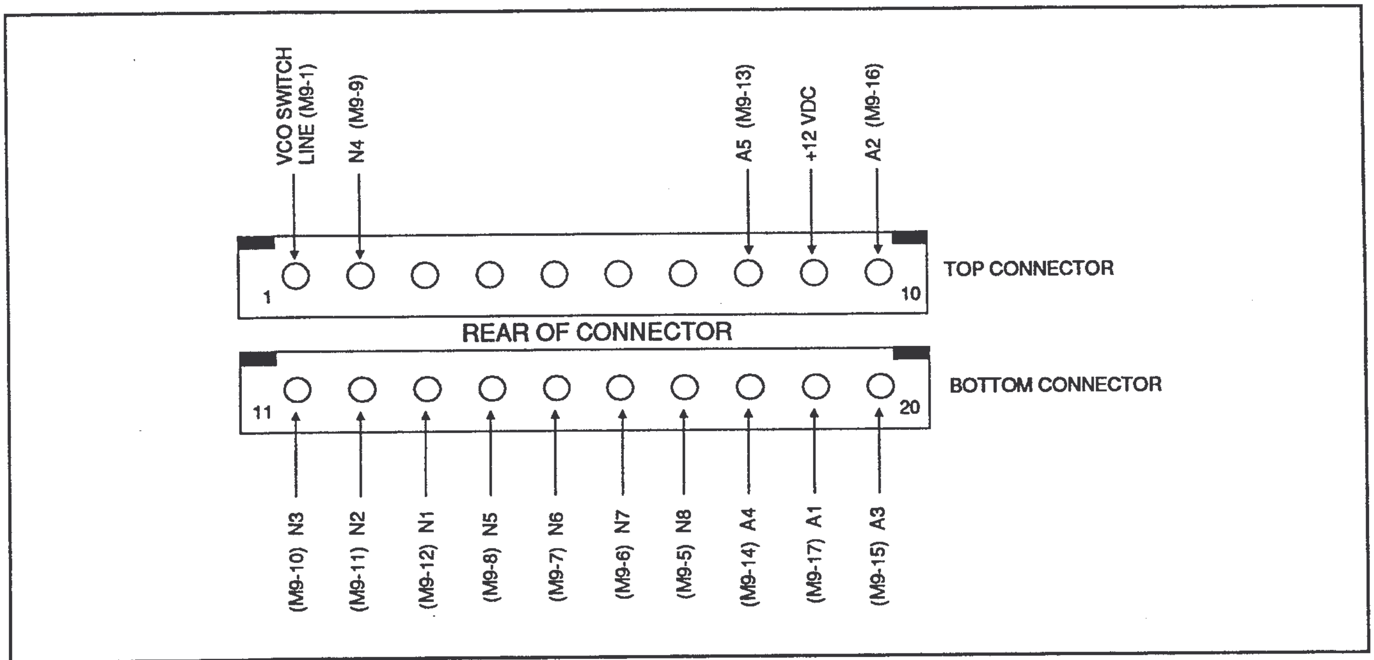


FIGURE 10.6-3.
10-kHz Loop I/O (View from outside).

quirements and should be used to check whether the module is programmed with a valid number.

3. If steps 1 and 2 do not reveal a problem, then the signal should be traced around the phase-locked loop.

Length of each count in the cycle is $10^{-4}/N$ seconds. Therefore, the following can be used to check that the synthesizer is responding to its input programming correctly:

Check the output of the ÷32/33 prescaler at U5, pin 2. It should be a 5-V, peak-to-peak, square wave. If not, check the dc supply of pin 8 and the VCO input at pin 3. If the prescaler output is all right, check to see that it also appears at U6, pin 1.

Check U6, pin 3 for the regulated 8 Vdc. Check U6, pins 4, 5 and 6 to see that the proper internal reference divide ratio is set. Pins 4 and 5 should be grounded, while pin 6 should equal 8 Vdc.

Check U6, pin 9, the dual modulus control line, to the ÷32/33 prescaler. This line should be at 8 V whenever the prescaler is dividing by 33. It provides an accurate barometer of input frequency programming. It is low at the start of a count cycle, and remains low until the internal ÷A-counter has counted down from its programmed value. At this time, the line goes high and remains so until the internal ÷N-counter has counted the rest of its programmed "N" counts.

Figure 10.6-4 illustrates the waveforms that are present when the loop is locked.

Since the reference frequency is 10 kHz, the length of each count cycle is 1/10 kHz or 100 microseconds. The length of each count in the cycle is $10^{-4}/N$ seconds. Therefore, the following can be used to check that the synthesizer is responding to its input programming correctly:

If A = 0, the control line is always high.

If A = 1, the line is low for $10^{-4}/N$ seconds, and high for $(N-1) \times 10^{-4}$ seconds.

If A = 2, the line is low for $2 \times 10^{-4}/N$ seconds and high for $(N-2) \times 10^{-4}$ seconds.

"A" can be any number from 0-31.

Check U6, pins 7 and 8. These are the phase detector outputs that are combined in U4 for the loop error signal. When the loop is locked, pins 7 and 8 both remain high except for a 100-nanosecond pulse at 10-kHz intervals.

If $F_{L.O.}$ is greater than F_{ref}, then pin 8 pulses low while pin 7 remains high. If $F_{L.O.}/N_T$ is less than F_{ref}, then pin 7 pulses low while pin 8 remains high.

If the reference frequency is correct (equal to 10 kHz), then these lines will show whether the VCO frequency is higher or lower than its programmed value.

Check the output of the active filter at U4, pin 1. When the loop is locked, it is a dc voltage from 4-10 V depending on the programmed VCO frequency. (Low dc voltages correspond to the low frequencies in each VCO range.)

TABLE 10.6-4. 10-kHz Loop Ac Voltage Levels.
(RMS voltages measured with Boonton RF millivoltmeter.)

	76.6 MHz	89.99 MHz	90 MHz	104.99 MHz
Module Output Pins	1.60	1.95	2.15	1.30
Q9-Collector	1.70	3.25	3.50	2.80
Q9-Base	0.25	0.20	0.30	0.25
Q8-Collector	2.50	1.70	2.20	1.20
Q8-Base	0.08	0.10	0.08	0.10
Q7-Collector	0.25	0.30	0.30	0.30
Q7-Base	0.10	0.11	0.12	0.12
D5/D6 Cathodes	1.30	1.30	1.00	0.90

TABLE 10.6-5.
10-kHz Loop Programming.

L.O. Output Frequency = FL.O. = NT x 10 kHz.

Total loop divide ratio = NT = FL.O./104.

NT = 32N + A, where: N = binary number programmed into N-counter.

A = binary number programmed into A-counter.

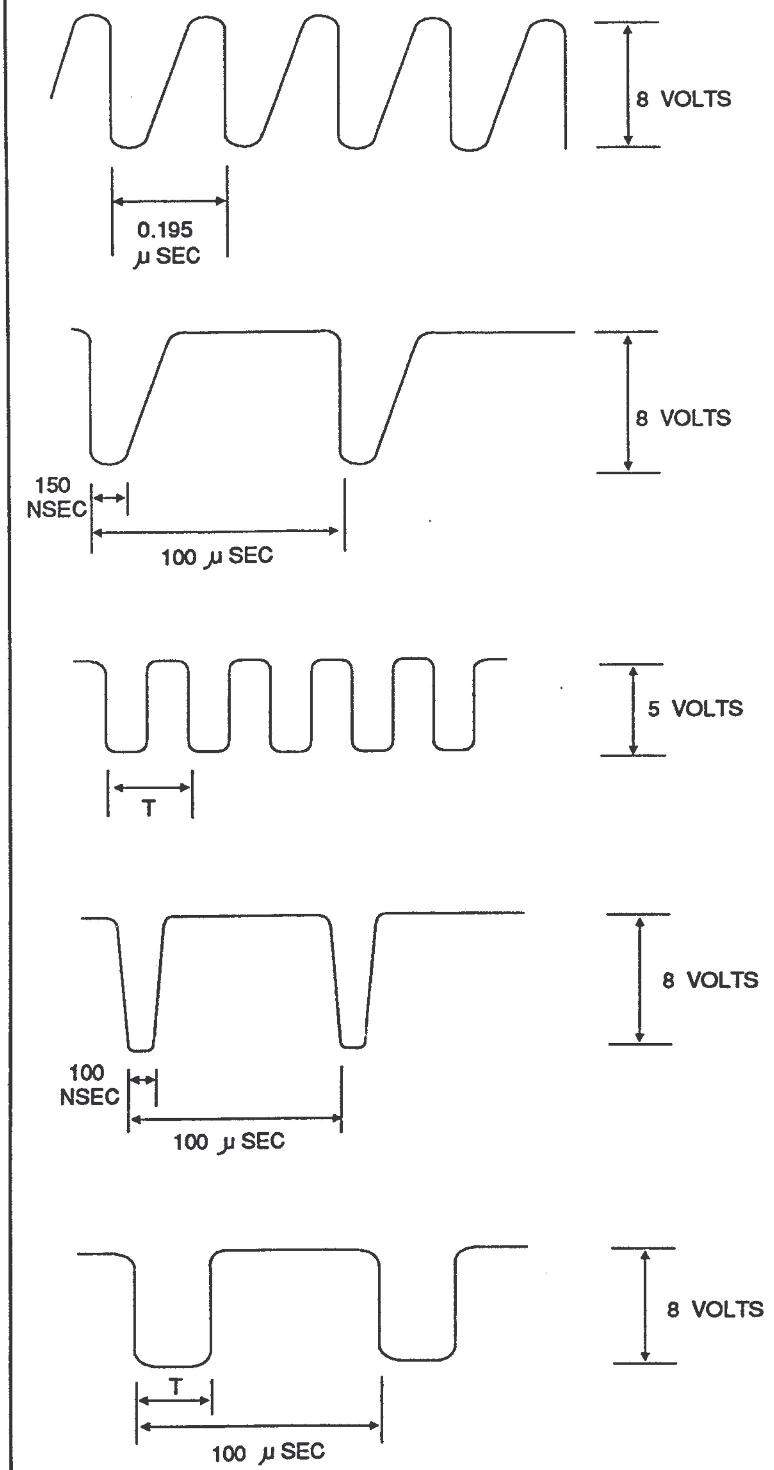
MC145152 10-bit N-counter is configured as:

MC145152 Pin #	"N" Value	Binary Value	Input From
11	N1	1	input program line
12	N2	2	input program line
13	N3	4	input program line
14	N4	8	input program line
15	N5	16	input program line
16	N6	32	input program line
17	N7	64	input program line
18	N8	128	input program line
19	N9	256	always opposite to N8; programmed on board
20	N10	512	fixed low (always = 0)

MC145152 6 bit A-counter is configured as:

MC145152 Pin #	"A" Value	Binary Value	Input From
23	A1	1	input program line
21	A2	2	input program line
22	A3	4	input program line
24	A4	8	input program line
25	A5	16	input program line
10	A6	32	fixed low (always = 0)

The VCO's are switched at 90 MHz, or an NT = 9000.



a) Reference frequency input to U6, pin 27: 5.12 MHZ.

b) Lock detect indication at U6, pin 28.

c) ÷32/33 prescaler output at U6, pin 1:

$$T = \frac{32}{f_{vco}} \text{ secs}$$

d) Dual phase-detector outputs at U6, pins 7, 8.

e) Dual-modulus control line at U6, pin 9:

$$T = \frac{A \times 10^{-4}}{N} \text{ secs}$$

FIGURE 10.6-4.
10-kHz Loop Waveforms ("Locked" Condition).

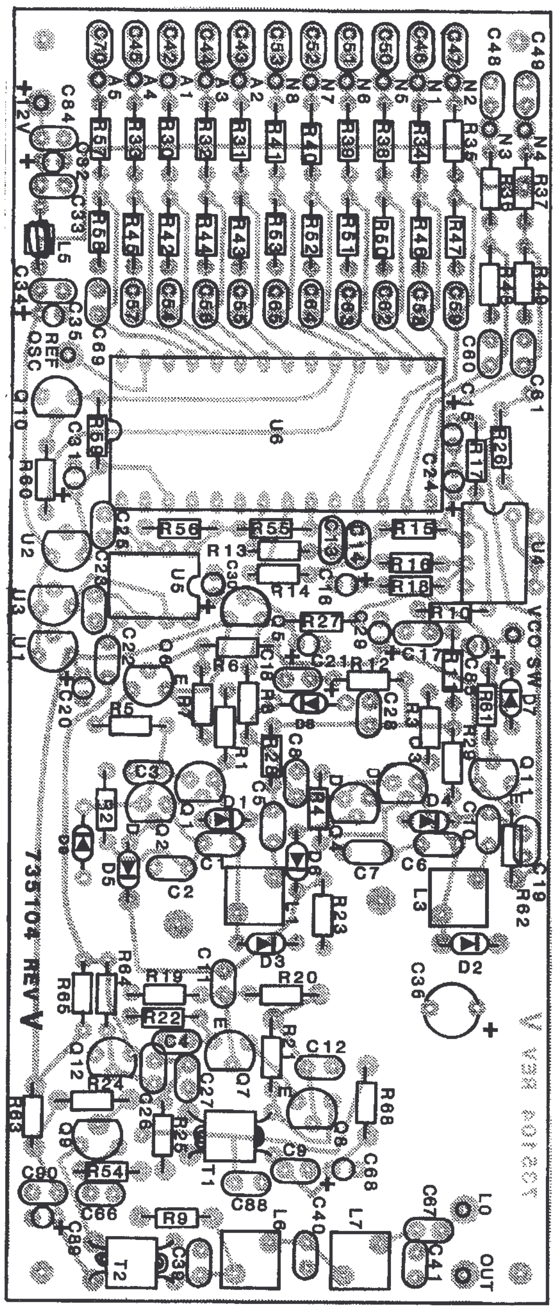
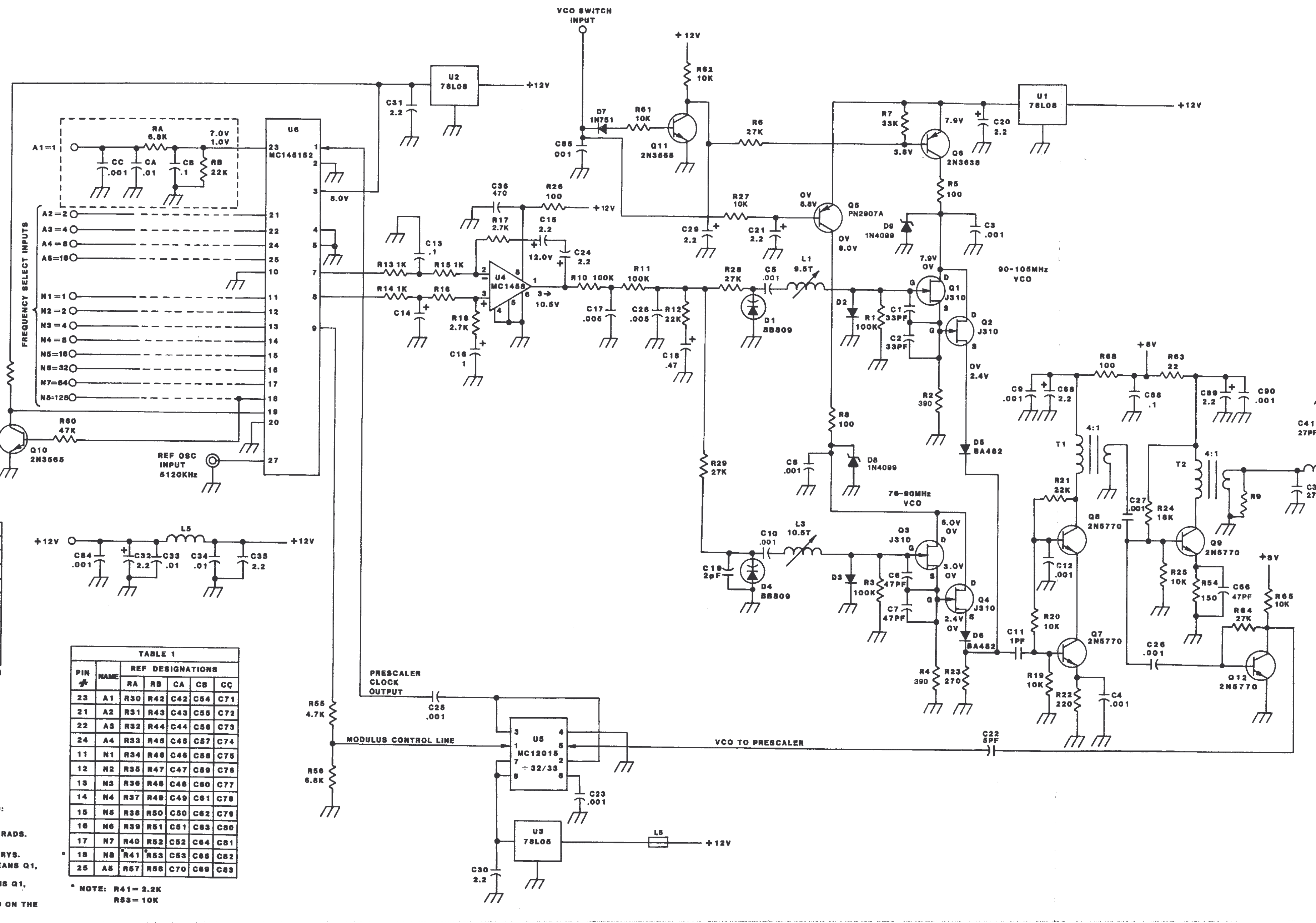


FIGURE 10.6-5.
Component Locations, 10-kHz Loop Synthesizer Module, M6.



CONNECTOR WIRING

1	VCO SW
2	N4
3	
4	
5	
6	
7	
8	A5
9	+12V
10	A2

TOP CONN J1A

11	N3
12	N2
13	N1
14	N5
15	N6
16	N7
17	N8
18	A4
19	A1
20	A3

BOTTOM CONN J1B

TABLE 1

PIN #	NAME	REF DESIGNATIONS RA	RB	CA	CB	CC
23	A1	R30	R42	C42	C54	C71
21	A2	R31	R43	C43	C55	C72
22	A3	R32	R44	C44	C56	C73
24	A4	R33	R45	C45	C57	C74
11	N1	R34	R46	C46	C58	C75
12	N2	R35	R47	C47	C59	C76
13	N3	R36	R48	C48	C60	C77
14	N4	R37	R49	C49	C61	C78
15	N5	R38	R50	C50	C62	C79
16	N6	R39	R51	C51	C63	C80
17	N7	R40	R52	C52	C64	C81
18	N8	*R41	*R53	C53	C65	C82
25	A5	R57	R58	C70	C69	C83

* NOTE: R41 = 2.2K
R53 = 10K

NOTES:
UNLESS OTHERWISE SPECIFIED:
1. RESISTANCE IS IN OHMS.
2. CAPACITANCE IS IN MICROFARADS.
3. ALL DIODES ARE IN4148
4. INDUCTANCE IS IN MICROHENRYS.
5. VCO SWITCH INPUT = 8.5V MEANS Q1, Q2 ACTIVE, Q3, Q4 OFF.
VCO SWITCH INPUT 0V MEANS Q1, Q2 OFF, Q3, Q4 ACTIVE.
6. C71 THRU C85 ARE LOCATED ON THE INTERCONNECT BOARD

TABLE 10.6-6.
Parts List, 10-kHz Loop Synthesizer, M6.

C1, C2	210330	Capacitor, Disc NPO 33 pF
C3-C5	210102	Capacitor, Disc 0.001 μF
C6, C7	210470	Capacitor, Disc NPO 47 pF
C8-C10	210102	Capacitor, Disc 0.001 μF
C11	210010	Capacitor, Disc NPO 1 pF
C12	210102	Capacitor, Disc 0.001 μF
C13, C14	275104	Capacitor, Monolithic 50 V 0.1 μF
C15	241020	Capacitor, Tantalum 2.2 μF
C16	241010	Capacitor, Tantalum 1 μF
C17	275472	Capacitor, Monolithic 0.0047 μF
C18	241047	Capacitor, Tantalum 0.47 μF
C19	210020	Capacitor, Disc NPO 2 pF
C20, C21	241020	Capacitor, Tantalum 2.2 μF
C22	210050	Capacitor, Disc NPO 5 pF
C23	210102	Capacitor, Disc 0.001 μF
C24	241020	Capacitor, Tantalum 2.2 μF
C25-C27	210102	Capacitor, Disc 0.001 μF
C28	275472	Capacitor, Monolithic 0.0047 μF
C29-C32	241020	Capacitor, Tantalum 2.2 μF
C33, C34	214103	Capacitor, Monolithic 50 V 0.01 μF
C35	241020	Capacitor, Tantalum 2.2 μF
C36	231471	Capacitor, Electrolytic 16 V 470 μF
C37, C38		Not Used.
C39	221270	Capacitor, Mica DM5 27 pF
C40	221470	Capacitor, Mica DM5 47 pF
C41	221270	Capacitor, Mica DM5 27 pF
C42-C53	214103	Capacitor, Monolithic 50 V 0.01 μF
C54-C65	275104	Capacitor, Monolithic 50 V 0.1 μF
C66, C67	210470	Capacitor, Disc NPO 47 pF
C68	241020	Capacitor, Tantalum 2.2 μF
C69	275104	Capacitor, Monolithic 50 V 0.1 μF
C70	214103	Capacitor, Monolithic 50 V 0.01 μF
C71-C84	210102	Capacitor, Disc 0.001 μF
C85	241020	Capacitor, Tantalum 2.2 μF
C86, C87		Not Used.
C88	275104	Capacitor, Monolithic 50 V 0.1 μF
C89	241020	Capacitor, Tantalum 2.2 μF
C90	210102	Capacitor, Disc 0.001 μF
D1	320307	Diode, BB809
D2, D3	320002	Diode, 1N4148
D4	320307	Diode, BB809
D5, D6	320005	Diode, PIN BA482
D7	320204	Diode, Zener 1N751
D8, D9	320226	Diode, Zener 1N4099
L1	490127	Inductor, Variable 9.5 turns
L2		Not Used.
L3	490128	Inductor, Variable 10.5 turns
L4		Not Used.
L5	459204	Inductor, Variable 5 turns
L6, L7	490112	Inductor, Variable 2.5 turns
Q1-Q4	310033	Transistor, FET J310
Q5	310052	Transistor, PNP PN2907A
Q6	310007	Transistor, PNP 2N3638

TABLE 10.6-6.
Parts List, 10-kHz Loop Synthesizer, M6, Continued.

Q7-Q9	310032	Transistor, NPN 2N5770
Q10, Q11	310006	Transistor, NPN 2N3565
Q12	310032	Transistor, NPN 2N5770
R1	113104	Resistor, Film 1/8 W 5% 100 kΩ
R2	113391	Resistor, Film 1/8 W 5% 390 Ω
R3	113104	Resistor, Film 1/8 W 5% 100 kΩ
R4	113391	Resistor, Film 1/8 W 5% 390 Ω
R5	113101	Resistor, Film 1/8 W 5% 100 Ω
R6	113273	Resistor, Film 1/8 W 5% 27 kΩ
R7	113333	Resistor, Film 1/8 W 5% 33 kΩ
R8, R9	113101	Resistor, Film 1/8 W 5% 100 Ω
R10, R11	113104	Resistor, Film 1/8 W 5% 100 kΩ
R12	113223	Resistor, Film 1/8 W 5% 22 kΩ
R13-R16	113102	Resistor, Film 1/8 W 5% 1 kΩ
R17, R18	113272	Resistor, Film 1/8 W 5% 2.7 kΩ
R19, R20	113103	Resistor, Film 1/8 W 5% 10 kΩ
R21	113223	Resistor, Film 1/8 W 5% 22 kΩ
R22	113221	Resistor, Film 1/8 W 5% 220 Ω
R23	113271	Resistor, Film 1/8 W 5% 270 Ω
R24	113183	Resistor, Film 1/8 W 5% 18 kΩ
R25	113103	Resistor, Film 1/8 W 5% 10 kΩ
R26	113101	Resistor, Film 1/8 W 5% 100 Ω
R27	113103	Resistor, Film 1/8 W 5% 10 kΩ
R28, R29	113273	Resistor, Film 1/8 W 5% 27 kΩ
R30-R40	113682	Resistor, Film 1/8 W 5% 6.8 kΩ
R41	113222	Resistor, Film 1/8 W 5% 2.2 kΩ
R42-R52	113223	Resistor, Film 1/8 W 5% 22 kΩ
R53	113103	Resistor, Film 1/8 W 5% 10 kΩ
R54	113151	Resistor, Film 1/8 W 5% 150 Ω
R55	113472	Resistor, Film 1/8 W 5% 4.7 kΩ
R56, R57	113682	Resistor, Film 1/8 W 5% 6.8 kΩ
R58	113223	Resistor, Film 1/8 W 5% 22 kΩ
R59	113472	Resistor, Film 1/8 W 5% 4.7 kΩ
R60	113473	Resistor, Film 1/8 W 5% 47 kΩ
R61, R62	113103	Resistor, Film 1/8 W 5% 10 kΩ
R63	113220	Resistor, Film 1/8 W 5% 22 Ω
R64	113273	Resistor, Film 1/8 W 5% 27 kΩ
R65	113103	Resistor, Film 1/8 W 5% 10 kΩ
R66, R67		Not Used.
R68	113101	Resistor, Film 1/8 W 5% 100 Ω
T1, T2	459205	Transformer 4:1
U1, U2	330018	IC, 78L08
U3	330025	IC, 78L05
U4	330019	IC, RC1458CP-1
U5	330105	IC, MC12015P
U6	330084	IC, MC145152P

10.7 RF FILTER & SWITCHING MODULE, M7

The M7 module contains the following circuits:

- RF low-pass filters
- T/R relay
- VSWR bridge & meter circuit
- Receive RF attenuator
- CW oscillator
- Transmit inhibit switch
- Receive High-pass Filter

All circuitry is contained on PCB 735102, which is mounted on the bottom of the transceiver, underneath the M1 and M2 modules.

10.7.1 TECHNICAL DESCRIPTION

10.7.1.1 MODULE INTERCONNECTIONS

RF Connections

a) Antenna Input/Output. RF to/from antenna connector on rear panel. PCB pins are on left front of board.
b) Channel Frequency Input. 100-W unfiltered transmit signal at channel frequency from M10. PCB pins at left rear of board.
c) Channel Frequency Output. Receive output to M4 after low-pass and high-pass filtering. PCB pin at left front of board.

Dc/Audio Connections

J1
Pins 2-7. Control lines for external equipment's filters. Low signal indicates "in-band" filter while "out-of-band" filter lines are +12 Vdc.

J2
Pins 1, 2. +12 Vdc.
Pin 3. Ground.
Pin 4. Spare.
Pins 5-7. RF Filter select lines from M9. BCD code lines: "high" = "1."

J3
Pins 1-4. PTT line.
Pin 5. MTR - ; goes to "-" meter terminal.
Pin 6. MTR + ; goes to "+" meter terminal.
Pins 7, 8. ALC line.
Pins 9-11. AGC line.
Pin 12. Ground.

J4
Pin 1. Receive RF attenuator control line. Ground to put 12-dB attenuator "in-circuit," open otherwise.
Pins 2-6. T+.
Pins 7-12. R+.

J5
Pin 1. Transmit control line from M9MP. "High" to inhibit transmit, "Low" otherwise.
Pin 2. T+ voltage to M3; controlled by "transmit inhibit" line.

J6
Pins 1-9. +12 Vdc.
Pin 10. CW key from front panel CW jack. Ground keys the CW circuit.
Pin 11. CW Microphone. CW audio input to M1.
Pin 12. CW Sidetone. Sidetone audio input to M1.

10.7.1.2 CIRCUIT DESCRIPTION - RF FILTERS

The RF filters are used to provide a high degree of attenuation to the transmitter harmonics and also attenuate out-of-band signals in the receive mode. A series of six low-pass filters is used dividing the frequency range as follows:

Filter #1	1.6-2.9999 MHz
Filter #2	3.0-4.9999 MHz
Filter #3	5.0-7.9999 MHz
Filter #4	8.0-12.9999 MHz
Filter #5	13.0-19.9999 MHz
Filter #6	20.0-29.9999 MHz

The filters are elliptic function filters designed for rapid roll off above the cutoff frequency and 0.1-dB ripple in the passband. The filters are selected by SPDT relays at the input and output of each filter. The unused filters are grounded and leakage around the filters is held at a very low level.

An additional seven-pole, high-pass filter is used in the receive mode only. This filter has a cutoff frequency of 1600 kHz and provides a high degree of attenuation to signals in the broadcast band. D13 and D14 provide protection against transients to the receive input.

10.7.1.3 CIRCUIT DESCRIPTION - FILTER SWITCHING

The filters are selected by the relays K2-K13. Each pair of relays is switched by a Darlington transistor Q1-Q6. These transistors are controlled by the CMOS decoder U1. The control is derived from three lines on the programming board designated SYN A, SYN B, SYN C. The control code is as follows in Table 10.7-1.

10.7.1.4 CIRCUIT DESCRIPTION - 12-dB FRONT END ATTENUATOR (Optional)

R51, R52, and R55 are configured as a 12-dB attenuator which can be switched in the receiver front end by relay K14 if it is desired to improve the IMD performance of the receiver. K14 is controlled by a front-panel switch whenever this option is installed in the transceiver.

10.7.1.5 TRANSMIT INHIBIT

Q14 is a PNP transistor used to switch off the T+ line to the M3 module whenever the microprocessor is awake and running. This effectively prevents the transmitter from working during this time and possibly putting out spurious signals. Q14 is controlled by the "Tx-Inhibit" line from M9 which provides a high output during the inhibit period.

10.7.1.6 CIRCUIT DESCRIPTION - VSWR BRIDGE & METERING

The VSWR bridge is in the antenna output lead. L23 provides the current arm of the bridge and R13 and R14 are the voltage arm. D16 rectifies the forward output of the bridge which is applied to the ALC control circuits on M2. R16 sets the threshold level for the ALC. When the antenna is correctly matched, there is no output from D15, the reverse arm of the bridge. As the VSWR rises, a voltage is applied to the ALC circuit through D3 and D19. This limits the power output when the antenna is mismatched and protects the final amplifier transistor. The network C70, R15, D17 compensates for the reduced output of the bridge at the high end of the frequency range. In the receive mode, the front panel meter reads the relative received signal strength. In the transmit mode, the meter reads the output from the forward arm of the bridge. An alternate connection is provided so that the meter will read relative reflected power.

10.7.1.7 CIRCUIT DESCRIPTION - SWITCHING

The DPDT relay K1, controlled by the PTT line, switches the output from the RF filters to the power amplifier or the receiver input via the high-pass filter. The other pole is used to provide R+ and T+ dc voltages for the transceiver. Three separate +12-V supply lines are used in the transceiver: +12-V common, +12-V transmit, +12-V receive. These three supply lines control the appropriate circuitry in all of the modules. Pins are provided on the PCB to connect an optional high-speed switching board when system usage dictates it. This option will allow electronic transmit-receive switching whenever increased speed is necessary.

10.7.1.8 CIRCUIT DESCRIPTION - AMPLIFIER CONTROL

The transceiver is designed for simple interface with all the Transworld amplifiers. These amplifiers use the same filter ranges as the transceiver, and outputs are provided to the accessory socket from the filter switching transistors Q1-Q6. When the amplifier is correctly interfaced, the amplifier filters will switch automatically when the transceiver channel switch is turned.

10.7.1.9 CIRCUIT DESCRIPTION - RECEIVER S METER

The front-panel meter reads the voltage on the AGC line and gives a relative indication of received signal strength. The AGC voltage is approximately 3.8 V with no signal and decreases with increased signal strength. A bridge circuit is used to give a forward-reading meter. The AGC voltage is applied to the base of the emitter follower Q10. This stage has a high-impedance input and prevents the meter from loading the circuit. The voltage across the meter is adjusted to be equal in both arms of the bridge, and the meter reads zero with no signal. The voltage on the emitter of Q10 drops as the AGC voltage decreases (with increasing signal strength). This unbalances the bridge and the meter reading increases. D20, D21 and R29 provide compensation for the nonlinear characteristics of the AGC voltage. Q11 is a switch that grounds the negative side of the meter in the transmit mode, which causes the meter to read forward power. D23, D24 and D25 prevent the residual voltage on the R+ line from causing a meter reading in the transmit mode.

10.7.1.10 CW OSCILLATOR

The transceiver CW oscillator is incorporated in the M7 PCB. Operational amplifier U2 is configured as a bridge-type oscillator generating a 1-kHz audio tone. Q12 is a switch that is normally on and shunts the audio output to ground. When the oscillator is keyed (ground applied at J6-10), Q12 is turned off and the 1-kHz tone is delivered to the microphone input in the M1 module through R48. The audio is also provided through R49 to M1 for use as a sidetone signal.

Keying the oscillator also turns on Q13, which grounds the PTT line and keys the transmitter. C90 provides the time constant which allows approximately a 0.8-s interval between oscillator unkeying and transmitter unkeying.

10.7.2 ADJUSTMENT PROCEDURE

ALC—R16, the ALC threshold adjustment, is used to limit the power output to any desired level. If maximum power output is desired, select an operating frequency below 10 MHz. The transceiver should be connected to a

TABLE 10.7-1. Control Codes.

FILTER RANGE	SYN A	SYN B	SYN C
1.6 - 3.0 MHz	High	Low	High
3.0 - 5.0 MHz	High	Low	Low
5.0 - 8.0 MHz	Low	High	High
8.0 - 13.0 MHz	Low	High	Low
13.0 - 20.0 MHz	Low	Low	High
20.0 - 30.0 MHz	Low	Low	Low

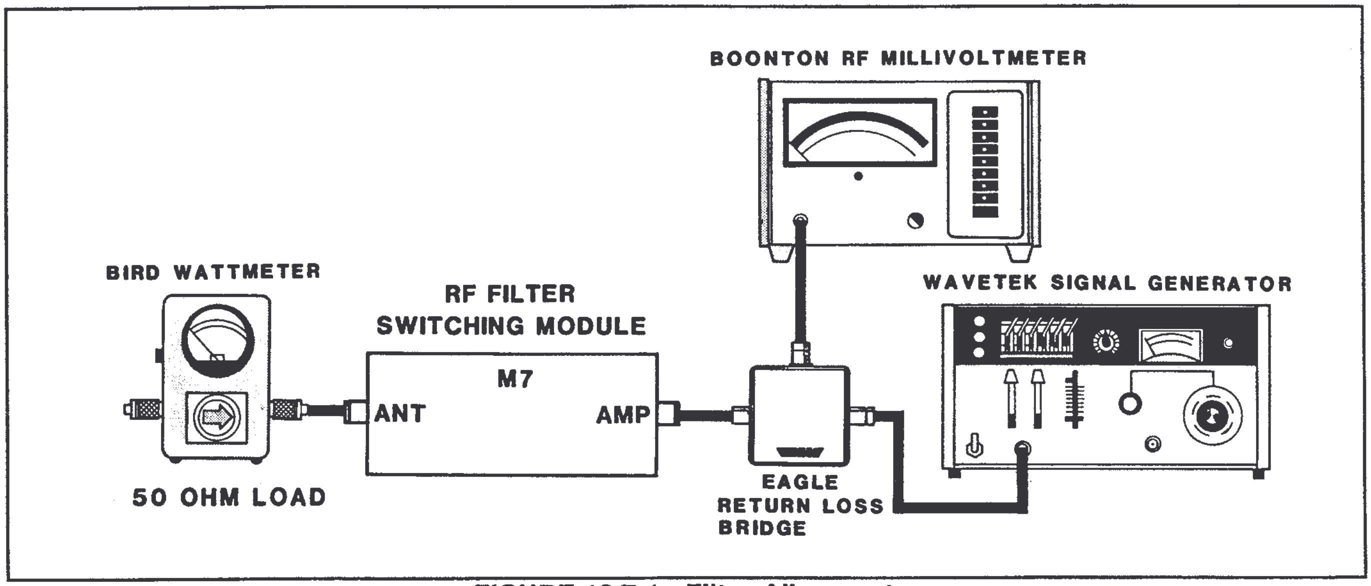


FIGURE 10.7-1. Filter Alignment.

50-ohm load and the output monitored by an oscilloscope. Speak into the microphone and carefully adjust R16 until there is no evidence of peak flattening on speech peaks. This will result in a power output of close to 150-W PEP through much of the frequency range. The power amplifier output will be automatically reduced to approximately 100 W at the high end of the operating range by the network C70, R15, D17, which automatically compensates for the reduced efficiency of the transistors in the final amplifier. If it is necessary to limit the power output to 100 W (or any other specified power level), use a two-tone test signal at the microphone input and adjust the ALC for a power output reading of 100-W PEP. Refer to Section 8.4.1 for information on power measurement. It is most desirable to check the transceiver using an oscilloscope to ensure that the amplifier is not peak flattening. Inaccuracies in SSB power measurement may often result in incorrect ALC adjustment. The most important consideration is to prevent peak flattening, which can cause severe interference on adjacent channels.

S Meter—Adjust the signal generator to the center of the receiver passband at an output level of 100 μV. Adjust R31 so the meter reads half scale.

Filter Alignment—The output filters are aligned in the factory and should not require adjustment during the service life of the transceiver. If a filter inductor is damaged and replaced, it may be necessary to check the filter operation. This does require the use of a return loss bridge and signal generator. The equipment is connected as shown in Figure 10.7-1.

NOTE

The PTT line must be closed so that the module is in the transmit mode. Select the desired filter, using the channel switch or by grounding the accessory connector output for the desired filter (FL1-FL6).

The filter must be adjusted by changing the spacing of wires on the three inductors so that the return loss is less than 15 dB over the operating range of the filter. Change each inductor wire spacing only a small amount and check the filter performance after each change. This procedure may have to be repeated many times as there is considerable interaction in the adjustment of the inductors. It will be noted that no measurements are made of the forward power loss through the filter. This has already been optimized in the filter design and component selection. If the filter is adjusted for minimum return loss, the forward power losses will be minimized. The importance of minimizing return loss cannot be overemphasized. As the return loss increases, the mismatch to the amplifier increases and the amplifier will not deliver the rated power output. It is quite possible for a filter to show quite low insertion loss, yet provide a severe mismatch to the transmitter. This is the reason for using the return loss of the filter, which gives a direct measure of the mismatch to the power amplifier.

The elliptic function filters provide a much faster rate of attenuation after cutoff than the Butterworth or Chebishev filters. The parallel capacitor across the three inductors provide rejection notches at the resonant frequency and the filter is designed so that these notches appear in the filter stopband. The most important rejection notch is the one closest to the cutoff frequency of the filter. This rejection notch is controlled by the center inductor and parallel capacitor. Therefore, the adjustment of this inductor is most critical and adjusting it for maximum inductance (close turns spacing) will ensure best harmonic attenuation at the low frequencies in the operating range of the filter.

10.7.3 VOLTAGE CHART

Table 10.7-1 defines the relevant voltages for the RF filter & switching module, M7.

10.7.4 SERVICING

The filters will not require adjustment unless physical damage occurs. Component failure is usually self-evident, as the transmitter will cause defective components to overheat. Incorrect filter performance is usually indicated by failure of the transceiver to make normal power output on one filter range. The operation of the filter selection relays can be checked by measuring dc continuity through the filter in the transmit mode. Do note that L24 provides a low resistance to ground.

The operation of K1, the antenna-switching relay, can be checked by making a dc continuity check of the receive and transmit signal paths.

The filter selection should be checked by measuring the collector voltage on Q1-Q6. The operational filter should read low and all other filters should indicate 12 V. If the filter switching is not operating correctly, check the coding information from the channelizing module, the operation of the decoder U1, and the switching transistors Q1-Q6.

The VSWR bridge and ALC control circuitry will seldom require servicing. The operation of the bridge may be checked by connecting the transceiver to a 50-ohm load and changing the positive lead from the meter from "forward power" to "reflected power". The meter should show zero or only a small residual reading at full power output. If the bridge appears unbalanced, check all diodes and the resistance values. If L23 is replaced, the polarity of the windings must be observed or the forward and reverse arms of the bridge will be reversed.

10.7.5 CIRCUIT DESCRIPTION - VSWR BRIDGE & METERING

The VSWR bridge is in the output lead to the antenna tuner. L23 provides the current aim of the bridge and R13 and R14 are the voltage arm. D16 rectifies the forward output of the bridge, which is applied to the ALC/AGC amplifier on M2. R16 sets the threshold control level of the ALC. It should be noted that the output of R16 is shunted to ground by R4, an 820-ohm resistor, mounted at the thermostat and in series with the high/low-power switch, the tune switch, the over-temperature thermostat on the transmitter heat sink, and the automatic-antenna-tuner control interface. The ALC is adjusted for the correct power output 100 W AVG (125 W PEP) with R4 shunting the ALC to ground. When the circuit to R4 is interrupted, the ALC voltage rises and reduces the output power to 10 W. This one circuit provides over-temperature protection, high/low-power operation, and antenna-tune power.

When the antenna is correctly matched, there is no output from D15 at the reverse arm of the bridge. At a VSWR of approximately 2:1 the voltage exceeds the forward potential of diodes D19 and D3 and is applied to the ALC circuit. This limits the power output when the antenna is mismatched and protects the final amplifier transistors. The network C70, R15, D17 corrects for the small drop in efficiency in the bridge at 30 MHz, which would cause the power output level to rise at the high end of the frequency range.

In the transmit mode, the meter reads the output from the forward arm of the bridge. In the tune mode, the tune switch shorts out the series resistor, R60, so that the meter will deflect approximately 90-% full scale at tune power (10 W). The tune switch also shorts out diodes D19 and D3, applying full output from the reverse arm of the bridge to the ALC circuitry. This means that the transmitter is limited to very low power output until the antenna is correctly matched. In the tune mode, the transceiver is tuned for maximum output power (maximum meter deflection) and this will correspond to lowest VSWR. In the receive mode the meter will read relative reflected power.

TABLE 10.7-2.
Voltage Chart, RF Filter and Switching Module, M7.

	Non Operating Filters	Operating Filters
Q1		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
Q2		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
Q3		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
Q4		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
Q5		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
Q6		
Emitter: 0 V		
Base:	0 V	1.4 V
Collector:	12.0 V	1.0 V
	Receive	**Transmit**
Q7		
Emitter: 0 V		
Base:	0.0 V	0.7 V
Collector:	HIGH	LOW
Q10		
Emitter:	0-3.3 V	0-3.3 V
Base:	0-4.0 V	0-4.0 V
Collector:	12.0 V	12.0 V
Q11		
Emitter:	0.0 V	0.0 V
Base:	0.0 V	0.7 V
Collector:	0-3.3 V	0.0 V

	Receive	Transmit
Q12		
Emitter:	0.0 V	0.0 V
Base:	0.7 V	0.0 V (CW mode)
Collector:	0.0 V	HIGH
Q13		
Emitter:	11.0 V	0.0 V
Base:	11.0 V	0.0 V
Collector:	0.0 V	0.0 V
Q14		
Emitter:	0.0 V	12.0 V
Base:	0.0 V	0.0 V (12 V, inhibit)
Collector:	0.0 V	12.0 V (0.0 V, inhibit)
Q15		
Emitter:	0.0 V	0.0 V
Base:	0.0 V	0.7 V
Collector:	12.0 V	0.0 V
U1		
Pin 1	12.0 V	3.0-5.0 MHz
Pin 2	12.0 V	8.0-13.0 MHz
Pin 3	12.0 V	20.0-30.0 MHz
Pin 6	12.0 V	1.6-2.0 MHz
Pin 10	Refer to 10.7.2	High = 12V, Low = 0V
Pin 11	0.0 V	
Pin 12	Refer to 10.7.2	High = 12V, Low = 0V
Pin 13	Refer to 10.7.2	High = 12V, Low = 0V
Pin 14	12.0 V	13.0-20.0 MHz
Pin 15	12.0 V	5.0-8.0 MHz
Pin 16	12.0 V	

(Pins 1, 2, 3, 14 and 15 0 V when filter is not switched.)

	Receive	Transmit
U2		
Pin 1	6.0 V	6.0 V
Pin 2	6.0 V	6.0 V
Pin 3	6.0 V	6.0 V
Pin 4	0.0 V	0.0 V
Pin 5	0.0 V	0.0 V
Pin 6	0.0 V	0.0 V
Pin 7	10.5 V	10.5 V
Pin 8	11.0 V	11.0 V

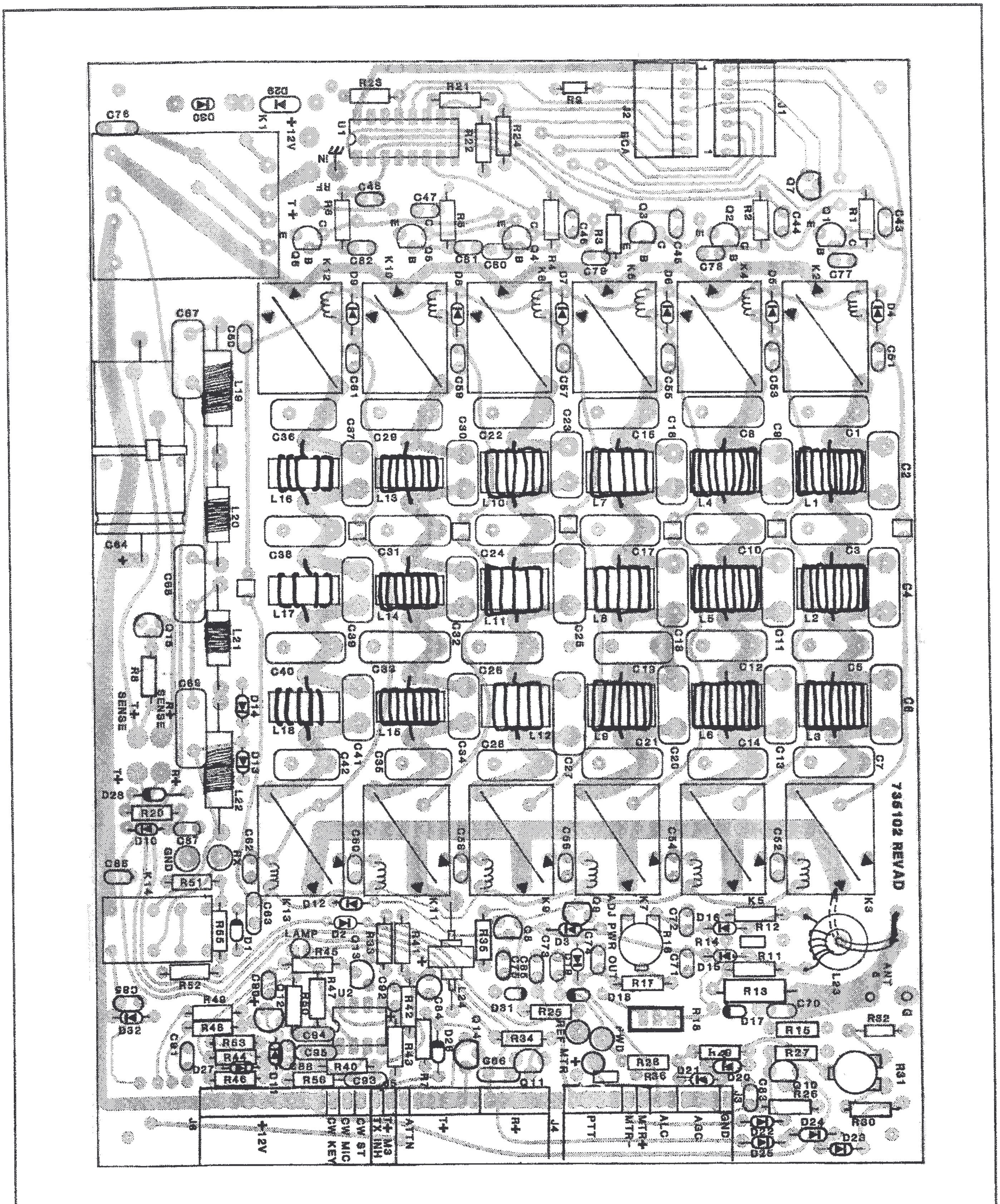
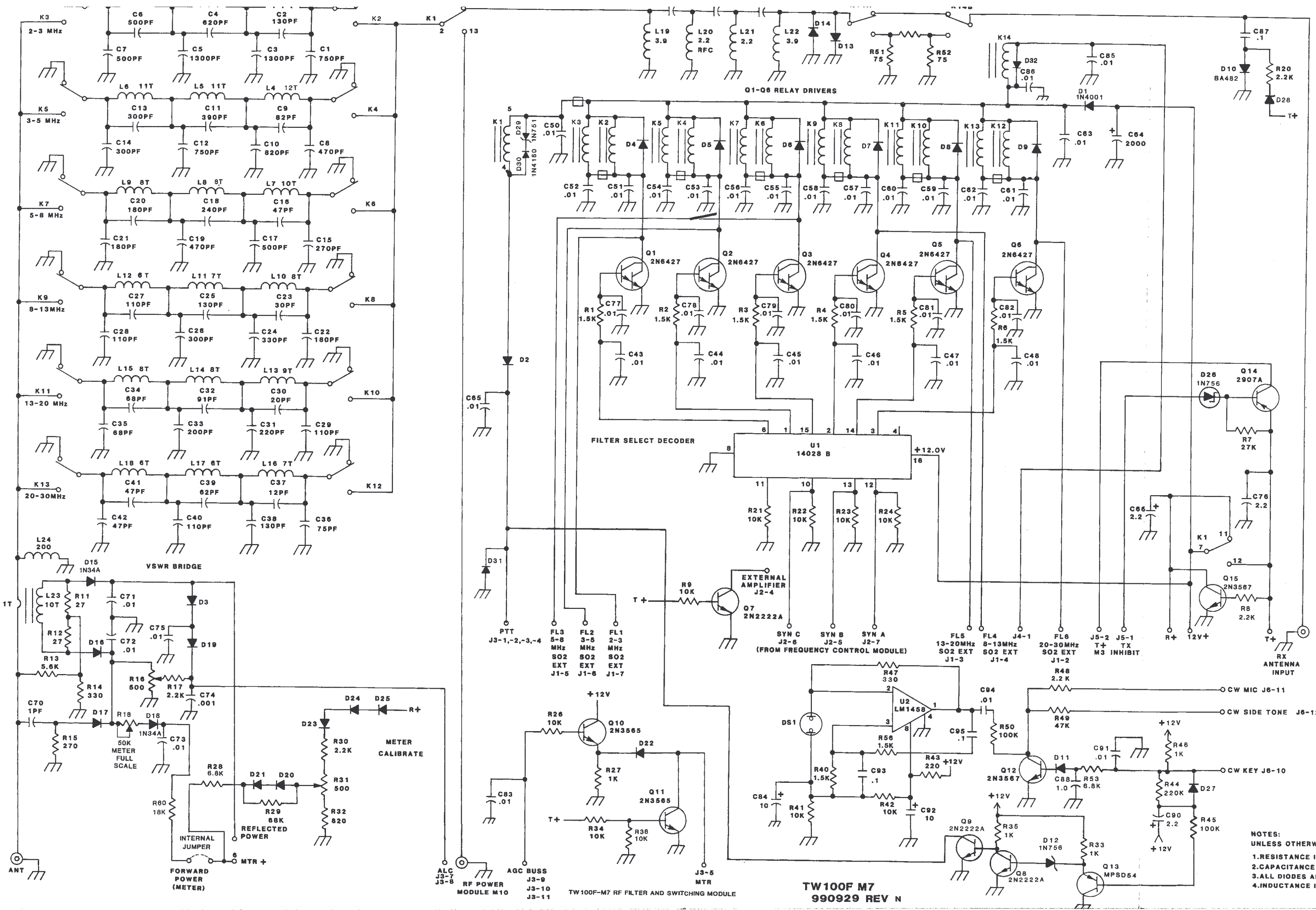


FIGURE 10.7-2.
Component Locations, RF Filter & Switching Module, M7.



J1	
1	N/C
2	FL6
3	FL5
4	FL4
5	FL3
6	FL2
7	FL1

J2	
7	A
6	C
5	B
4	EXT AMP
3	GND
2	+12
1	+12

FILTER SELECT (J2 pins 7, 6, 5)

J3	
1	PTT
2	PTT
3	PTT
4	PTT
5	MTR –
6	MTR +
7	ALC
8	ALC
9	AGC
10	AGC
11	AGC
12	GND

J4	
1	ATTN
2	T+
3	T+
4	T+
5	T+
6	T+
7	R+
8	R+
9	R+
10	R+
11	R+
12	R+

J5	
1	TX INHIBIT
2	T+ M3

J6	
1	+12
2	+12
3	+12
4	+12
5	+12
6	+12
7	+12
8	+12
9	+12
10	CW KEY
11	CW MIC
12	CW OUT TONE

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

TW100F M7
990929 REV N

TABLE 10.7-3.
Parts List, RF Filter & Switching Module, M7.

C1	224751	Capacitor, Mica DM19 750 pF
C2	224131	Capacitor, Mica DM19 130 pF
C3	224132	Capacitor, Mica DM19 1300 pF
C4	224621	Capacitor, Mica DM19 620 pF
C5	224132	Capacitor, Mica DM19 1300 pF
C6,C7	224501	Capacitor, Mica DM19 500 pF
C8	224471	Capacitor, Mica DM19 470 pF
C9	220820	Capacitor, Mica DM15 82 pF
C10	224821	Capacitor, Mica DM19 820 pF
C11	224391	Capacitor, Mica DM19 390 pF
C12	224751	Capacitor, Mica DM19 750 pF
C13,C14	224301	Capacitor, Mica DM19 300 pF
C15	224271	Capacitor, Mica DM19 270 pF
C16	220470	Capacitor, Mica DM15 47 pF
C17	224501	Capacitor, Mica DM19 500 pF
C18	224241	Capacitor, Mica DM19 240 pF
C19	224471	Capacitor, Mica DM19 470 pF
C20-C22	224181	Capacitor, Mica DM19 180 pF
C23	220300	Capacitor, Mica DM15 30 pF
C24	224331	Capacitor, Mica DM19 330 pF
C25	224131	Capacitor, Mica DM19 130 pF
C26	224301	Capacitor, Mica DM19 300 pF
C27-C29	224111	Capacitor, Mica DM19 110 pF
C30	220200	Capacitor, Mica DM15 20 pF
C31	224221	Capacitor, Mica DM19 220 pF
C32	220910	Capacitor, Mica DM15 91 pF
C33	224201	Capacitor, Mica DM19 200 pF
C34-C35	220680	Capacitor, Mica DM15 68 pF
C36	220750	Capacitor, Mica DM15 75 pF
C37	220120	Capacitor, Mica DM15 12 pF
C38	224131	Capacitor, Mica DM19 130 pF
C39	220620	Capacitor, Mica DM15 62 pF
C40	224111	Capacitor, Mica DM19 110 pF
C41,C42	220470	Capacitor, Mica DM15 47 pF
C43-C48	214103	Capacitor, Monolithic 50 V 0.01 μF
C49		Not Used.
C50-C63	214103	Capacitor, Monolithic 50 V 0.01 μF
C64	230202	Capacitor, Electrolytic 16 V 2000 μF
C65	214103	Capacitor, Monolithic 50 V 0.01 μF
C66	241020	Capacitor, Tantalum 2.2 μF
C67-C69	224132	Capacitor, Mica DM19 1300 pF
C70	210010	Capacitor, Disc NPO 1 pF
C71-C73	214103	Capacitor, Monolithic 50 V 0.01 μF
C74	210102	Capacitor, Disc 0.001 μF
C75	214103	Capacitor, Monolithic 50 V 0.01 μF
C76	241020	Capacitor, Tantalum 2.2 μF
C77-C82	214103	Capacitor, Monolithic 50 V 0.01 μF
C83	275104	Capacitor, Monolithic 50 V 0.1 μF
C84	241100	Capacitor, Tantalum 10 μF
C85,C86	214103	Capacitor, Monolithic 50 V 0.01 μF
C87	275104	Capacitor, Monolithic 50 V 0.1 μF
C88	241010	Capacitor, Tantalum 1 μF
C89		Not Used.
C90	241020	Capacitor, Tantalum 2.2 μF
C91	214103	Capacitor, Monolithic 50 V 0.01 μF
C92	241100	Capacitor, Tantalum 10 μF

TABLE 10.7-3.
Parts List, RF Filter & Switching Module, M7, Continued.

C93	275104	Capacitor, Monolithic 50 V 0.1 μF
C94	214103	Capacitor, Monolithic 50 V 0.01 μF
C95	275104	Capacitor, Monolithic 50 V 0.1 μF
D1	320102	Diode, 1N4001
D2-D9	320002	Diode, 1N4148
D10	320005	Diode, PIN BA482
D11	320002	Diode, 1N4148
D12	320202	Diode, Zener 1N756
D13,D14	320002	Diode, 1N4148
D15	320003	Diode, 1N34A
D16,D17	320002	Diode, 1N4148
D18	320003	Diode, 1N34A
D19-D25	320002	Diode, 1N4148
D26	320202	Diode, Zener 1N756
D27,D28	320002	Diode, 1N4148
D29	320204	Diode, Zener 1N751
D30-D32	320002	Diode, 1N4148
DS1	390007	Lamp, 10 V 14 mA
K1	540008	Relay, DPDT 12 V
K2-K13	540009	Relay, SPDT 12 V
K14	540020	Relay, DPDT 12 V
L1	451115	Inductor, Toroid 15 turns
L2,L3	451117	Inductor, Toroid 12 turns
L4	451147	Inductor, Toroid 12 turns
L5,L6	451119	Inductor, Toroid 11 turns
L7	459134	Inductor, Toroid 10 turns
L8-L10	451122	Inductor, Toroid 8 turns
L11	451124	Inductor, Toroid 7 turns
L12	459131	Inductor, Toroid 6 turns
L13	451126	Inductor, Toroid 9 turns
L14,L15	451127	Inductor, Toroid 8 turns
L16	451128	Inductor, Toroid 7 turns
L17,L18	451129	Inductor, Toroid 6 turns
L19	430020	Inductor, Fixed 3.9 μH
L20,L21	430019	Inductor, Fixed 2.2 μH
L22	430020	Inductor, Fixed 3.9 μH
L23	451130	Inductor, Toroid 10 turns
L24	430002	Inductor, Fixed 200 μH
Q1-Q6	310064	Transistor, 2N6427
Q7-Q9	310057	Transistor, NPN PN2222A
Q10,Q11	310006	Transistor, NPN 2N3565
Q12	310003	Transistor, NPN 2N3567
Q13	310060	Transistor, MPSD54
Q14	310052	Transistor, PNP PN2907A
Q15	310003	Transistor, NPN 2N3567
R1-R6	124152	Resistor, Film 1/4W 5% 1.5 kΩ
R7	124273	Resistor, Film 1/4W 5% 27 kΩ
R8	124222	Resistor, Film 1/4W 5% 2.2 kΩ
R9	113103	Resistor, Film 1/8W 5% 10 kΩ
R10		Not Used.

TABLE 10.7-3.
Parts List, RF Filter & Switching Module, M7, Continued.

R11,R12	124270	Resistor, Film 1/4W 5% 27 Ω
R13	144562	Resistor, Flameproof 1W 5.6 kΩ
R14	124331	Resistor, Film 1/4W 5% 330 Ω
R15	124271	Resistor, Film 1/4W 5% 270 Ω
R16	170110	Resistor, Trimmer 500 Ω
R17	124222	Resistor, Film 1/4W 5% 2.2 kΩ
R18	170209	Resistor, Trimmer 50 kΩ
R19		Not Used.
R20	124222	Resistor, Film 1/4W 5% 2.2 kΩ
R21-R24	124103	Resistor, Film 1/4W 5% 10 kΩ
R25		Not Used.
R26	124103	Resistor, Film 1/4W 5% 10 kΩ
R27	124102	Resistor, Film 1/4W 5% 1 kΩ
R28	124682	Resistor, Film 1/4W 5% 6.8 kΩ
R29	124683	Resistor, Film 1/4W 5% 68 kΩ
R30	124222	Resistor, Film 1/4W 5% 2.2 kΩ
R31	170110	Resistor, Trimmer 500 Ω
R32	124821	Resistor, Film 1/4W 5% 820 Ω
R33	124102	Resistor, Film 1/4W 5% 1 kΩ
R34	124103	Resistor, Film 1/4W 5% 10 kΩ
R35	124102	Resistor, Film 1/4W 5% 1 kΩ
R36	124103	Resistor, Film 1/4W 5% 10 kΩ
R37-R39		Not Used.
R40	124152	Resistor, Film 1/4W 5% 1.5 kΩ
R41,R42	124103	Resistor, Film 1/4W 5% 10 kΩ
R43	124221	Resistor, Film 1/4W 5% 220 Ω
R44	124224	Resistor, Film 1/4W 5% 220 Ω
R45	124104	Resistor, Film 1/4W 5% 100 kΩ
R46	124102	Resistor, Film 1/4W 5% 1 kΩ
R47	124331	Resistor, Film 1/4W 5% 330 Ω
R48	124222	Resistor, Film 1/4W 5% 2.2 kΩ
R49	124473	Resistor, Film 1/4W 5% 47 kΩ
R50	124104	Resistor, Film 1/4W 5% 100 kΩ
R51,R52	124750	Resistor, Film 1/4W 5% 75 Ω
R53	124682	Resistor, Film 1/4W 5% 6.8 kΩ
R54		Not Used.
R55	124101	Resistor, Film 1/4W 5% 1 kΩ
R56	124152	Resistor, Film 1/4W 5% 1.5 kΩ
R57-R59		Not Used.
R60	124183	Resistor, Film 1/4W 5% 18 kΩ
U1	330082	IC, MC14028BCP
U2	330019	IC, RC1458CP-1

10.8 12-V REGULATOR MODULE, M8

10.8.1 CIRCUIT DESCRIPTION

Module M8 is a voltage regulator designed to provide a nominal 12-V ±10 % for the low-voltage circuits. Since the line voltage may drop below 12 V, the regulator is designed for a low-voltage drop of approximately 0.4 V.

The regulator schematic is shown in Figure 10.8-2. The unregulated voltage is applied to the emitter of Q10. The output (collector of Q10) will initially be low, and the base of Q12 will be pulled down thru R12. When Q12 turns on it supplies a voltage to Q11 which turns on and pulls the base of Q10 low, which turns on Q10. As Q10 comes on the voltage at divider R11/R12 raises, which starts to turn Q12 off. At approximately 4.6 V at the divider, equilibrium is reached and the supply stabilizes. R14 is provided to sink some current out of Q12, which improves the voltage regulation versus output current. A five-ampere fuse protects the low-power circuits and the regulator in the event of a short circuit on the +12-V regulated line.

10.8.2 ADJUSTMENT PROCEDURE

There are no adjustments for the 12-V regulator module.

10.8.3 SPECIFICATIONS

Table 10.8-1 lists the specifications for the 12-V regulator module.

10.8.4 VOLTAGE CHART

Table 10.8-2 defines the relevant voltages for the 12-V regulator module.

10.8.5 SERVICING

Component failure can be diagnosed by using a voltmeter and measuring the voltages in the circuit. A troubleshooting chart, Table 10.8-3, is provided to aid in troubleshooting the unit.

TABLE 10.8-1.
Specifications, 12-V Regulator Module, M8.

Voltage Input:	12-20 Vdc.
Voltage Output:	12 Vdc ±0.05 V.
Current Output:	4A maximum.

TABLE 10.8-2.
Voltage Chart, 12-V Regulator Module, M8.

U10	IN:	20.0 V
	OUT:	5.0 V
	GND:	0.0 V
Q10	Emitter:	20.0 V
	Base:	19.3 V
	Collector:	12.0 V
Q11	Emitter:	0.1 V
	Base:	0.7 V
	Collector:	19.4 V
Q12	Emitter:	5.0 V
	Base:	4.6 V
	Collector:	0.7 V

NOTE

Measurements are made with the internal ac supply providing primary power input. Unit is in receive with the squelch closed.

TABLE 10.8-3.
Troubleshooting Chart.

PROBLEM	SYMPTOM	CURE
No Output	No voltage at F3: No voltage at Q10 emitter: No voltage at Q10 collector:	dc fuse or ac fuse open Check F3 Check Q10 open Check U10 has 5 V Check Q12 supply Q11 base Check Q11 and R13
Output voltage same as input	Q10 base low, greater than 1.0 V below emitter Q12 collector Volt high: Q11 collector low & base Low:	Q10 defective R10 open Check U10 5 V Check R11/R12 divider Check Q12 Check R10 Check Q11 is OK
Output voltage sags High current	Q11 base sags: Q11 base high:	R14 open or wrong value Q12 in backwards or low Beta Input voltage at Q10 Emitter sagging Q10 beta low

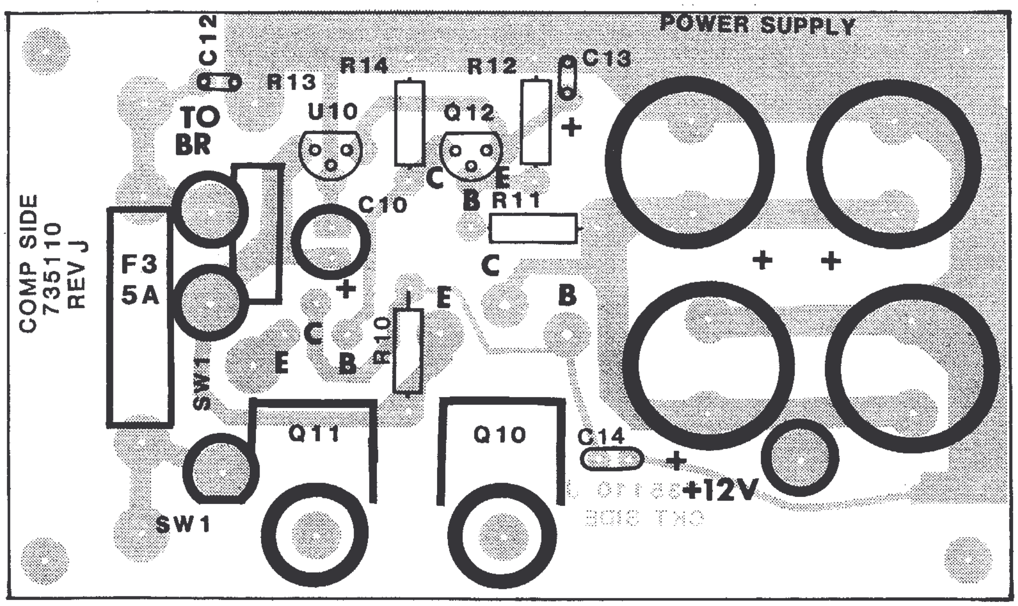


FIGURE 10.8-1.
Component Locations, 12 V Regulator Module, M8.

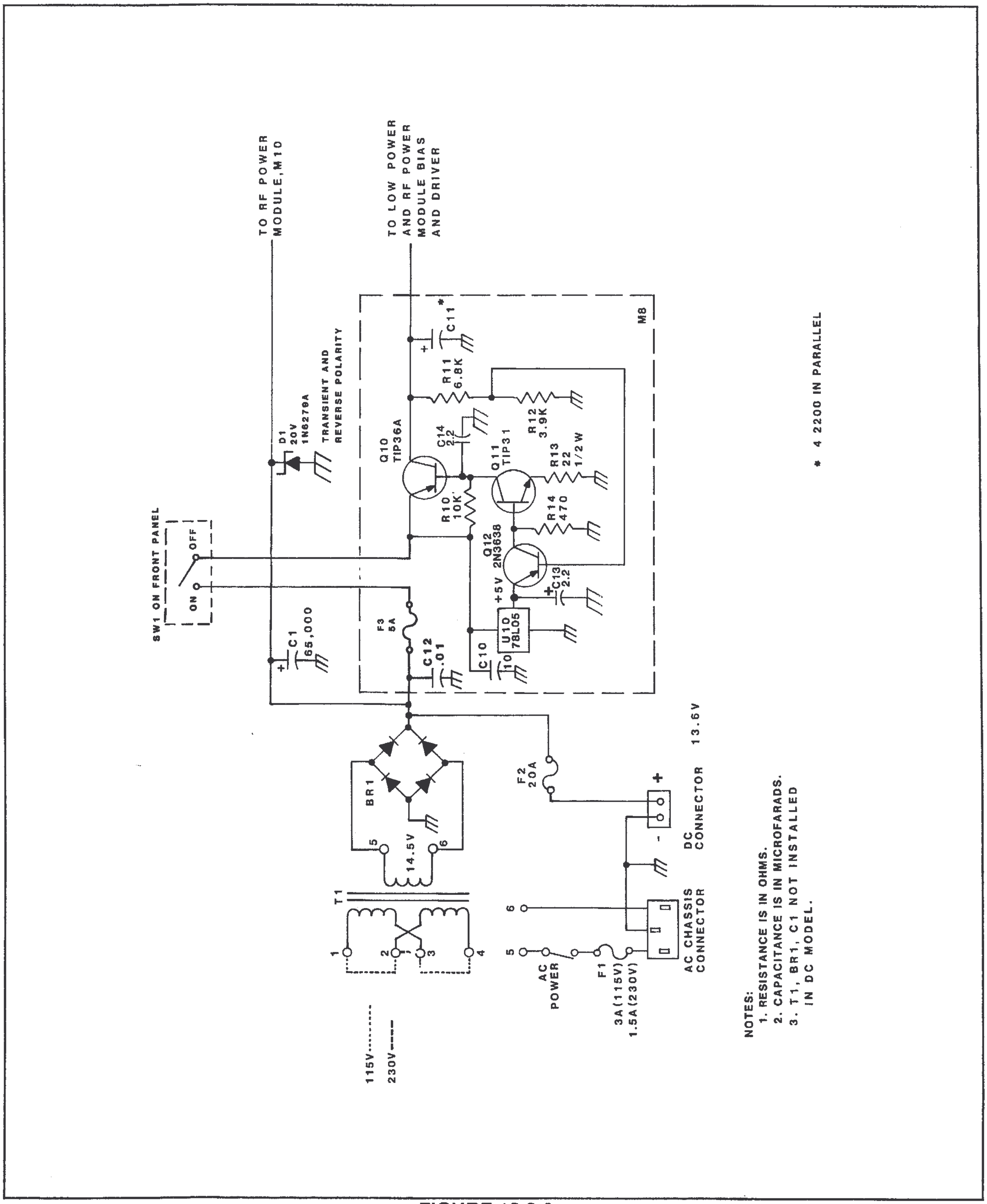


FIGURE 10.8-2.
Schematic Diagram - 12-V Regulator Module, M8.

TABLE 10.8-4.
Parts List, 12 V Regulator Module, M8.

C10	231100	Capacitor, Electrolytic 16 V 10 μF
C11A-C11D	231222	Capacitor, Electrolytic 2200 μF
C12	214103	Capacitor, Monolithic 50 V 0.01μF
C13,C14	241020	Capacitor, Tantalum 2.2 μF
F3	550005	Fuse 3AG 5A
Q10	310068	Transistor, TIP36A
Q11	310023	Transistor, NPN TIP31
Q12	310007	Transistor, PNP 2N3638
R10	124103	Resistor, Film 1/4 W 5% 10 kΩ
R11	124682	Resistor, Film 1/4 W 5% 6.8 kΩ
R12	124392	Resistor, Film 1/4 W 5% 3.9 kΩ
R13	134220	Resistor, Film 1/2 W 5% 22 Ω
R14	124471	Resistor, Film 1/4 W 5% 470 Ω
U10	330025	IC, 78L05
BR1*	320501	Diode Bridge
C1*	230653	Capacitor, Electrolytic 25 V 65000 μF
D1*	320209	Diode Zener 1N6279A
F1*	550003	Fuse 3 AG 3 A (115 V)
	550018	Fuse 3 AG 1.5 A (230 V)
F2*	550010	Fuse 20 A
SW1*	530203	Switch, Power
T1*	410026	Transformer, 115/230 14.5 V

*Part located on chassis.

10.9 FREQUENCY CONTROL MODULE (M9MP)

10.9.1 GENERAL

The M9MP or CPU module is a microprocessor and associated components that perform the various control functions within the transceiver. These include the basic tuning of the synthesizers, harmonic filter selection; and optionally, interface with the selective calling module, antenna tuner, and remote control circuits. The module is also responsible for the liquid crystal display (LCD), and for the scanning of 16 panel keys.

The circuitry of the M9 is almost all CMOS low current drain devices. Brief descriptions of the different chips and their functions appear in Table 10.9-1.

10.9.2 CIRCUIT DESCRIPTION

10.9.2.1 CPU PORT FUNCTIONS

The circuit is based around the 80C39 microprocessor (CPU). The CPU has 27 input/output lines (I/O) for communication with the rest of the circuit. These take the form of three 8-bit ports, two 1-bit I/O lines, and an interrupt (INT) line. One of the 8-bit ports is called the bus port and performs two functions in this system. First, it acts as the port for transfer of data between the CPU and the other devices on the bus. Second, it is time-multiplexed with the lower 8 bits of the internal address bus such that the external latch, U2, latches those address bits at the proper time in conjunction with the Address Latch Enable (ALE) signal. The data bus port consists of pins 12 through 19 of U1, and ALE is pin 11.

The other ports are split among the various other communications requirements in the system. Some of the port bits are actually performing more than one function. These ports are designated as port 1 and port 2 and are pins 27 through 34, and pins 21 through 24 and pins 35 through 38, respectively.

The lower three bits of port 2 serve as the three most significant address lines. This is their only function. P23 is located at pin 24 of the CPU, and its dedicated function is to input the selective call "Preamble detect" line to the CPU.

The four higher order bits of port 2, pins 35 to 38, form a serial output port which drives both the interface to the transceiver and the LCD module, M12. Pin 35, or P24, serves only as a clock for the transceiver interface shift registers, U5 through U9. U10 is a quad level shifter which turns the 5-V levels coming out of the CPU to the 8.7-V levels required by the interface.

P25, or pin 36, is the latch strobe signal for the shift registers, and also goes through the level shifter. When this signal goes to a high level, the data which has been shifted into the interface will appear at the outputs. It also serves as the driving level for the receiver mute transistor Q2. This transistor conducts to ground when the latch line is high, and mutes the receiver audio while the CPU is running. When the CPU does not detect a button being pressed, this line should fall to a low state.

P26, or pin 37, is the clock for the display interface, and only changes state when the display is updated. It is a 5-V level. P27, or pin 38, serves as the data line in both the transceiver and display interfaces. It also doubles as a "Scan-Enable" line which goes to a high level when the scan mode is entered. This enables wake-up interrupts to be generated by U12, the low-speed timing generator.

The main use of port 1 is in scanning (polling) the keyboard to see if a key has been pressed. The keyboard (and auxiliary keys in the case of the commercial type) is essentially a four-by-four matrix arrangement so that a key closure causes two of the lines to be shorted. The columns are connected to P10 through P13, and the rows are connected to P14 through P17.

Some of the keypad column lines also double as other functions when the keyboard is not being polled. P13 is connected through an isolation diode to the open collector of a transistor, which is driven in turn by T+. The transistor conducts when the transceiver is in the transmit mode. P12 is connected through another isolation diode with the selective-call alarm line. This signal goes low for about 2 seconds when a correct selective call has been received.

The two other I/O lines, T0 and T1, at pins 1 and 39, respectively, serve to enable or disable the two lockout modes in the transceiver. T1, when shorted to ground either by the DIP switch or by insertion of the proper IC, disables the entry of frequencies in any channel other than channel 00. Channel 00 then becomes a full- coverage receiver only. This condition is known as Mode 2 operation.

T0, when shorted to ground along with T1, disables the operator from seeing the operating frequency, and he now cannot change any of the frequencies, even in Channel 00. This is Mode 3 operation and the set is just a channelized set.

Pin 4 of the CPU is the RESET line and when grounded, resets the CPU to initialize itself. This should be done after changing the setting of either of the other lockout switches to allow the machine to read the switches. If the DIP switch is installed in the unit, S1 is the RESET control, S2 is the T0 control, and S3 is the T1 control. None of the other switches will have an effect.

Pin 6 of the CPU is the "INT" input of the device. The software does not actually enable the interrupts to occur, but when one of the signals which is wire "NANDed" to the INT line goes low, the INT line is pulled low and the CPU is activated (this is called a "wake-up"). As soon as the source of the interrupt has been removed; that is, the INT line is allowed to revert to the high state, the CPU