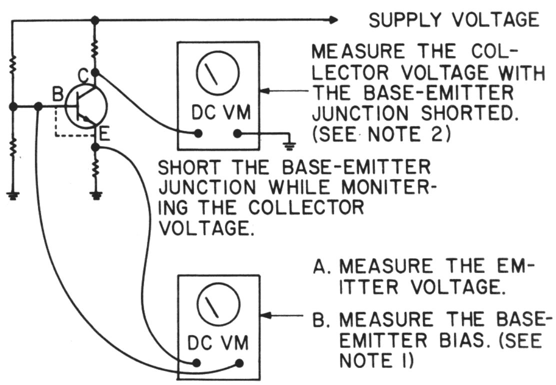
A high impedance DC voltmeter is usually the only measuring instrument required for determining the operating status of an in-circuit transistor. The meter is used to measure the transistor bias voltages. See Figure 5-2 for the correct voltmeter connections for measuring in-circuit transistor bias.



TEST CONNECTIONS FOR
IN-CIRCUIT TRANSISTOR TESTING
FIGURE 5-1

NOTES

1. Enough loop current is present in the leads of some electronic voltmeters to destroy transistors if measurements are made directly across transistor junctions. If an electronic voltmeter is used, perform the above measurements with respect to the circuit voltage common.

2. If the collector voltage is measured with a VOM the meter leads may be connected directly across the collector resistor. The difference between the supply voltage and the collector voltage will then be indicated directly on the VOM.

3. Be careful when connecting test leads to in-circuit transistors. Operating transistors can be ruined by shorting the base to the collector and, in some circuit configurations, the emitter to ground.

4. Turn power off when removing or installing transistors.

5.2.3 IN-CIRCUIT TRANSISTOR TESTING

a. Refer to Figure 5-1 for test connections.

b. Measure the emitter voltage. Compare your measurement to the voltage listed on the schematic diagram. A correct emitter voltage reading generally indicates that the transistor is working properly. If you are in doubt as to the condition of the transistor after measuring the emitter voltage, proceed to the following tests.

c. Measure the base-emitter junction bias. The voltage measured across a forward biased junction should be approximately 0.3 volts for a germanium transistor and 0.6 volts for a small signal silicon transistor.

d. Check for amplifier action by shorting the base to the emitter while monitoring the collector voltage.* The transistor should cut off (not conduct emitter to collector) because the base-emitter bias is removed. The collector voltage should rise to near the supply level. Any difference is the result of leakage current through the transistor. Generally, the smaller the leakage current the better the transistor. If no change occurs in the collector voltage when the base-emitter junction is shorted the transistor should be removed from the circuit and checked with an ohmmeter or a transistor tester. The following section describes the technique for testing transistors out of the circuit with an ohmmeter.

* Not recommended for power transistors under driving conditions.

5.2.4 OUT OF CIRCUIT TRANSISTOR TESTING

Only high quality ohmmeters should be used to measure the resistance of transistors. Many ohmmeters of both VOM and electronic types have short circuit current capabilities in their lower ranges that can be damaging to semiconductor devices. A good "rule of thumb" is to never measure the resistance of a semiconductor on any ohmmeter range that produces more than 3 milliamperes of short circuit current. Also, it is not advisable to use an ohmmeter that has an open circuit voltage of more than 1.5 volts. The following section describes a method for determining the short circuit current capabilities of ohmmeters.

5.2.5 HOW TO DETERMINE OHMMETER CURRENT

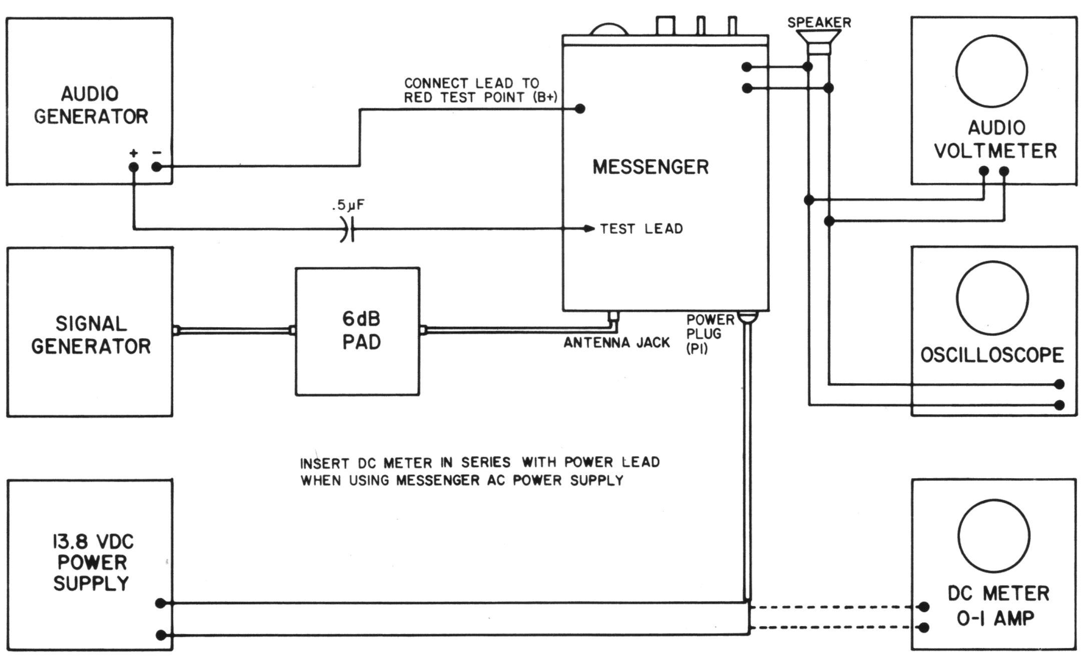
When the ohmmeter test probes are shorted together (measuring the forward resistance of a diode or the base-emitter junction of a transistor amounts to the same thing) the meter deflects full scale and the entire battery voltage appears across a resistance that we will designate as R1. The current through the probes is the battery voltage divided by the resistance of R1. A very easy method is available for determining the value of R1. Look at the exact center of the ohmmeter scale. Your reading is the value of R1 on the Rx1 range.

The only other unknown required to calculate the short circuit current of an ohmmeter is the internal battery voltage. Let's take a well known meter that has a center scale reading on the ohms scale of 4.62 and a battery voltage of 1.5 volts. Its short circuit current can be calculated by using Ohm's Law. Dividing 1.5 volts by 4.62 ohms equals a short circuit current of 324 mA on the Rx1 range. Obviously, the Rx1 range of this meter cannot be used to

TABLE 5-1

OUT OF CIRCUIT TRANSISTOR MEASUREMENTS

Transistor Type		Ohmmeter Connections + lead	Ohmmeter Connections - lead	Resistance in ohms
Germanium PNP	Power	Emitter	Base	30 to 50 ohms
		Emitter	Collector	Several hundred
	Small Signal	Emitter	Base	200 to 250 ohms
		Emitter	Collector	10 k to 100 k ohms
Silicon PNP	Small Signal	Emitter	Base	10 k to 100 k ohms
		Emitter	Collector	Very high (Might read open)
Silicon NPN	Power	Base	Emitter	200 to 1000 ohms
		Collector	Emitter	High; often greater than 1 megohm
	Small Signal	Base	Emitter	1 k to 3 k ohms
		Collector	Emitter	Very high (Might read open)



TEST INSTRUMENT CONNECTIONS FOR RECEIVER SERVICING AND ALIGNMENT
FIGURE 5-2

TABLE 5-2
TEST INSTRUMENTS REQUIRED FOR SERVICING AND ALIGNMENT

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
VTVM	A low range of 0-1.5 volts on AC and DC	Measure RF, AF and DC voltages	Heath IM-11 with RF probes or equivalent
Oscilloscope with RF Pickup Loop	Direct connection to vertical plates, or vertical amplifier good to 30 MHz. Refer to Figure 5-8 for pickup loop fabrication details.	Check modulated waveforms and audio.	Heath IO-12 or equivalent modified for direct connection to vertical plate. Precision ES-550B
Audio Voltmeter	Measure from -40 dB to +10 dB	Measure audio	Heath IM-21 or equivalent
Audio Generator	With variable attenuator and frequency of 400 to 2500 Hz	Check audio amps. Modulate transmitter.	Heath IG-72 or equivalent
Frequency Meter	Accuracy of ±0.0005% Frequency range of 455 kHz and from 25 to 30 MHz	Measure receiver and transmitter RF frequencies	Viking Instruments Model VFS 700
Thruline Wattmeter	Input and output impedance of 50 ohms. 5 or 10 watts. Accuracy of ±5% of full scale reading.	Measure transmitter power output. Measure antenna VSWR.	Bird Model 43 with 5A or 10A element
DC Current Meter		Measure receiver and transmitter current drain.	Simpson 270 or Triplett 630 or equivalent
Dummy Antenna	Power rating of at least 5 watts 50 ohms resistive	Load for Thruline Wattmeter	Bird Model 80 coaxial resistor or equivalent
Crystal controlled RF Signal Generator with 6 dB 50 ohm pad	23 CB frequencies plus 455 kHz and attenuated output of 1 to 100,000 microvolts capable of 30% modulation at 400 and 1000 Hz	Receiver RF source	Radio Research, Model 71-4 or Model 72 or equivalent. Accuracy ±0.0005% except ±.01% at 455 kHz
RF Voltmeter with	10 mV - 300 volts	Measure RF voltages	Millivac 38B or equivalent

The following is a list of instruments that can be used if the instruments in the above list are not available.

TYPE	CHARACTERISTICS	USE
International crystal C-12B test set NOTE: This instrument lacks 1000 Hz modulation for signal generator and accuracy is lower than the 0.0005% desired, but offers a desirable combination of features at low cost. It is battery operated and portable.	Frequency Meter - 23 CB frequencies, 26.965 to 27.255 MHz, with an accuracy of ±0.0015%.	Measure receiver and transmitter RF frequencies
	RF Power Meter - 5 watts ±1/4 watt	Measure transmitter power output
	Dummy antenna - 5 watts	Load for transmitter
	RF signal generator - 23 CB frequencies ±0.0015%, output 1 to 100 microvolts, 30% modulation at 400 Hz	Receiver RF source
	AM modulation meter - range 0-100% accuracy 3% at 400 Hz and 80% modulation.	Measure transmitter percent of modulation
E. F. Johnson antenna meter, Model 250-849	50 ohms	Measure antenna VSWR

measure the resistance of semiconductors. When the value of R1 is known for the Rx1 range it can then be determined for any range by multiplying R1 by the multiplier value of the range. The value of R1 for the Rx10 range of a meter with an R1 value on the Rx1 range of 4.62 ohms is 4.62 x 10 or 46.2 ohms. The short circuit current on the Rx10 range can then be calculated: 1.5 volts divided by 46.2 ohms equals 32.5 mA. By using this method, the lowest safe range for measuring semiconductor resistance may be determined for any ohmmeter.

Remember that you should not measure any semiconductor resistance on any ohmmeter range which produces more than three milliamperes of short circuit current.

Table 5-1 indicates the results that should be obtained from operational transistors measured out of circuit.

5.3 RECEIVER PERFORMANCE TEST

(With troubleshooting information.)

Receiver RF input values are given into a 6dB 50 ohm pad.

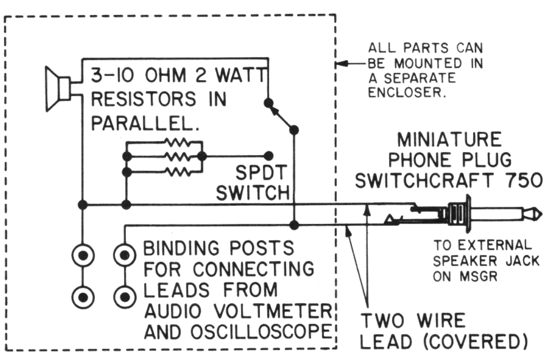
5.3.1 TEST INSTRUMENT CONNECTIONS

Refer to Figure 5-2 for test instrument connections and Table 5-2 for test instruments required.

NOTES

1. Any 117 VAC operated test instruments with grounded power plugs, used for servicing the Messenger 320 and 323, must be "floated" (ungrounded).

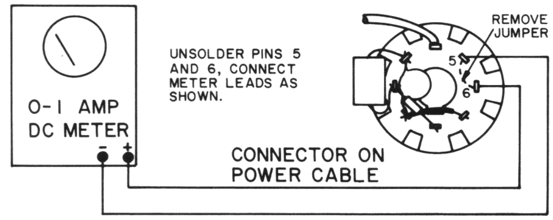
2. The audio voltmeter called for in Table 5-2 can be connected directly across the speaker coil or to a test assembly constructed as illustrated in Figure 5-3.



TEST ASSEMBLY CONNECTING AUDIO VOLTMETER AND OSCILLOSCOPE
FIGURE 5-3

3. Use the red test point (B+) as the test instrument common when injecting signals and making voltage measurements.

4. Connect a VOM to the power plug as illustrated in Figure 5-4. Set the function switch to DC current and the range selector to the range nearest one ampere full scale.



CURRENT METER CONNECTIONS TO POWER PLUG
FIGURE 5-4

5.3.2 SENSITIVITY AND RECEIVER CURRENT DRAIN

a. Set the volume control maximum clockwise (maximum volume) and the squelch control to maximum counterclockwise (minimum squelch).

b. Set the channel selector to channel 11.

c. Set the signal generator output for 1 μV modulated 30% at 1000 Hz on channel 11 (27.085 MHz). Use a crystal controlled generator equivalent to the one listed in Table 5-2.

d. Adjust the volume control for a 0dB indication on the audio voltmeter.

e. Switch the signal generator audio off. The indication on the audio voltmeter should drop 8 dB or more.

f. Reset the volume control to maximum clockwise (maximum volume). Switch the signal generator audio on.

g. Check the receiver current drain. It should be approximately 500 mA with 2.5 VAC across the speaker terminals.

5.3.3 AUDIO

1. Performance Test

   a. Set the squelch control fully counterclockwise.

   b. Set the audio voltmeter range selector to the 3 volt range.

   c. Set the volume control full on.

d. Set the signal generator output for 1 μV modulated 30% at 1000 Hz.

e. The audio output on the voltmeter should be 2.5 volts ±3 dB on channels 1, 11 and 21.

2. Troubleshooting

The condition of the receiver audio can be checked by signal injection. Refer to the following procedure.

a. 1. Connect the "hot" side of an audio generator to a 5 μF capacitor. Connect the common side of the audio generator to the red test point (B+). The red test point is TP1 in the Messenger 320 and TP2 in the Messenger 323.

2. Set the volume control maximum clockwise and the squelch control maximum counter-clockwise.

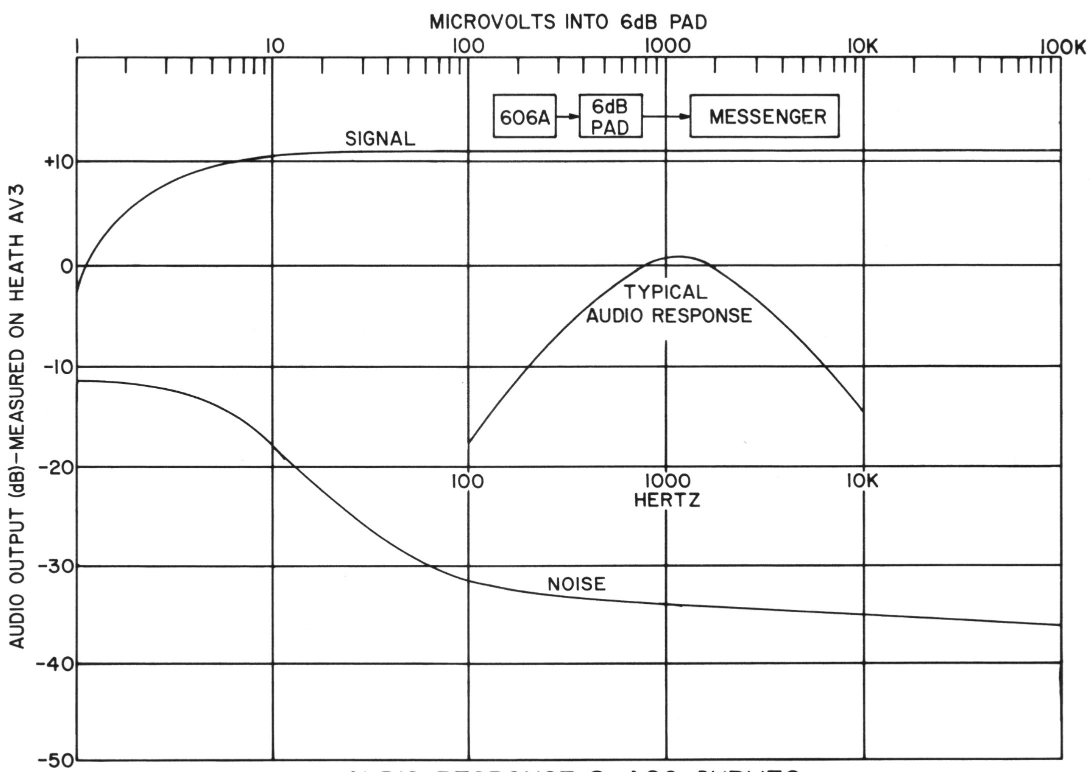
b. 1. The reference level for Table 5-3 is 2.5 volts RMS of audio across the speaker terminals.

2. Use an oscilloscope to check stage to stage distortion.

3. Table 5-3, Typical Audio Levels, lists the audio gain distribution, measured with an audio voltmeter that should be obtained from a typical audio section.

TABLE 5-3
TYPICAL AUDIO LEVELS

Test Point	Volts RMS Levels required to produce 2.5 V RMS
top of volume control	0.0036
base of Q16	0.00235
collector of Q16	0.021
base of Q17	0.021
collector of Q17	3.1



AUDIO RESPONSE & AGC CURVES
FIGURE 5-5

NOTES

(Class B audio output transistors Q18 and Q19)

1. Check the base and emitter voltages of the class B audio output transistors, Q18 and Q19. The voltages should be approximately equal. If one of the transistors shows no voltage difference between emitter and base, it is probably faulty.

2. Severe audio distortion may be the result of an open Q18 or Q19. A shorted transistor can cause R58 to burn and possibly blow the fuse. The faulty transistor may have an excessively warm case.

5.3.4 AGC

1. AGC Performance Test

   a. Set the channel selector to channel 11.

   b. Set the squelch control to the maximum counterclockwise position.

   c. Set the signal generator output to 0.1 volt modulated 30% at 1000 Hz on channel 11 (27.085 MHz).

   d. Adjust the volume control for a 0 dB indication on the audio voltmeter.

   e. Reduce the signal generator output to 1 μV. The audio voltmeter should drop 12 dB ± 6 dB.

2. AGC Troubleshooting

   a. Increase RF signal generator output from 1 μV to 0.1 V. The audio voltage at the speaker should increase relatively fast at first, as signal generator output is increased from 1 μV - 10 μV, then tend to level off, following the general signal curve illustrated in Figure 5-5.

   b. If the voltage at the speaker increased proportionately as the input voltage increased, check D1 by bridging it with a new diode, and check its associated circuitry.

   c. If D1 and its associated circuitry appear to be good, connect a DC voltmeter between Z3 terminal 4 and red test point (B+). The AGC voltage measured here should go less negative as the input voltage is increased from 1 μV to 0.1 V.

   d. If AGC voltage goes less negative as the signal is increased, but the voltage at the speaker as measured above does not level off, check Q6 and Q7, the AGC amplifiers, and their associated circuitry.

   e. Refer to Table 5-4 for a list of typical AGC voltage readings.

TABLE 5-4
TYPICAL AGC LEVELS

Test Conditions:

Volume control advanced for reference of 2.5 VRMS at the speaker terminals with 1000 μV input to 50 ohm 6 dB pad between generator and antenna terminal. Signal generator set to 27.085 MHz (channel 11) at 30% modulation, 1000 Hz. Audio measured across the speaker.

RF Input to 6 dB pad (microvolts)	Relative Audio Output (dB)	Voltage at Terminal 4 of Z3 (VDC)
1	- 2	.98
3	+ 6	.85
10	+ 7.8	.56
30	+ 8.4	.40
100	+ 8.8	.31
300	+ 9.3	.25
1,000	+10	.20
3,000	+10	.17
10,000	+ 9.8	.13
30,000	+ 9.6	.08
100,000	+ 9.5	-.02
300,000	+10	-.20
1,000,000	+13	-.25
3,000,000	+14	-.04

5.3.5 IF and RF Troubleshooting

Check the RF and IF stages by signal injection. Connect an audio voltmeter across the speaker terminals. Set the signal generator to 30% modulation at 1000 Hz. Set the channel selector to channel 11. Table 5-5 lists the injection points and the input levels necessary to obtain 3 VRMS at the speaker terminals with the volume control set to maximum and the squelch control to minimum.

TABLE 5-5
TYPICAL RF AND IF LEVELS IN RECEIVER

Conditions: The input levels listed in this table are the levels required to produce 3 VRMS at the speaker terminals with the volume maximum and the squelch minimum.

Test Point	Input Frequency	Input Level
Antenna terminal	27.085 MHz	1 μV
Base of first mixer	27.085 MHz	17.5 μV
Base of second mixer	4.3 MHz	62 μV
Base of first IF amp	455 kHz	405 μV
Base of second IF amp	455 kHz	13 mV
Collector of second IF amp	455 kHz	1.14 V

5.3.6

1. Squelch Threshold Performance Test

   a. Set the channel selector to channel 11 (27.085 MHz).

   b. Disconnect the signal generator (if connected) from the antenna terminal.

   c. Adjust the squelch control until the background noise disappears.

   d. Set the signal generator to 100 μV 30% modulated at 1000 Hz.

   e. Connect the signal generator to the antenna jack. The squelch should open.

   f. Reduce the signal generator to 1 μV. The squelch should remain open.

2. Squelch Troubleshooting

   a. The squelch amplifiers Q9 and Q10 obtain their information from AGC amplifier Q6. When squelch action is faulty, check the AGC section first.

   b. If the AGC section appears to be functioning properly, connect a DC voltmeter to the emitter of Q16 (-15 VDC range).

   c. With power applied to the receiver, monitor the DC voltmeter while rotating the squelch control from minimum to maximum. The voltage indicated should go from approximately -2.6 V to 6.5 V.

   d. If the voltage does not change at Q16, substitute D7 with a diode known to be good.

NOTE

If D7 is shorted, the voltage at Q10 will be normal but the squelch will operate very slowly. The emitter of Q16 would read very low at minimum squelch and normal at maximum squelch.

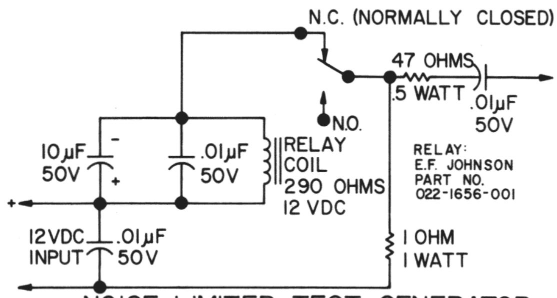
   e. Check the voltages at Q9 and Q10.

5.3.7 Noise Limiter Performance Test

A noise limiter test generator such as illustrated in Figure 5-6 must be available to perform the following test.

   a. Turn the squelch control full counterclockwise.

   b. Connect the noise generator illustrated in Figure 5-6 to the center conductor of the antenna jack inside the chassis. The signal generator is connected to the antenna jack at the outside of the chassis rail.



NOISE LIMITER TEST GENERATOR
FIGURE 5-6

   c. Set the RF signal generator to 1 μV unmodulated.

   d. Connect an audio voltmeter across the speaker terminals and set the volume control for an indication of 0 dB.

   e. Turn the noise generator on. The audio voltmeter should indicate an increase of no more than 5 dB.

5.3.8 S-Meter Performance Test

Refer to the Receiver Alignment section for S-meter calibration instructions.

5.4 TRANSMITTER PERFORMANCE TEST

(With troubleshooting information)

5.4.1 Test Instrument Connections

   a. Refer to Table 5-1 for test instruments required.

   b. Refer to Figures 5-7 and 5-8 for test instrument connections.

   c. Remove the cap from the power plug, J2.

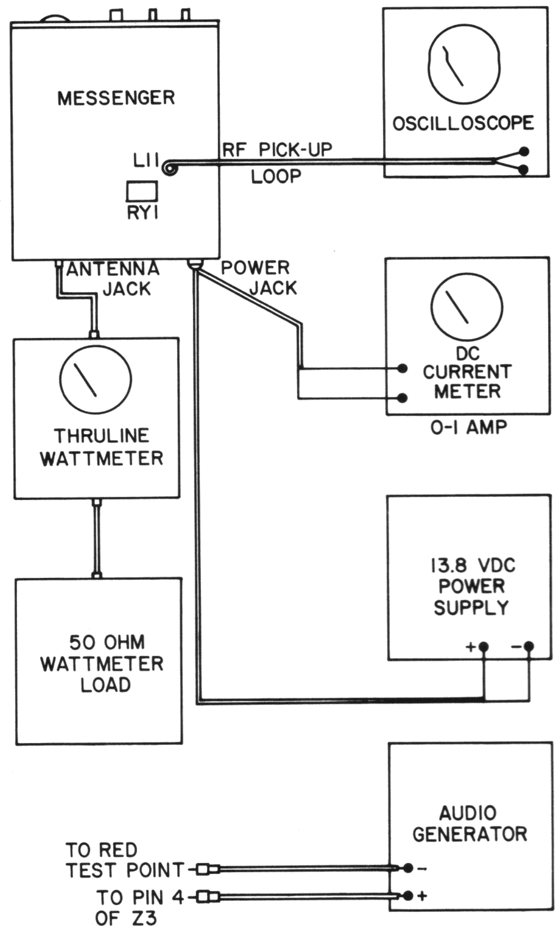
   d. Remove the jumper from terminals 5 and 6 on the power plug and connect a DC current meter as illustrated in Figure5-4.

5.4.2 RF Power Output and Modulation

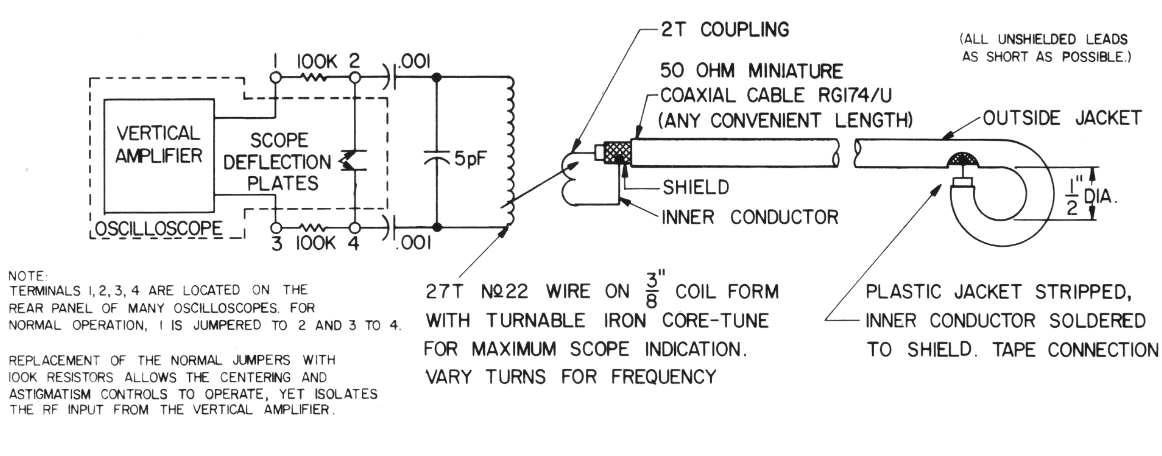
NOTE

All the measurements given in this section are for a normally operating transceiver with 13.8 VDC power supply.

   a. Key the transmitter with no modulation applied. Check the power output on channels 1 through 23. The limits are 4.0 watts maximum and 2.8 watts minimum with a Q24 emitter current of 410 mA. The power output difference between any two channels should not be more than 0.5 watts. Refer to section 6 for the transmitter



TEST INSTRUMENT CONNECTIONS
FOR TRANSMITTER SERVICING
AND ALIGNMENT
FIGURE 5-7



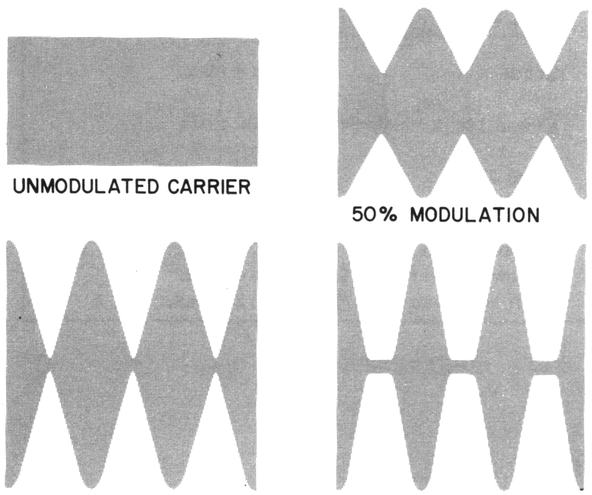
OSCILLOSCOPE RF PICK-UP LOOP
AND METHOD OF CONNECTION
FIGURE 5-8

alignment procedure. Check the relative power output meter with no modulation. It should indicate approximately mid-scale.

b. Adjust R49, if required, for a mid-scale reading.

c. Connect an RF pick-up loop, constructed as illustrated in Figure 5-8 to L11.

d. Apply 4 mV of audio at 1000 Hz to pin 5 of Z2. Key the transmitter. Approximately 50% modulation should be indicated on the oscilloscope. Refer to the transmitter waveforms illustrated in Figure 5-9.



TRANSMITTER WAVEFORMS
FIGURE 5-9

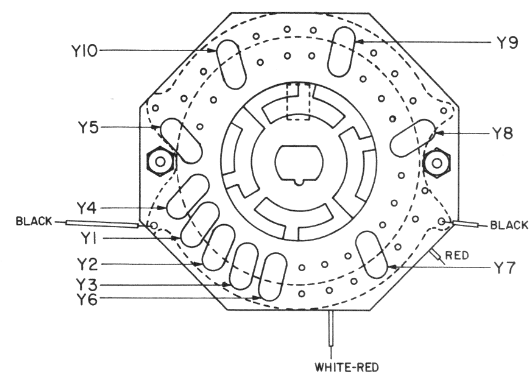
e. Increase the audio level to 8 mV. The modulation should increase to at least 70% minimum upward and 80% minimum downward.

f. Increase the audio to 80 mV. The waveform should be clean and free of RF distortion. Refer to the alignment section for remedies if distortion is present.

5.5 SYNTHESIZER

The following measurements are necessary only if the synthesizer has been repaired or is suspected of functioning improperly. Refer to Tables 5-6, 5-7 and 5-8 for synthesizer troubleshooting information.

a. Couple a small sample of the transmitter power output, unmodulated, to a frequency meter or electronic counter.



CRYSTAL MOUNTING DETAILS
FRONT VIEW
FIGURE 5-10

b. Measure the frequency on channels 1, 6, 11, 16, 20 and 23. Table 5-7 lists the maximum frequency variations at a standard temperature of +25° centigrade (72° fahrenheit).

c. If the synthesizer fails to meet the limits listed in Table 5-7, refer to Table 5-6 and 5-8 and the synthesizer alignment instructions in section 6. Refer to section 5-2 and Figure 5-11, semiconductor case diagrams, if a semiconductor is suspected of being faulty. Refer to the transparency for component identification.

TABLE 5-6
FREQUENCY SYNTHESIZER TROUBLESHOOTING

Trouble	Probable Cause
Receiver and transmitter completely inoperative. No apparent synthesizer output.	Q13
Receiver completely inoperative.	D6
Transmitter inoperative.	D13
Transceiver operation intermittent.	Alignment improper. Selector switch dirty.
Transceiver inoperative on some channels, operates normally on others.	Faulty crystal. Refer to Table 5-8 and Figure 5-10.

TABLE 5-7
LIMITS FOR TRANSMITTER FREQUENCY VARIATION

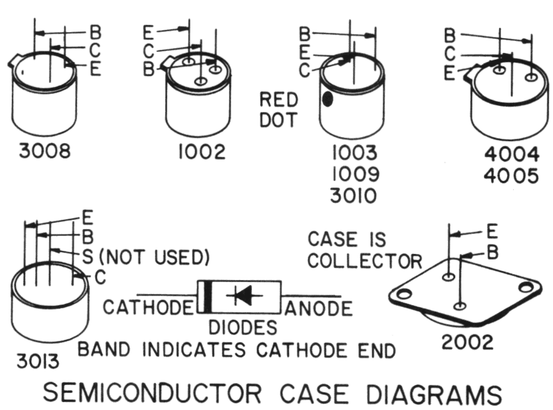
Channel No.	Frequency, kHz	High Limit, kHz	Low Limit, kHz
1	26,965.000	26,965.674	26,964.326
6	27,025.000	27,025.676	27,024.324
11	27,085.000	27,085.677	27,084.323
16	27,155.000	27,155.679	27,154.321
20	27,205.000	27,205.680	27,204.320
23	27,255.000	27,255.681	27,254.319

TABLE 5-8
SYNTHESIZER CRYSTAL TROUBLESHOOTING

Channels Inoperative	Faulty Crystal
1, 5, 9, 13, 17 and 21	Y1
2, 6, 10, 14, 18 and 22	Y2
3, 7, 11, 15 and 19	Y3
4, 8, 12, 16, 20 and 23	Y4
1, 2, 3 and 4	Y5
5, 6, 7 and 8	Y6
9, 10, 11 and 12	Y7
13, 14, 15 and 16	Y8
17, 18, 19 and 20	Y9
21, 22 and 23	Y10

TABLE 5-9
TYPICAL COMPONENT RESISTANCE MEASUREMENTS

Component	Symbol	Winding	Measure between (wire colors or pin no.)	Resistance Ohms
Filter Choke	L7	Coil	Leads	0.4 max.
Relay	RY1	Coil	13 and 14	100 ±10%
Driver Transformer	T10	Primary	1 and 2	200 max.
		Secondary	3 and 5	25 max.
Audio Output and Modulation Transformer	T11	Primary	Blue to Brown (1 &2)	3.4 max.
		Secondary 1	Yellow to Orange (3 & 4)	1.4 max.
		Secondary 2	Black to Green (5 & 7)	0.22 max.



SEMICONDUCTOR CASE DIAGRAMS
BOTTOM VIEWS
FIGURE 5-11