MOBILE RADIO

DESCRIPTION AND MAINTENANCE

138—174 MHz, 60-WATT MASTR® EXECUTIVE II TRANSMITTER

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ILLUSTRATIONS

DESCRIPTION

MASTR® Executive II transmitters are crystal controlled, phase modulated transmitters designed for operation in the 138-174 MHz frequency band. This solid state, high reliability transmitter uses one integrated circuit and discrete components to provide 60 Watts of transmitted RF power. The transmitter consists of:

- Exciter, Board; with audio, modulator, stages. Power Amplifier Assembly; with amplifier and driver, PA final, power control and low pass filter assembly.
- Multi-Frequency board; used with multi-frequency radios only (common to transmitter and receiver).

Figure 1 is a block diagram of the MASTR Executive II transmitter showing the exciter, PA and multi-frequency boards.

The exciter contains the oscillator, audio IC, modulator and multipliers to provide 250 milliwatts of modulated RF power to the power amplifier. In vehicles with a positive ground, a polarity converter is used to power the exciter.

The power amplifier assembly includes three transistor stages (amplifier, driver and power amplifier), a low pass filter, and a power control circuit to adjust the output power level.

MAINTENANCE

The PA operates from a floating DC source to permit operation in negative or positive 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 inline fuses to blow.

DISASSEMBLY

- To service the transmitter, remove the two retaining screws from the front cap assembly and pull the radio out of the case assembly.
- To remove the exciter board:
  1. Unplug the exciter/PA cable and multi-frequency cable W2601 (when present).
  2. Remove the six screws holding the exciter board to the mounting frame and gently lift the exciter board out of the radio.

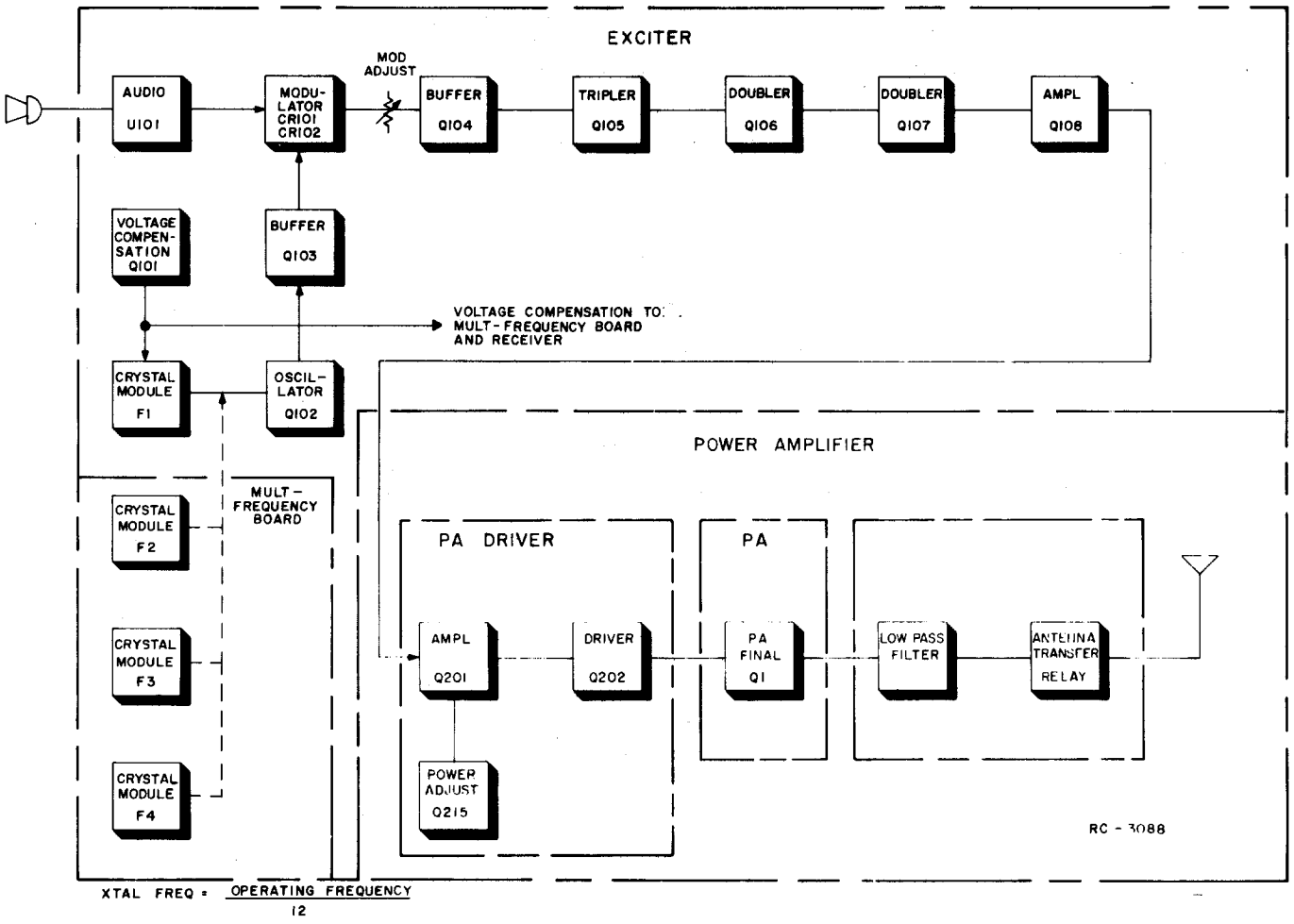

Figure 1 - Transmitter Block Diagram

- To remove PA Driver board A201 (See PA Outline Diagram):

  1. Remove the PA top cover and unplug the exciter/PA cable.

     NOTE: The PA heat sink assembly pivots 90° to permit access to the PA boards.

  2. Unsolder the power feed cables W201 from E1 and C297, and W202 from E2.

  3. Unsolder W203 from H15 and W204 from H18. Next, unsolder W217 from H1 and G11. Then remove the retaining screw, nut, washer and plate from Q215.

  4. Remove the four mounting screws securing A201 and lift the board out.

- To remove PA board A202 (See PA Outline Diagram):

  1. Remove the PA top cover.

  2. Unsolder W203 from H3 and W204 from H4. Then unsolder W217 from H1 and G12 on A202.

  3. Unsolder the PA/low pass filter cable W214 from H2 and the shield from ground.

  4. Remove the four PA board mounting screws and lift the board out.

PA TRANSISTOR REPLACEMENT

WARNING

The 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.

- To remove the RF transistors:

  1. Remove the two retaining screws in the transistor leads.

  2. With a 50-Watt soldering iron and a de-soldering tool such as a SOLDA-PULLT®, remove the excess solder from the transistor leads. Use a scribe or X-acto® knife to

hold the leads away from the printed circuit board until the solder cools.

3. Lift out the transistor and remove the old solder from the printed circuit board with a de-soldering tool such as a SOLDA-PULLT®.

- To replace the RF PA transistors:

1. Trim the new transistor leads (if required) to the lead length of the removed transistor. The collector lead of the transistors is identified by the smaller center lead (See Figure 2). The letter "C" on top of each transistor also identifies the collector.

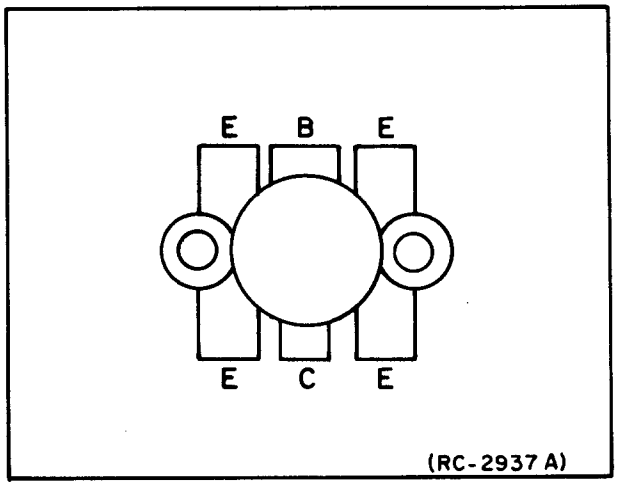

Figure 2 - Transistor Lead Identification

2. Apply a coat of silicon grease around the transistor mounting surface. Next, align the leads as shown on the PA Assembly Outline Diagram. Then replace the two transistor retaining screws using 6-inch pounds of torque.

3. 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. Do not use excessive heat which causes the printed wire runs to lift up from the board. Check for shorts and solder bridges with an ohmmeter 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.

TROUBLESHOOTING

A Troubleshooting Procedure, including QUICK CHECKS, permits rapid location of any trouble in the exciter and power amplifier.

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MODULATION LEVEL ADJUSTMENT

The MOD ADJUST (R108) 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, instaneously limits the slope of the audio wave to the modulator, thereby preventing over-modulation 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

PROCEDURE

1. Connect the audio oscillator and the meter across audio input terminals J10 (Gree-Hi) and J11 (Black-Lo) on GE Test Set, or across P902-4 (Mike High) through a 0.5 microfarad (or larger) DC blocking capacitor, and P902-5 (Mike-Low) on the Exciter board.
2. Adjust the audio oscillator for 1-Volt RMS at 1000 Hz.
3. For transmitters without Channel Guard, set MOD ADJUST R108 for a 4.5 kHz swing using the deviation polarity that provides the highest reading on the frequency modulation monitor.
4. For transmitters with Channel Guard, set Channel Guard MOD ADJUST R643 for zero tone deviation. Next, with the 1-Volt signal at 1000 Hz applied, set MOD ADJUST R108 for 3.75 kHz deviation. Then remove the signal from the audio oscillator and set Channel Guard MOD ADJUST R643 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 using the following formula:

$$P_i = \text{PA voltage X PA current}$$

where:

P_i 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 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 (read as 10 amperes full scale).

Example:

P_i = 13 Volts X 9 amperes = 117 Watts

OSCILLATOR FREQUENCY ADJUSTMENT

First, check the frequency to determine if any adjustment is required. The frequency should be set using 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 30°C (86° F).

The oscillator should be reset only when the frequency shows deviation in excess of the following limits:

A. ±0.6 PPM, when the radio is at 30°C (86°F).

F. ±5 PPM at any other temperature within the range of -30°C to +75°C (-22°F to +167°F)

If an adjustment is required, proceed as follows:

If the radio is at an ambient temperature of 30°C (86°F), set the oscillator for the correct operating frequency.

If the radio is not at an ambient temperature of 30°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 crystal oscillators):

1. Maintain the radio at 30°C and set the oscillator to desired frequency, or
2. Maintain the radio at 30°C (+5°C, -15°C) offset the operating frequency as a function of actual temperature, by the amount shown in Figure 3.

For example: Assume the ambient temperature of the radio is 20°C (68°F). At that temperature, the curve shows a correction factor of 225 Hz.

Set C3 on the selected crystal module for a reading of 225 Hz higher than the licensed operating frequency. If a negative correction factor is obtained (at temperatures above 30°C), set the oscillator for the indicated frequency lower than the licensed operating frequency.

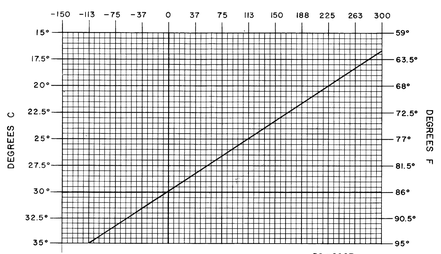
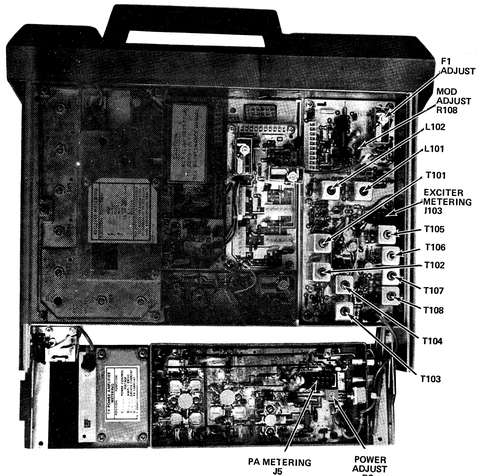


Figure 3 - Frequency Characteristics Vs. Temperature



TRANSMITTER ALIGNMENT

EQUIPMENT

1. GE Test Set Model 4EX3A11 or Test Kit 4EX8K12.
2. A 50-ohm wattmeter connected to antenna jack J2.
3. A frequency counter.
4. Deviation Monitor.

PRELIMINARY CHECKS AND ADJUSTMENTS

1. Place crystal modules for F1 on Exciter Board and F2-F4 on multi-frequency board. (crystal frequency - operating frequency ÷ 12).
2. For a large change in frequency or a badly mis-aligned transmitter, preset all slugs to the top of the coil form.
3. For multi-frequency transmitters with a frequency spacing less than .000 MHz for frequencies between 138-155 MHz or less than 1.00 MHz for frequencies between 150.8-174 MHz tune the transmitter (except L101 and L102) on the lowest frequency. See Step 1 below.

   For multi-frequency transmitters with a frequency spacing up to 1.8 MHz for frequencies between 138-155 MHz or 2.0 MHz for frequencies between 150.8 - 174 MHz. Tune the transmitter using a center frequency tune-up crystal module. These limits can be extended to 2.25 MHz and 2.5 MHz respectively with degraded output.
4. Connect the red plug on the GE Test Set to the SAS Board metering jack, and the black plug to the Exciter metering jack. Set the polarity to +, and set the range to the Test 1 position (1-Volt position for 4EX8K12) for all adjustments.
   NOTE: With the Test Set connected to the PA metering jack, the voltage reading at position "F" with the HIGH SENSITIVITY button pressed may be converted to driver collector current by reading the current as 10 amperes full scale. The voltage reading at position "G" with the HIGH SENSITIVITY button pressed may be converted to PA collector current by reading the current as 10 amperes full scale.
5. All adjustments are made with the transmitter keyed. Unkey the transmitter between steps to avoid unnecessary heating.
6. Set tuning slugs in L101, L102 and T101 through T108 to top of coil form.

ALIGNMENT PROCEDURE

STEP	METER POSITION	TUNING CONTROL	METER READING	PROCEDURE
1.	A (MULT-1)	L101, L102 & T101	See Procedure	Tune L101 then L102 for maximum meter reading on highest frequency. then with lowest frequency selected, tune T101 for a dip in meter reading.
2.	A	L102	See Procedure	Using a deviation monitor, check the symmetry of the modulator at 300 Hz using the highest and lowest assigned operating frequencies. If more than 0.5 kHz diesymmetry exists, tune L102 to optimize symetry. NOTE L102 should not be adjusted more than 21/8 turn from previous setting. If a deviation monitor is not available, adjust L102 1/4 turn counter-clockwise.
3.	B (MULT-2)	T102, T101 & T103	See Procedure	Tune T102 for maximum meter reading and re-adjust T101 for maximum meter reading. Then tune T103 for a dip in meter reading.
4.	C (MULT-3)	T104, T103 & T105	See Procedure	Tune T104 for maximum meter reading and re-adjust T103 for maximum meter reading. Then tune T105 for a dip in meter reading.
5.	F (AMPL-1)	T106 & T105	Maximum	Tune T106 for maximum meter reading, and then re-adjust T105 for maximum meter reading.
6.	F (Rel. Power Out)	T107 & T108	Maximum	Tune T107 and then T108 for maximum meter reading. Then, alternately retune T107 & T108 for maximum meter reading.
7.	D (AMPL-1 Driver on PA)	T107 & T108	Maximum	Move the black metering plug to PA metering jack and re-adjust T109 and T108 for maximum meter reading.
8.	F (AMPL-1 DRIVE)	T105 & T106	Maximum	Move the black metering plug back to the Exciter metering jack and re-adjust T105 and T106 for maximum meter reading.
9.		R8		With the battery voltage at 13.6 Volts or the PA collector voltage at 13.6 Volts, set Power Adjust potentiometer R8 on the PA board for the desired power output. If the battery voltage is not at 13.6 Volts or the collector voltage is not at 13.6 Volts and full rated output is desired, set R8 for the output power according to the battery voltage or collector voltage shown in Figure 4. NOTE: The PA collector voltage is measured as described in the PA POWER INPUT section.
ADDITIONAL STEPS FOR TRANSMITTERS USING CENTER FREQUENCY TUNE-UP CRYSTAL MODULE				
10.	B (MULT-2)	T101 & T102	See Procedure	Check drive on highest and lowest frequency. If drive is lower on lowest frequency, preset the tuning slugs of T101 and T102 to top of coil form and return for maximum meter reading. (0.1 Volt typical difference between lowest and highest frequency).
11.	C (MULT-3)	T103	See Procedure	Check drive on highest and lowest frequency. If drive is lower on lowest frequency, return T103 for maximum meter reading on lowest frequency.
12.	G Rel. Power Out	T105	See Procedure	Return T105 for equal drive on highest and lowest frequency. Note: For two frequency spread approaching maximum limits, a difference in drive may exist. If this occurs, be sure the lower frequency has greater drive. Repeat step 8.

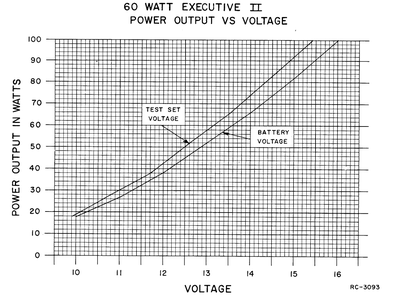


Figure 4 - Power Output Setting Chart

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 Executive 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): 15.5 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:
   Bird # 43
   Jones #711N
2. VTVM similar to:
   Triplett #850
   Heath # IM-21
3. Audio Generator similar to:
   GE Model 4EX6A10
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 (R8).

Refer to the QUICK CHECKS on the Transmitter Troubleshooting Procedure.

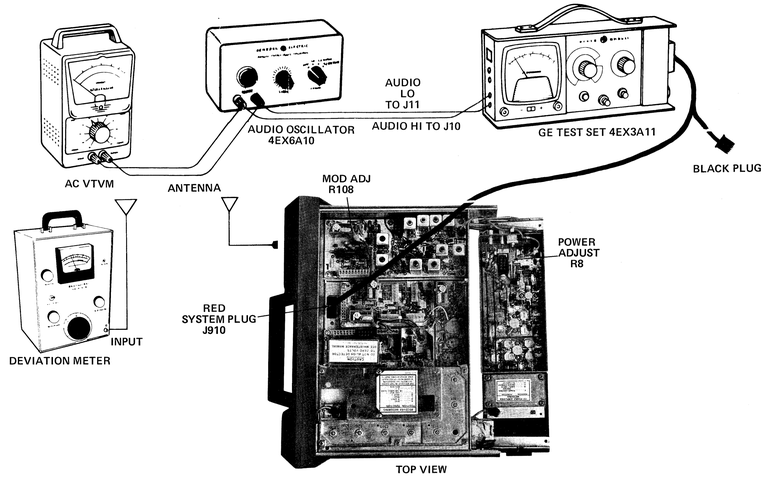
VOICE DEVIATION, SYMMETRY AND AUDIO SENSITIVITY

TEST PROCEDURE

1. Connect the test equipment to the transmitter as shown.
2. In radios equipped with Channel Guard set Channel Guard Mod Adjust for zero tone deviation. NOTE. When external Channel Guard is used, adjust Channel Guard Mod Adjust R982 on SAS board for zero tone deviation.
3. Set the Audio generator output to 1.0 VOLTS RMS and 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 with Channel Guard.
6. If necessary, adjust MOD ADJUST control R108 for the proper deviation on plus (+) or minus (-) deviation, whichever is greater.

NOTES:-- MASTR Executive 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 Step 1 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 R643 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 Step 1 in the Transmitter Alignment Chart).
2. The Tone Deviation Test Procedures should be repeated every time the Tone Frequency is changed.

STEP 1 - QUICK CHECKS

METER POSITION OR TEST SET	PROBABLE DEFECTIVE STAGE		
	HIGH METER READING	LOW METER READING	ZERO METER READING
EXCITER			
"A" (MULT-1)	Q104, Q105 T101	Q104, Q105	Q104, Q105 T101
"B" (MULT-2)	Q106, T103	Q106, T101, T102	T101, T102, Q106, T103
"C" (MULT-3)	Q107, T105	T103, T104, Q107	T103, T104, Q107, T105
"F" (AMPL-1)	Q108, C149	T105, T106, Q108	T105, T106, Q108, L108
POWER AMPLIFIER			
"D" (AMPL-1 DRIVE)		Low Output from Exciter	No output from Exciter, CR1
"C" (AMPL-1 POWER CONTROL VOLTAGE)	Q215	Q215	No Exciter output, Q215, CR1
"F" (DRIVER CURRENT)	Q1, Q202	Q202, Low Output from Q201	Q202, Q201. Check Pos. D & C
"G" (PA CURRENT)	Q1	Q201, Q202, Q1	Q1, Q202, Q201, Q215