

DESCRIPTION AND MAINTENANCE

138—174 MHz, 35-WATT MASTR® II TRANSMITTER

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DESCRIPTION

MASTR® II transmitters are crystal-controlled, phase modulated transmitters designed for one through eight-frequency operation in the 138 to 174 megahertz band.

The solid state transmitter utilizes both integrated circuits (ICs) and discrete components, and consists of the following assemblies:

- Exciter Board; with audio, modulator, amplifier and multiplier stages.

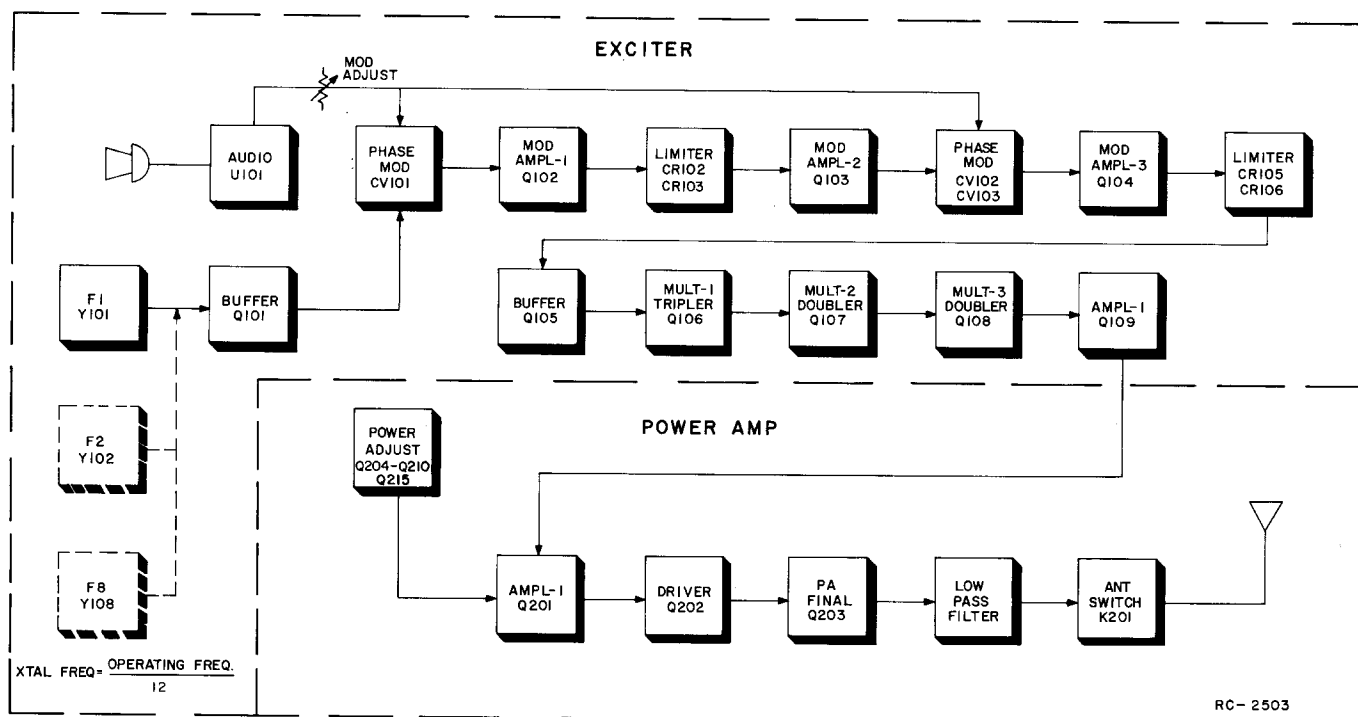


Figure 1 - Transmitter Block Diagram

- Power Amplifier Assembly; with amplifiers, driver, PA, power control, filter and antenna switch.

Figure 1 is a block diagram of the 138-174 MHz MASTR II transmitter, showing the Exciter Board and Power Amplifier Assembly.

The exciter uses nine transistors and one integrated circuit to drive the PA assembly. The exciter can be equipped with up to eight Integrated Circuit Oscillator Modules (ICOMs). The ICOM crystal frequency ranges from approximately 11.5 to 14.5 megahertz, and the crystal frequency is multiplied 12 times.

The PA assembly uses three RF power transistors to provide 35 watts output power. Seven transistors are used in the power control circuit.

MAINTENANCE

The PA assembly is insulated from vehicle ground to permit operation in positive or negative ground vehicles.

NOTE

In positive ground vehicles, A- is "hot" with respect to vehicle ground. Shorting the transmitter PA printed wiring board ground pattern to the radio case may cause one of the in-line fuses to blow.

MOBILE DISASSEMBLY

To service the transmitter from the top:

1. Pull the locking handle down, then pry up the top cover at the front notch and lift off the cover.

To service the transmitter from the bottom:

1. Pull the locking handle down and pull the radio out of the mounting frame.
2. Remove the top cover, then loosen the two bottom cover retaining screws and remove the bottom cover (see Figure 2).
3. To gain access to the bottom of the exciter board, remove the six screws (A) holding the exciter board and its bottom cover to the module mounting frame, and remove the bottom cover (see Figure 3).

STATION DISASSEMBLY

For a more complete mechanical parts breakdown refer to the station manual. To service the transmitter exciter from the front:

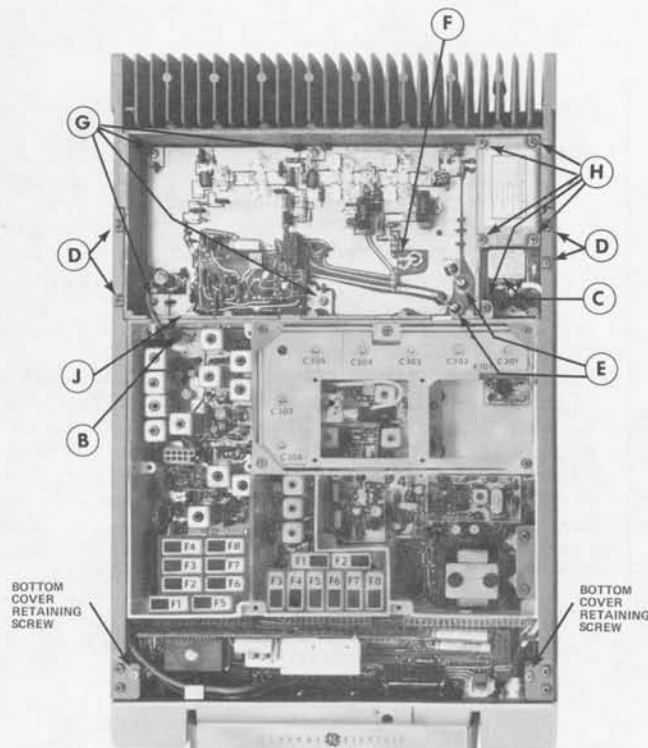


Figure 2 - Disassembly Procedure Top View

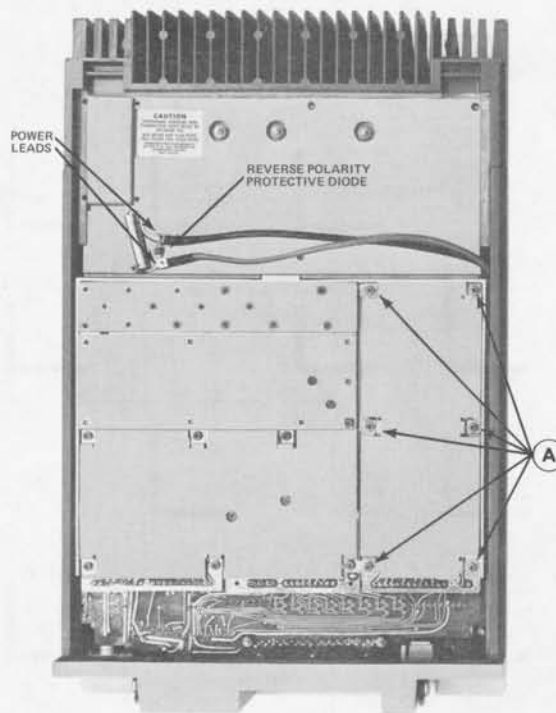


Figure 3 - Disassembly Procedure Bottom View

1. Turn the two latching knobs (A) counter-clockwise to unlatch the Radio Panel Front Door. Refer to Figure 4.
2. Swing the Radio Panel Front Door down as shown.
3. Remove covers.

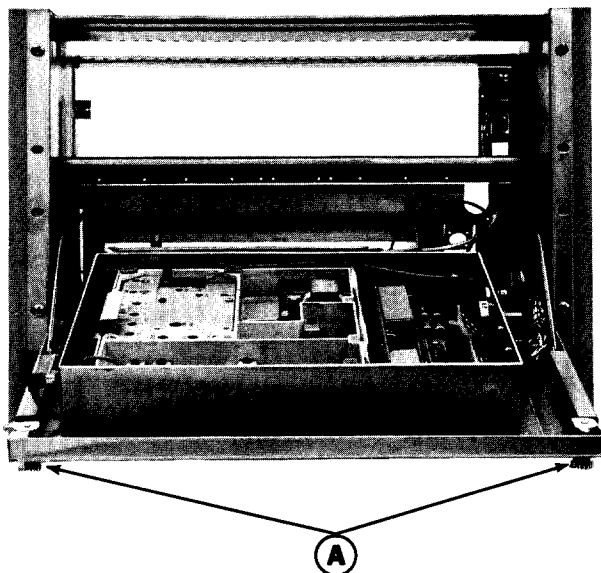


Figure 4 - Access to Exciter Front View

To service the transmitter Power Amplifier from the rear:

1. Remove the top two screws (B) on the Intermittent or Continuous Duty Power Amplifier. Refer to Figure 5.
2. Swing the Power Amplifier down as shown. Remove the top cover of the Power Amplifier.

NOTE

If the heatsink blower option is present, this blower must be removed before the Power Amplifier can be lowered.

EXCITER DISASSEMBLY

To remove the exciter board from the radio:

1. Unplug the exciter/PA cable (B).
2. Remove the six screws (A) holding the exciter board and its bottom cover to the module mounting frame.
3. Press straight down on the plug-in exciter from the top to avoid bending the pins when unplugging the board from the system board jack.

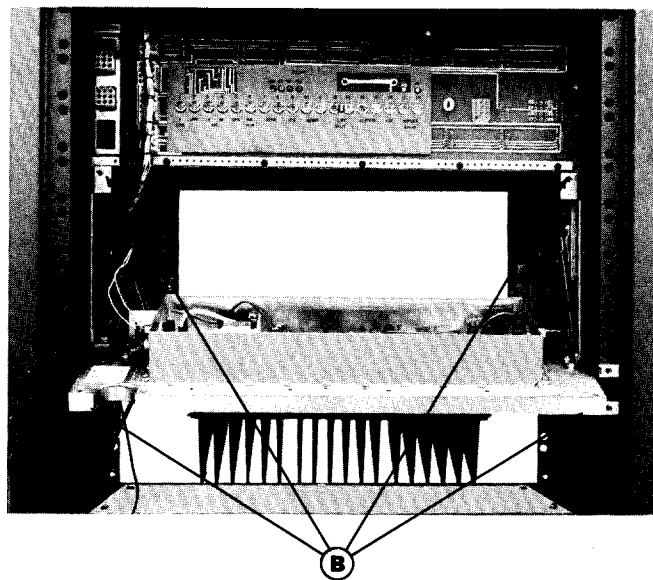


Figure 5 - Access to Power Amplifier Rear View

POWER AMPLIFIER DISASSEMBLY

To remove the PA assembly:

1. Remove the PA top cover and unplug the exciter/PA cable (B), the antenna, receiver and PTT cables (C).
2. Remove the four side-rail screws (D), and unsolder the power cables from the bottom of the PA assembly if desired.

To remove the PA board:

1. Remove the PA top cover and unplug the exciter/PA cable (B).
2. Unsolder the two feedthrough coils E and the thermistor leads (F).
3. Remove the PA transistor hold-down nuts and spring washers on the bottom of the PA assembly.
4. Remove the four PA board mounting screws (G), the five screws in the filter casting (H), and the retaining screw in Q215 (J), and lift the board out.

PA TRANSISTOR REPLACEMENT

WARNING

The stud mounted RF Power Transistors used in the transmitter contain Beryllium Oxide, a TOXIC substance. If the ceramic or other encapsulation is opened, crushed, broken, or abraded, the dust may be hazardous if inhaled. Use care in replacing transistors of this type.

lead at a 45° angle for future identification (see Figure 6). The letter "C" on the top of the transistor also indicates the collector.

To replace the PA RF transistors:

1. Unsolder one lead at a time with a 50-Watt soldering iron. Use a scribe to hold the lead away from the printed circuit board until the solder cools.
2. Turn the transmitter over.
3. Hold the body of the transistor to prevent it from turning. Remove the transistor hold-down nut and spring washer through the hole in the heat-sink with an 11/32-inch nut-driver for Q201, Q202 and Q203. Lift out the transistor, and remove old solder from the printed circuit board with a desoldering tool such as a SOLDA PULLT®. Special care should be taken to prevent damage to the printed circuit board runs because part of the matching network is included in the base and collector runs.
4. Trim the new transistor leads (if required) to the lead length of the removed transistor. Cut the collector
5. Applying a coating of silicon grease around the transistor mounting surface, and place the transistor in the mounting hole. Align the leads as shown in the Outline Diagram. Then hold the body of the transistor and replace the holding-down nut and spring-washer, using moderate torque (8 inch-pounds). A torque wrench must be used for this adjustment since transistor damage can result if too little or too much torque is used.
6. Make sure that the transistor leads are formed as shown in Figure 7 so that the leads can be soldered to the printed circuit pattern, starting from the inner edge of the mounting hole.
7. Solder the leads to the printed circuit pattern. Start at the inner edge of mounting hole and solder the remaining length of transistor lead to the board. Use care not to use excessive heat that causes the printed wire board runs to lift up from the board. Check for shorts and solder bridges before applying power.

CAUTION

Failure to solder the transistor leads as directed may result in the generation of RF loops that could damage the transistor or may cause low power output.

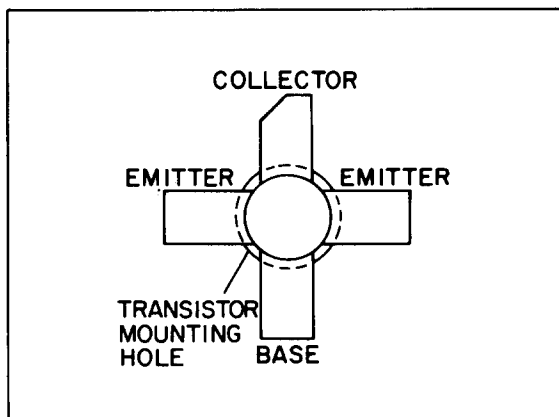


Figure 6 - Lead Identification

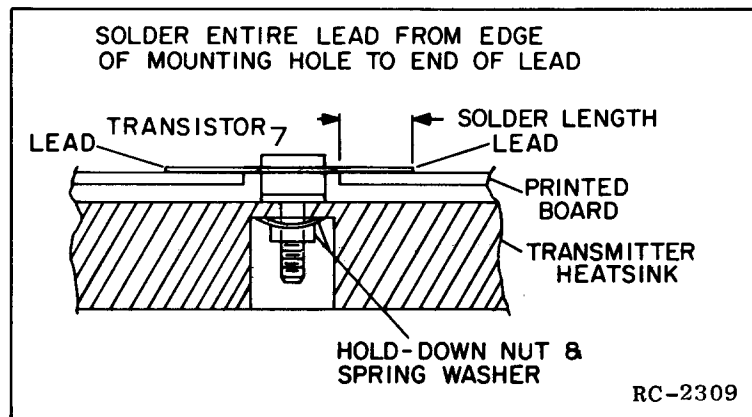


Figure 7 - Lead Forming

MODULATION LEVEL ADJUSTMENT

The MOD ADJUST (R104) was adjusted to the proper setting before shipment and should not normally require readjustment. This setting permits approximately 75% modulation for the average voice level. The audio peaks which would cause overmodulation are clipped by the modulation limiter. The limiter, in conjunction with the de-emphasis network, instantaneously limits the slope of the audio wave to the modulator, thereby preventing overmodulation while preserving intelligibility.

TEST EQUIPMENT

1. An audio oscillator (GE Model 4EX6A10)
2. A frequency modulation monitor
3. An output meter or a VTVM
4. GE Test Set Model 4EX3A11 or 4EX8K12

MOBILE PROCEDURE

1. Connect the audio oscillator and the meter across audio input terminals J10 (Green-Hi) and J11 (Black-Lo) on GE Test Set, or across P902-6 (Mike High) through a 0.5 microfarad (or larger) DC blocking capacitor, and P902-5 (Mike-Low) on the System Board.
2. Adjust the audio oscillator for 1-Volt RMS at 1000 Hz.
3. For transmitters without Channel Guard, set MOD ADJUST R104 for a 4.5-kHz swing with the deviation polarity which gives the highest reading as indicated on the frequency modulation monitor.
4. For transmitters with Channel Guard, set Channel Guard MOD ADJUST R105 for zero tone deviation. Next with the 1-Volt signal at 1000 Hz applied, set MOD ADJUST R104 for 3.75 kHz deviation. Then remove the signal from the audio oscillator and set Channel Guard MOD ADJUST R105 for 0.75 kHz tone deviation.
5. For multi-frequency transmitters, set the deviation as described in Steps 3 or 4 on the channel producing the largest amount of deviation.

STATION PROCEDURE

1. Connect the audio oscillator and the meter across audio input terminals J10 (Green-Hi) and J11 (Black-Lo) on GE Test Set, and connect red Test Set plug to the System red metering plug. Set the Pre-amp level as outlined in the Combination Manual.
2. Set the audio generator frequency to 1 kHz.
 - A. In all station combinations except Local Control Intermittent Duty combinations, set the audio generator output to 30 millivolts RMS.
 - B. In local Control Intermittent Duty station combinations, set the audio generator output to 1.0 Volt RMS.
3. For transmitters without Channel Guard, set MOD ADJUST R104 for a 4.5 kHz swing with the deviation polarity which gives the highest reading as indicated on the frequency modulation monitor.
4. For transmitters with Channel Guard, set Channel Guard MOD ADJUST R105 for zero tone deviation. Next, with the audio set as in Step 2, set MOD ADJUST R104 for 3.75 kHz deviation. Then remove the signal from the audio oscillator and set Channel Guard MOD ADJUST R105 for 0.75 kHz tone deviation.
5. For multi-frequency transmitters, set the deviation as described in Steps 3 or 4 on the channel producing the largest amount of deviation.

PA POWER INPUT

For FCC purposes, the PA power input can be determined by measuring the PA supply voltage and PA current, and using the following formula:

$$P_1 = \text{PA voltage} \times \text{PA current}$$

where:

P_1 is the power input in Watts,

PA voltage is measured with Test Set Model 4EX3A11 in Position G on the 15-Volt range (read as 15 Volts full scale), and with the polarity switch in the (-) position. With Test Set Model 4EX8K12, use the B+ position and the 1-Volt range (read as 15 Volts full scale), with the HIGH SENSITIVITY button pressed and the polarity switch in the (-) position.

PA current is measured with the Test Set in Position G in the Test 1 position, and with the HIGH SENSITIVITY button pressed (10 amperes full scale).

Example:

$$P_1 = 12.6 \text{ Volts} \times 6.0 \text{ amperes} = 75 \text{ Watts}$$

ICOM FREQUENCY ADJUSTMENT

First, check the frequency to determine if any adjustment is required. The frequency should be set with a frequency meter or counter with an absolute accuracy that is 5 to 10 times better than the tolerance to be maintained, and with the entire radio as near as possible to an ambient temperature of 26.5°C (79.8°F).

MASTR II ICOMs should be reset only when the frequency shows deviation in excess of the following limits:

- A. ± 0.5 PPM when the radio is at 26.5°C (79.8°F).
- B. ± 2 PPM at any other temperature within the range of -5°C to +55°C (+23°F to +131°F).
- C. The specification limit (± 2 PPM or ± 5 PPM) at any temperature within the ranges of -40°C to -5°C (-40°F to +23°F) or +55°C to +70°C (+131°F to +158°F).

If an adjustment is required, pry up the cover on the top of the ICOM to expose the trimmer, and use one of the following procedures:

If the radio is at an ambient temperature of 26.5°C (79.8°F), set the oscillator for the correct operating frequency.

If the radio is not at an ambient temperature of 26.5°C, setting errors can be minimized as follows:

- A. To hold the setting error to ± 0.6 PPM (which is considered reasonable for 5 PPM ICOMs):
 1. Maintain the radio at 26.5°C ($\pm 5^\circ\text{C}$) and set the oscillator to desired frequency, or-
 2. Maintain the radio at 26.5°C ($\pm 10^\circ\text{C}$) and offset the oscillator, as a function of actual temperature, by the amount shown in Figure 8.
- B. To hold setting error to ± 0.35 PPM (which is considered reasonable for 2 PPM ICOMs): Maintain unit at 26.5°C ($\pm 5^\circ\text{C}$) and offset the oscillator as a function of actual temperature, by the amount shown in Figure 8.

For example: Assume the ambient temperature of the radio is 18.5°C (65.4°F). At that temperature, the curve shows a correction factor of 0.3 PPM. (At 138 MHz, 1 PPM is 138 Hz. At 174 MHz, 1 PPM is 174 Hz).

With an operating frequency of 150 MHz, set the oscillator for a reading of 45 Hz (0.3 x 150 Hz) higher than the licensed frequency. If a negative correction factor is obtained (at temperatures above 26.5°C), set the oscillator for the indicated PPM lower than the licensed operating frequency.

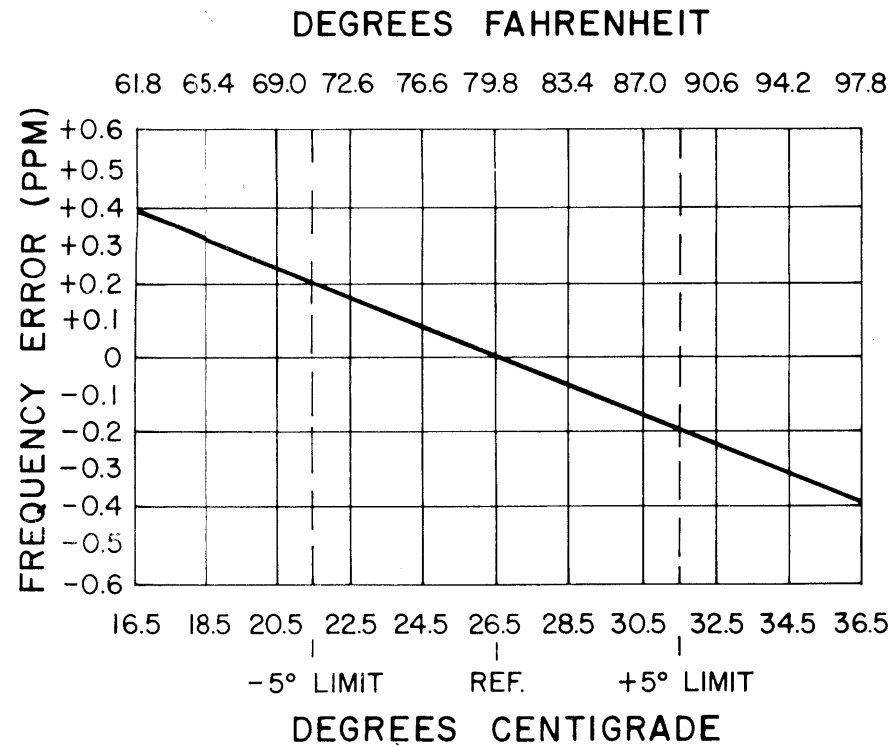
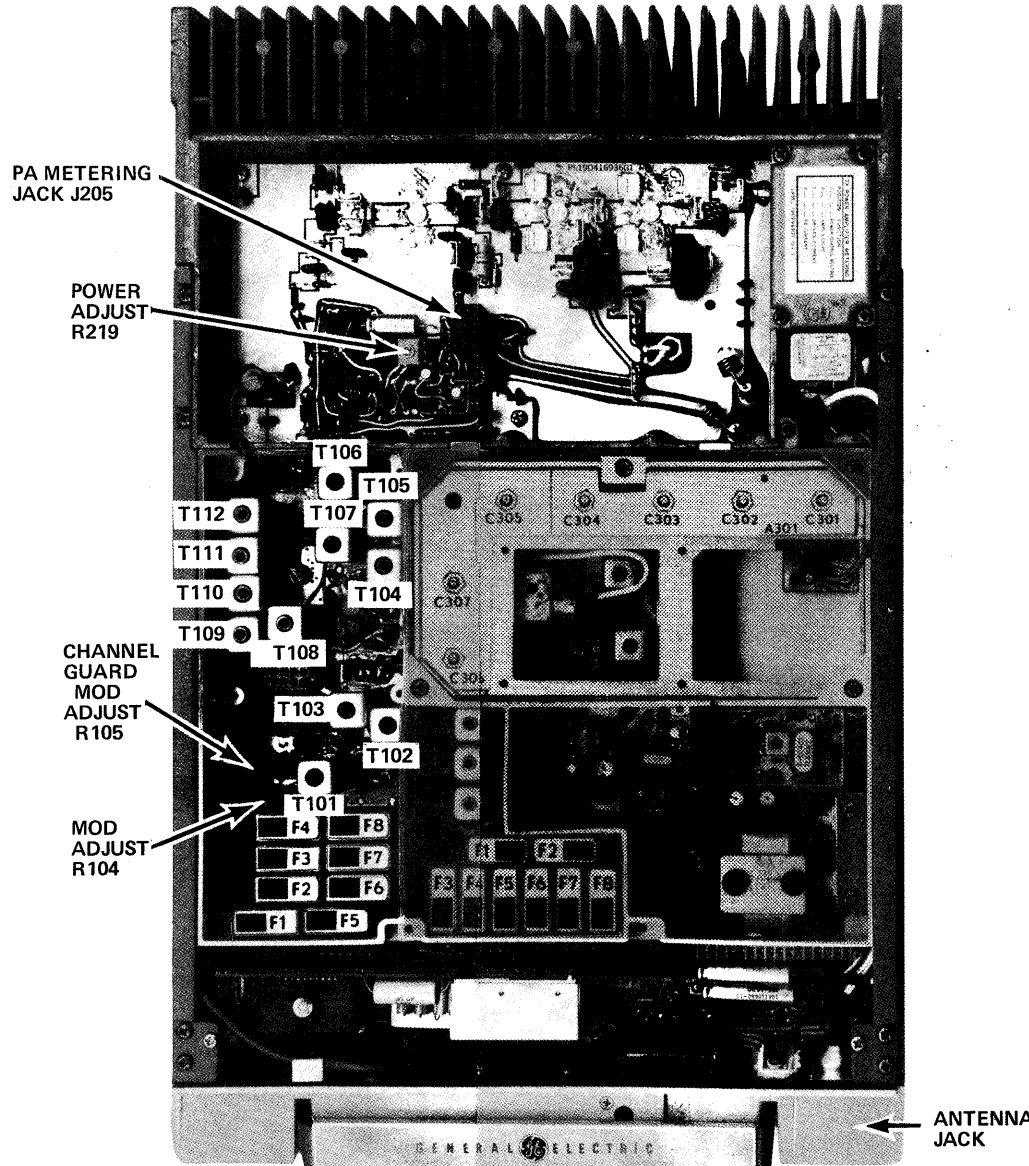


Figure 8 - Frequency Characteristics Vs. Temperature



TEST PROCEDURES

These Test Procedures are designed to assist you in servicing a transmitter that is operating-- but not properly. Problems encountered could be low power output, tone and voice deviation, defective audio sensitivity, and modulator adjust control set too high. Once a defect is pin-pointed,

refer to the "Service Check" and the additional corrective measures included in the Transmitter Troubleshooting Procedure. Before starting with the Transmitter Test Procedures, be sure the transmitter is tuned and aligned to the proper operating frequency.

CAUTION

Before bench testing the MASTR II Mobile Radio, be sure of the output voltage characteristics of your bench power supply.

To protect the transmitter power output transistors from possible instant destruction, the following input voltages must not be exceeded:

Transmitter unkeyed: 20 Volts
Transmitter keyed (50 ohm resistive load): 18 Volts
Transmitter keyed (no load or non-resistive load): 14.5 Volts

These voltages are specified at the normal vehicle battery terminals of the radio and take the voltage drop of standard cables into account. The voltage limits shown for a non-optimum load is for "worst case" conditions. For antenna mismatches likely to be encountered in practice, the actual limit will approach the 18 Volt figure.

Routine transmitter tests should be performed at EIA Standard Test Voltages (13.6 VDC for loads of 6 to 16 amperes; 13.4 VDC for loads of 16 to 36 amperes). Input voltages must not exceed the limits shown, even for transient peaks of short duration.

Many commonly used bench power supplies cannot meet these requirements for load regulation and transient voltage suppression. Bench supplies which employ "brute force" regulation and filtering (such as Lapp Model 73) may be usable when operated in parallel with a 12-Volt automotive storage battery.

TEST EQUIPMENT REQUIRED

for test hookup as shown:

- | | | |
|--|--|--------------------------------|
| 1. Wattmeter similar to: | 2. VTVM similar to: | 3. Audio Generator similar to: |
| Bird # 43 | Triplet # 850 | GE Model 4EX6A10 |
| Jones # 711N | Heath # IM-21 | |
| 4. Deviation Meter (with a .75 kHz scale) similar to: Measurements # 720 | 5. Multimeter similar to: | |
| | GE TEST SET MODEL 4EX3A11, MODEL 4EX8K12 or 20,000 ohms-per-Volt voltmeter | |

POWER MEASUREMENT

TEST PROCEDURE

1. Connect transmitter output from the antenna jack to the wattmeter through a 50-ohm coaxial cable. Make sure the wattmeter is terminated into a 50-ohm load.
2. Key the transmitter and check the wattmeter for the desired power output.

SERVICE CHECK

Check the setting of the Power Adjust Control (R219).

Refer to the QUICK CHECKS on the Transmitter Troubleshooting Procedure.

VOICE DEVIATION, SYMMETRY AND AUDIO SENSITIVITY

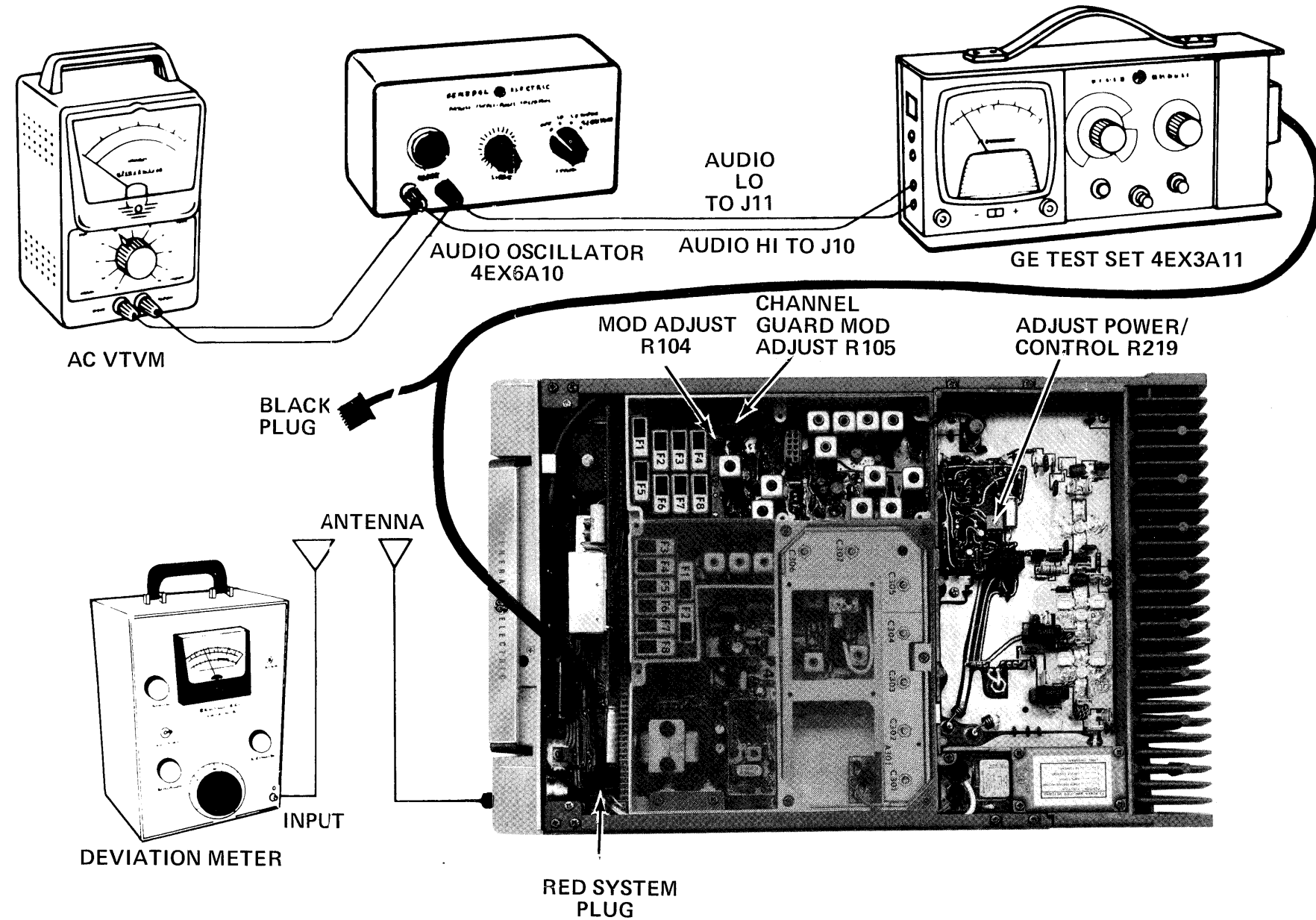
TEST PROCEDURE

1. Connect the test equipment to the transmitter as shown.
2. In radios with Channel Guard, set Channel Guard Mod Adjust R105 for zero tone deviation.
3. In Mobile and Local Control Intermittent Duty Station combinations only, set the audio generator output to 1.0 volt RMS and the frequency to 1 KHz.

In all other Station combinations, set the audio generator output to 30 millivolts RMS and the frequency to 1 KHz.
4. Key the transmitter and adjust Deviation Meter to carrier frequency.
5. Deviation reading should be ± 4.5 kHz in radios without Channel Guard, and ± 3.75 kHz in radios with Channel Guard.
6. If necessary, adjust MOD ADJUST control R104 for the proper deviation on plus (+) or minus (-) deviation, whichever is greater.

NOTES:-- MASTR II transmitters are adjusted for 4.5 kHz deviation at the factory. The factory adjustment will prevent the transmitter from deviating more than 5.0 kHz under the worst conditions of frequency, voltage and temperature.

7. If the deviation reading plus (+) or minus (-) differs by more than 0.5 kHz, recheck Steps 1 and 2 as shown in the Transmitter Alignment Chart.
8. Check Audio Sensitivity by reducing generator output until deviation falls to 3.0 kHz for radios without Channel Guard, or 2.25 kHz for radios with Channel Guard. Voltage should be LESS than 120 millivolts. If not, refer to the Transmitter Troubleshooting Procedure.



TONE DEVIATION WITH CHANNEL GUARD

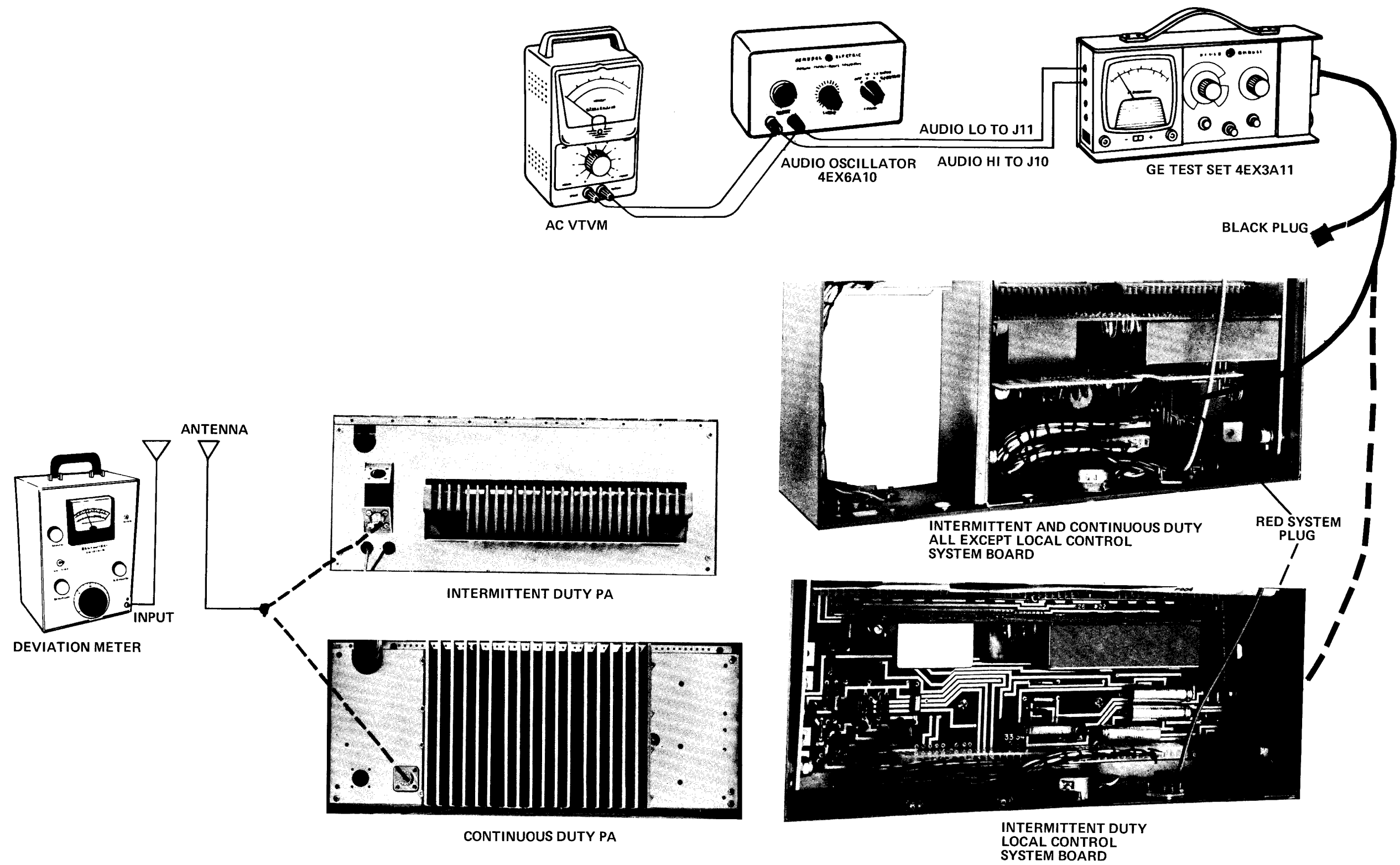
TEST PROCEDURE

1. Set up the Deviation Meter and monitor the output of the transmitter.
2. Remove the 1000 Hz signal from the audio generator.
3. Key the transmitter and check for 0.75 kHz deviation. If the reading is low or high, adjust Channel Guard MOD ADJUST R105 for a reading of 0.75 kHz.

NOTES:

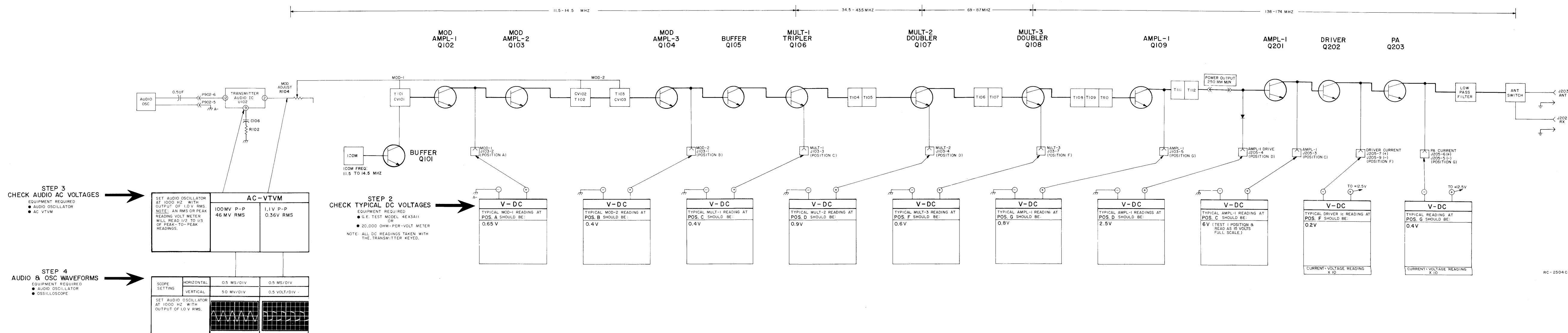
1. On units supplied with Channel Guard, the Phase Modulator Tuning should be adjusted carefully to insure proper performance. (Refer to Steps 1 and 2 in the Transmitter Alignment Chart).
2. The Tone Deviation Test Procedures should be repeated every time the Tone Frequency is changed.

STATION METERING



STEP I - QUICK CHECKS

METER POSITION GE TEST SET	PROBABLE DEFECTIVE STAGE		
	HIGH METER READING	LOW METER READING	ZERO METER READING
EXCITER			
A (MOD-1)	Q102, 10- Volt Regulator	Q102, CV101, T101, 10-Volt regulator	ICOM, Q101, Q102, CR101, 10-Volt regulator or Channel Selector switch ground.
B (MOD-2)	Q104, 10- Volt regulator	Q103, T102, T103, CV102, CV103, Q104	Q103, T102, CV102, T103, CV103, CR104, Q104
C (MULT-1)	Q105, Q106 T104	Q105, Q106	Q105, Q106, T104
D (MULT-2)	Q107, T106	T104, T105, Q107	T104, T105, Q107, T106
F (MULT-3)	Q108, T108	T106, T107, Q108	T106, T107, Q108, T108
G (AMPL-1)	Q109, C157,	T108, T109 T110, Q109	T108, T109, T110, Q109, L106
POWER AMPLIFIER			
"D" (AMPL-1 DRIVE)		Low Output from Exciter	No output from Exciter, CR201
"C" (AMPL-1 POWER CONTROL VOLT- AGE)	Q215	Q215	No Exciter output, Q215, Q204, CR201
"F" (DRIVER CURRENT)	Q203 Q202	Q202, Low Output from Q201.	Q202, Q201. Check Pos. D & C
"G" (PA CURRENT)	Q203	Q201, Q202, Q203.	Q203, Q202, Q201, Q215



TROUBLESHOOTING PROCEDURE

138—174 MHz, 35-WATT TRANSMITTER