DESCRIPTION AND MAINTENANCE
406-420 & 450-512 MHz MASTR EXECUTIVE II TRANSMITTER

TABLE OF CONTENTS

DESCRIPTION

MASTR Executive II transmitters are crystal controlled, phase modulated transmitters designed for one through four frequency operation in the 406-420 and 450-512 MHz frequency bands. This solid state, high reliability transmitter uses one integrated circuit and discrete components to provide 40 watts of transmitted RF power. The transmitter consists of:

- Exciter Board; with audio, modulator, amplifier and multiplier stages.
- Power Amplifier Assembly; with amplifier, driver, PA final, power control and low pass filter assembly
- Multi-frequency board; used in multi-frequency radios and in station applications where ICOMs are used (0.0002% stability) (common to transmitter and receiver).

Figure 1 is a block diagram of the 406-512 MHz MASTR Executive II transmitter, showing the exciter, PA board and multi-frequency board.

The exciter contains the oscillator, audio IC, modulator and multipliers to provide 200 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 four transistor stages (two amplifiers, a driver and power amplifier) to provide 40 watts of output power, a low pass filter and a power adjust circuit to adjust the output power to the desired 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 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 cables W216 (exciter output and when present W2601 (multi-frequency cable).

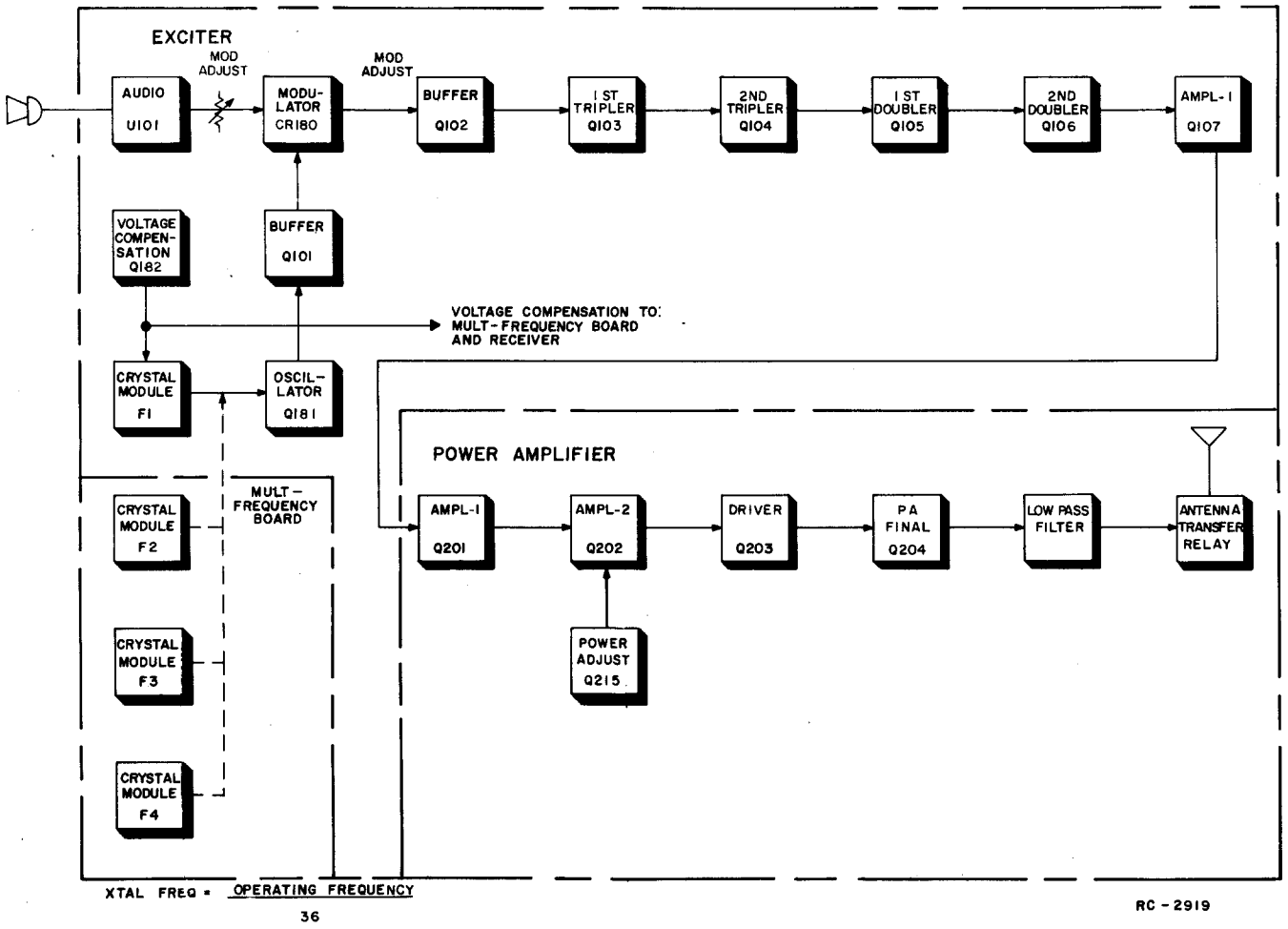


Figure 1 - Transmitter Block Diagram

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

- To remove PA Board:

(1) Remove PA top cover and unplug the exciter/PA cable W216 from J201; unsolder the PA/low pass filter cable W214 from W205 and the shield from ground. NOTE: The PA heat sink assembly pivots 90° to permit access to the PA board.

(2) Unsolder the two power feed through coils (C297, C298) and remove the retaining screw from power adjust transistor Q215 to the chassis. Be careful not to damage the mica insulation placed between the transistor and the chassis.

(3) Remove the PA transistor (Q202) hold-down nut and spring washer on the rear of the PA assembly.

(4) Remove the two screws securing each of the two flange transistors to the PA board.

(5) Remove the four PA board mounting screws, 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 remove PA RF transistor Q202:

(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 PA board 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 for Q202. 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 because part of the matching network is included in the base and collector runs.

- To remove RF PA transistors Q203 and Q204 (Flange type):

(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. 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.

- To replace RF PA transistors:

(1) Trim the new transistor leads (if required) to the lead length of the removed transistor. Cut the collector lead of Q202 at a 45° angle for future identification. (see Figure 2). The letter "C" on the top of each transistor also indicates the collector.

(2) 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 (Q202) or the two retaining screws (Q203 and Q204) using moderate torque, 8 inch-pounds for Q202 or 6 inch-pounds for Q203 and Q204. A torque wrench must be used for this adjustment since transistor damage can result if too little or too much torque is used.

(3) Make sure that the transistor leads are formed as shown in Figure 3 (Q202) so that the leads can be soldered to the printed circuit pattern, starting from the inner edge of the mounting hole.

(4) 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.

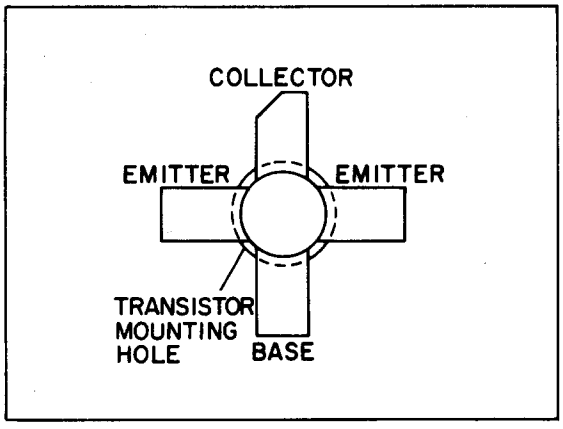


Figure 2 - Lead Identification

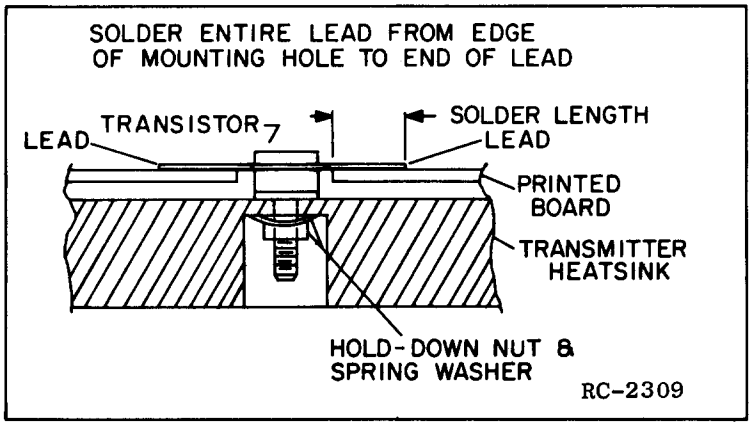


Figure 3 - Lead Forming

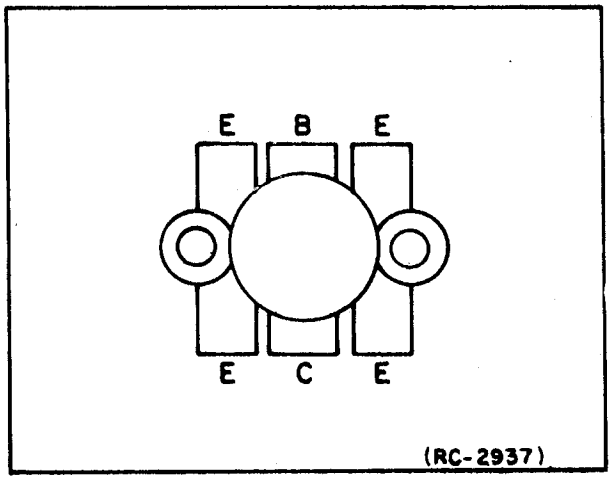


Figure 4 - Lead Identification for Q203 and Q204

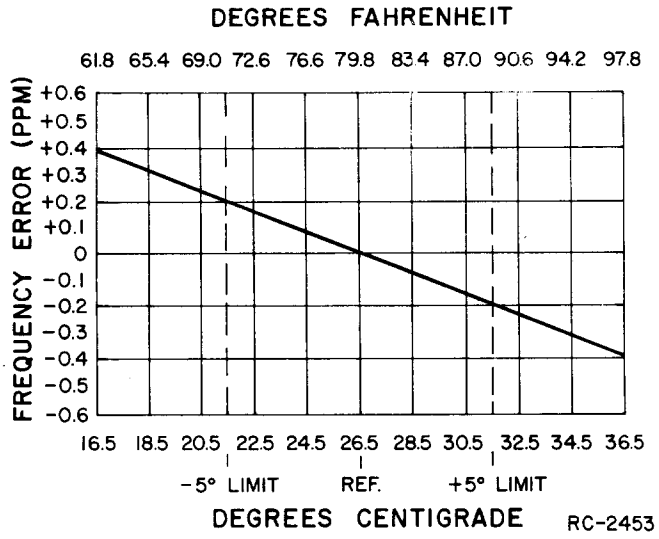


Figure 5 - ICOM Frequency Offset Chart

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°V (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 (±5°C) and set the oscillator to desired frequency, or-

2. Maintain the radio at 26.5°C (±10°C) and offset the oscillator, as a function of actual temperature, by the amount shown in Figure 5.

B. To hold setting error to ±0.35 PPM (which is considered reasonable for 2 PPM ICOMs): Maintain unit at 26.5°C (±5°C) and offset the oscillator, as a function of actual temperature, by the amount shown in Figure 5.

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 406 MHz, 1 PPM is 406 Hz. At 512 MHz, 1 PPM is 512 Hz).

With an operating frequency of 450 MHz, set the oscillator for a reading of 135 Hz (0.3 x 450 Hz) higher than the licensed operating 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.

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 is 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

PROCEDURE

1. Connect the audio oscillator and the meter across audio input terminals J10 (Green-81) and J11 (Black-LO) on GE Test Set, or across P900-4 (Mike High) through a 0.5 microfarad (or larger) DC blocking capacitor, and P900-5 (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 R104 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 R104 for 3.75 kHz deviation. 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:

$$P_I = PA\ voltage \times PA\ current$$

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 10 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 (read as 15 amperes full scale).

Example:

P_I = 12.6 Volts x 3.1 amperes = 39 Watts

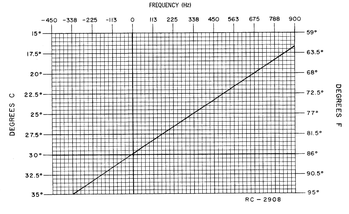


Figure 6 - Frequency Offset Chart

CRYSTAL MODULE 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. 50.6 PPM, when the radio is at 30°C (86°F).

B. 55 PPM at any other temperature within the range of -30°C to +75°C (-22°F to +167°F), or

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 correct operating frequency.

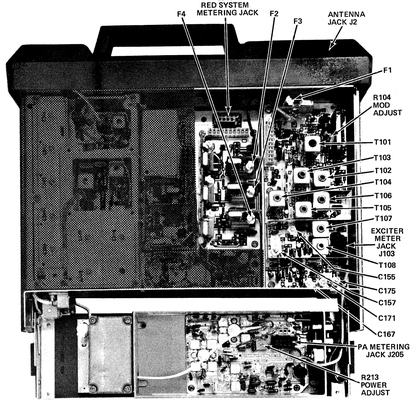
If the radio is not at an ambient temperature of 30°C, setting errors can be minimized as follows:

A. To hold the setting error to 50.6 PPM (which is considered reasonably 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 6.

For example: Assume the ambient temperature of the radio is 20°C (68°F). At that temperature, the curve shows a correction factor of 675 Hz.

Set C3 on the selected crystal module for a reading of 675 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.



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 ÷ 36). In station applications where a stability of ±0.0002% is required, ICOMs are used. Place all ICOMs on the multi-frequency board.
2. For a large change in frequency or a badly mis-aligned transmitter, preset all slugs to the top of the coil form.
3. Set output impedance matching capacitor to 1/4 mesh.
4. Set all other air variable capacitors to minimum capacity (not meshed).

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.

5. For multi-frequency transmitters with a frequency spread less than that specified in column (1) tune the transmitters to the lowest frequency. For a frequency spread exceeding the limits specified in column (3) tune the transmitters using a center frequency tune up crystal module or ICOM as required. The maximum frequency spread can be extended to the limits specified in column (3) with 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)
406-420 MHz	2.50 MHz	5.00 MHz	9.00 MHz
450-470 MHz	2.75 MHz	5.50 MHz	9.00 MHz
470-512 MHz	3.00 MHz	6.00 MHz	9.75 MHz

6. 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 15 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 15 amperes full scale.

7. All adjustments are made with the transmitter keyed. Unkey the transmitter between steps to avoid unnecessary heating.

NOTE

When the need for minor adjustments to the transmitter are indicated, perform steps 13 through 17 for a quick transmitter tune-up.

ALIGNMENT PROCEDURE

STEP	METER POSITION	TUNING CONTROL	METER READING	PROCEDURE
				NOTE: When aligning transmitter, proceed as instructed below. DO NOT retune a previously tuned control unless specifically directed to do so.
1.	B (MULT-1)	T101, T102 & T103	See Procedure	Tune T101 for maximum meter reading. Then tune T102 for a dip (small) in meter reading and tune T103 for maximum meter reading.
2.	C (MULT-2)	T104 and T105	See Procedure	Tune T104 for maximum meter reading, then tune T105 for a dip (small) in meter reading.
3.	D (MULT-3)	T106 and T107	See Procedure	Tune T106 for maximum meter reading and then tune T107 for a dip in meter reading.
4.	F (MULT-4)	T108 and C155	See Procedure	Tune T108 for maximum meter reading and then tune C155 for a dip in meter reading.
5.	G (AMPL-1)	C157 and C167	See Procedure	Tune C157 for maximum meter reading, and then tune C167 for a dip in meter reading.
6.	A (Rel. Power Out)	C171 and C175	Maximum	Tune C171 and then C175 for maximum meter reading.
7.	B (MULT-1)	T101	Maximum	Tune T101 for maximum meter reading.
8.	C (MULT-2)	T102, T103 & T104	Maximum	In order, tune T102, T103 and T104 for maximum meter reading.
9.	D (MULT-3)	T105 and T106	Maximum	Tune T105 and then T106 for maximum meter reading.

ALIGNMENT PROCEDURE (Cont'd)

STEP	METER POSITION	TUNING CONTROL	METER READING	PROCEDURE
10.	F (MULT-4)	T107 and T108	Maximum	Tune T107 and then T108 for maximum meter reading.
11.	G (AMPL-1)	C155 and C157	Maximum	Tune C155 and then C157 for maximum meter reading.
12.	A (Rel. Power Out)	C167, C171 & C175	Maximum	In order, tune C167, C171 and C175 for maximum meter reading.
				NOTE: A quick transmitter tune-up procedure is provided in steps 13 through 17.
13.	C (MULT-2)	T102, T103 and T104	Maximum	Alternately tune T102, T103 and T104 for maximum meter reading.
14.	D (MULT-3)	T105 and T106	Maximum	Alternately tune T105 and T106 for maximum meter reading.
15.	F (MULT-4)	T107 and T108	Maximum	Alternately tune T107 and T108 for maximum meter reading.
16.	G (AMPL-1)	C155 and C157	Maximum	Alternately tune C155 and C157 for maximum meter reading. For optimum operation repeat steps 13 through 16.
17.	A (Rel. Power Out)	C167, C171 and C175	Maximum	Alternately tune C155, C171 and C175 for maximum meter reading.
		R213		With the battery voltage at 13.6 Volts or the PA collector voltage at 13.0 Volts, set Power Adjust potentiometer R213 on the PA board for the desired power output from 1 to 40 watts. If the battery voltage is not at 13.6 Volts or the collector voltage at 13.0 Volts and full rated output is desired (40 watts at 13.6 Volts), set R213 for the output power according to the battery voltage or collector voltage shown in Figure 7, 8, or 9. NOTE: The PA collector voltage is measured as described in the PA POWER INPUT section.

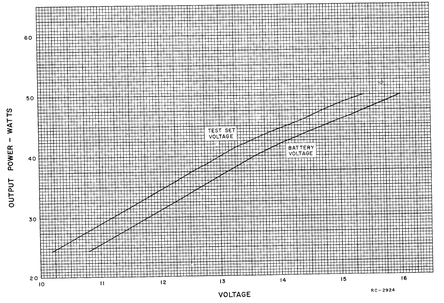


Figure 7 - 406-420 MHz Power Output Setting Chart

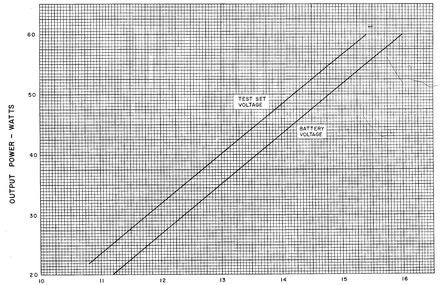


Figure 8 - 450-470 MHz Power output Setting Chart

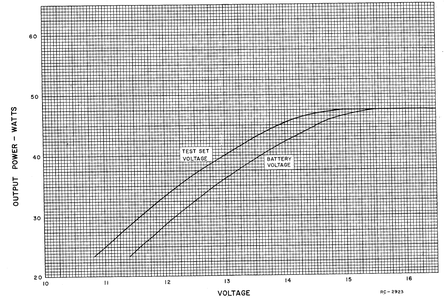


Figure 9 - 470-512 MHz Power output Setting Chart

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 (R213).

Refer to the QUICK CHECKS on the Transmitter Troubleshooting Procedure.

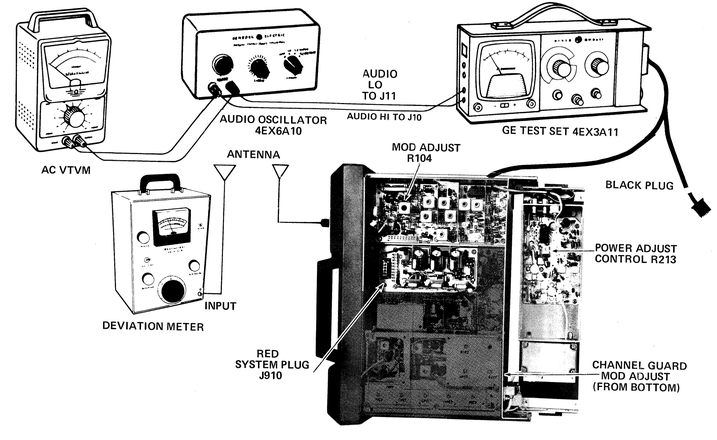
VOICE DEVIATION, SYMMETRY AND AUDIO SENSITIVITY

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 R104 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 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			
B (MULT-1)	Q102, Q103, T102	Q102, Q103	Q103, Q103, T102
C (MULT-2)	Q104, T105	T102, T103, Q104, T104	T103, T104, Q104, T105, T103
D (MULT-3)	Q105, T107	T105, T106, Q105	T105, T106, Q105, T107
F (MULT-4)	Q106, C155	Q106, T107, T108	Q106, T107, T108 L104
G (AMPL-1)	Q107, L113	Q107, C115 - C117 L107	Q107, C155 - 157 L107
A (Power Out)	W216	C8181, C190 Q107	C8181, C190, Q107 C167, C171, C175
POWER AMPLIFIER			
C (Power Control)	Q215, R213	Q215, R213	Q215, R213
"D" (AMPL-1 INPUT)		Low Output from Exciter CR201, C205	No output from Exciter CR201, C205
"F" (DRIVER CURRENT)	Q203	Q203, Low Output from Q201, Q202	Q203, Q203, Q201, Check, Pos, C & D
"G" (PA CURRENT	Q204	Q201, Q202, Q204, Q203	Q204, Q203, Q202, Q201, Q215