MOBILE RADIO

DESCRIPTION AND MAINTENANCE
30—50 MHz, 100-WATT MASTR® EXECUTIVE II TRANSMITTER

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DESCRIPTION

MASTR® Executive II transmitters are crystal controlled, phase modulated transmitters designed for one through four frequency operation in the 30-50 MHz frequency band. This solid state, high reliability transmitter uses two integrated circuits, a crystal module and discrete components to provide 100 watts of transmitted RF power. The transmitter consists of:

- Exciter Board; with audio IC, crystal module modulator, amplifier and multiplier stages.
- Power Amplifier Assembly; with amplifier, driver, PA, power control, filter and antenna switch.
- 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 board and multi-frequency board.

The exciter contains the oscillator, audio IC, crystal module modulator and multipliers to provide 250 millivolts 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 six RF power transistors, a low-pass filter, an antenna switch and seven transistors for the power control circuit. The amplifier driver and the four paralleled power amplifiers provide up to 100 watts of output power.

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 printed wiring board ground patterns to the radio case may cause one of the line fuses to blow.

DISASSEMBLY

To service the transmitter remove the two retaining screws from the front cap assembly and pull radio out of case assembly.

To remove exciter board:

1. Unplug the exciter/PA cable and multi-frequency W2601 (if present).

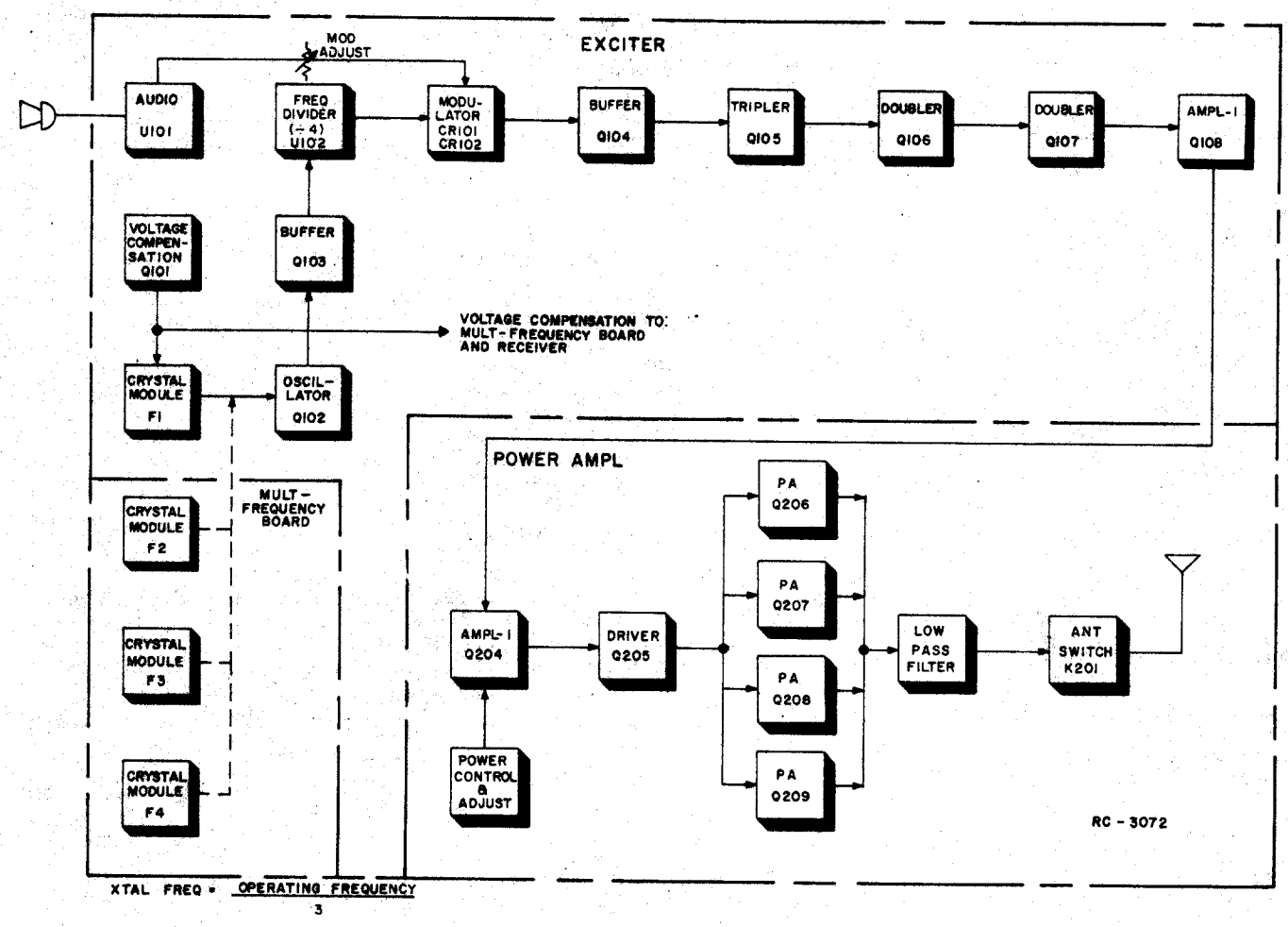

Figure 1 - Transmitter Block Diagram

2. Remove the six screws holding the exciter board to the mounting frame and gently lift exciter board out of radio.

To remove the PA assembly:

1. Remove the PA top cover and unplug the exciter/PA cable, the antenna, receiver and PTT cables.

2. Remove the four side-rail screws 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.

2. Unsolder the two feedthrough coils and the thermistor leads.

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, the five screws in the filter casting, the retaining screw in Q210 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.

To replace the PA RF transistors:

1. Unsolder one lead at a time with a 50-watt soldering iron. Use a scribe or X-acto® knife 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 heatsink with an 11/32-inch nut-driver. Lift out the transistor, and remove the old solder from the printed circuit board with a de-soldering tool such as a SOLDA PULLT®. Special care should be taken to prevent damage to the printed circuit board runs.

4. Trim the new transistor leads (if required) to the lead length of the removed transistor. Cut the collector lead at a 45° angle for future identification (see Figure 2). The letter "C" on the top of the transistor also indicates the collector.

5. Apply a coat of silicon grease around the transistor mounting surface, and place the transistor in the mounting hole. Align the leads as shown on the Outline Diagram. Then hold the body of the transistor and replace the hold-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 3 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.

TROUBLESHOOTING

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

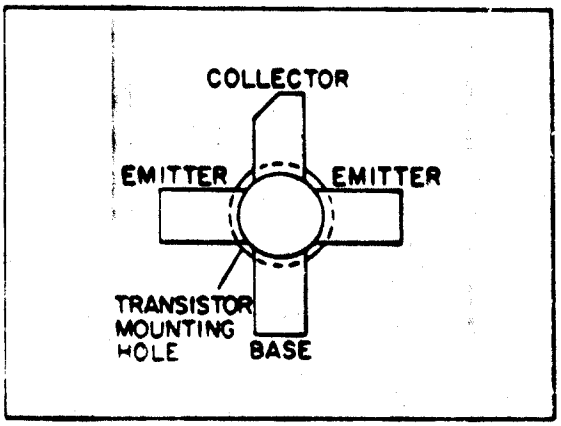

Figure 2 - Lead Identification

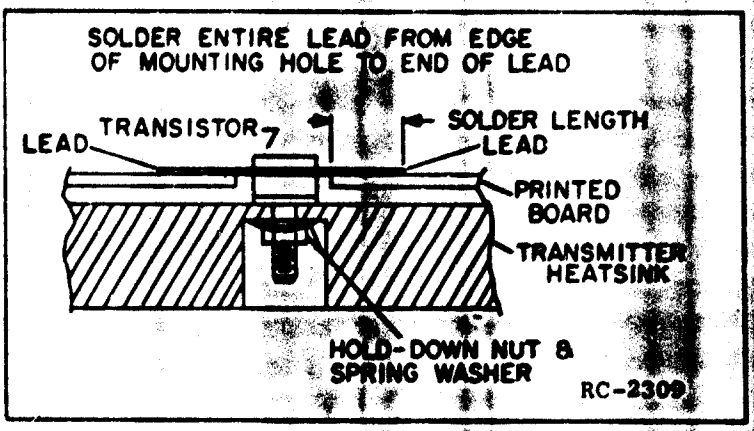

Figure 3 - Lead Forming

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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, 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 Models 4EX3A11 or 4EX8K12

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 P902-4 (Mike High) through a 0.5 microfarad (or larger) DC blocking capacitor, and P902-5 (Mike-Low) on the SAS board.
2. Adjust the audio oscillator for 1-Volt RMS at 1000 Hz.
3. For transmitters with Channel Guard, set MOD ADJUST R108 for a 4.5-kilohertz 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 for zero tone deviation. Next, with the 1-Volt signal at 1000 Hz applied, set MOD ADJUST R108 for a 3.75 kHz deviation. Then remove the signal from the audio oscillator and set Channel Guard MOD ADJUST for 0.75 kHz tone deviation.
5. For multi-frequency transmitters, set the deviation as described in Step 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:

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

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 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 (30 amperes full scale).

Example:

P_i = 12.4 Volts x 16 amperes = 198.4 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. ±0.5 PPM, when the radio is at 30°C (86°F)

B. ±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 (±5°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 4.

For example: Assume the ambient temperature of the radio is 20°C (68°F). At that temperature, the curve shows a correction factor of 66 Hz for the 30-36 MHz frequency band.

Set the oscillator for a reading of 66 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.

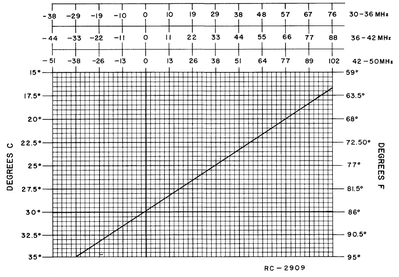
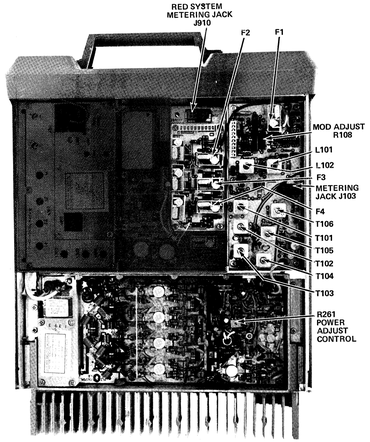


Figure 4 - Frequency Offset Chart



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 - 3).
2. For a large change in frequency or a badly mis-aligned transmitter, preset all slugs to the bottom of the coil form.

NOTE

The tuning frequency for multi-frequency transmitters is determined by the operating frequency and the frequency spread between transmitters. Refer to the table below for maximum frequency spread.

3. For multi-frequency transmitters with a frequency spread less than that specified in column (1), tune the transmitters to the lowest frequency.

   For frequency spread exceeding the limits specified in column (1), tune the transmitter using a center frequency tune up crystal module. These limits can be extended to the limits specified in column (3) with a 1 dB degradation.

Multi-frequency Transmitter Tuning

Transmitter Frequency Range	MAXIMUM FREQUENCY SPREAD		
	(1) without center tuning	(2) with center tuning	(3) with center tuning (1 dB degradation)
30-36 MHz	.100 MHz	.200 MHz	.400 MHz
36-42 MHz	.120 MHz	.240 MHz	.470 MHz
42-50 MHz	.140 MHz	.280 MHz	.540 MHz

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).
   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 30 amperes full scale.
5. All adjustments are made with the transmitter keyed. Unkey the transmitter between steps to avoid unnecessary heating.

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 dissymmetry exists, tune L102 to optimize symmetry. NOTE L102 should not be adjusted more than ~ 1/6 turn from previous setting. If a deviation monitor is not available, adjust L102 1/6 turn clockwise.
3.	B (MULT-2)	T102, T101 & T 103	See Procedure	Set channel selector switch to lowest frequency used and 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 T103 for a dip in meter reading.
5.	F (AMPS-1)	T106 & T105	Maximum	Tune T106 for maximum meter reading, and then re-adjust T105 for maximum meter reading.
6.	G (Rel. Power Out)	C144 & C146	Maximum	Tune C144 and then C146 for maximum meter reading. Then alternately re-tune C144 and C146 for maximum meter reading.
7.	D (AMPS-1 Driver on PA)	C144 & C146	Maximum	Move the black metering plug to PA metering jack and re-adjust C144 and C146 for maximum meter reading.
8.		R11		With the battery voltage at 13.4 Volts or the PA collector voltage at 12.4 Volts, set Power Adjust potentiometer R14 on the PA board for the desired power output. If the battery voltage is not at 13.4 Volts or the collector voltage at 12.4 Volts and full rated output is desired, set R261 for the output power according to the battery voltage or collector voltage shown in Figure 5. NOTE The PA collector voltage is measured as described in the PA POWER INPUT SECTION.
		ADDITIONAL STEP FOR TRANSMITTERS USING CENTER FREQUENCY TUNE-UP CRYSTAL MODULE		
9.	G Rel. Power Out	T106	See Procedure	Retune T106 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.

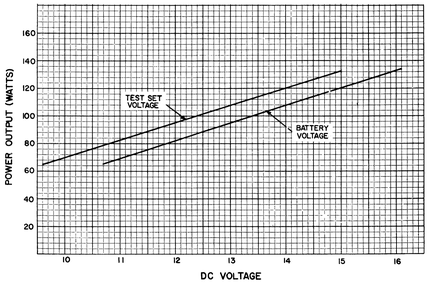


Figure 5 - Power Output Setting Chart

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 limit 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 R261.

Refer to the QUICK CHECKS on the Transmitter Troubleshooting Procedure.

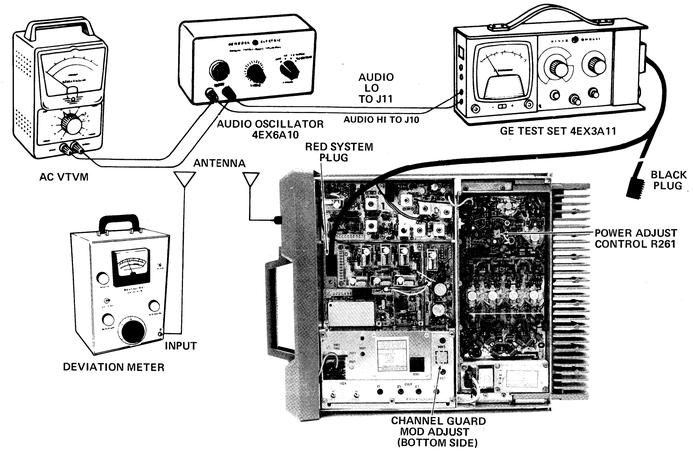
VOICE DEVIATION, SYMMETRY AND AUDIO SENSITIVITY

TEST PROCEDURE

1. Connect the test equipment to the transmitter as shown.
2. In radios with Channel Guard, set Channel Guard Mod Adjust 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 in radios 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 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 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.

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	Q105, Q104, T101, Q102, T102, Q103, VR101
"B" (MULT-2)	Q106, T103,	T101, T102, T103, Q106	T101, T102, T103, Q106
"C" (MULT-3)	Q107, T105	T103, T104, T105, Q107	T103, T104, Q107, T105
"F" (AMPL-1)	Q108, C143, C145	T105, T106, Q108, L105	T105, T106, Q108, L106, L104
"G" (Power Out)	R136, W216	CR103, R137	Q108, CR103, R137, C147,-C148
POWER AMPLIFIER			
"D" (AMPL-1 DRIVE)		Low Output from Exciter	No output from Exciter, CR201
"C" (AMPL-1 CONTROL VOLTAGE)	Q217	Q217	No Exciter output Q217, Q211, CR201
"F" (DRIVER CURRENT)	Q205	Q205, Low Output from Q204	Q205, Q204, Check Pos. D & C
"G" (PA CURRENT)	Q206, Q207 Q208, Q209	Q204, Q205, Q206-Q209	Q204, Q205, Q206-Q209 ANTENNA SWITCH K201