

**FM-5T  
FM-5TS  
5 KILOWATT  
FM BROADCAST  
TRANSMITTERS**

**July, 1999**

**IM No. 597-0033-014**

# IMPORTANT INFORMATION

## EQUIPMENT LOST OR DAMAGED IN TRANSIT.

When delivering the equipment to you, the truck driver or carrier's agent will present a receipt for your signature. Do not sign it until you have: 1) inspected the containers for visible signs of damage and 2) counted the containers and compared with the amount shown on the shipping papers. If a shortage or evidence of damage is noted, insist that notation to that effect be made on the shipping papers before you sign them.

Further, after receiving the equipment, unpack it and inspect thoroughly for concealed damage. If concealed damage is discovered, immediately notify the carrier, confirming the notification in writing, and secure an inspection report. This item should be unpacked and inspected for damage WITHIN 15 DAYS after receipt. Claims for loss or damage will not be honored without proper notification of inspection by the carrier.

## RF PRODUCT TECHNICAL ASSISTANCE – REPAIR SERVICE – REPLACEMENT PARTS.

Technical assistance is available from Broadcast Electronics by letter, prepaid telephone, fax, or E-mail. Equipment requiring repair or overhaul should be sent by common carrier, prepaid, insured, and well protected. If proper shipping materials are not available, contact the Customer Service Department for a shipping container. Do not use the mail equipment. We can assume no liability for inbound damage, and necessary repairs become the obligation of the shipper. Prior arrangement is necessary. Contact the Customer Service Department for a Return Authorization.

Emergency and warranty replacement parts may be ordered from the following address. Be sure to include the equipment model number, serial number, part description, and part number. Non-emergency replacement parts may be ordered directly from the Broadcast Electronics stock room by fax at the number shown below.

### FACILITY CONTACTS –

Broadcast Electronics, Inc. – Quincy Facility  
4100 N. 24th St. P.O. BOX 3606  
Quincy, Illinois 62305  
Telephone: (217) 224-9600  
Fax: (217) 224-9607  
E-Mail: General – [bdcast@bdcast.com](mailto:bdcast@bdcast.com)  
Web Site: [www.bdcast.com](http://www.bdcast.com)

## RF PRODUCT TECHNICAL ASSISTANCE – REPAIR – EMERGENCY/WARRANTY REPLACEMENT PARTS –

Telephone: (217) 224-9600  
E-Mail: [rfservice@bdcast.com](mailto:rfservice@bdcast.com)  
Fax: (217) 224-9607

### NON-EMERGENCY REPLACEMENT PARTS –

Fax: (217) 224-9609

## RETURN, REPAIR, AND EXCHANGES.

Do not return any merchandise without our written approval and Return Authorization. We will provide special shipping instructions and a code number that will assure proper handling and prompt issuance of credit. Please furnish complete details as to circumstances and reasons when requesting return of merchandise. All returned merchandise must be sent freight prepaid and properly insured by the customer.

## WARRANTY ADJUSTMENT.

Broadcast Electronics, Inc. warranty is included in the Terms and Conditions of Sale. In the event of a warranty claim, replacement or repair parts will be supplied F.O.B. factory. At the discretion of Broadcast Electronics, the customer may be required to return the defective part or equipment to Broadcast Electronics, Inc. F.O.B. Quincy, Illinois. Warranty replacements of defective merchandise will be billed to your account. This billing will be cleared by a credit issued upon return of the defective item.

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## MODIFICATIONS.

Broadcast Electronics, Inc. reserves the right to modify the design and specifications of the equipment in this manual without notice. Any modifications shall not adversely affect performance of the equipment so modified.

## WARNING

### OPERATING HAZARDS

READ THIS SHEET AND OBSERVE ALL SAFETY PRECAUTIONS

ALL PERSONS WHO WORK WITH OR ARE EXPOSED TO POWER TUBES, POWER TRANSISTORS, OR EQUIPMENT WHICH UTILIZES SUCH DEVICES MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS BODILY INJURY. EXERCISE EXTREME CARE AROUND SUCH PRODUCTS. UNINFORMED OR CARELESS OPERATION OF THESE DEVICES CAN RESULT IN POOR PERFORMANCE, DAMAGE TO THE DEVICE OR PROPERTY, SERIOUS BODILY INJURY, AND POSSIBLY DEATH.

#### DANGEROUS HAZARDS EXIST IN THE OPERATION OF POWER TUBES AND POWER TRANSISTORS

The operation of power tubes and power transistors involves one or more of the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel.

- A. HIGH VOLTAGE – Normal operating voltages can be deadly. Additional information follows.
- B. RF RADIATION – Exposure to RF radiation may cause serious bodily injury possibly resulting in blindness or death. Cardiac pacemakers may be affected. Additional information follows.
- C. BERYLLIUM – OXIDE POISONING – Dust or fumes from BeO ceramics used as thermal links with conduction cooled power tubes and power transistors are highly toxic and can cause serious injury or death. Additional information follows.
- D. HOT SURFACES – Surfaces of air-cooled radiators and other parts of tubes can reach temperatures of several hundred degrees centigrade and cause serious burns if touched. Additional information follows.
- E. RF BURNS – Circuit boards with RF power transistors contain high RF potentials. Do not operate an RF power module with the cover removed.

#### HIGH VOLTAGE

Many power tubes operate at voltages high enough to kill through electrocution. Personnel should always break the primary circuits of the power supply and discharge high voltage capacitors when direct access to the tube is required.

#### RADIO FREQUENCY RADIATION

Exposure of personnel to RF radiation should be minimized, personnel should not be permitted in the vicinity of open energized RF generating circuits, or RF transmission systems (waveguides, cables, connectors, etc.), or energized antennas. It is generally accepted that exposure to "high levels" of radiation can result in severe bodily injury including blindness. Cardiac pacemakers may be affected.

The effect of prolonged exposure to "low level" RF radiation continues to be a subject of investigation and controversy. It is generally agreed that prolonged exposure of personnel to RF radiation should be limited to an absolute minimum. It is also generally agreed that exposure should be reduced in working areas where personnel heat load is above normal. A 10 mW/cm<sup>2</sup> per one tenth hour average level has been adopted by several U.S. Government agencies including the Occupational Safety and Health Administration (OSHA) as the standard protection guide for employee work environments. An even stricter standard is recommended by the American National Standards Institute which recommends a 1.0 mW/cm<sup>2</sup> per one tenth hour average level exposure between 30 Hz and 300 MHz as the standard employee protection guide (ANSI C95.1-1982).

RF energy must be contained properly by shielding and transmission lines. All input and output RF connections, such as cables, flanges and gaskets must be RF leakproof. Never operate a power tube without a properly matched RF energy absorbing load attached. Never look into or expose any part of the body to an antenna or open RF generating tube or circuit or RF transmission system while energized. Monitor the tube and RF system for RF radiation leakage at regular intervals and after servicing.

#### DANGER — BERYLLIUM OXIDE CERAMICS (BeO) – AVOID BREATHING DUST OR FUMES

BeO ceramic material is used as a thermal link to carry heat from a tube or transistor to the heat sink. Do not perform any operation on any BeO ceramic which might produce dust or fumes, such as grinding, grit blasting, or acid cleaning. Beryllium oxide dust or fumes are highly toxic and breathing them can result in serious personal injury or death. BeO ceramics must be disposed of only in a manner prescribed by the device manufacturer.

#### HOT SURFACES

The anode portion of power tubes is often air-cooled or conduction-cooled. The air-cooled external surface normally operates at a high temperature (up to 200° to 300°C). Other portions of the tube may also reach high temperatures, especially the cathode insulator and the cathode/heater surfaces. All hot surfaces may remain hot for an extended time after the tube is shut off. To prevent serious burns, take care to prevent and avoid any bodily contact with these surfaces both during and for a reasonable cooling down period after tube operation.

**PUBLICATION ADDENDUM  
SPECIAL ASSEMBLY REQUIREMENTS  
FM-5T/FM-5TS TRANSMITTERS**

**1-1. INTRODUCTION.**

1-2. Due to special shipping requirements, selected components of the Broadcast Electronics FM-5T/FM-5TS transmitters have been disassembled to prevent damage during shipment. This publication addendum provides information required for the re-assembly of the transmitter IN ADDITION TO the information provided in SECTION II, INSTALLATION of FM-5T/FM-5TS instruction manual 597-0033-004. Perform the following assembly instructions prior to executing the procedures described in the instruction manual.

**1-3. SPECIAL ASSEMBLY.**

**1-4. GENERAL.**

1-5. Components removed from the transmitter contain identification tags to facilitate re-installation. Items such as interconnecting wires, cables, and miscellaneous small parts are taped or tied for shipment. Remove all tape, string, and packing material used for shipping purposes as each item is installed.

1-6. Terminal blocks and wires contain identification tags with information regarding reconnection. Mounting hardware will be placed in small bags attached to each removed component or inserted in the component mounting holes.



**WARNING**

***ENSURE NO PRIMARY POWER IS CONNECTED TO THE TRANSMITTER BEFORE PROCEEDING.***

**WARNING**

**1-7. INSTALLATION.**

1-8. **TRANSMITTER BASE PLATE.** Install components removed from the transmitter base plate by performing the following procedures. Ensure no primary power is applied to the transmitter before any component installation.

1-9. **Plate Transformer Installation.** Refer to Figure 1 and install the plate transformer as follows:

A. Using a small fork-lift, place the plate transformer on the transmitter base plate as indicated.

B. Secure the plate transformer to the transmitter base plate with four 3/8 inch bolts, flat washers, and lock washers.



**WARNING**

***ENSURE THE GROUND WIRE ON THE PLATE TRANSFORMER BASE IS PROPERLY CONNECTED TO THE CABINET GROUND STRAP.***

**WARNING**

C. Connect wire 352 from the cabinet ground strap to the plate transformer base as indicated.

D. Connect the appropriate wires to the plate transformer terminals as indicated.

1-10. **Plate Choke Installation.** Refer to Figure 1 and install the plate choke as follows:

- A. Place the plate choke on the transmitter base plate as indicated.
- B. Secure the plate choke to the transmitter base plate with four 3/8 inch bolts, flat washers, and lock washers.



**WARNING**      ***ENSURE THE GROUND WIRE ON THE PLATE CHOKE  
BASE IS PROPERLY CONNECTED TO THE CABINET  
GROUND STRAP.***

**WARNING**

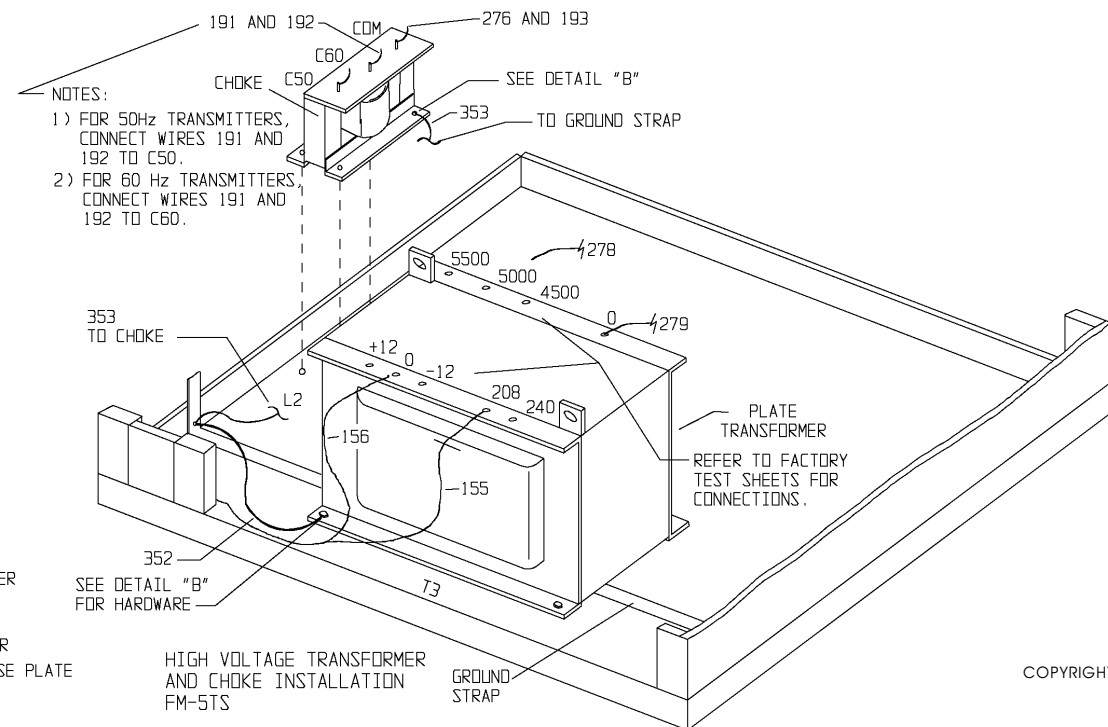
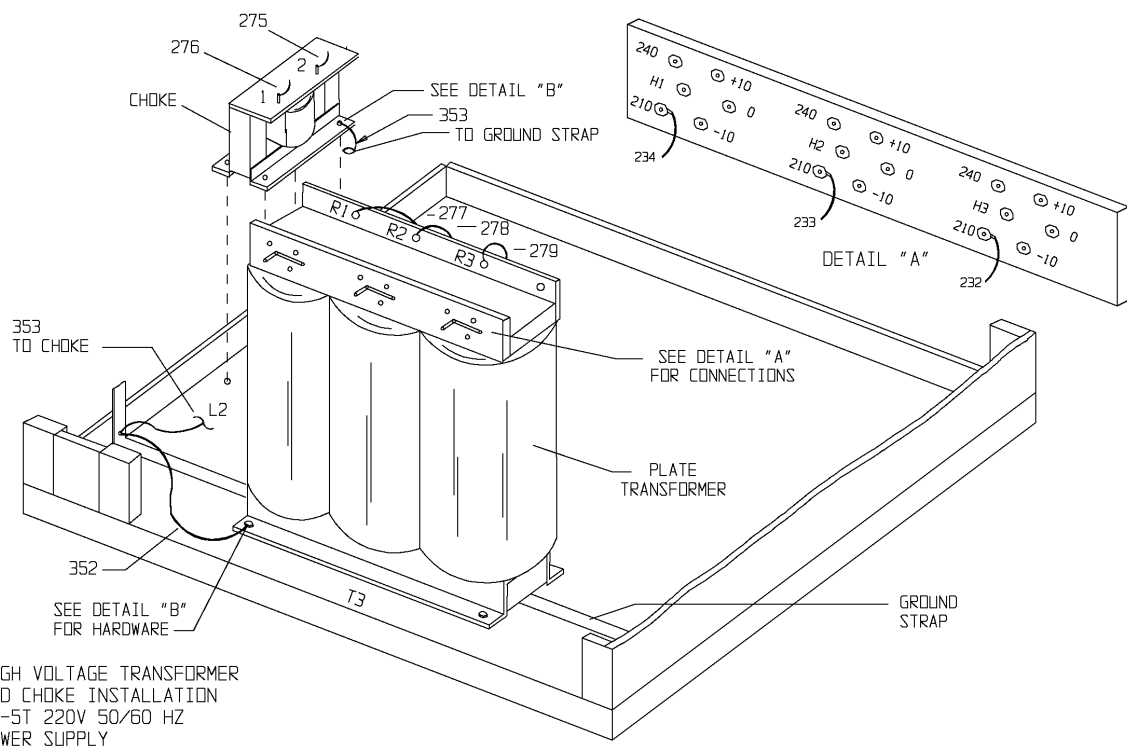
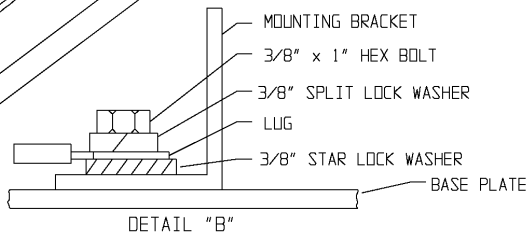
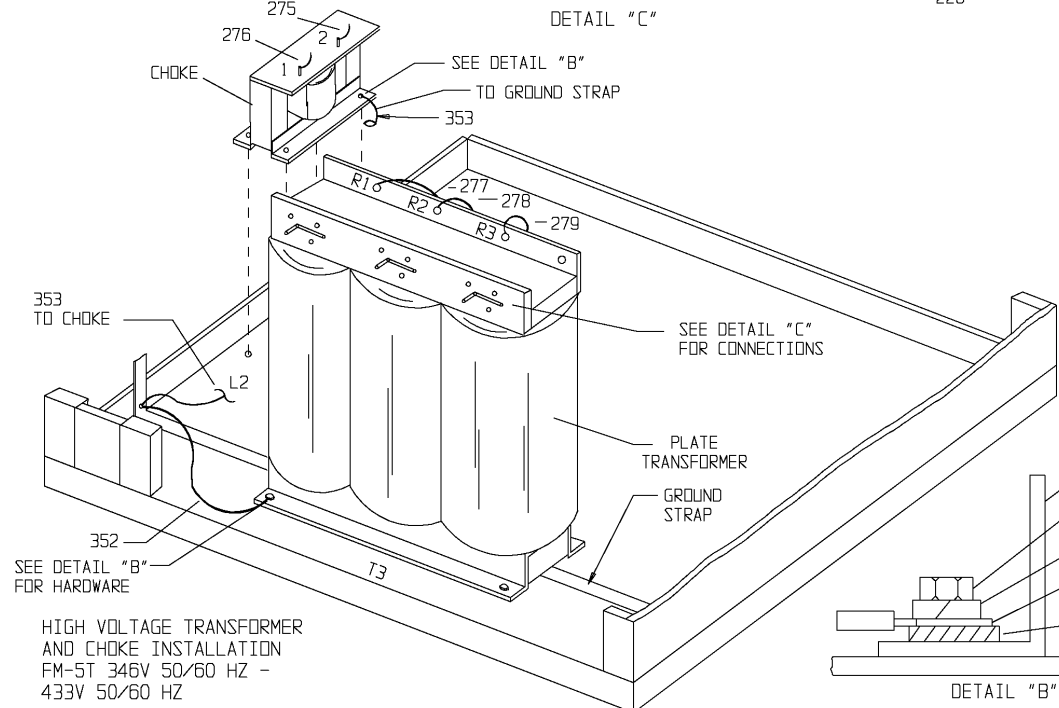
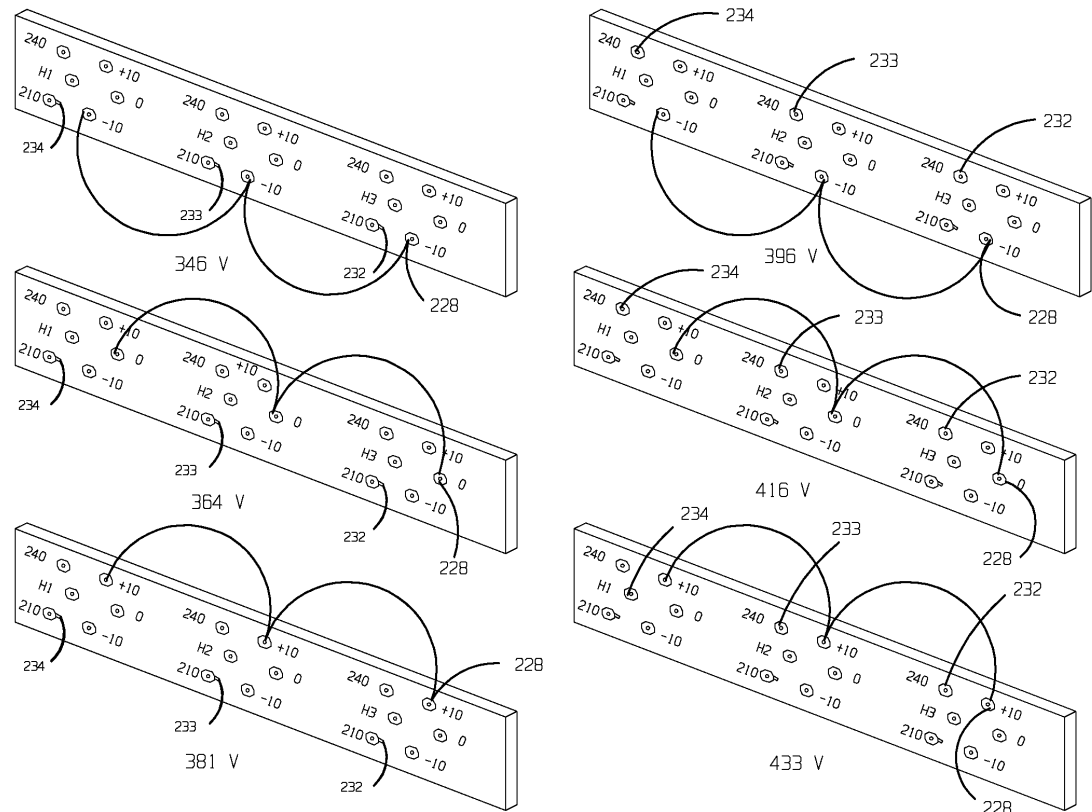
- C. Connect wire 353 from the cabinet ground strap to the plate choke base as indicated.
- D. Connect the appropriate wires to the plate choke terminals as indicated.



**WARNING**      ***ENSURE NO PRIMARY POWER IS CONNECTED TO  
THE TRANSMITTER BEFORE PROCEEDING.***

**WARNING**

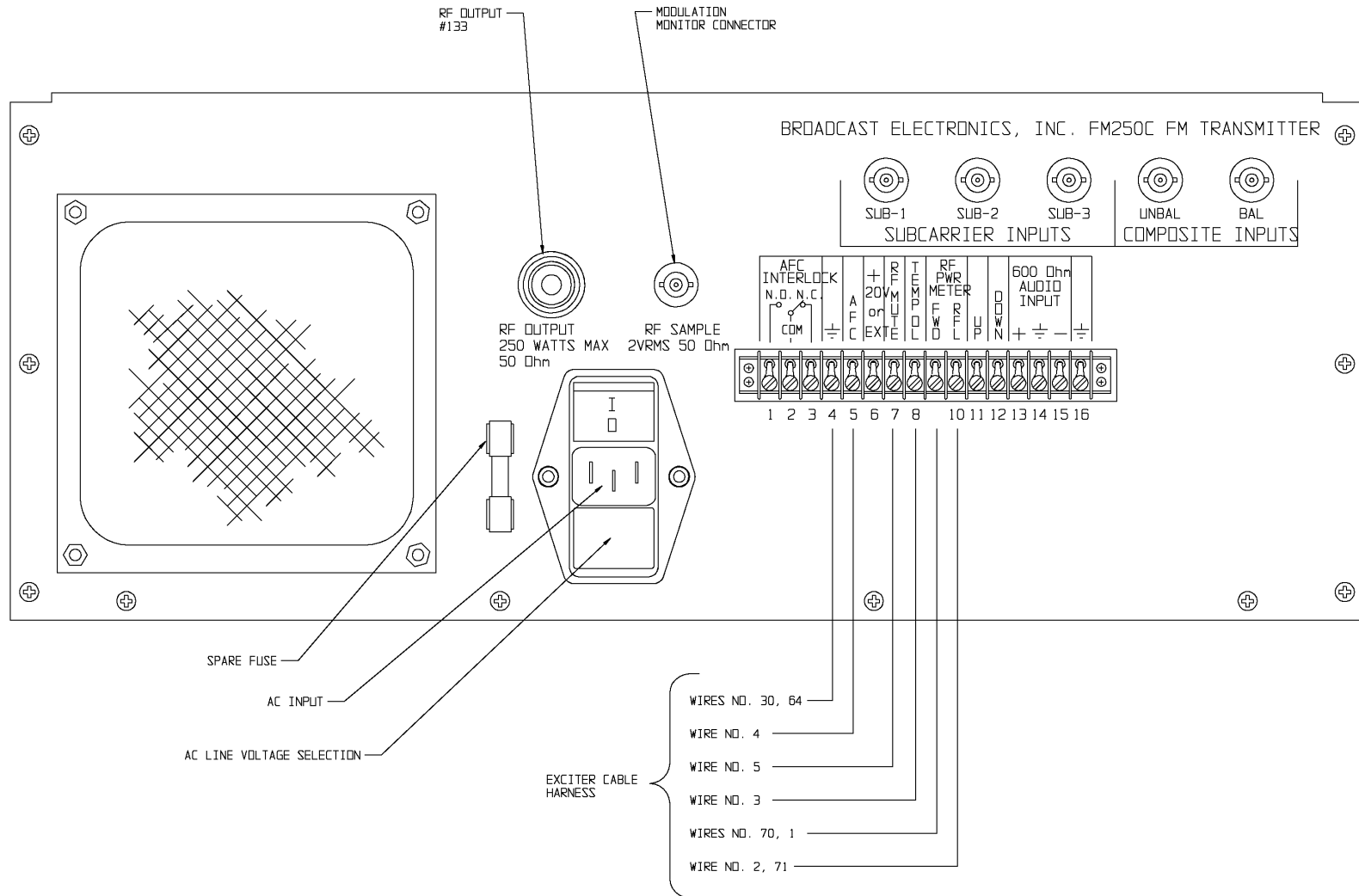
1-11. **EXCITER INSTALLATION.** Refer to Figure 2 and install the exciter. Ensure no primary power is applied before any component installation. The exciter is installed by lifting the unit onto the slide-rails.



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**FIGURE 1. HIGH VOLTAGE TRANSFORMER AND CHOKE INSTALLATION**  
(-3-/-4-)



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FIGURE 2. FM-250C REAR-PANEL CONNECTIONS

# SCOPE OF MANUAL

This manual consists of two sections providing the following information for the Broadcast Electronics FM-5T/FM-5TS 5 kW FM Broadcast Transmitters.

- A. PART I - Contains information relative to installation, operation, and maintenance applicable to the overall transmitter.
- B. PART II - Contains detailed information for the following transmitter modular units.

## TRANSMITTER CONTROLLER

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# SECTION I

## GENERAL INFORMATION

### 1-1. INTRODUCTION.

- 1-2. Information presented by this section provides a general description of the FM-5T/FM-5TS FM transmitters and lists equipment specifications.

### 1-3. RELATED PUBLICATIONS.

- 1-4. The following list of publications provides data for equipment associated with the FM-5T/FM-5TS transmitters.

PUBLICATION NUMBER	EQUIPMENT
597-1004	FM-250C FM Exciter
597-0008-004	FC-30 SCA Generator
597-9900	LYNX FM Digital Stereo Generator
597-8000	PREDATOR FM Digital Exciter

### 1-5. EQUIPMENT DESCRIPTION.

- 1-6. The Broadcast Electronics FM-5T/FM-5TS are 5 kW FM Transmitters designed for continuous operation in the 87.5 MHz to 108 MHz FM broadcast band. The RF power amplifier, FM exciter, and the control circuitry are housed in a single cabinet (see Figure 1-1). Specific transmitter features include: 1) a folded half wave cavity PA stage, 2) a microprocessor control system, and 3) a 250 watt solid-state exciter with a digital frequency synthesizer. The following text presents ordering information for various transmitter configurations, optional equipment, and recommended spare parts kits.

### 1-7. TRANSMITTER CONFIGURATIONS.

- 1-8. The FM-5T/FM-5TS transmitters may be ordered in the following configurations.

MODEL NO.	PART NUMBER	DESCRIPTION
FM-5T	909-5000-215	FM-5T 5 kW FM transmitter complete with FM-250C FM Exciter, 208/240V ac three phase 60 Hz operation.
FM-5T	909-5000-315	FM-5T 5 kW FM transmitter complete with FM-250C FM Exciter, 208/240V ac three phase 50 Hz operation.
FM-5T	909-5000-385	FM-5T 5 kW FM transmitter complete with FM-250C FM Exciter, 339V/437V ac three phase 50 Hz operation.
FM-5TS	909-5000-255	FM-5T 5 kW FM transmitter complete with FM-250C FM Exciter, 208/240V ac single phase 60 Hz operation.
FM-5TS	909-5000-355	FM-5T 5 kW FM transmitter complete with FM-250C FM Exciter, 208/240V ac single phase 50 Hz operation.

### 1-9. OPTIONAL EQUIPMENT AND SPARE PARTS KITS.

- 1-10. The following optional equipment and spare parts kits are available for use in the FM-5T/FM-5TS transmitters:

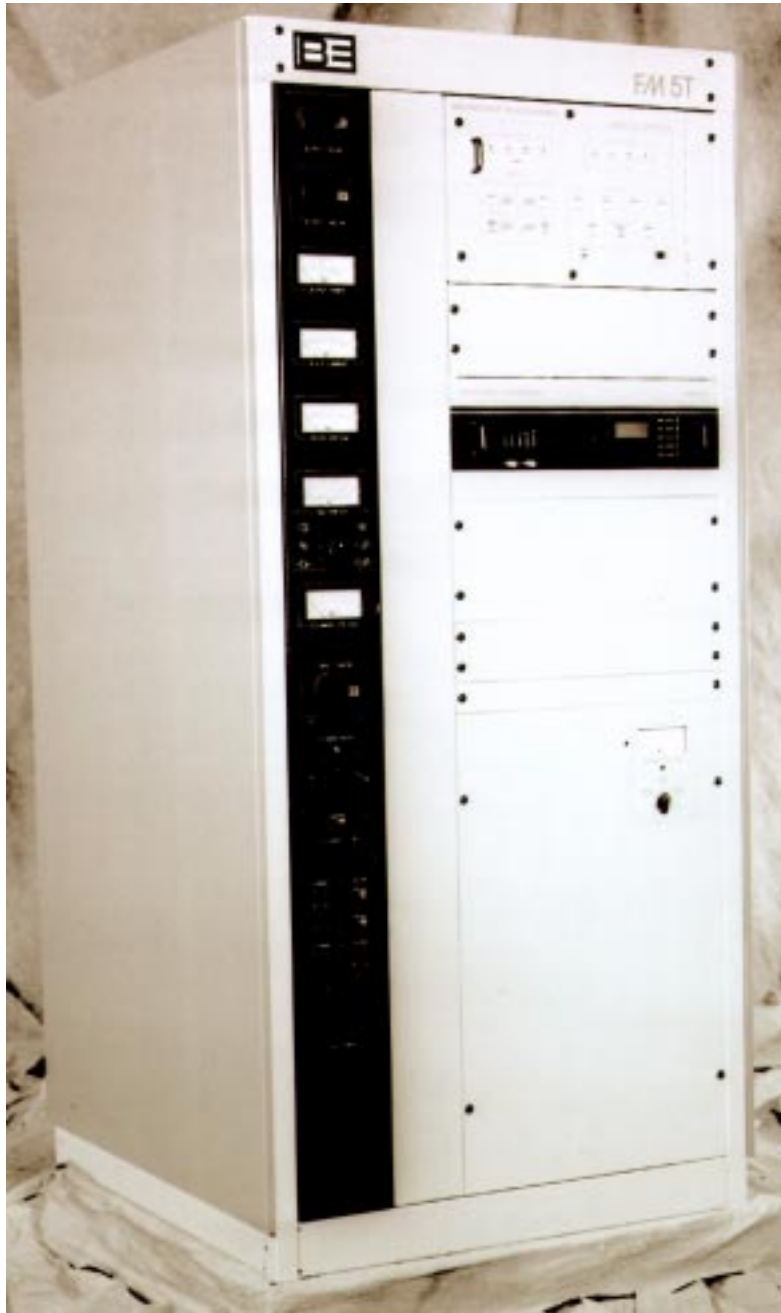
<b>PART NUMBER</b>	<b>DESCRIPTION</b>
909-9000	LYNX FM digital stereo generator.
909-0051-204	FC-30 FM SCA generator.
909-8250	PREDATOR 250 Watt FM Digital Exciter And Digital Input.
909-8251	PREDATOR 250 Watt FM Digital Exciter And Analog Input.
909-8252	PREDATOR 250 Watt FM Analog Exciter And Analog Input.
907-0016-034	VMC-16 Voice Remote Control Unit, FM-5T.
907-0016-094	VMC-16 Voice Remote Control Unit, FM-5TS.
979-0035-004	Recommended spare parts kit for the FM-5T/ FM-5TS and the FX-50 exciter. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979-0095	Recommended semiconductor kit for the FM-5T/FM-5TS and FM-250 exciter.
979-0095-005	Recommended semiconductor kit for the FM-5T/FM-5TS transmitter only. Does not include exciter spare semiconductors.
979-0095-015	Recommended spare parts kit for the FM-5T/ FM-5TS transmitters only. Includes selected meters, switches, relays, etc. Does not include semiconductors.
979-0034-014	Recommended spare HV rectifier kit for the FM-5T/FM-5TS transmitters.

1-11. **EQUIPMENT SPECIFICATIONS.**

1-12. Refer to Table 1-1 for electrical specifications or Table 1-2 for physical specifications of the FM-5T/FM-5TS FM Transmitters.

**TABLE 1-1. ELECTRICAL CHARACTERISTICS**  
(Sheet 1 of 3)

<b>PARAMETER</b>	<b>SPECIFICATIONS</b>
RF POWER OUTPUT	2500 to 5500 Watts (as ordered).
RF FREQUENCY RANGE	87.5 to 108 MHz (as ordered). Exciter program- mable in 10 kHz increments.
RF OUTPUT IMPEDANCE	50 Ohms, Resistive (others available by special request).
RF OUTPUT CONNECTOR	1 5/8 Inch (4.13 cm) EIA flange.
MAXIMUM VSWR	1.8:1 (Will operate into higher VSWR with auto- matic power reduction).
TUBE COMPLEMENT	4CX3500A (1).



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**597-0033-1**

**FIGURE 1-1. FM-5T/FM-5TS TRANSMITTER**

**TABLE 1-1. ELECTRICAL CHARACTERISTICS**  
(Sheet 2 of 3)

PARAMETER	SPECIFICATIONS
FM SIGNAL-TO-NOISE RATIO:	
Mono/Composite	82 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
Stereo	78 dB below 100% modulation at 400 Hz measured in a 20 Hz to 30 kHz bandwidth with 75 us deemphasis.
AM SIGNAL-TO-NOISE RATIO:	
Asynchronous	55 dB below equivalent reference carrier with 100% AM at 400 Hz, 75 us deemphasis (no FM modulation present).
Synchronous	40 dB below equivalent 5 kW reference carrier with 100% AM at 1 kHz, no deemphasis (FM modulation $\pm 75$ kHz at 1 kHz).
RF HARMONIC SUPPRESSION	Meets all FCC/DOC requirements and CCIR recommendations.
POWER SUPPLY RECTIFIERS	Silicon.
DISTORTION	
Mono/Composite	
Harmonic	0.03% or less at 400 Hz.
SMPTE Intermodulation Distortion	0.05% or less, 60 Hz/7 kHz, Ratio: 4:1 Monophonic, 1:1 Composite.
CCIF Intermodulation Distortion	
Mono	0.02% or less, 15 kHz/14 kHz, 1:1 Ratio.
Composite	0.03% or less, 15 kHz/14 kHz, 1:1 Ratio.
Transient Intermodulation Distortion	0.02% or less, Sine Wave/Square Wave.
Stereo	
Harmonic	0.03% or less at 400 Hz.
SMPTE Intermodulation Distortion	0.05% or less, 60 Hz/7 kHz, 4:1 Ratio.
CCIF Intermodulation Distortion	0.02% or less, 15 kHz/14 kHz, 1:1 Ratio.
Transient Intermodulation Distortion	0.05% or less, Sine Wave/Square Wave.

**TABLE 1-1. ELECTRICAL CHARACTERISTICS**  
(Sheet 3 of 3)

PARAMETER	SPECIFICATIONS
STEREO SEPARATION	50 dB or better, 30 Hz to 15 kHz.
DYNAMIC STEREO SEPARATION	40 dB or better, 30 Hz to 15 kHz (normal program content).
LINEAR CROSSTALK (Main to Sub/Sub to Main Due to Phase Matching)	45 dB minimum below 100% modulation, 30 Hz to 15 kHz.
NON-LINEAR CROSSTALK (Main to Sub/Sub to Main Due to Distortion Products)	70 dB minimum below 100 % modulation.
AC INPUT POWER:	
FM-5T	196 to 252V ac 50/60 Hz or 341V to 435V ac 50 Hz three phase closed-delta or wye (as specified), 28 amperes per phase maximum.
FM-5TS	196 to 252V ac 50/60 Hz single phase (as speci- fied), 55 amperes maximum.
AC POWER CONSUMPTION	
FM-5T	8500 Watts typical at a 5 kW RF power output, 0.92 power factor.
FM-5TS	9600 Watts typical at a 5 kW RF power output, 0.98 power factor.
OVERALL EFFICIENCY	
FM-5T	58% Typical (ac line input to RF output).
FM-5TS	52% Typical (ac line input to RF output).

**TABLE 1-2. PHYSICAL CHARACTERISTICS**  
(Sheet 1 of 2)

PARAMETER	SPECIFICATIONS
AMBIENT TEMPERATURE RANGE	+14°F to +122°F (-10°C to +50°C).
MAXIMUM ALTITUDE	
60 Hz Models	0 to 10,000 Feet above sea level (0 to 3048 Meters).
50 Hz Models	0 to 7500 Feet above sea level (0 to 2286 Meters).



**TABLE 1-2. PHYSICAL CHARACTERISTICS**  
**(Sheet 2 of 2)**

PARAMETER	SPECIFICATIONS
MAXIMUM HUMIDITY	95%, Non-condensing.
HEAT DISSIPATION	3500 Watts maximum (11,945 BTU/Hr) at 5000 Watts output.
COOLING AIR REQUIREMENT	800 ft <sup>3</sup> /min overall (22.6 m <sup>3</sup> /min).
SIZE:	
WIDTH	34.5 Inches (87.63 cm).
DEPTH	37.25 Inches (94.61 cm).
HEIGHT	70 Inches (177.8 cm).
WEIGHT:	
UNPACKED	1,000 Pounds (454 kg).
PACKED	1,200 Pounds (544 kg).
CUBAGE	60 Cubic Feet (1.7 m <sup>3</sup> ).

## SECTION II INSTALLATION

### 2-1. INTRODUCTION.

- 2-2. This section contains information required for installation and preliminary checkout of the Broadcast Electronics FM-5T/FM-5TS FM Transmitters.

### 2-3. UNPACKING.

- 2-4. The equipment becomes the property of the customer when the equipment is delivered to the carrier. Carefully unpack the transmitter. Perform a visual inspection to determine that no apparent damage has been incurred during shipment. All shipping materials should be retained until it is determined that the unit has not been damaged. Claims for damaged equipment must be promptly filed with the carrier or the carrier may not accept the claim.
- 2-5. The contents of the shipment should be as indicated on the packing list. If the contents are incomplete, or if the unit is damaged electrically or mechanically, notify both the carrier and Broadcast Electronics, Inc.

### 2-6. ENVIRONMENTAL REQUIREMENTS.

- 2-7. Table 1-2 provides environmental conditions which must be considered prior to transmitter installation.

### 2-8. COOLING AIR REQUIREMENTS.

- 2-9. If outside air is to be used to cool the transmitter, the air inlet duct must be sized to allow adequate air flow. The air must be dry and well filtered. If intake louvers are used, operation of the louvers must be electrically interlocked with the transmitter operation.
- 2-10. If the heated transmitter air is to be ducted from the room, the duct system must not introduce any back-pressure on the equipment. Proper allowances for air flow will ensure that only a limited amount of heat is dissipated into the equipment interior. The duct system must allow for a minimum air flow of 800 cubic feet of air per minute (22.6 m<sup>3</sup>/min).
- 2-11. As a minimum requirement, any duct work must have a cross-sectional area equal to the exhaust area of the cabinet (refer to Figure 2-1). Sharp bends in the duct system will introduce back pressure and are not permissible. A radius bend must be used if a right angle turn is required. An exhaust fan may be used to overcome duct losses or overcome wind pressures if the duct is vented to the outside.

### 2-12. INSTALLATION.

- 2-13. Each transmitter is wired, operated, tested and inspected at the factory prior to shipment and is ready for installation when received. Prior to installation, this publication should be studied to obtain an understanding of the operation, circuitry nomenclature, and installation requirements. Installation is accomplished as follows: 1) placement, 2) component installation, 3) remote control connections, 4) wiring, and 5) initial checkout.

### 2-14. PRIMARY AC POWER.

- 2-15. **FM-5T.** The FM-5T transmitter is designed for operation from a closed-delta or wye connected three-phase source. Operation from an unsatisfactory power source will void the warranty on this transmitter as any resultant damage is beyond the control of the manufacturer. Before attempting installation of the transmitter, assure that the proper power source is installed. Acceptable power input configurations are shown in Figure 2-2.

- 2-16. An open-delta, V to V, T to T, T to L, or Scott connected power source will provide unsatisfactory transmitter performance as transients and unstable power can damage components of the FM-5T and degrade transmitter specifications. Any of these systems will develop a considerable imbalance between phases in voltage, phase angle, or both voltage and phase angle. These problems can result in premature failure of power supply and RF circuit components.
- 2-17. It is important that the local electric utility be consulted to ensure that the correct service is provided before connection of the FM-5T transmitter to a primary power source. The proper power source can readily be identified by the use of three transformers with one winding each or one transformer with three windings instead of the use of two transformers as required for the unacceptable configurations.
- 2-18. **FM-5TS.** The FM-5TS transmitter is designed for operation from a 220V ac 50/60 Hz single phase power source. Consult the local electric utility company to ensure that the correct service is provided before connection of the transmitter to the primary power source.
- 2-19. **EQUIPMENT PLACEMENT.**
- 2-20. Access holes in the top and bottom of the cabinet allow either overhead or under-floor ducting of interconnecting wiring (see Figure 2-1). The floor must be capable of supporting the total transmitter weight of approximately 130 pounds per square foot. The floor support should be more than marginal to maintain the proper cabinet alignment and reduce vibration.
- 2-21. After it has been determined where and how the cabinet will be positioned, set the cabinet in place on a smooth and level location.
- 2-22. **COMPONENT INSTALLATION.**



**WARNING**

***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**

- 2-23. Interconnecting wires and cables are tied in for shipment. Remove all tape, wire ties, string, and packing material used for shipment. Remove the cover from the FAILSAFE SOLENOID ASSEMBLY and cut loose all tie wraps, freeing the plunger. A No. 2 Phillips screwdriver is required. Replace the cover. Also, remove all ties from the shorting stick hanger.
- 2-24. Cables, connectors, and miscellaneous components to be installed are shipped in separate containers. The following text provides information concerning the installation of these items.

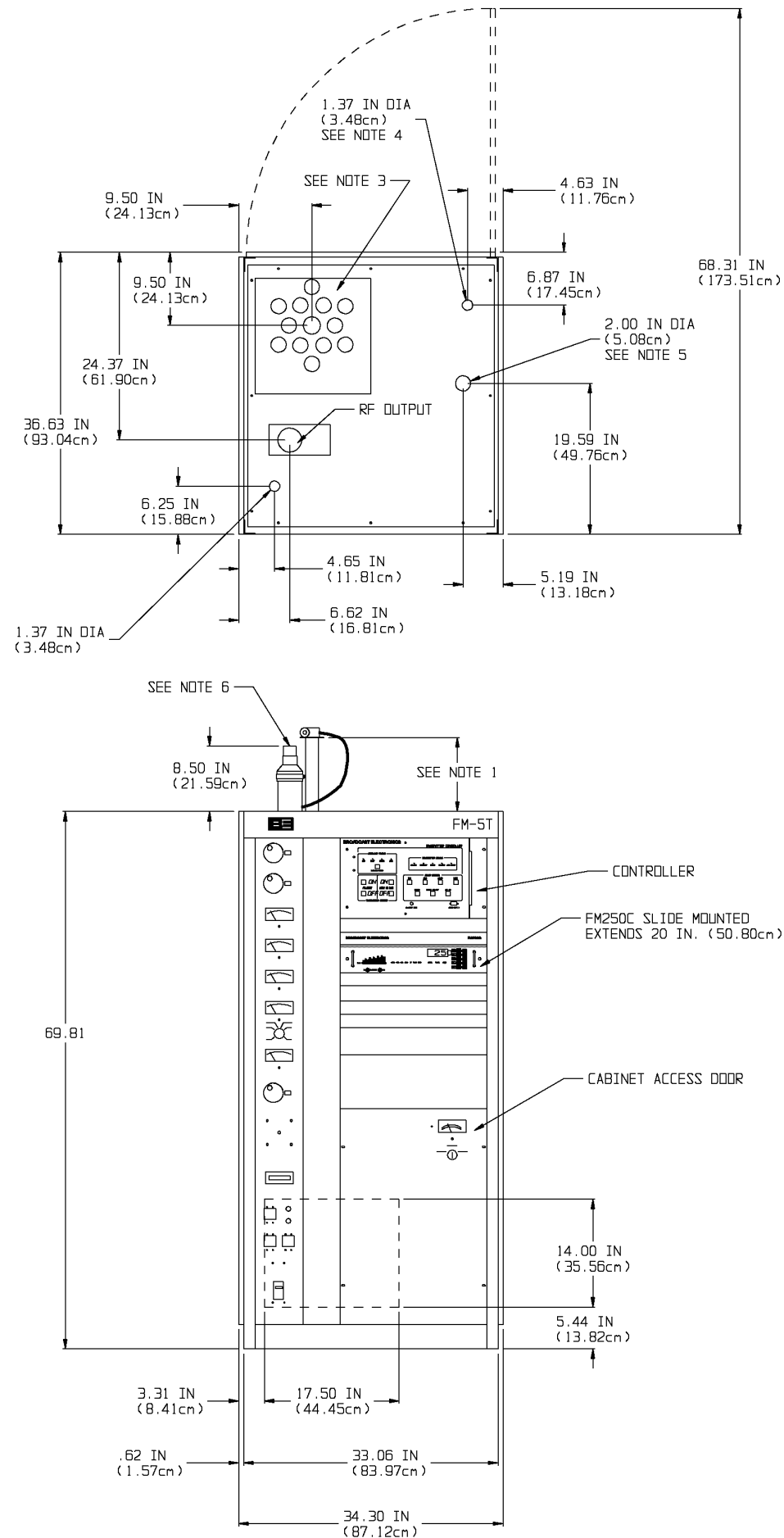


**NOTE**

***ENSURE ADJUSTMENTS ARE NOT MOVED FROM THEIR FACTORY PRESET POSITIONS DURING INSTALLATION.***

**NOTE**

- 2-25. Connect the antenna to the transmitter. A 1 5/8 inch EIA flange is provided with the transmitter to assist installation. The flange can remain off if unflanged connections are desired. A center conductor bullet may be required (BE P/N 427-0009).
- 2-26. Open the transmitter rear door.
- 2-27. Remove the lower front access panel. A 5/32 inch hex key is shipped with the transmitter for this purpose.



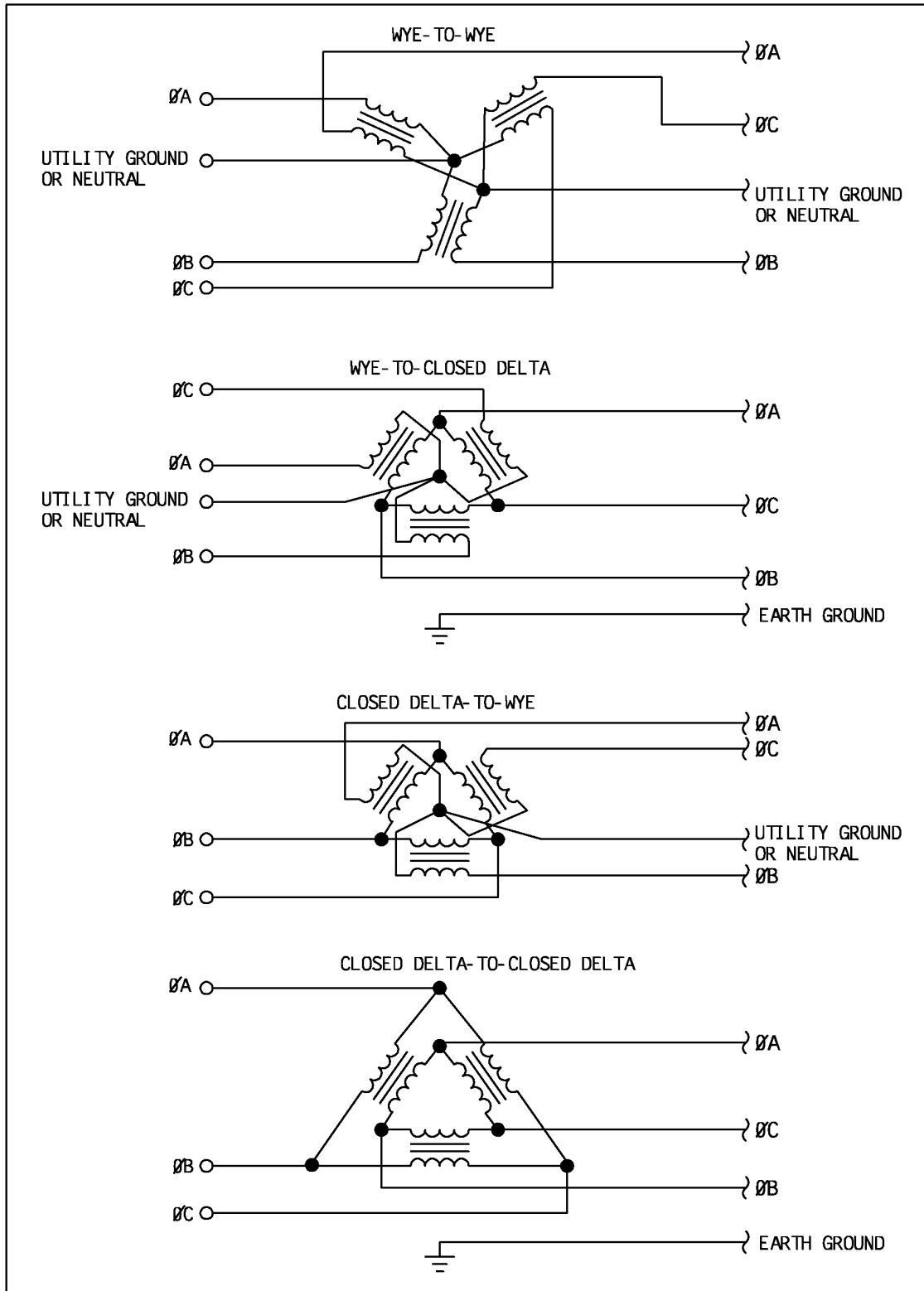
#### NOTES:

1. TUNING LINE HEIGHT (DETERMINED BY TRANSMITTER FREQUENCY):  
MAXIMUM: 11 INCHES (27.94cm), FREQUENCY: 108 MHz.  
MINIMUM: 1 INCH (2.54cm), FREQUENCY: 87.5 MHz.
2. AIR INLET, FILTER REQUIRED (BE P/N 407-0062).  
LOCATION: REAR OF PA/DRIVER CABINET  
DIMENSIONS:  
WIDTH: 17.5 INCHES (44.5cm).  
HEIGHT: 14 INCHES (35.6cm).
3. AIR OUTLET:  
LOCATION: TOP OF PA/DRIVER CABINET
4. ACCESS FOR A.C. POWER THROUGH 1 3/8" (3.47cm) DIA. HOLE IN TOP COVER IN REAR. GROUND STRAP ENTRY POINT IN LOWER RIGHT CORNER.
5. ACCESS FOR REMOTE CONTROL AND AUDIO CONNECTIONS THROUGH 2" (5.08cm) DIA. HOLE IN BASEPLATE OR THROUGH EITHER 1 3/8" (3.47cm) DIA. HOLE TOP COVER.
6. RF OUTPUT CONNECTION: 1.625 INCH (4.13cm) EIA 50 OHM COUPLING, 1.625 FEMALE EIA FLANGE, OR 1.625 MALE EIA FLANGE.
7. CUBAGE:  
PA/DRIVER CABINET: 53.0 CUBIC FEET (1.5m<sup>3</sup>)
8. WEIGHT: 1000 LBS. (455kg).
9. FLOOR: 121 POUNDS PER SQUARE FOOT (MAX.)
10. HEAT DISSIPATION (5 kW OUTPUT):  
FM-5T: 3.5 kW (11,995 BTU/H)  
FM-5TS: 4.6 kW (15,700 BTU/H)
11. COOLING AIR REQUIREMENTS: 800 CUBIC FEET PER MINUTE (22.6m<sup>3</sup>/MIN).
12. AC INPUT:  
THREE PHASE: 196-252 VAC, 3 WIRE, 3 PHASE AT 40 AMPERES PER PHASE MAXIMUM LINE CURRENT, 60 Hz WITH 909-5000-215 (50 Hz WITH 909-5000-315). 909-5000-385 REQUIRES 340-436 PHASE TO PHASE VAC, 50 Hz, 4 WIRE, 3 PHASE AT 40 AMPERES PER PHASE MAXIMUM LINE CURRENT. FUSED DISCONNECT SWITCH RECOMMENDED. FOR PROPER SIZING OF FUSES REFER TO NATIONAL ELECTRICAL CODE OR LOCAL CODES.  
SINGLE PHASE: 196-252 VAC, 60 Hz, SINGLE PHASE AT 55 AMPERES MAXIMUM LINE CURRENT WITH 909-5000-255 (50Hz WITH 909-5000-355). FUSED DISCONNECT SWITCH RECOMMENDED. FOR PROPER SIZING OF FUSES REFER TO NATIONAL ELECTRICAL CODE OR LOCAL CODES.
13. POWER CONSUMPTION:  
FM-5T: 8.5 kW AT A 5 kW RF POWER OUTPUT.  
0.92 POWER FACTOR  
FM-5TS: 9.6 kW AT A 5 kW RF POWER OUTPUT.  
0.98 POWER FACTOR

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**FIGURE 2-1. FM-5T/FM-5TS TRANSMITTER INSTALLATION**  
(2-3/2-4)



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**FIGURE 2-2. ACCEPTABLE AC POWER INPUT CONFIGURATIONS**

- 2-28. Open the cavity access door.
- 2-29. Disconnect the plate line B+ banana plug along the right side of the plate line.
- 2-30. Remove all tape and shims from the plate line at the shelf to free the plate line. Raise and rotate the plate line to lock the plate line in the up position.
- 2-31. Carefully remove all packing material from over the tube socket.
- 2-32. Carefully install the PA tube with a steady downward pressure. Do not rotate or rock the tube during installation or the tube socket may be damaged.
- 2-33. After the PA tube is fully seated, rotate and lower the fixed portion of plate line over the PA tube. Slowly lower the fixed portion of plate line down with both hands until the plate line stops contact with the cavity shelf.
- 2-34. Reconnect the plate RF choke banana plug into the plate line and verify that the choke is straight and perpendicular to the line with all connections secure. The plate line may be rotated as required. The choke turns do not touch when properly aligned.
- 2-35. Secure the plate line to the tube with the strap clamp provided until the line does not slip from the PA tube when upward pressure is applied. A flat-blade screwdriver with a 1/4 inch tip is required.
- 2-36. Close and latch the cavity access door.
- 2-37. On top of the cavity, loosen the PA tuning line clamp. A flat-blade screwdriver with a 1/4 inch (0.64 cm) tip is required.
- 2-38. Raise the PA tuning line until the scribed line is aligned with the top of the cavity clamping flange. Ensure the tuning line is perpendicular to the top of the cabinet and secure the strap clamp.
- 2-39. Ensure the coarse PA input tuning cyclometer on the rear of the PA input enclosure is set to the value listed on the factory final test data sheets and the control is locked.
- 2-40. Remove the slide retainers from the exciter.
- 2-41. Loosen the exciter front-panel turn-lock fasteners and extend the unit forward.
- 2-42. Loosen the eight turn-lock fasteners on top of the exciter and remove the top cover.
- 2-43. Remove any packing material from the inside of the exciter.
- 2-44. Ensure the **POS-MUTE-NEG** switch on the power supply/control circuit board is operated to POS.
- 2-45. Ensure the **NORM-EXT** switch is operated to **NORM**.
- 2-46. Refer to the final test data sheets shipped with the transmitter and ensure the AFC/PLL assembly SYNTHESIZER FREQUENCY SELECTION switches are correctly positioned.
- 2-47. Replace the exciter top-panel.
- 2-48. **Optional Equipment.** If the transmitter is equipped with the optional LYNX stereo generator and the FC-30 SCA generator, refer to the LYNX and FC-30 instruction manuals and perform any unpacking and programming checks described in SECTION II, INSTALLATION.
- 2-49. **REMOTE CONTROL.**
- 2-50. The FM-5T/FM-5TS transmitters are designed for complete remote control operations (refer to Figure 2-3). The transmitters will interface with almost any remote control unit such as the Broadcast Electronics VMC-16 Voice Remote Control System. The following text presents a description of the FM-5T/FM-5TS remote control functions and indications. The remote control connections are located on the transmitter remote interface panel (refer to Figure 2-3).

# TB1 PIN DESCRIPTIONS

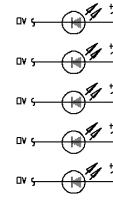
① APC ON COMMAND	<p>* AUTOMATIC POWER CONTROL ON CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO OPERATE APC ON.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO OPERATE APC ON.</p>	
② FILAMENT ON COMMAND	<p>* FILAMENT ON CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO ENABLE THE FILAMENTS.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO ENABLE THE FILAMENTS.</p>	
③ FILAMENT OFF COMMAND	<p>* FILAMENT OFF CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO DISABLE THE FILAMENTS.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO DISABLE THE FILAMENTS.</p>	
④ HIGH VOLTAGE ON COMMAND	<p>* HIGH VOLTAGE ON CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO ENABLE THE HIGH VOLTAGE.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO ENABLE THE HIGH VOLTAGE.</p>	
⑤ HIGH VOLTAGE OFF COMMAND	<p>* HIGH VOLTAGE OFF CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO DISABLE THE HIGH VOLTAGE.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO DISABLE THE HIGH VOLTAGE.</p>	
⑥ RAISE PA PWR COMMAND	<p>* TRANSMITTER RAISE POWER CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO RAISE TRANSMITTER POWER.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO RAISE TRANSMITTER POWER.</p>	
⑦ LOWER PA PWR COMMAND	<p>* TRANSMITTER LOWER POWER CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO LOWER TRANSMITTER POWER.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO LOWER TRANSMITTER POWER.</p>	
⑧ PRESET PA PWR COMMAND	<p>* PRESET POWER ON CONTROL</p> <p>POSITIVE CONTROL - SUSTAINED CONTACT TO +5 TO +15VDC REQUIRED TO ENABLE PRESET POWER.</p> <p>NEGATIVE CONTROL - SUSTAINED CONTACT TO GROUND REQUIRED TO ENABLE PRESET POWER.</p>	
⑨ OVERLOAD RESET COMMAND	<p>* OVERLOAD RESET CONTROL</p> <p>POSITIVE CONTROL - MOMENTARY CONTACT TO +5 TO +15VDC REQUIRED TO RESET THE OVERLOAD CIRCUIT.</p> <p>NEGATIVE CONTROL - MOMENTARY CONTACT TO GROUND REQUIRED TO RESET THE OVERLOAD CIRCUIT.</p>	
⑩ NO CONNECTION		
⑪ NO CONNECTION		
⑫ NO CONNECTION		
⑬ NO CONNECTION		
⑭ NO CONNECTION		
⑮ APC ON STATUS	APC ON INDICATION. LOW (0 VDC) WHEN ACTIVE	
⑯ FILAMENT ON STATUS	FILAMENT ON INDICATION. LOW (0 VDC) WHEN ACTIVE	
⑰ REMOTE DISABLE STATUS	REMOTE DISABLE INDICATION. LOW (0 VDC) WHEN ACTIVE	
⑱ HIGH VOLTAGE ON STATUS	HIGH VOLTAGE ON INDICATION. LOW (0 VDC) WHEN ACTIVE.	
⑲ PLATE OVERLOAD STATUS	PLATE OVERLOAD INDICATION. LOW (0 VDC) WHEN ACTIVE.	
⑳ SCREEN OVERLOAD STATUS	SCREEN OVERLOAD INDICATION. LOW (0 VDC) WHEN ACTIVE.	
㉑ GRID OVERLOAD STATUS	GRID OVERLOAD INDICATION. LOW (0 VDC) WHEN ACTIVE.	
㉒ VSWR OVERLOAD STATUS	VSWR OVERLOAD INDICATION. LOW (0 VDC) WHEN ACTIVE.	
㉓ OVERLOAD STATUS	OVERLOAD CIRCUIT INDICATION. LOW (0 VDC) WHEN ACTIVE.	
㉔ PRESET STATUS	PRESET POWER INDICATION. LOW (0 VDC) WHEN ACTIVE.	
㉕ NO CONNECTION		

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FIGURE 2-3. REMOTE CONTROL INTERFACING (SHEET 1 OF 2)

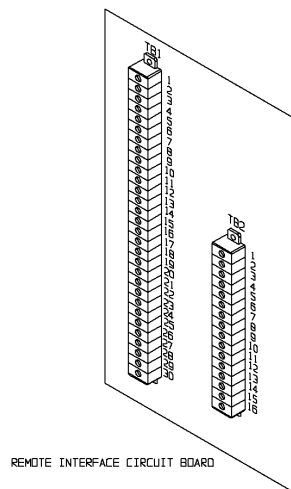
# TB1 PIN DESCRIPTIONS

- |                          |  |
|--------------------------|--|
| (26) FAILSAFE STATUS     | FAILSAFE INTERLOCK INDICATION.<br>LOW (0 VDC) WHEN ACTIVE. |
| (27) INTERLOCK STATUS    | INTERLOCK INDICATION.<br>LOW (0 VDC) WHEN ACTIVE.          |
| (28) BLOWER STATUS       | BLOWER ON INDICATION.<br>LOW (0 VDC) WHEN ACTIVE.          |
| (29) FILAMENT STATUS     | FILAMENT ON INDICATION.<br>LOW (0 VDC) WHEN ACTIVE.        |
| (30) HIGH VOLTAGE STATUS | HIGH VOLTAGE ON INDICATION.<br>LOW (0 VDC) WHEN ACTIVE.    |



# TB2 PIN DESCRIPTIONS

- |                        |   |                |
|------------------------|---|----------------|
| (1) FWD PWR OUT        | <p>== TRANSMITTER FORWARD POWER METER OUTPUT.<br/>+2V OR +4 VDC FULL SCALE INDICATION<br/>+2V = INSTALL JUMPER P12 IN POSITION 2-3<br/>+4V = INSTALL JUMPER P12 IN POSITION 1-2<br/>LOG OR LINEAR FORMAT. LOG = INSTALL JUMPER<br/>IN JB PINS 15-16. LINEAR = REMOVE JUMPER<br/>FROM JB PINS 15-16. METER GROUND RECOMMENDED.</p>   | +2 OR +4 VDC   |
| (2) RFL PWR OUT        | <p>== TRANSMITTER REFLECTED POWER METER OUTPUT.<br/>+2V OR +4 VDC FULL SCALE INDICATION<br/>+2V = INSTALL JUMPER P13 IN POSITION 2-3<br/>+4V = INSTALL JUMPER P13 IN POSITION 1-2<br/>LOG OR LINEAR FORMAT. LOG = INSTALL JUMPER<br/>IN JB PINS 15-16. LINEAR = REMOVE JUMPER<br/>FROM JB PINS 15-16. METER GROUND RECOMMENDED.</p> | +2 OR +4 VDC   |
| (3) IPA FWD PWR OUT    | <p>== IPA FORWARD POWER METER OUTPUT.<br/>+2V OR +4 VDC FULL SCALE INDICATION<br/>+2V = INSTALL JUMPER P14 IN POSITION 2-3<br/>+4V = INSTALL JUMPER P14 IN POSITION 1-2<br/>LOG OR LINEAR FORMAT. LOG = INSTALL JUMPER<br/>IN JB PINS 15-16. LINEAR = REMOVE JUMPER<br/>FROM JB PINS 15-16. METER GROUND RECOMMENDED.</p>           | +2 OR +4 VDC   |
| (4) PLATE VOLTAGE OUT  | <p>== PLATE VOLTAGE METER OUTPUT.<br/>+2V OR +4 VDC FULL SCALE INDICATION<br/>+2V = INSTALL JUMPER P10 IN POSITION 2-3<br/>+4V = INSTALL JUMPER P10 IN POSITION 1-2<br/>LOG OR LINEAR FORMAT. LOG = INSTALL JUMPER<br/>IN JB PINS 15-16. LINEAR = REMOVE JUMPER<br/>FROM JB PINS 15-16. METER GROUND RECOMMENDED.</p>               | +2 OR +4 VDC   |
| (5) PLATE CURRENT OUT  | <p>== PLATE CURRENT METER OUTPUT.<br/>+2V OR +4 VDC FULL SCALE INDICATION<br/>+2V = INSTALL JUMPER P11 IN POSITION 2-3<br/>+4V = INSTALL JUMPER P11 IN POSITION 1-2<br/>LOG OR LINEAR FORMAT. LOG = INSTALL JUMPER<br/>IN JB PINS 15-16. LINEAR = REMOVE JUMPER<br/>FROM JB PINS 15-16. METER GROUND RECOMMENDED.</p>               | +2 OR +4 VDC   |
| (6) METERING GROUND    | METER GROUND<br>FOR METER CONNECTIONS.  | METER GROUND   |
| (7) METERING GROUND    | METER GROUND<br>FOR METER CONNECTIONS.  | METER GROUND   |
| (8) METERING GROUND    | METER GROUND<br>FOR METER CONNECTIONS.  | METER GROUND   |
| (9) NO CONNECTION      |   |                |
| (10) EXT INTERLOCK OUT | <p>CONNECTION FOR AN EXTERNAL INTERLOCK SUCH AS<br/>A TEST LOAD OR MOTORIZED COAXIAL SWITCH.</p>  |                |
| (11) EXT INTERLOCK IN  |   |                |
| (12) NO CONNECTION     |   |                |
| (13) CHASSIS GROUND    | CHASSIS GROUND.<br>CHASSIS GROUND FOR REMOTE CONTROL CONNECTIONS.   | CHASSIS GROUND |
| (14) CHASSIS GROUND    | CHASSIS GROUND.<br>CHASSIS GROUND FOR REMOTE CONTROL CONNECTIONS.   | CHASSIS GROUND |
| (15) RMT PWR +15 VDC   | +15 VDC SUPPLY FROM CONTROLLER.<br>PROVIDES A +15 VDC SUPPLY FOR REMOTE SWITCHES AND INDICATORS.  | +15 VDC        |
| (16) RMT PWR +15 VDC   | +15 VDC SUPPLY FROM CONTROLLER.<br>PROVIDES A +15 VDC SUPPLY FOR REMOTE SWITCHES AND INDICATORS.  | +15 VDC        |

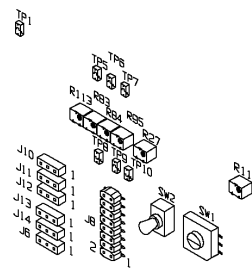


REMOTE INTERFACE CIRCUIT BOARD

NOTES: \* POSITIVE CONTROL - INSTALL  
P6 ON CONTROLLER MAIN  
CIRCUIT BOARD IN POSITION  
2-3. FACTORY DEFAULT.  
SEE DETAIL 'A'.

NEGATIVE CONTROL - INSTALL  
P6 ON CONTROLLER CIRCUIT  
BOARD IN POSITION 1-2.  
SEE DETAIL 'A'.

DETAIL 'A'  
CONTROLLER MAIN CIRCUIT BOARD



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FIGURE 2-3. REMOTE CONTROL INTERFACING (SHEET 2 OF 2)



- 2-51. The transmitter controller allows the selection of positive or negative control logic. Positive/negative control is determined by header J6 on the controller main circuit board assembly. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to activate the function. Negative control requires the use of a momentary contact to ground to activate the function. The transmitter controller is factory programmed for positive remote control operations.
- 2-52. The remote meter outputs can be configured for: 1) +2/+4 volt dc full-scale indications and 2) a log or linear format. +2/+4 volt dc full-scale programming is determined by headers J10 through J12 on the controller main circuit board. The log/linear control is determined by header J8 pins 15-16 on the controller main circuit board. Refer to Figure 2-3 and the following text to connect remote control equipment to the transmitter.
- 2-53. **Remote APC On Control.** The APC (automatic-power-control) on function is located at TB1-1. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to enable APC operation. Negative control requires the use of a momentary contact to ground to enable APC operation.
- 2-54. **Remote Filament On Control.** The filament on function is located at TB1-2. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to enable the filaments. Negative control requires the use of a momentary contact to ground to enable the filaments.
- 2-55. **Remote Filament Off Control.** The filament off function is located at TB1-3. The function: 1) provides one-button-off control by disabling the high voltage and the filaments and 2) can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to disable the: 1) filaments and 2) high voltage if not previously disabled. Negative control requires the use of a momentary contact to ground to disable the: 1) filaments and 2) high voltage if not previously disabled.
- 2-56. **Remote High Voltage On Control.** The high voltage on function is located at TB1-4. The function: 1) provides one-button-on control by enabling the high voltage and the filaments and 2) can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to enable the: 1) high voltage and 2) filaments if not previously enabled. Negative control requires the use of a momentary contact to ground to enable the: 1) high voltage and 2) filaments if not previously enabled.
- 2-57. **Remote High Voltage Off Control.** The high voltage off function is located at TB1-5. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to disable the high voltage. Negative control requires the use of a momentary contact to ground to disable the high voltage.
- 2-58. **Remote PA Power Level Raise Control.** The transmitter PA power level raise control is located at TB1-6. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to raise the transmitter power level. Negative control requires the use of a momentary contact to ground to raise the transmitter power level.
- 2-59. **Remote Power Level Lower Control.** The transmitter PA power level lower control is located at TB1-7. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to lower the transmitter power level. Negative control requires the use of a momentary contact to ground to lower the transmitter power level.

- 2-60. **Remote Preset Power On Control.** The preset power on function is located at TB1-8. The function can be activated using positive or negative control. Positive control requires the use of a sustained contact to a +5 volt to +15 volt dc signal to enable preset power operation. Negative control requires the use of a sustained contact to ground to enable preset power operation. When a sustained remote control signal is applied, preset power will be enabled if the APC switch/indicator is illuminated and the REMOTE DISABLE switch/indicator is extinguished. The transmitter will automatically return to full power when the sustained remote control signal is removed.
- 2-61. **Remote Overload Reset Control.** The overload reset control is designed to reset the transmitter overload circuitry. The reset control is located at TB1-9. The function can be activated using positive or negative control. Positive control requires the use of a momentary contact to a +5 volt to +15 volt dc signal to reset the transmitter overload circuitry. Negative control requires the use of a momentary contact to ground to reset the transmitter overload circuitry.
- 2-62. **No Connection.** No connection at the following locations:
- 1) TB1-10 through TB1-14.
  - 2) TB1-25.
  - 3) TB2-9.
  - 4) TB2-12.
- 2-63. **APC On Indicator.** The APC on indicator provides a signal to indicate when APC operation is enabled. The APC on indicator is located at TB1-15. The indicator will go LOW (0 volts dc) to indicate when APC operation is enabled.
- 2-64. **Filament On Indicator.** The filament on indicator provides a signal to indicate when the filaments are enabled. The filament on indicator is located at TB1-16. The indicator will go LOW (0 volts dc) to indicate when the filaments are enabled.
- 2-65. **Remote Disable Indicator.** The remote disable indicator provides a signal to indicate when the remote control inputs are disabled. The remote disable indicator is located at TB1-17. The indicator will go LOW (0 volts dc) to indicate when the remote control inputs are disabled.
- 2-66. **Remote High Voltage On Indicator.** The remote high voltage on indicator provides a signal to indicate when the high voltage is enabled. The remote high voltage on indicator is located at TB1-18. The indicator will go LOW (0 volts dc) to indicate when the high voltage is enabled.
- 2-67. **Remote Plate Overload Indicator.** The remote plate overload indicator provides a signal to indicate when a plate overload has occurred. The remote plate overload indicator is located at TB1-19. The indicator will go LOW (0 volts dc) to indicate when a plate overload has occurred.
- 2-68. **Remote Screen Overload Indicator.** The remote screen overload indicator provides a signal to indicate when a screen overload has occurred. The remote screen overload indicator is located at TB1-20. The indicator will go LOW (0 volts dc) to indicate when a screen overload has occurred.
- 2-69. **Remote Grid Overload Indicator.** The remote grid overload indicator provides a signal to indicate when a grid overload has occurred. The remote grid overload indicator is located at TB1-21. The indicator will go LOW (0 volts dc) to indicate when a grid overload has occurred.
- 2-70. **Remote VSWR Overload Indicator.** The remote VSWR overload indicator provides a signal to indicate when a VSWR overload has occurred. The remote VSWR overload indicator is located at TB1-22. The indicator will go LOW (0 volts dc) to indicate when a VSWR overload has occurred.

- 2-71. **Remote Overload Indicator.** The remote overload indicator provides a signal to indicate when a plate, screen, grid, or VSWR overload has occurred. The remote overload indicator is located at TB1-23. The indicator will go LOW (0 volts dc) to indicate when an overload has occurred.
- 2-72. **Remote Preset Power Indicator.** The preset power indicator provides a signal to indicate when preset power operation is enabled. The preset power indicator is located at TB1-24. The indicator will go LOW (0 volts dc) to indicate when preset power operation is enabled.
- 2-73. **Remote Failsafe Indicator.** The failsafe indicator provides a signal to indicate when the failsafe interlock is closed. The failsafe indicator is located at TB1-26. The indicator will go LOW (0 volts dc) to indicate when the failsafe interlock is closed.
- 2-74. **Remote Interlock Indicator.** The interlock indicator provides a signal to indicate when the internal interlock is closed. The interlock indicator is located at TB1-27. The indicator will go LOW (0 volts dc) to indicate when the internal interlocks are closed.
- 2-75. **Remote Blower Indicator.** The blower indicator provides a signal to indicate when the transmitter blower is operational. The blower indicator is located at TB1-28. The indicator will go LOW (0 volts dc) to indicate when the blower is operational.
- 2-76. **Remote Filament Indicator.** The filament indicator provides a signal to indicate when the filament contactor is energized. The filament indicator is located at TB1-29. The indicator will go LOW (0 volts dc) to indicate when the filament contactor is energized.
- 2-77. **Remote High Voltage Indicator.** The high voltage indicator provides a signal to indicate when the high voltage contactor is energized. The high voltage indicator is located at TB1-30. The indicator will go LOW (0 volts dc) to indicate when the high voltage contactor is energized.
- 2-78. **Remote Forward Power Meter Indications.** Remote forward power meter indications are located at TB2-1. The forward power meter output can be configured for a +2 or +4 volt dc full-scale meter indication. The forward power full-scale indication is 5500 watts. In addition, the forward power sample can be provided in a log or linear format. The transmitter is shipped with the sample programmed for a linear format. The meter ground is recommended for remote metering connections (TB2-6 through TB2-8).
- 2-79. **Remote Reflected Power Meter Indications.** Remote reflected power meter indications are located at TB2-2. The reflected power meter output can be configured for a +2 or +4 volt dc full-scale meter indication. The reflected power full-scale indication is 1540 watts. In addition, the reflected power sample can be provided in a log or linear format. The transmitter is shipped with the sample programmed for a linear format. The meter ground is recommended for remote metering connections (TB2-6 through TB2-8).
- 2-80. **Remote Plate Voltage Meter Indications.** Remote plate voltage meter indications are located at TB2-4. The plate voltage meter output can be configured for a +2 or +4 volt dc full-scale meter indication. The plate voltage full-scale indication is 6000 volts. In addition, the plate voltage sample can be provided in a log or linear format. The transmitter is shipped with the sample programmed for a linear format. The meter ground is recommended for remote metering connections (TB2-6 through TB2-8).
- 2-81. **Remote Plate Current Meter Indications.** Remote plate current meter indications are located at TB2-5. The plate current meter output can be configured for a +2 or +4 volt dc full-scale meter indication. The plate current full-scale indication is 1.5 amps. In addition, the plate current sample can be provided in a log or linear format. The transmitter is shipped with the sample programmed for a linear format. The meter ground is recommended for remote metering connections (TB2-6 through TB2-8).
- 2-82. **Remote IPA Forward Power Meter Indications.** Not used in FM-5T/FM-5TS.
- 2-83. **Chassis Ground.** Chassis ground is designed to be used for remote control connections. Chassis ground is located at TB2-13 and TB2-14.
- 2-84. **+15V DC Supply.** A +15 volt dc supply is provided for the remote control switches and indicators. The +15 volt dc supply is located at TB2-15 and TB2-16.

2-85. **WIRING.**



**WARNING**

***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**

2-86. **TRANSFORMER TAPS.** Ensure that the transmitter is wired for the input voltage and line frequency to be used. The screen transformer, the plate transformer, the bias transformer, the filament regulator, and the plate supply choke must be checked and changed if required. Refer to Figure 2-4 and the final test data sheets for transformer tap information.

2-87. **INPUT VOLTAGE CHECK.** The FM exciter, stereo generator, and SCA generator should be checked as follows:

- A. The primary ac line voltage with which the transmitter will be used (220V or 230/240V) must be visible on the ac line voltage selector circuit board located adjacent to the ac input connector on each unit.
- B. If an ac line voltage selector must be changed, remove the ac line voltage selector circuit board with a small pair of needle-nose pliers. Reinsert the circuit board so that the correct ac line voltage is visible when the circuit board is reinserted into the receptacle.



**WARNING**

***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**



**CAUTION**

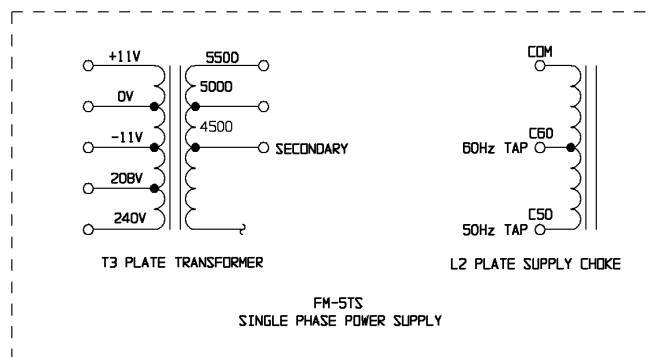
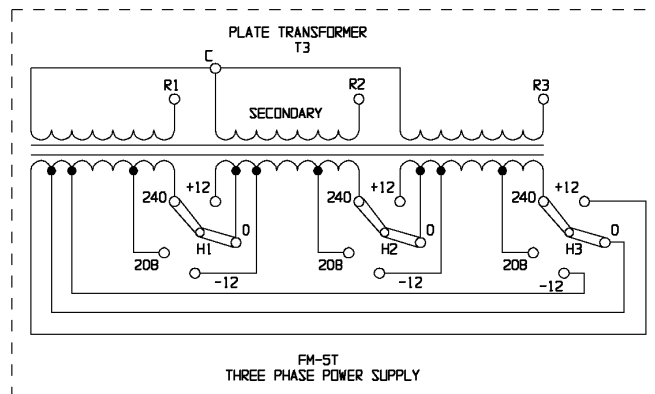
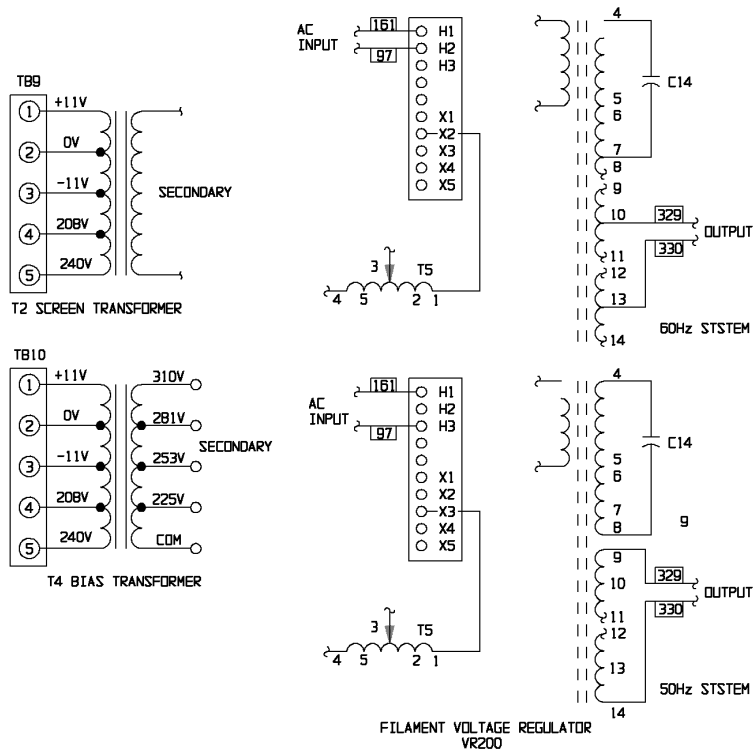
***THE AC DISTRIBUTION PANEL PROVIDES A 220V AC OPERATING SUPPLY FOR OPTIONAL EQUIPMENT. ENSURE ALL 220V AC AND 110V AC EQUIPMENT IS PROPERLY CONNECTED TO THE PANEL.***

**CAUTION**

2-88. **OPTIONAL EQUIPMENT WIRING.** An ac distribution panel is provided for the application of ac power to the transmitter modular components. Mount and wire any optional equipment not provided with the transmitter to the distribution panel (refer to Figure 2-5). The ac distribution panel provides a 220V ac operating supply for the optional equipment. Ensure all 220V ac and 110V ac equipment is properly connected to the panel.

2-89. **SIGNAL INPUTS.** Refer to the applicable technical manual for the exciter, stereo generator, and SCA generator and wire the inputs and control connections to each unit. All audio wiring must be routed in the wiring channel away from the power supply components in the base.

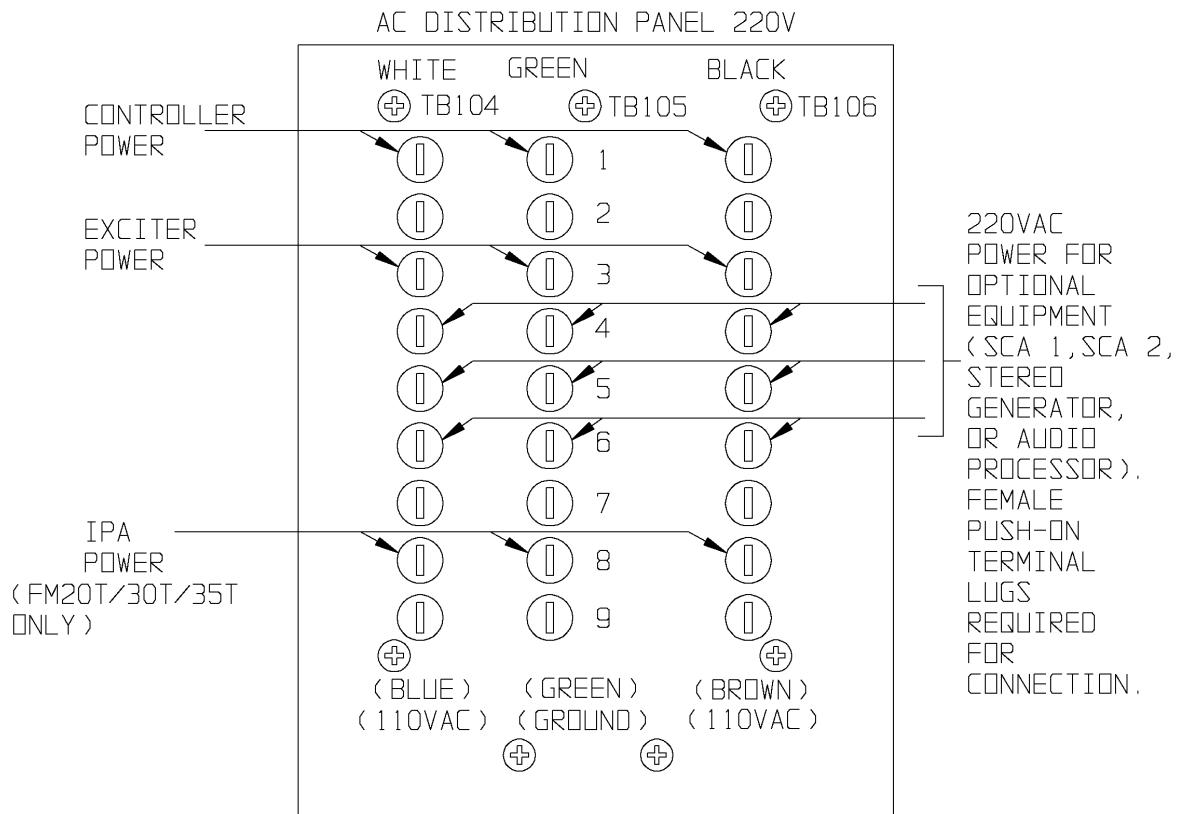
2-90. **FAILSAFE INTERLOCK.** The FM-5T/FM-5TS transmitters are equipped with a failsafe interlock circuit such as for a test load or remote control failsafe connection. The failsafe interlock circuit is independent of the transmitter safety interlock circuit and will disable only the high voltage plate supply when opened. The interlock is located at TB2-10 and TB2-11 on the transmitter remote interface panel. Refer to Figure 2-3 and connect the interlock wiring to TB2-10 and TB2-11 as shown. If unused, ensure the factory installed jumper is connected between the terminals.



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597-0033-415

FIGURE 2-4. TRANSFORMER TAPS



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**FIGURE 2-5. OPTIONAL EQUIPMENT WIRING**

**597-0220-403**

- 2-91. **TRANSMITTER MONITORING - MODEM CONNECTIONS.** The FM-5T/FM-5TS transmitters are equipped with: 1) a built-in front-panel modem port and 2) a built-in rear-panel modem port. The modem ports allow modems to be connected to the transmitter for local and remote monitoring of transmitter parameters using a future local/remote diagnostic system.
- 2-92. **TRANSMITTER MONITORING - PRINTER CONNECTIONS.** The FM-5/FM-5TS transmitters are equipped with a built-in printer port. The printer port allows transmitter parameters to be printed using a local printer and a future local/remote diagnostic system.



**WARNING**

***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**

- 2-93. **AC POWER CONNECTIONS.** The following text presents three phase ac power connections for an FM-5T transmitter and single phase ac power connections for an FM-5TS transmitter. Refer to the following information and connect the FM-5T/FM-5TS transmitters to the appropriate power supply.



**WARNING**      ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**



**WARNING**      ***ENSURE AN EARTH GROUND CONDUCTOR IS SECURELY CONNECTED TO THE TRANSMITTER***

**WARNING**      ***GROUND SYSTEM.***

- 2-94. **FM-5T.** A three phase source of 196V to 252V ac 50 Hz or 60 Hz or 341 to 435V ac 50 Hz at 40 Amperes per phase is required for the FM-5T transmitter ac input. Ensure the power source is supplied from an acceptable ac transformer configuration (refer to PRIMARY AC POWER). For operating safety, the power source must be routed to the transmitter through a fused power disconnect (refer to Figure 2-6).
- 2-95. Refer to Figure 2-6 and connect the 40 Ampere three phase service to TB1 on the transmitter base-plate through a fused service disconnect. Ensure a utility company ground conductor is securely connected to the transmitter ground system. For a three phase 380V WYE service, ensure the neutral wire is connected to ac input terminal TB1-4.



**WARNING**      ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**



**WARNING**      ***ENSURE AN EARTH GROUND CONDUCTOR IS SECURELY CONNECTED TO THE TRANSMITTER***

**WARNING**      ***GROUND SYSTEM.***

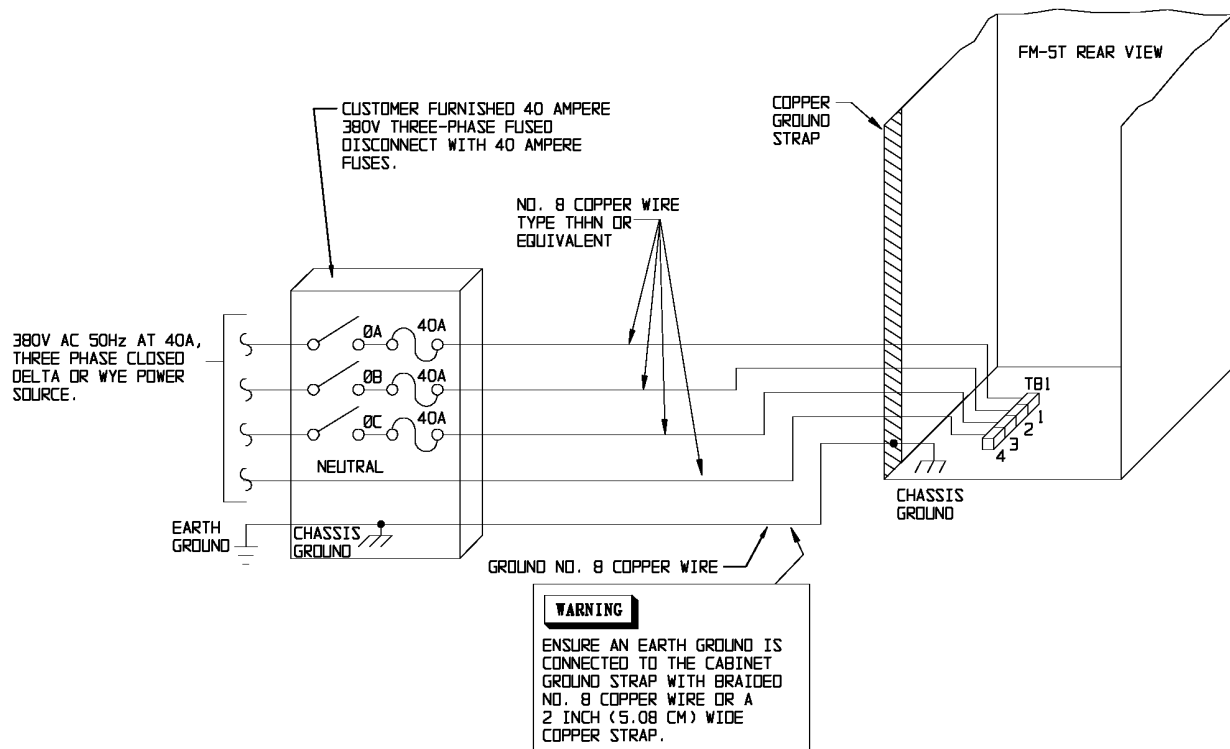
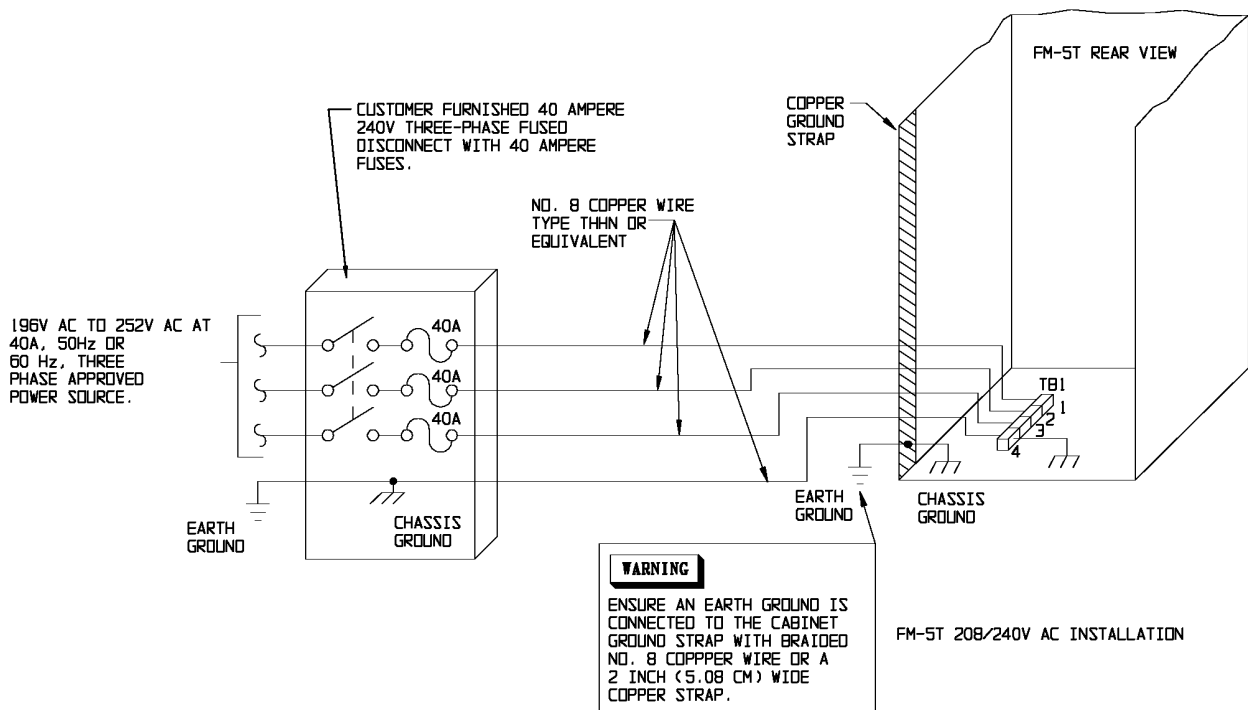
- 2-96. **FM-5TS.** A single phase source of 196V to 252V ac, 50 or 60 Hz at 70 Amperes is required for the FM-5TS transmitter ac input. For operating safety, the power source must be routed to the transmitter through a fused power disconnect (refer to Figure 2-7).
- 2-97. Refer to Figure 2-7 and connect the 70 Ampere service to TB1 on the transmitter base-plate through a fused service disconnect. Ensure a utility company ground conductor is securely connected to the transmitter ground system and the neutral wire is securely connected to TB1-2.
- 2-98. **INITIAL CHECKOUT.**



**WARNING**      ***ENSURE PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**

- 2-99. Ensure that the transmitter is completely installed, the transmitter is connected to a suitable RF load, and the station monitors are connected to the MON port in the RF low-pass filter output. The MON port provides a harmonic-filtered RF sample which is approximately 40 dB below the carrier power level. Check the following:
- A. Ensure primary power is correctly wired.
  - B. Ensure all ground connections are secure.
  - C. Ensure all RF connections are secure.
  - D. Ensure all connections at terminal boards are secure.
  - E. Rotate the blower and fans by hand to ensure no obstructions are present.
  - F. Using an insulator, check relay operation manually to be certain all have free movement.

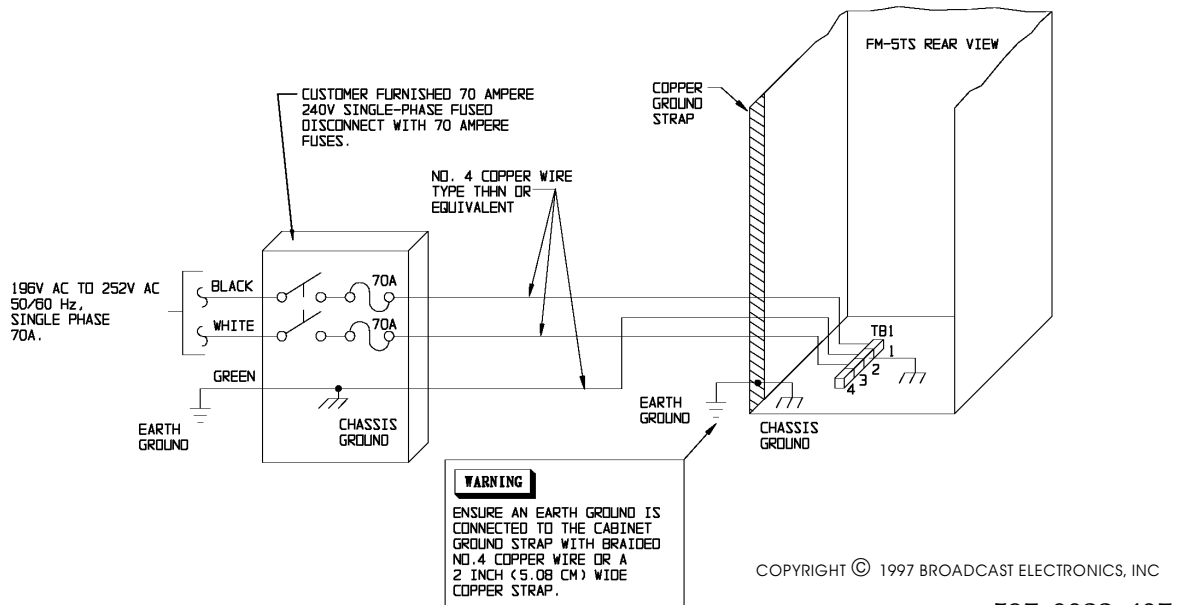


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597-0033-406

FIGURE 2-6. FM-5T PRIMARY AC WIRING





**FIGURE 2-7. FM-5TS PRIMARY AC WIRING**

**597-0033-407**

- 2-100. Remove any extra hardware and wire lying within the cabinets and close all doors. Replace the lower front access panel using the black hex-head screws and hex wrench shipped with the transmitter.
- 2-101. Adjust the **FILAMENT ADJUST** control fully counterclockwise (minimum).
- 2-102. Operate all five front-panel circuit breakers to **OFF**.
- 2-103. Close the wall-mounted fused disconnect.
- 2-104. Extend the exciter forward, out of the rack on the slide rails to expose the **R.F. POWER OUTPUT ADJ.** control access hole in the top cover. Adjust the control fully counterclockwise (minimum output).
- 2-105. The following procedure will refer to the factory final test data sheets supplied with the transmitter. Some differences in the actual operation may be noted due to differences in primary power or antenna systems. Ensure all controls are preset to the positions indicated on the final test data sheets.
- 2-106. **CONTROLLER AND INTERLOCK CHECKOUT.** Check the controller and the transmitter interlock circuit by performing the following procedure.
- 2-107. Operate the **AC POWER** and the **BLOWER** circuit breakers to **ON**. The **FILAMENT** and **SCREEN** circuit breakers must remain **OFF**.
- 2-108. Open the controller cabinet door and check the following items on the main circuit board.
  - A. Ensure the **-15** indicator is illuminated.
  - B. Ensure the **+15** indicator is illuminated.
  - C. Ensure the **+5** indicator is illuminated.



**WARNING**

**WARNING**

***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE TRANSMITTER WITH POWER ENERGIZED.***

- 2-109. Remove the transmitter lower front access panel. The controller **TRANSMITTER STATUS INTERLOCK** indicator will extinguish.
- 2-110. Replace the transmitter lower front access panel. The controller **TRANSMITTER STATUS INTERLOCK** indicator will illuminate.
- 2-111. Open the transmitter rear door. The controller **TRANSMITTER STATUS INTERLOCK** indicator will extinguish.
- 2-112. Close the transmitter rear door. The controller **TRANSMITTER STATUS INTERLOCK** indicator will illuminate.
- 2-113. Open the transmitter rear door and perform the following:



**WARNING**

**WARNING**

***PERFORM THE FOLLOWING PROCEDURES AS INDICATED. DO NOT TOUCH ANYTHING WITHIN THE TRANSMITTER WITH POWER ENERGIZED.***

- A. Depress the transmitter rear door interlock switch and raise the grounding stick from the hanger. The controller **TRANSMITTER STATUS INTERLOCK** indicator will extinguish.
  - B. Replace the grounding stick. The controller **TRANSMITTER STATUS INTERLOCK** indicator will illuminate.
  - C. While depressing the transmitter rear door interlock switch, open the PA cavity access door. The controller **TRANSMITTER STATUS INTERLOCK** indicator will extinguish.
  - D. Close the PA cavity access door. The controller **TRANSMITTER STATUS INTERLOCK** indicator will illuminate.
  - E. Close the transmitter rear door.
- 2-114. If equipment is connected to the failsafe interlock circuit, check the operation as follows:
  - A. Open the failsafe interlock. The controller **TRANSMITTER STATUS INTERLOCK** indicator will extinguish.
  - B. Close the failsafe interlock. The controller **TRANSMITTER STATUS INTERLOCK** indicator will illuminate.
- 2-115. **BLOWER CHECKOUT.** Check blower operation by performing the following procedure.
- 2-116. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON**. The **FILAMENT** and **SCREEN** circuit breakers must remain **OFF**.
- 2-117. Depress the **FILAMENT ON** switch/indicator to illuminate the switch/indicator. The **FILAMENT ON** switch/indicator, **TRANSMITTER STATUS BLOWER**, and the **TRANSMITTER STATUS FILAMENT** indicators will illuminate and the blower will begin operation.
- 2-118. Ensure the blower, **TRANSMITTER STATUS BLOWER** indicator, and the **TRANSMITTER STATUS FILAMENT** indicator are operating properly. At high altitudes, the **TRANSMITTER STATUS BLOWER** indicator may not illuminate. If this occurs, contact the Broadcast Electronics Customer Service Department.

- 2-119. **EXCITER CHECKOUT.** Check exciter operation by performing the following procedure.
- 2-120. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON**. The **SCREEN** and **FILAMENT** circuit breakers must remain **OFF**.
- 2-121. Depress the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator.
- 2-122. Depress the exciter multimeter **AFC** switch.
- A. The multimeter will indicate a potential within the range of +2.0 volts to +9.0 volts, dependent upon carrier frequency. Refer to the final test data sheets for the correct voltage indication.
- 2-123. Depress the exciter multimeter **PAV** switch.
- A. The multimeter will indicate a potential of approximately +0.0 volts to 0.5 volts (assuming the exciter is configured for a minimum RF power output).
- 2-124. Depress the exciter multimeter **PAI** switch.
- A. The multimeter will indicate approximately 0.0 amperes (assuming the exciter is configured for a minimum RF power output).
- 2-125. Depress the **FILAMENT OFF** switch.
- 2-126. **PRELIMINARY OPERATION AND TUNING.** Operate and tune the transmitter by performing the following procedure.
- 2-127. Ensure the **AC POWER** and **BLOWER** circuit breakers are operated to **ON**. The **SCREEN** and **FILAMENT** circuit breakers must remain **OFF**.
- 2-128. Ensure the controller **TRANSMITTER STATUS INTERLOCK** indicator is illuminated. If the indicator is extinguished, open the wall-mounted fused disconnect and check the following:
- A. All panels are installed.
  - B. All shorting sticks are on the hangers.
  - C. All doors are closed.
- 2-129. If equipment is connected to the failsafe interlock, ensure the controller **TRANSMITTER STATUS FAILSAFE** indicator is illuminated. If the indicator is extinguished, open an appropriate power source disconnect if required and check the interlock switch.
- 2-130. Ensure the **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators are extinguished.
- 2-131. Ensure the exciter **RF OUTPUT POWER ADJ** control is fully counterclockwise (minimum).
- 2-132. Depress the controller **APC ON** switch/indicator to extinguish the switch/indicator.
- 2-133. Depress the controller **REMOTE DISABLE** switch/indicator to illuminate the switch/indicator.
- 2-134. Depress the controller **FWD** switch/indicator to illuminate the switch/indicator.



**CAUTION**  
**CAUTION**

***ENSURE AN RF LOAD IS CONNECTED TO THE TRANSMITTER AND THE FILAMENT VOLTAGE CONTROL IS ADJUSTED TO APPROXIMATELY MID-RANGE.***

- 2-135. Operate the **FILAMENT** circuit breaker to **ON**.
- 2-136. Depress the **FILAMENT ON** switch/indicator. Both the **FILAMENT ON** switch/indicator and the **FILAMENT TRANSMITTER STATUS** indicator will illuminate and the blower will begin operation.
- 2-137. Adjust the **FILAMENT ADJUST** control to obtain a **FILAMENT VOLTAGE** meter indication of 5.0 volts.
- 2-138. Operate the **MULTIMETER** switch to **GRID VOLTAGE** and note the presence of PA stage grid bias without drive.
- 2-139. Operate the **SCREEN** circuit breaker to **ON**.
- 2-140. Depress the **HIGH VOLTAGE ON** switch/indicator. Both the **HIGH VOLTAGE ON** switch/indicator and the **HIGH VOLTAGE TRANSMITTER STATUS** indicator will illuminate.
- 2-141. Note the presence of plate voltage on the **PLATE VOLTAGE** meter.
- 2-142. If equipment is connected to the failsafe interlock, check the external interlock operation as follows:



**WARNING**  
**WARNING**

***OBSERVE PROPER SAFETY PRECAUTIONS WHEN PERFORMING THE FOLLOWING PROCEDURE.***

- A. Open the failsafe interlock. The controller **FAILSAFE TRANSMITTER STATUS** and the **HIGH VOLTAGE TRANSMITTER STATUS** indicators will extinguish and the high voltage plate supply will be disabled.
  - B. Close the failsafe interlock. The plate supply will be restored, the transmitter will resume operation, and the controller **FAILSAFE TRANSMITTER STATUS** and the **HIGH VOLTAGE TRANSMITTER STATUS** indicators will illuminate.
- 2-143. Adjust the exciter **RF POWER OUTPUT ADJ** control to obtain approximately five watts from the exciter.
- 2-144. Depress the exciter multimeter **PAV** switch.
  - A. The multimeter will indicate a potential within the range of +0.0 volts to +0.5 volts (assuming an RF output power of 1 watt).
- 2-145. Depress the exciter multimeter **PAI** switch.
  - A. The multimeter will indicate approximately 0.0 amperes (assuming RF output power of 1 watt).
- 2-146. Depress the exciter multimeter **FWD** switch.
- 2-147. Operate the **MULTIMETER** switch to **EXCITER RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.



**CAUTION**  
**CAUTION**

***CHECK THE TRANSMITTER OUTPUT POWER INDICATION TO ENSURE TRANSMITTER OUTPUT POWER IS PRESENT.***

- 2-148. Note the presence of output power on the **OUTPUT POWER** meter. If no output power is indicated, perform the following:
1. Ensure the PA coarse tuning line is properly adjusted.
  2. Adjust the **OUTPUT TUNING** control for a maximum indication on the **OUTPUT POWER** meter.
- 2-149. Adjust the exciter output to approximately 90 watts.
- 2-150. The FM-250C VSWR indicator illuminates during the remainder of the initial checkout procedure, this indicates that the IPA load is incorrect. To correct the situation, operate the **MULTIMETER** switch to **EXCITER RFL POWER** and re-adjust the **INPUT TUNING** control for a minimum reflected power indication on the FM-250C.
- 2-151. The **OUTPUT POWER** and **PLATE CURRENT** meters will indicate a low level of less than 20% full-scale.
- 2-152. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum **OUTPUT POWER** meter indication.
- 2-153. Depress the controller **RAISE** switch/indicator until a 400 mA **PLATE CURRENT** meter indication is noted.
- 2-154. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum **OUTPUT POWER** meter indication.
- 2-155. Operate the **MULTIMETER** switch to **EXCITER RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.
- 2-156. Depress the controller **RAISE** switch/indicator until a 50% indication is obtained on the **OUTPUT POWER** meter.
- 2-157. Depress the controller **VSWR** switch/indicator to illuminate the switch/indicator.
- 2-158. The **OUTPUT POWER** meter must indicate a VSWR of less than 1.8:1. An excessive VSWR indicates improper load connections.
- 2-159. Depress the controller **FWD** switch/indicator to illuminate the switch/indicator.
- 2-160. Adjust the **OUTPUT TUNING** and **OUTPUT LOADING** controls for maximum indication on the **OUTPUT POWER** meter, concurrent with a minimum indication on the **PLATE CURRENT** meter.
- 2-161. Adjust the exciter **RF OUTPUT POWER ADJ** control to the value stated on the factory test data sheets.
- 2-162. Operate the **MULTIMETER** switch to **EXCITER RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.
- 2-163. Depress the controller **RAISE** switch/indicator. Continue to depress the switch/indicator until a 100% power indication is noted on the **OUTPUT POWER** meter. If a plate or screen current overload occurs, it may be necessary to adjust the **OUTPUT LOADING** for better efficiency before increasing power to 100%.
- 2-164. Operate the **MULTIMETER** switch to **EXCITER RFL POWER** and adjust the **INPUT TUNING** control to obtain a minimum reflected power indication on the **MULTIMETER**.

- 2-165. Adjust the **OUTPUT LOADING** and **OUTPUT TUNING** controls to obtain the values stated on the factory test data sheets.
- 2-166. Check the **FILAMENT VOLTAGE** meter and adjust the **FILAMENT ADJUST** control as required. The meter must indicate 5 volts.
- 2-167. Adjust the PA stage for the most efficient operation by adjusting the **OUTPUT TUNING** and **OUTPUT LOADING** controls for a maximum indication on the **OUTPUT POWER** meter concurrent with a minimum indication on the **PLATE CURRENT** meter.
- 2-168. Operate the **MULTIMETER** to **EXCITER RFL POWER** and adjust the **INPUT TUNING** control for a minimum reflected power indication.
- 2-169. Depress the controller **RAISE** or **LOWER** switch/indicators as required to obtain a 100% **OUTPUT POWER METER** indication.
- 2-170. Compare the meter indications to those provided on the final test data sheets. All meter indications should be approximately the same as those stated on the final test data sheets.
- 2-171. Depress the **APC ON** switch/indicator. The switch/indicator will illuminate and the transmitter will maintain a constant 100% rated RF output.
- 2-172. Apply programming to the exciter. The presence of programming may be noted on the exciter **MODULATION** meter.
- 2-173. To adjust the automatic power control unit to maintain a level other than 100%, the **APC ON** switch/indicator must be illuminated. Depress either the **RAISE** or the **LOWER** switch/indicator as desired until the desired percentage of transmitter power output is indicated by the **OUTPUT POWER** meter. The automatic power control circuitry operates in small increments and will take some time to track the reference to the new set point. The automatic power control circuitry will then maintain this new established RF output level.
- 2-174. If remote operation is desired, the **REMOTE DISABLE** switch/indicator must be extinguished. TB1-17 on the remote interface circuit board provides a signal which can be connected to a relay or logic circuit to control a light or alarm to remind the engineer of the status of the remote disable switch. This feature will hopefully prevent inadvertent remote lockout if the engineer should leave the transmitter site and forget to enable remote operation.

## SECTION III OPERATION

### 3-1. INTRODUCTION.

3-2. This section identifies all controls and indicators associated with the FM-5T/FM-5TS FM transmitters and provides standard operating procedures.

### 3-3. CONTROLS AND INDICATORS.

3-4. Refer to Figure 3-1 for the location of all controls and indicators associated with normal operation of the FM-5T/FM-5TS transmitters. The function of each control or indicator is described in Table 3-1.

### 3-5. OPERATION.



#### NOTE

***THE FOLLOWING PROCEDURE IS PRESENTED UNDER THE ASSUMPTION THAT THE TRANSMITTER IS FULLY INSTALLED AND IS FREE OF ANY DISCREPANCIES.***

#### NOTE

### 3-6. TURN ON.

3-7. Operate all circuit breakers to **ON**.

3-8. Depress the **REMOTE DISABLE** switch/indicator to illuminate the switch/indicator.

3-9. Depress the **FILAMENT ON** switch/indicator, then depress the **HIGH VOLTAGE ON** switch/indicator. Each switch/indicator will illuminate as it is depressed.

3-10. If all interlocks are closed, the transmitter will be operational after a short delay to allow PA tube filament warm-up.

3-11. Check and log all meter indications and the status of the various indicators to assure proper equipment operation. A sample log sheet is provided as Table 3-2.

3-12. Depress the **FWD** switch/indicator to illuminate the switch/indicator and check the forward power output.



#### NOTE

***THE VSWR METER IS MOST ACCURATE WHEN THE TRANSMITTER IS OPERATED AT 100% (NORMAL TPO) POWER. TRANSMITTER OPERATION AT A REDUCED POWER LEVEL WILL RESULT IN REDUCED VSWR METER ACCURACY.***

#### NOTE

3-13. Depress the **VSWR** switch/indicator to illuminate the switch/indicator and check the VSWR.

3-14. Select the type of RF output power control:

A. If manual power control is desired, proceed as follows:

1. Depress the **APC ON** switch/indicator to extinguish the switch/indicator.
2. Depress the **RAISE** or **LOWER** switch/indicator to raise or lower the transmitter RF output power as indicated by the OUTPUT POWER meter.

- B. If automatic power control is desired, depress the **APC ON** switch/indicator to illuminate the switch/indicator. To adjust the level at which the automatic power control circuitry will maintain, proceed as follows:
1. Depress the **APC ON** switch/indicator to illuminate the switch/indicator.
  2. Depress the **RAISE** or **LOWER** switch/indicator to establish a new RF power output level as indicated by the OUTPUT POWER meter.
- 3-15. If remote operation is desired, depress the **REMOTE DISABLE** switch/indicator to extinguish the switch/indicator. This will enable both local and remote operation.
- 3-16. **TURN OFF.**
- 3-17. Depress the **FILAMENT OFF** switch/indicator. After a period of blower operation to allow the PA tube to cool, the equipment will de-energize.
- 3-18. Operate the **AC POWER** circuit breaker to **OFF**.
- 3-19. **OPERATING THE TRANSMITTER FOR MAXIMUM TUBE LIFE.**
- 3-20. The FM-5T/FM-5TS is equipped with an Eimac 4CX3500A tetrode. Maximum tube life is obtained by the implementation of a tube management program. A tube management program consists of operating and monitoring the transmitter to maintain an optimum tube filament voltage. This optimum voltage prevents premature de-carbonization of the tube filament and will result in maximum tube life. To maximize transmitter tube life, implement the procedures and operations presented in the following tube management program.

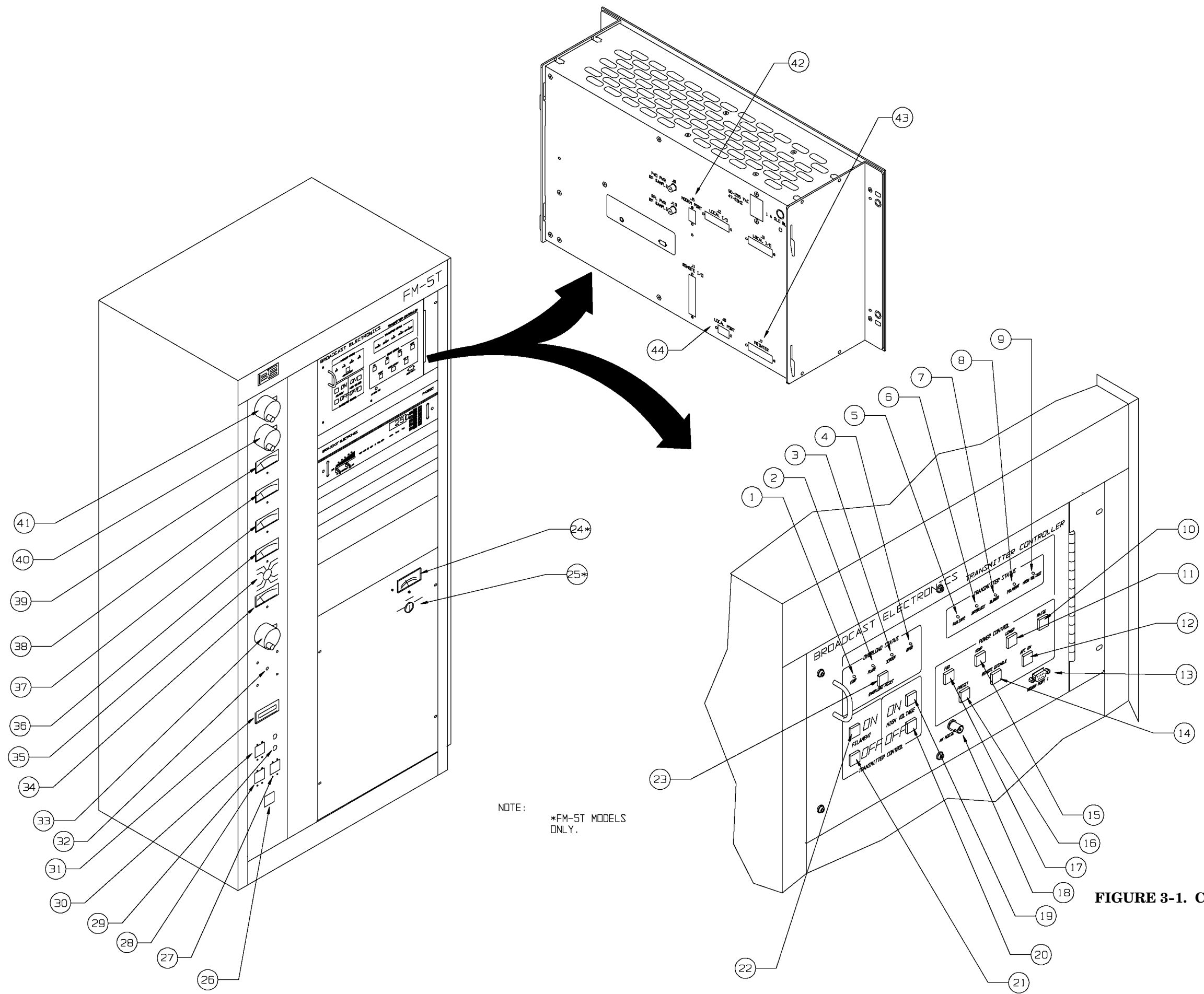
#### **TUBE MANAGEMENT PROGRAM**

- 1) Refer to APPENDIX A and perform the procedures presented in the Eimac publication titled "Extending Transmitter Tube Life - Eimac Application Bulletin No. 18. - March 1990".
  - 2) Refer to APPENDIX A and the information presented in "Eimac Technical Data Sheet - 4CX3500A Tetrode".
  - 3) The procedures presented in any "Eimac Product Bulletins" shipped with the tube.
- 3-21. **CONTINUOUSLY FLASHING CONTROLLER SWITCH/INDICATOR.**
- 3-22. The FM-5T/FM-5TS controller is equipped with an automatic remote/local control troubleshooting feature. This feature can determine if a remote control or a front-panel control is being continuously held in operation by a device such as a defective remote control unit. If a control is continuously held in operation, the front-panel switch/indicator will flash. If this condition occurs, contact the Broadcast Electronics RF Customer Service Department.

**TABLE 3-1. FM-5T/FM-5TS PA/DRIVER CABINET CONTROLS AND INDICATORS**  
(Sheet 1 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
1	<b>VSWR OVERLOAD</b>	Indicates a PA stage VSWR overload has occurred when Indicator illuminated.
2	<b>PLATE OVERLOAD Indicator</b>	Indicates a PA plate circuit overload has occurred when illuminated.





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**FIGURE 3-1. CONTROLS AND INDICATORS**  
(3-3/3-4)

**TABLE 3-1. FM-5T/FM-5TS PA/DRIVER CABINET CONTROLS AND INDICATORS**  
(Sheet 2 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
3	<b>SCREEN OVERLOAD</b> Indicator	Indicates a PA screen circuit overload has occurred when illuminated.
4	<b>GRID OVERLOAD</b> Indicator	Indicates a PA grid power supply overload has occurred when illuminated.
5	<b>FAILSAFE STATUS</b> Indicator	Indicates the failsafe interlock is closed when illuminated.
6	<b>INTERLOCK STATUS</b> Indicator	Indicates all transmitter internal interlocks are closed when illuminated.
7	<b>BLOWER STATUS</b> Indicator	Indicates proper operation of the blower when illuminated.
8	<b>FILAMENT STATUS</b> Indicator	Indicates primary ac power is applied to the PA filament regulator when illuminated.
9	<b>HIGH VOLTAGE STATUS</b> Indicator	Indicates the plate power supply is operational when illuminated.
10	<b>POWER CONTROL RAISE</b> Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference upward when depressed. In the manual mode, operates the screen control motor in a direction which will raise transmitter RF output power when depressed.  INDICATOR: Illuminates to indicate the screen control motor is operating in a direction which will raise the transmitter RF power output.
11	<b>POWER CONTROL LOWER</b> Switch/Indicator	SWITCH: In the automatic mode, moves the APC reference downward when depressed. In the manual mode, operates the screen control motor in a direction which will reduce transmitter RF output power when depressed.  INDICATOR: Illuminates to indicate the screen control motor is operating in a direction which will lower the transmitter RF power output.
12	<b>POWER CONTROL APC ON</b> Switch/Indicator	SWITCH: Selects APC control operation of the transmitter. INDICATOR: Indicates the transmitter is under APC control when illuminated.
13	<b>MODEM PORT 1</b>	A modem port used for transmitter monitoring and remote control operations.

**TABLE 3-1. FM-5T/FM-5TS PA/DRIVER CABINET CONTROLS AND INDICATORS**  
(Sheet 3 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
14	<b>POWER CONTROL REMOTE DISABLE</b> Switch/Indicator	SWITCH: Inhibits or enables transmitter remote operation. INDICATOR: Indicates remote operation is inhibited when illuminated.
15	<b>POWER CONTROL VSWR</b> Switch/Indicator	SWITCH: Configures the <b>OUTPUT POWER</b> meter to display VSWR. INDICATOR: Illuminates to indicate the <b>OUTPUT POWER</b> meter is configured to display VSWR.
16	<b>POWER CONTROL PRESET</b> Switch/Indicator	SWITCH: Selects transmitter operation at a preset RF power output level. INDICATOR: Indicates transmitter operation at a preset RF power level (such as half power) when illuminated.
17	<b>POWER CONTROL FWD</b> Switch/Indicator	SWITCH: Configures the <b>OUTPUT POWER</b> meter to display forward power. INDICATOR: Illuminates to indicate the <b>OUTPUT POWER</b> meter is configured to display forward power.
18	<b>AM NOISE TEST</b> Receptacle	Test receptacle for AM noise measurements.
19	<b>HIGH VOLTAGE ON</b> Switch/Indicator	SWITCH: Energizes the step/start contactors when depressed to activate the plate and screen power supplies and enables the exciter. INDICATOR: Indicates a high voltage-on command has been received by the transmitter controller.
20	<b>HIGH VOLTAGE OFF</b> Switch/Indicator	SWITCH: De-energizes the plate and screen power supplies and mutes RF drive when depressed. INDICATOR: Indicates a high voltage-off command has been received by the transmitter controller.
21	<b>FILAMENT OFF</b> Switch/Indicator	SWITCH: De-energizes all transmitter RF circuit power. The blower and flushing fans will operate for approximately thirty-five seconds after the <b>FILAMENT OFF</b> switch has been depressed. INDICATOR: Indicates a filament-off command has been received by the transmitter controller.
22	<b>FILAMENT ON</b> Switch/Indicator	SWITCH: 1) Energizes the control contactor when depressed to apply voltage to the exciter, filament, and grid circuitry. 2) Energizes the blower and flushing fans. INDICATOR: Indicates a filament-on command has been received by the transmitter controller.



































**TABLE 3-1. FM-5T/FM-5TS PA/DRIVER CABINET CONTROLS AND INDICATORS**  
(Sheet 4 of 5)

INDEX NO.	NOMENCLATURE	FUNCTION
23	<b>OVERLOAD RESET</b> Switch/Indicator	SWITCH: Clears the overload circuit memory when depressed. INDICATOR: Indicates an overload condition exists when illuminated.
24	<b>PRIMARY VOLTAGE</b> Meter	Displays PHASE 1-2, PHASE 2-3, or PHASE 3-1 primary ac input voltage potentials as selected by the <b>PRIMARY VOLTAGE</b> switch.
25	<b>PRIMARY VOLTAGE</b> Switch	Selects PHASE 1-2, PHASE 2-3, and PHASE 3-1 primary ac input voltage parameters to be displayed on the <b>PRIMARY VOLTAGE</b> meter.
26	<b>AC POWER</b> Circuit Breaker	Provides overload protection and primary power control for the transmitter AC input.
27	<b>BLOWER</b> Circuit Breaker	Provides overload protection and primary power control for the blower, flushing fans, the automatic power control unit, and the transmitter controller.
28	<b>FILAMENT</b> Circuit Breaker	Provides overload protection and primary power control for the PA tube filament supply, the control grid bias supply, and the hum null circuitry.
29	<b>DRIVER</b> Circuit Breakers	Provides overload protection and primary power control for the FM exciter and intermediate power amplifier.
30	<b>SCREEN</b> Circuit Breaker	Provides overload protection and primary power control for the PA screen grid power supply.
31	<b>FILAMENT TIME</b> Meter	Indicates hours of filament circuit operation.
32	<b>FILAMENT ADJUST</b> Control	Adjusts the PA tube filament voltage.
33	<b>INPUT TUNING</b> Control and Cyclometer	Tunes the PA stage input circuit to resonance.
34	<b>FILAMENT VOLTAGE</b> Meter	Indicates the PA tube filament voltage.
35	<b>MULTIMETER</b> Switch	Selects <b>PA SCREEN VOLTAGE, SCREEN CURRENT, GRID CURRENT, GRID VOLTAGE, EXC FWD POWER, or EXC RFL POWER</b> parameters to be displayed on the <b>MULTIMETER</b> .

**TABLE 3-1. FM-5T/FM-5TS PA/DRIVER CABINET CONTROLS AND INDICATORS**  
(Sheet 5 of 5)

<b>INDEX NO.</b>	<b>NOMENCLATURE</b>	<b>FUNCTION</b>
36	<b>MULTIMETER</b>	Displays <b>PA SCREEN VOLTAGE, SCREEN CURRENT, GRID CURRENT, GRID VOLTAGE, EXC FWD POWER, or EXC RFL POWER</b> as selected by the <b>MULTIMETER</b> switch.
37	<b>PLATE VOLTAGE</b> Meter	Displays the PA stage plate potential.
38	<b>PLATE CURRENT</b> Meter	Displays the PA stage plate current.
39	<b>OUTPUT POWER</b> Meter	Displays transmitter percentage of RF output power or output VSWR as selected by the <b>POWER CONTROL FWD</b> and <b>VSWR</b> switch/indicators.
40	<b>OUTPUT LOADING</b> Control and Cyclometer	Adjusts the PA stage output loading.
41	<b>OUTPUT TUNING</b> Control and Cyclometer	Tunes the PA stage output circuit to resonance.
42	<b>MODEM PORT 2</b>	A modem port used with a future transmitter monitoring and diagnostic option.
43	<b>PRINTER PORT</b>	A printer port used with a future transmitter monitoring and diagnostic option.
44	<b>LOCAL PORT</b>	A communication port used with a future dual/main/alternate transmitter control system.

**TABLE 3-2. INDICATOR CHECKLIST**

INDICATOR	STATUS	
FAILSAFE STATUS		
INTERLOCK STATUS		
BLOWER STATUS		
FILAMENT STATUS		
HIGH VOLTAGE STATUS		
VSWR OVERLOAD		
PLATE OVERLOAD		
SCREEN OVERLOAD		
GRID OVERLOAD		
OVERLOAD RESET SWITCH/INDICATOR		
FILAMENT ON SWITCH/INDICATOR		
HIGH VOLTAGE ON SWITCH/INDICATOR		
REMOTE DISABLE SWITCH/INDICATOR	 OR 	
PRESET SWITCH/INDICATOR		
APC ON SWITCH/INDICATOR		
LOWER SWITCH/INDICATOR		
RAISE SWITCH/INDICATOR		
METER	INDICATION	
	POWER	VSWR
OUTPUT POWER	%	: 1
PLATE CURRENT	A	
PLATE VOLTAGE	kV	
MULTIMETER		
SCREEN VOLTAGE	V	
SCREEN CURRENT	mA	
GRID VOLTAGE	V	
GRID CURRENT	mA	
EXCITER FWD POWER	W	
EXCITER REFLECTED POWER	W	
FILAMENT VOLTAGE	V	
FILAMENT TIME	HOURS	

**NOTE**

OPERATIONAL STATUS  
SHOWN BY SHADED  
INDICATOR

**597-0098-412**

# SECTION IV

## THEORY OF OPERATION

### 4-1. INTRODUCTION.

- 4-2. This section presents general theory of operation for the FM-5T/FM-5TS FM Transmitters.
- 4-3. The FM-5T/FM-5TS transmitters are divided into functional blocks which are discussed by the following text. The functional blocks consist of the FM exciter, the power amplifier, the transmitter controller, metering circuitry, and the associated power supply circuitry. The power supply and RF circuitry are discussed in further detail at the end of this section. The transmitter controller is described in detail by the CONTROLLER section of this manual. Refer to Figure 4-1 and the overall schematic diagram in SECTION VII as required for the following explanation.

### 4-4. ELECTRICAL DESCRIPTION.

#### 4-5. FM EXCITER.

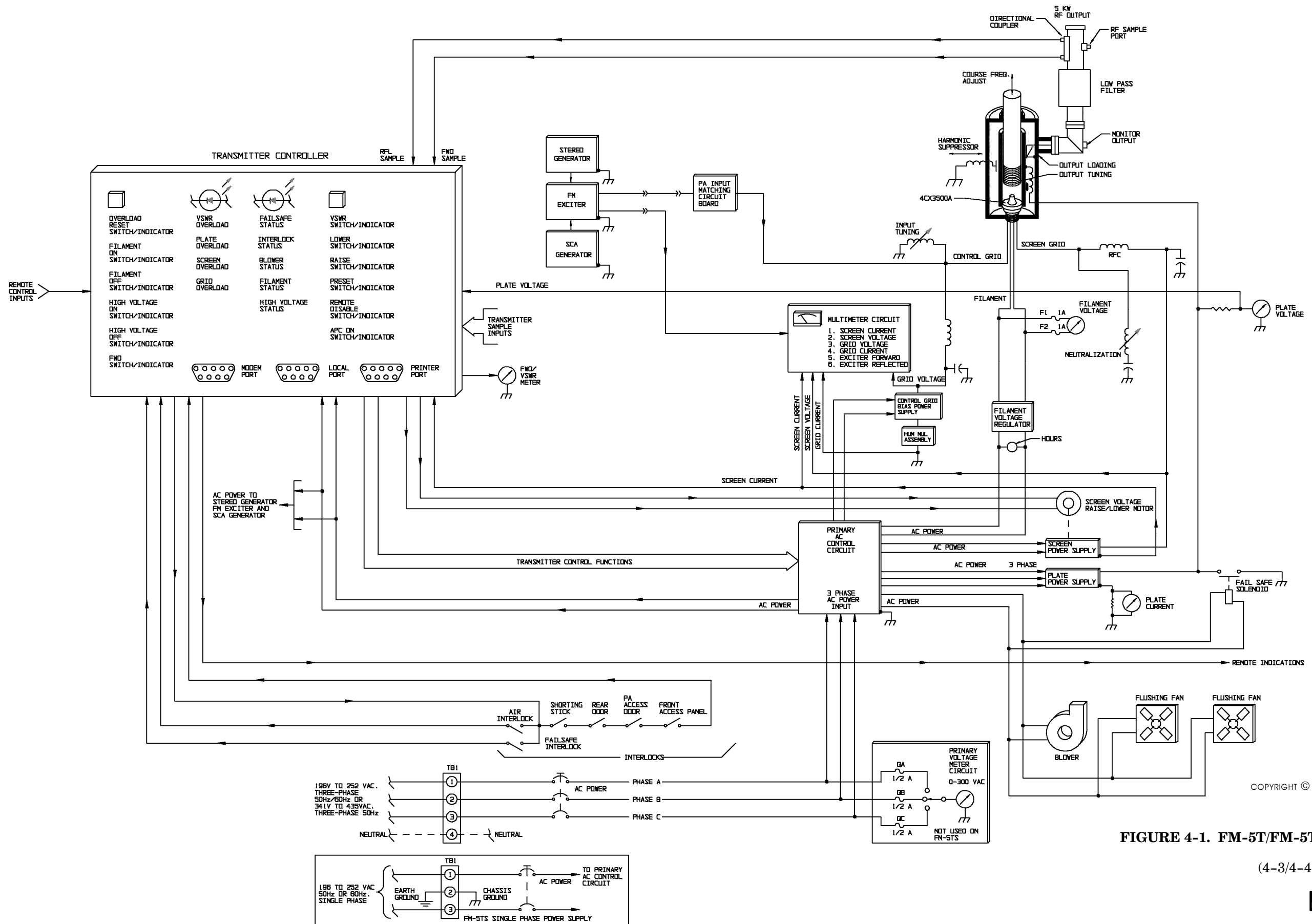
- 4-6. The Broadcast Electronics FM-250C is a totally solid-state wideband FM exciter providing a continuously variable RF output from 25 to 250 watts. The FM-250C operates into a 50 Ohm load at any frequency within the 87.5 to 108 MHz FM broadcast band. The exciter may be programmed to any frequency within the FM band in 10 kHz increments. The FM-250C is mounted on slides to allow easy access to the internal semi-modular exciter circuitry.
- 4-7. The FM-250C will accept multiple wideband composite inputs from a stereo generator or SCA generator as well as a 600 Ohm balanced audio input. Refer to publication 597-1004 for a detailed explanation of the FM-250C exciter features.

#### 4-8. POWER AMPLIFIER.

- 4-9. The FM-5T/FM-5TS uses a single 4CX3500A tetrode to provide 5000 Watts of RF power on a single frequency within the FM broadcast band of 87.5 MHz to 108 MHz. The power amplifier operates in a high-gain, grid-driven class C configuration. A patented input circuit matches the 50 Ohm output of the IPA up to the higher grid input impedance. Use of a large coaxial cavity results in high PA efficiency for comparatively low power consumption. Removal of the PA tube is a simple and quick procedure due to the cavity arrangement. A dual-blower cooling system forces air through the tube socket, anode fins, and out through the main transmission line chimney. A differential air pressure sensor monitors the effectiveness of the cooling system and removes power to the tube if air flow is interrupted.
- 4-10. **POWER AMPLIFIER CAVITY.** The patented PA cavity used in the FM-5T/FM-5TS employs a folded half-wave coaxial transmission line resonator constructed with aluminum and copper tubing. This cavity design eliminates the high voltage blocking capacitors and high current sliding contacts of conventional cavities by connecting the main transmission line conductor directly to the anode of the power tube. A grounded concentric transmission line center conductor tunes this cavity by varying the length inserted into the open end of a main transmission line inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is fed at the RF voltage null point, approximately one-quarter wave from the anode for effective RF decoupling. A large surface area without sliding contacts results in minimal RF loss at this point in the cavity.

- 4-11. **OUTPUT COUPLING.** Energy is coupled into the transmission line by an adjustable untuned loop which functions in the electromagnetic field within the cavity. One end of the output loop is connected to ground, while the other connects to the center conductor of the output transmission line through flexible straps.
- 4-12. **PLATE TUNING.** Plate tuning is accomplished by adjusting a threaded rod which mechanically expands or contracts a beryllium copper bellows on the end of the grounded transmission line center conductor inserted into the main line. Coarse frequency adjustment is accomplished by pre-setting the length of the center conductor into the cavity.
- 4-13. **NEUTRALIZATION.** Neutralization is accomplished in the FM-5T/FM-5TS by distributed inductance added in series between the screen connection and the screen bypass capacitors. The inductance develops a counteractive voltage swing between the screen and ground which cancels out the voltage fed through the internal capacitances of the tube and the stray capacitances of the tube socket. This form of self-neutralization results in very stable operation and requires no adjustment when the power tube is replaced.
- 4-14. **SECOND HARMONIC SUPPRESSOR.** A patented second harmonic suppressor is included in the PA cavity. This consists of a capacitive disc and a series inductance to ground coupled to the main transmission line at the fundamental frequency RF voltage null point. Here the second harmonic exhibits a high voltage and the suppressor presents a low impedance to ground which reduces the amplitude of the second harmonic. This unique method of harmonic suppression has minimal effect on the fundamental frequency and does not add losses to the PA cavity at the fundamental frequency.
- 4-15. **OUTPUT CIRCUIT.** A separate low-pass filter is contained within the FM-5T/FM-5TS cabinet to attenuate all residual second and higher order harmonics. This filter functions over the entire FM broadcast band. Three RF directional couplers are mounted after the filter in the output transmission line connection. Two of these supply filtered forward and reflected power RF samples to the controller and the third port supplies a forward power sample at 40 dB below carrier at 50 Ohms for external test equipment.
- 4-16. **TRANSMITTER CONTROLLER.**
- 4-17. Transmitter control operations and parameter monitoring are performed by a built-in microprocessor based controller. The controller incorporates extensive use of RFI filtering, optical isolation, and state-of-the-art microprocessor technology to assure maximum reliability.
- 4-18. The controller is designed with 12 switch/indicators, 9 status indicators, 3 modem ports, and a printer port. Adjustable timers are provided to determine filament warm-up time, blower run-down time, overload-recycle time, and warm-up defeat time. In addition, the controller is equipped with adjustable plate, screen, grid, and VSWR overload limits. The timers and the overload limits are adjusted by controls on the main circuit board. The range of all controls is limited, however so that the safe operating limits of the transmitter cannot be exceeded by incorrect adjustment.
- 4-19. All transmitter control and monitoring operations are directed by a state-of-the-art Z-SOFT microcontroller. The microcontroller is housed on a single plug-in daughter circuit board. The circuit board plugs directly into a header on the controller main circuit board.
- 4-20. The controller operates from a modular switching power supply assembly. Three LEDs on the main circuit board monitor the status of the +5V, +15V, and -15V power supplies. A Lithium battery backup system has been incorporated into the circuit design. The battery is designed to maintain the controller memory during power failures and has a useful life of approximately 2 years.





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FIGURE 4-1. FM-5T/FM-5TS BLOCK DIAGRAM

(4-3/4-4)

- 4-21. The transmitter controller performs several operations. The following text presents a description of the major controller functions.
- 4-22. **AUTOMATIC RF OUTPUT LEVEL CONTROL.** The controller is designed to provide manual and automatic RF output power level controller. When the unit is configured for automatic power control (APC) operation, the controller monitors screen current, PA forward power, PA reflected power, and the exciter forward power and automatically adjusts the PA screen voltage via a dc servo motor-driven variable autotransformer to maintain a constant transmitter RF output. If excessive PA reflected power, excessive screen current, or low exciter power is measured, the “raise power” command will be inhibited to prevent an overload from occurring. Manual screen control is assumed by switching the APC feature to off. In the manual mode the raise and lower switches directly control the dc servo motor to vary the screen voltage supply. In the APC mode, the switches control a reference voltage stored in the microprocessor memory. This memory is maintained by the battery backup system so that the transmitter can automatically return to the desired power level whenever power is applied.
- 4-23. The dc servo motor control circuit uses a full-on/full-off scheme to drive the dc servo motor. This feature, combined with a deadband, eliminates hunting in this servo loop. The front panel **RAISE** and **LOWER** switches illuminate when the motor is driven by manual or automatic operation.
- 4-24. **VSWR FOLDBACK PROTECTION.** When the unit is in the APC mode, PA forward power is automatically reduced if output reflected power becomes excessive enough to overload the transmitter. As the condition which caused the high VSWR returns to normal, RF power will be proportionately raised until full power is again restored.
- 4-25. **SOFT START.** The controller monitors PA plate voltage and reduces the screen voltage to zero upon its absence. When the plate supply is energized, as during initial turn on, the controller will gradually increase the screen voltage until the stored power setting is achieved. This prevents inadvertent VSWR overloads at turn on, such as during icing of an antenna.
- 4-26. **MOMENTARY POWER INTERRUPTION.** In the event of a momentary power interruption, proper transmitter operation will resume immediately after power returns. If an extended power failure occurs, information maintained by the battery back-up system will enable the controller to initiate a start cycle to automatically return the transmitter to operation without assistance. If the transmitter internal interlock string opens during a power failure, the automatic restart feature will be defeated and the transmitter will enter the off condition when power is re-applied.
- 4-27. **OVERLOADS.** If an overload occurs, the transmitter will deenergize, allow the overload to clear, then automatically return to operation. If four overloads occur within 60 seconds, the transmitter will deenergize. The overload must be manually cleared and the transmitter **HIGH VOLTAGE ON** switch/indicator depressed before operation will resume. Single overloads of greater than 220 milliseconds duration will immediately deenergize the high voltage and filament supplies.
- 4-28. **INDICATORS.** Four LEDs are provided on the front panel as overload status indicators. The first overload that occurs will be latched into the controller and will illuminate the appropriate red VSWR, PLATE, SCREEN, or GRID LED and the yellow overload reset switch/indicator. All further overloads are monitored by the controller but will not be displayed by the LEDs.

- 4-29. Five STATUS indicators illuminate to indicate an operational condition as follows: 1) the **FAILSAFE** LED indicates the external interlock is closed, 2) the **INTERLOCK** LED indicates that the internal interlock loop is closed, 3) the **BLOWER** LED indicates that the air pressure is correct for the PA stage to operate, 4) the **FILAMENT** LED indicates primary ac power is applied to the filament transformer, and 5) the **HIGH VOLTAGE** LED indicates primary ac power is applied to the high voltage plate supply.
- 4-30. **METERING.**
- 4-31. Seven front panel meters on the FM-5T and six on the FM-5TS are provided to indicate transmitter operating parameters. Output power and output VSWR indications are presented on a precision output power meter. Plate voltage and plate current information are displayed on separate meters for optimum convenience.
- 4-32. Additional transmitter metering features include a six function multimeter. The multimeter selects and displays information on vital transmitter operating parameters such as: 1) screen current, 2) screen voltage, 3) grid current, 4) grid voltage, 5) exciter forward power, and 6) exciter reflected power. An iron-vane voltmeter is used to measure filament voltage. A **FILAMENT TIME** meter is provided to indicate hours of filament circuit operation. On FM-5T models, primary ac voltage monitoring is provided by a primary ac voltmeter. The meter selects and displays the voltage between all three phases of the ac input. All meter currents are measured on the ground side of each supply to prevent high voltages across the meters.
- 4-33. **EXCITER METERING.** The exciter operating parameters are displayed by two additional meters and three status indicators. For detailed information on exciter metering, refer to FX-250C exciter manual 597-1004.
- 4-34. **POWER SUPPLIES.**
- 4-35. The FM-5T transmitter is designed for operation from a 196 to 252 volt three phase ac input. The plate supply is a conventional three phase power supply circuit. The remaining FM-5T transmitter power supplies are single phase circuits which are obtained from two phases of the three phase input. The FM-5TS transmitter is designed for operation from a 196 to 252 volt single phase ac input. All FM-5TS transmitter power supplies are single phase circuits obtained from the transmitter ac input.
- 4-36. The grid bias and screen power supplies consist of conventional full-wave rectification and choke input filter sections. A hum-null assembly consisting of a small unfiltered full-wave rectified supply injects a 120 Hz pulsating dc voltage in series with the ground return of the grid bias supply to cancel residual ripple from the screen supply in the tetrode amplifier.
- 4-37. The FM-5T plate supply is a three-phase primary, six-phase secondary supply. The primary circuit is connected in a closed delta arrangement and the secondary is connected in a wye configuration. The supply consists of a 3-phase full-wave bridge rectifier network with an LC filter section. Advantages of this type of supply is good regulation and low ripple which requires little filtering. The FM-5TS plate supply consists of a single phase full-wave rectifier network with a resonant LC filter stage. Power is applied to each plate supply through a step-start circuit to reduce the inrush current at power-on. This limits stress and extends component life.
- 4-38. The filament supply consists of a variable transformer assembly which is used to adjust a high-current low-voltage regulator assembly. The regulator assembly is designed to regulate a wide range of ac input potentials into a stable 240  $\pm 1\%$  volt output.
- 4-39. Each modular component of the transmitter is equipped with a self-contained ac power supply. In addition, a battery back-up supply in the transmitter controller maintains operational information during power outages.

4-40. **DETAILED DESCRIPTION.**

4-41. **FM-5T POWER SUPPLY.**

4-42. A 196 volt to 252 volt, 50 Hz or 60 Hz, three-phase ac input is required for proper operation of the FM-5T transmitter. The following supplies operate from the ac input (typical values are shown for the rated RF power output):

PARAMETER	APPROXIMATE VALUES
A. PA PLATE	+5300V at 1.3 Amperes
B. PA SCREEN GRID	+525V at 0.060 Amperes
C. PA CONTROL GRID	-260V at 0.045 Amperes
D. PA FILAMENT	5V ac at 90 Amperes
E. HUM NULL	+12.6V at 0.040 Amperes

4-43. **SEQUENCE OF OPERATION.** When the transmitter fused disconnect is closed, power is applied through **AC POWER** circuit breaker CB1 to: 1) the contacts of high voltage step contactor K7, 2) the contacts of high voltage start contactor K4, and 3) the contacts of filament/driver contactor K3 (see Figure 4-2). Power is also applied through **BLOWER** circuit breaker CB2 to the transmitter controller and to blower control relay K1.

4-44. When the **FILAMENT ON** switch/indicator is depressed, optically-coupled-relay K1 will apply power to blower B1, flushing fans B2 and B3, and energize high voltage shorting solenoid K5. After the blower comes up to speed, the air interlock will close and optically-coupled-relay K2 will energize filament/driver contactor K3 which applies power to: 1) the PA filament supply, 2) the PA control grid supply, 3) the hum-null power supply, 4) the FM exciter, and 5) the optional stereo and SCA generators.

4-45. Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, and the PA filament heating delay of at least ten seconds has expired, optically-coupled-relay K6 will pulse step contactor K7. After the current inrush to the plate supply has been limited by the step/start resistors (R1, R2, and R3), optically-coupled-relay K5 will energize start contactor K4 to apply full input to the plate and screen power supplies.

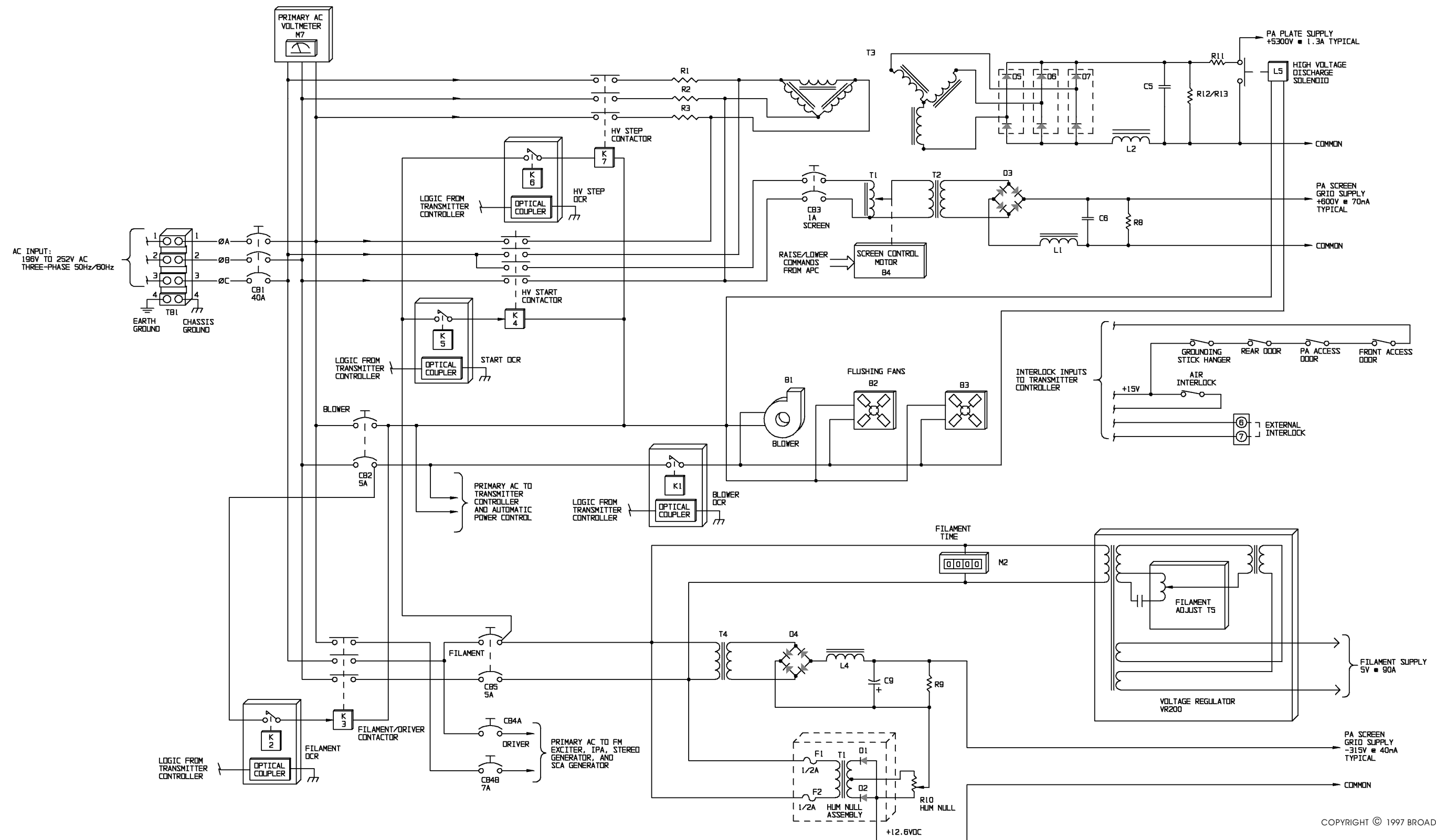
4-46. If during a start sequence an internal interlock opens, the entire start sequence will be cancelled and must be re-initiated manually. If an internal interlock opens during operation, the entire power supply section will deenergize. However, if the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube but a new start sequence will have to be initiated manually. Whenever power is removed from the blower and flushing fans, the high voltage discharge solenoid will short the plate supply to ground.

4-47. If the **HIGH VOLTAGE OFF** switch/indicator is depressed, the plate and screen power supplies will deenergize. If the **FILAMENT OFF** switch/indicator is depressed, all remaining power supplies will deenergize. The blower and flushing fans will continue operation for 30 seconds or more to cool the PA tube, then deenergize.

4-48. **PA PLATE POWER SUPPLY.** The plate power supply is a three-phase primary, six-phase secondary supply. The primary circuit is connected in a closed delta arrangement and protected by circuit breaker CB1. Component stress at power on is eliminated by a step/start circuit which limits supply inrush current.

4-49. The secondary of the high voltage transformer is connected in a wye configuration. Due to the physical construction of the transformer, each phase appearing in the secondary will lead and lag a respective phase appearing in the primary by 60 degrees. The secondary phase separation of 60 degrees divided into one primary phase of 360 degrees equals six secondary phases.

- 4-50. Minimal filtering is required as only 4.2 percent ripple is output from the rectifiers. One requirement of the multiphase supply, however is that the primary ac input must be balanced to within the percentage of ripple voltage which is to be obtained from the supply. Constant primary ac line unbalance can be corrected by the use of primary taps or a tapped three-phase autotransformer.
- 4-51. Filtering for the supply is accomplished by a one-section choke-input filter. The choke is inserted in the negative leg of the rectified output to eliminate the dc potential between the choke and ground. The negative leg of the supply is referenced to ground through the PA stage current meter shunt. A single shunt capacitor bypasses residual ac ripple at frequencies of 300 to 360 Hz and higher to ground. A bleeder resistor connected across the supply increases regulation and, in conjunction with high voltage discharge solenoid K5, enhances safety. A series resistance in the anode dc feedline limits peak energy in case of arc-overs in the power amplifier stage or high voltage discharge solenoid operations.
- 4-52. Component stress at power-on is eliminated by a step/start circuit which limits plate supply inrush current. The step/start circuit is interlocked through contacts of the filament circuit breaker and the filament/driver contactor to assure that the filament circuit is energized before a high-voltage-on sequence can be initiated. The controller will energize the step contactor via K6. After 100 milliseconds, the controller will energize the start contactor via K5. The step contactor will deenergize after it has been energized for 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between the step/start relay closures.
- 4-53. **PA SCREEN GRID POWER SUPPLY.** The screen power supply is a full-wave bridge-rectified supply with a single L-section filter. The primary of the screen transformer is connected through CB3 to the step/start contactors. The output of the screen supply is adjustable with a variable autotransformer connected in the primary of the screen transformer. A dc motor connected to the variable autotransformer allows both manual and automatic control of the screen voltage. The choke in this supply is connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C6.
- 4-54. **PA CONTROL GRID POWER SUPPLY.** The control grid bias supply is a full-wave bridge-rectified supply with a single L-section filter. The primary of the supply is connected to the primary ac input through CB5 and filament/driver contactor K3. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C9, a relatively high capacity electrolytic capacitor.
- 4-55. **Hum Null Supply.** The ground path for the grid bias supply is routed through the hum-null circuit which introduces a small 120 Hz pulsating dc component into the control grid bias supply to cancel hum in the PA tube from the screen supply. The amount of voltage added to the negative side of the control grid bias supply is adjusted by R10. This voltage is out-of-phase with the 120 Hz ripple component of the screen supply.
- 4-56. **PA FILAMENT SUPPLY.** The PA filament supply is a low-voltage high current ac supply. Overload protection for the circuit is provided by circuit breaker CB5. Filament voltage regulator VR200 provides a stable ac input voltage environment. Variable transformer T5 provides accurate filament voltage adjustment. A **FILAMENT TIME** meter indicates hours of filament circuit operation.



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FIGURE 4-2. FM-5T POWER SUPPLY SIMPLIFIED SCHEMATIC

(4-9/4-10)

4-57. **FM-5TS POWER SUPPLY.**

4-58. A 196 volt to 252 volt, 50 Hz or 60 Hz, single-phase ac input is required for operation of the FM-5TS transmitter. The following supplies operate from the ac input (typical values are shown for the rated RF power output):

PARAMETER	APPROXIMATE VALUES
A. PA PLATE	+5300V at 1.3 Amperes
B. PA SCREEN GRID	+525V at 0.060 Amperes
C. PA CONTROL GRID	-260V at 0.045 Amperes
D. PA FILAMENT	5V ac at 90 Amperes
E. HUM NULL	+12.6V at 0.040 Amperes

4-59. **SEQUENCE OF OPERATION.** Power is applied through **AC POWER** circuit breaker CB1 to: 1) the contacts of high voltage step contactor K7, 2) the contacts of high voltage start contactor K4, and 3) the contacts of filament/driver contactor K3 (see Figure 4-3). Power is also applied through **BLOWER** circuit breaker CB2 to: 1) the transmitter controller, 2) blower control relay K1, and 3) filament control relay K2.

4-60. When the **FILAMENT ON** switch/indicator is depressed, optically-coupled-relay K1 will apply power to blower B1, flushing fans B2 and B3, and energize high voltage shorting solenoid K5. After the blower comes up to speed, the air interlock will close and optically-coupled-relay K2 will energize filament/driver contactor K3 which applies power to: 1) the PA filament supply, 2) the PA control grid supply, 3) the hum-null power supply, 4) the FM exciter, and 5) the optional stereo and SCA generators.

4-61. Assuming the **HIGH VOLTAGE ON** switch/indicator has been depressed, and the PA filament heating delay of at least ten seconds has expired, optically-coupled-relay K6 will pulse step contactor K7. After the current inrush to the plate supply has been limited by the step/start resistors (R1 and R2), optically-coupled-relay K5 will energize start contactor K4 to apply full input to the plate and screen power supplies.

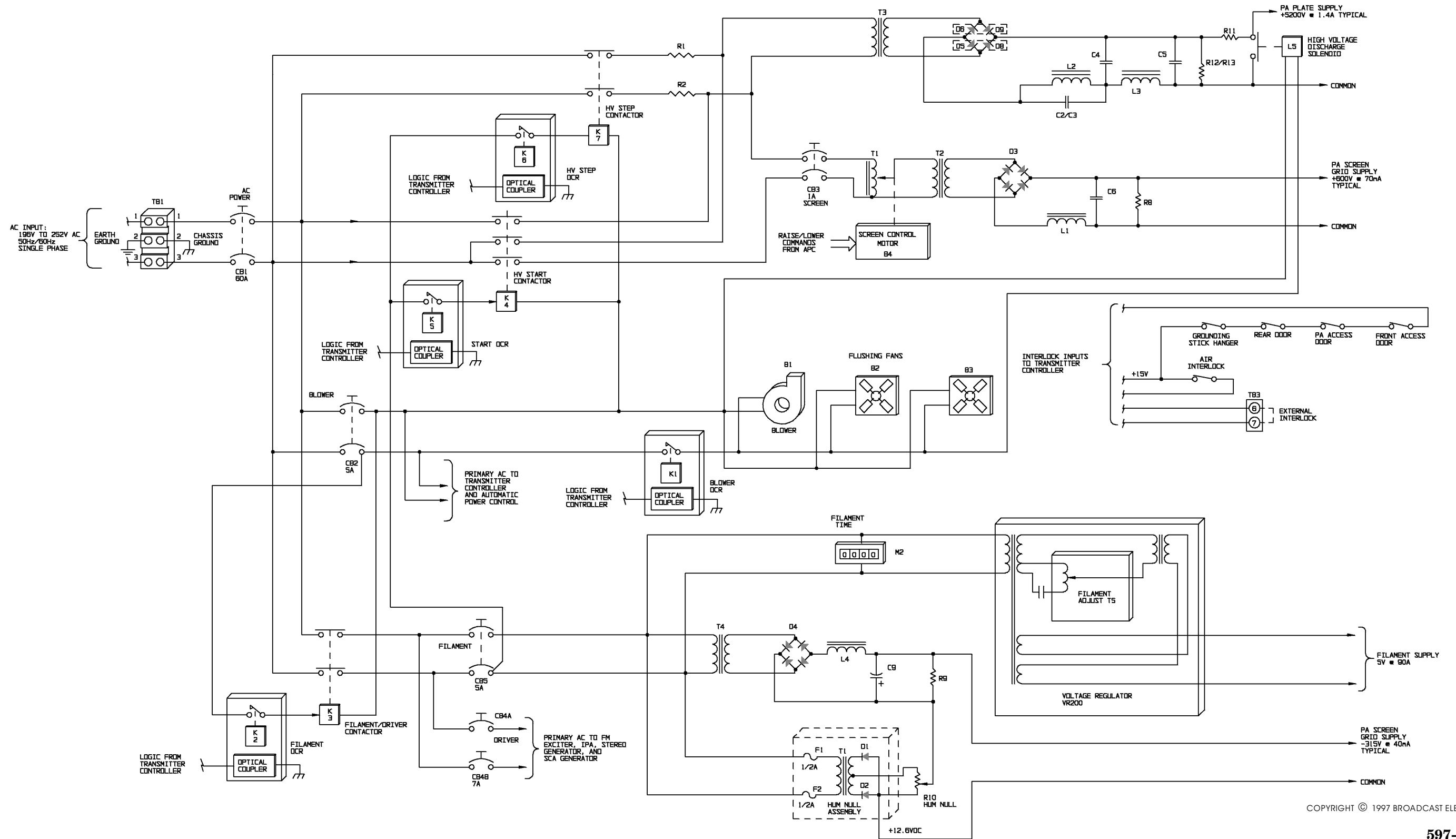
4-62. If during a start sequence an internal interlock opens, the entire start sequence will be cancelled and must be re-initiated manually. If an interlock opens during operation, the entire power supply section will deenergize. However, if the interlock is promptly closed, the blower and flushing fans will resume operation to cool the PA tube but a new start sequence will have to be initiated manually. Whenever power is removed from the blower and flushing fans, the high voltage discharge solenoid will short the plate supply to ground.

4-63. If the **HIGH VOLTAGE OFF** switch/indicator is depressed, the plate and screen power supplies will deenergize. If the **FILAMENT OFF** switch/indicator is depressed, all remaining power supplies will deenergize. The blower and flushing fans will continue operation for 30 seconds or more to cool the PA tube, then deenergize.

4-64. **PA PLATE POWER SUPPLY.** The plate power supply is a full-wave bridge-rectified supply with a two-section filter. The first filter section includes a 120 Hz resonant choke. This section provides good load regulation, low 120 Hz ripple, and lower stored energy than conventional filter sections with similarly sized components. The filter location in the negative leg of the rectifier output eliminates the dc potential between the choke and ground. A pi-section filter follows the resonant choke which reduces high frequency components which are passed by the resonant choke. The choke in the pi-section is also connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across the supply improves regulation, and in conjunction with high voltage discharge solenoid K5, enhances safety. A series resistance in the anode dc feed limits peak energy in case of arc-overs in the power amplifier stage and during high voltage discharge solenoid operation.

- 4-65. Component stress at power-on is eliminated by a step/start circuit which limits plate supply inrush current. The step/start circuit is interlocked through contacts of the filament circuit breaker and the filament/driver contactor to assure that the filament circuit is energized before a high-voltage-on sequence can be initiated. The controller will energize the step contactor via K6. After 100 milliseconds, the controller will energize the start contactor via K5. The step contactor will deenergize after it has been energized for 160 milliseconds. In this manner, the current limiting resistors will only be subject to heating during a 100 millisecond interval between the step/start relay closures. The limiting resistors are disconnected from the lines after 160 milliseconds, improving reliability.
- 4-66. **PA SCREEN GRID POWER SUPPLY.** The screen power supply is a full-wave bridge-rectified supply with a single L-section filter. The primary of the screen transformer is connected through CB3 to the step/start contactors. The output of the screen supply is adjustable with a variable autotransformer connected in the primary of the screen transformer. A dc motor connected to the variable autotransformer allows both manual and automatic control of the screen voltage. The choke in this supply is connected in the negative leg of the supply to eliminate the dc potential between the choke and ground. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C6.
- 4-67. **PA CONTROL GRID POWER SUPPLY.** The control grid bias supply is a full-wave bridge-rectified supply with a single L-section filter. The primary of the supply is connected to the primary ac input through CB5 and filament/driver contactor K3. A bleeder resistor connected across this supply improves regulation and enhances safety by discharging C9.
- 4-68. **Hum Null Supply.** The ground path for the grid bias supply is routed through the hum-null circuit which introduces a small 120 Hz pulsating dc component into the control grid bias supply to cancel hum in the PA tube from the screen supply. The amount of voltage added to the negative side of the control grid bias supply is adjusted by R10. This voltage is out-of-phase with the 120 Hz ripple component of the screen supply.
- 4-69. **PA FILAMENT SUPPLY.** The PA filament supply is a low-voltage high current ac supply. Overload protection for the circuit is provided by circuit breaker CB5. Filament voltage regulator VR200 provides a stable ac input voltage environment. Variable transformer T5 provides accurate filament voltage adjustment. A **FILAMENT TIME** meter indicates hours of filament circuit operation.
- 4-70. **RF CIRCUITRY.**
- 4-71. **FM EXCITER.** The modulated FM signal for RF circuit operation is generated by the FM-250C FM exciter (see Figure 4-4). Approximately 140 watts of drive is required to operate the PA circuitry. Refer to publication 597-1004 for a complete description of the FM exciter.
- 4-72. **POWER AMPLIFIER.** The PA stage contains a single 4CX3500A tetrode operated class C in a folded half-wave cavity to output 5 kW of RF power with approximately 150 Watts of RF drive. The following text describes the operation of components and circuits within the PA stage.
- 4-73. **PA Input Circuit.** The grid impedance-matching circuit used in the FM-5T/FM-5TS transmitter consists of a combination of series inductor and shunt capacitor circuit board elements, implemented with a printed circuit board. The inductors and capacitors are etched into the copper-clad laminate. Multiple LC sections match the 50 Ohm source impedance to the 300 to 400 Ohm input impedance of the grid-driven RF power amplifier.





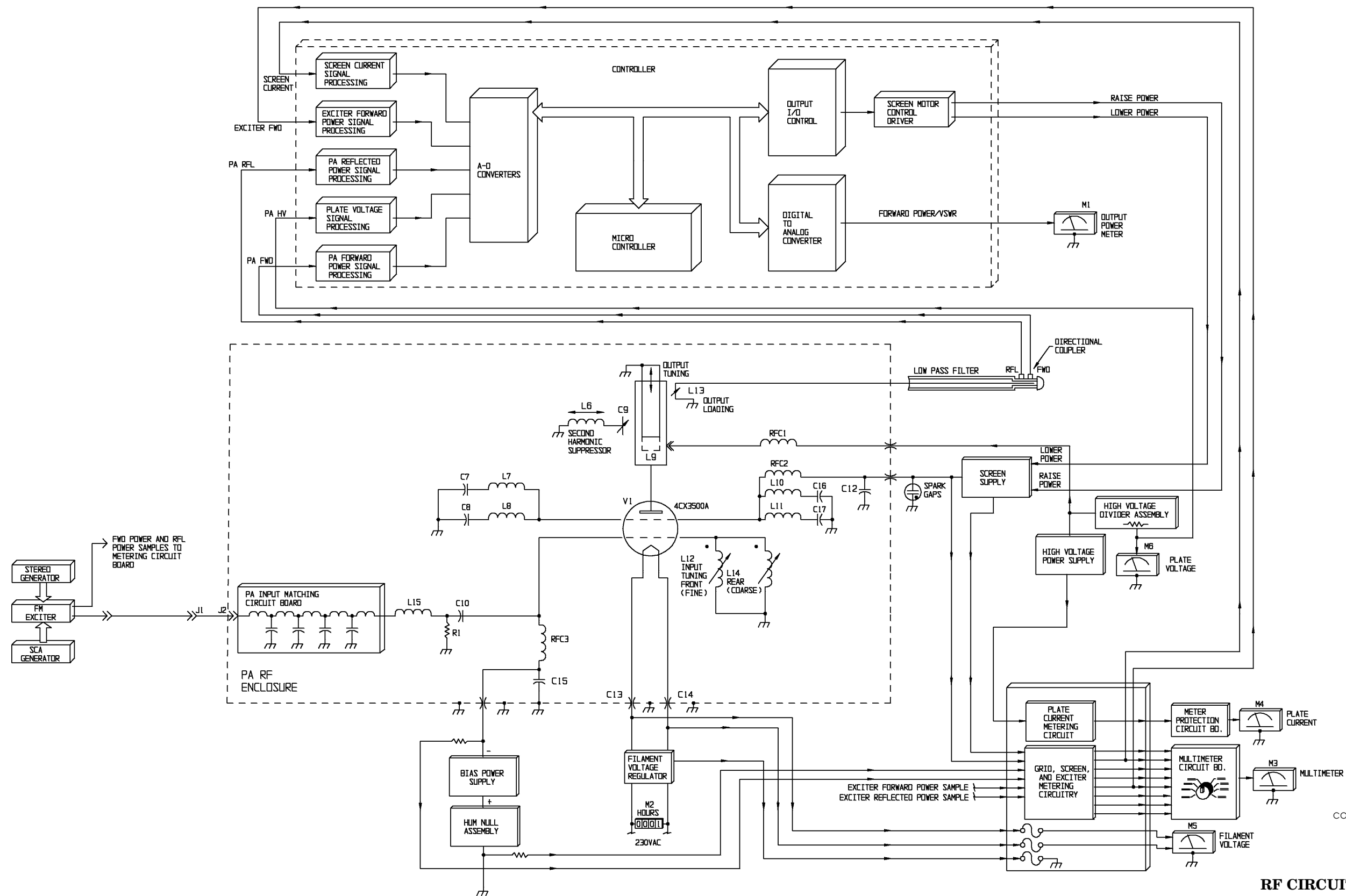
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FIGURE 4-3. FM-5TS POWER SUPPLY SIMPLIFIED SCHEMATIC

(4-13/4-14)

- 4-74. This input matching design provides a wide bandwidth and improves reliability, stability, and maintainability of the transmitter. A single tuning control in the input circuit is sufficient to tune and match the 50 Ohm IPA impedance to the high input impedance of the grid over the 88 to 108 MHz FM broadcast band with a 4:1 range of RF power levels. The input-matching circuit also eliminates separately mounted components which can be microphonically sensitive to vibrations due to mechanical instability in the cooling air flow.
- 4-75. The grid circuit is adjusted for proper operation with two paralleled “slider” inductors which connect to ground. These controls employ sliding shorts to tune the grid capacitance to resonance. One inductor is mechanically connected to the front panel input tuning control while the other inductor is connected to a counter in the rear of the FM-5T/FM-5TS. Fine tuning is accomplished by adjusting either one of the inductors (normally the front panel control). A resistive loading component is included in the input circuit to broaden its overall response. The filament bypassing and grid blocking capacitors are specially fabricated in a sandwich-type construction with etched copper-clad Kapton dielectrics for high capacitance with negligible inductance.
- 4-76. The screen grid ring is connected through eight flexible adjustable straps to four copper-clad Kapton bypass capacitors to ground. Self-neutralization is accomplished by adjusting the length of the straps, thereby varying the series inductance. This introduces an out-of-phase current component causing a voltage swing across the screen to ground which cancels out the voltage fed through internal plate-to-grid capacitances of the tube. A spark gap is included to safely bypass energy if the tube should arc internally.
- 4-77. **Power Amplifier Cavity.** The PA cavity used in the FM-5T/FM-5TS employs a folded half-wave coaxial transmission line resonator constructed with aluminum and copper tubing. This cavity design eliminates the high voltage blocking capacitors and high current shorting contacts of conventional cavities by connecting the main transmission line conductor directly to the anode of the power tube (see Figure 4-5). A grounded concentric transmission line center conductor tunes this cavity with a variable reentrant length inserted into the end of a main inner conductor. The main inner conductor is insulated from ground and carries the anode dc potential. DC power is fed at the RF voltage null point which is approximately one-quarter wave from the anode for effective RF decoupling. A large surface area without sliding contacts results in minimal loss at this point. Incorporated into the tank design is a second-harmonic suppressor. Rather than attenuating the second harmonic after the signal has been generated and amplified, the circuitry in the FM-5T essentially eliminates formation of this signal by series LC trapping the second harmonic waveform at the point where the wave exhibits a high voltage, approximately one-quarter wave length from the anode.
- 4-78. Plate tuning is accomplished by an adjustable bellows on the grounded or center portion of the plate line which is maintained at chassis ground potential. The PA plate potential is applied to the main conductor (the fixed portion of the plate line) at the fundamental frequency RF voltage null point. This point is also the point at which the second harmonic will peak in voltage. The basic LC circuit placed at this point will essentially eliminate the second harmonic component in the plate current waveform.
- 4-79. **PA Output Circuit.** Output coupling is accomplished with an untuned loop intercepting the magnetic field concentration at the voltage null point of the main line. The PA loading control varies the angular position of the plane of the loop with respect to the plate line, changing the amount of magnetic field which it intercepts. Multiple phosphor bronze leaves connect one side of the output loop to ground and the other side to the center conductor of the output transmission line connection. This allows for mechanical movement of the loop by the PA loading control without utilizing any sliding contacts. The grounded loop improves immunity to lightning and static buildup on the antenna connection.

- 4-80. A pair of directional couplers located in the output transmission line provide RF output voltages proportional to the PA forward and reflected power. The RF output voltages are rectified and amplified to provide power and VSWR indications on the **OUTPUT POWER** meter and samples for the transmitter controller. An additional port in the transmission line provides a point to connect a station modulation monitor.
- 4-81. **PA METERING.** Seven meters on the FM-5T and six on the FM-5TS are used to indicate transmitter operating parameters. The plate current, multimeter, and the filament voltage meters measure samples from a PA metering circuit board which is mounted on the side of the RF enclosure. Additional samples from this circuit board are routed to the controller for overload and diagnostic features. The PA metering circuit board also contains fuses which protect the filament meter wiring. Plate voltage metering is obtained from a high voltage meter multiplier circuit board. Power output metering is derived from circuitry within the controller. A filament time meter indicates total elapsed time of filament circuit operation. The filament voltage meter is an iron vane type and accurately measures the filament voltage at the cavity feed-thru terminals. On FM-5T models, monitoring of ac input potentials is provided by a primary ac voltage meter.
- 4-82. **AUTOMATIC POWER CONTROL.** The transmitter controller monitors a number of transmitter parameters to function as part of a closed loop which maintains a constant RF output level from the transmitter (see Figure 4-4).
- 4-83. PA forward and reflected power samples from the transmitter low-pass filter are applied to individual rectifier/amplifier circuits in the controller. The outputs from the rectifier/amplifier circuits are routed to analog-to-digital (A-to-D) circuitry. The A-to-D circuitry converts the signals to a digital format and routes the signals to the microprocessor. The microprocessor uses the signals: 1) to output forward power and VSWR samples to the output power meter, 2) to output forward and reflected power samples to the remote meter terminals, and 3) for automatic RF output power control operations. The controller monitors several parameters such as the forward and reflected power, screen current, and exciter forward power to determine if power control and correction is required. When automatic power control is enabled and power correction is required, the controller will use the adjustable screen supply autotransformer to obtain the desired power level.
- 4-84. When APC operation is enabled and as RF output power varies, the controller will act to maintain the established RF output level. If inadequate exciter drive exists for normal operation, PA reflected power increases, or if screen current is high, any power increase will be inhibited. If the PA reflected power increases to a point which may damage the RF circuitry of the transmitter, the controller will reduce the RF output to a safe level and the transmitter will continue to operate. Full power will be automatically re-established when the VSWR condition is corrected.
- 4-85. As an additional function, the controller will reduce the PA screen potential to minimum whenever the plate voltage is off. Whenever the plate voltage is energized, the controller will gradually increase the PA screen voltage until the rated transmitter RF output is established unless limited by low exciter drive, a high VSWR condition, or high screen current.



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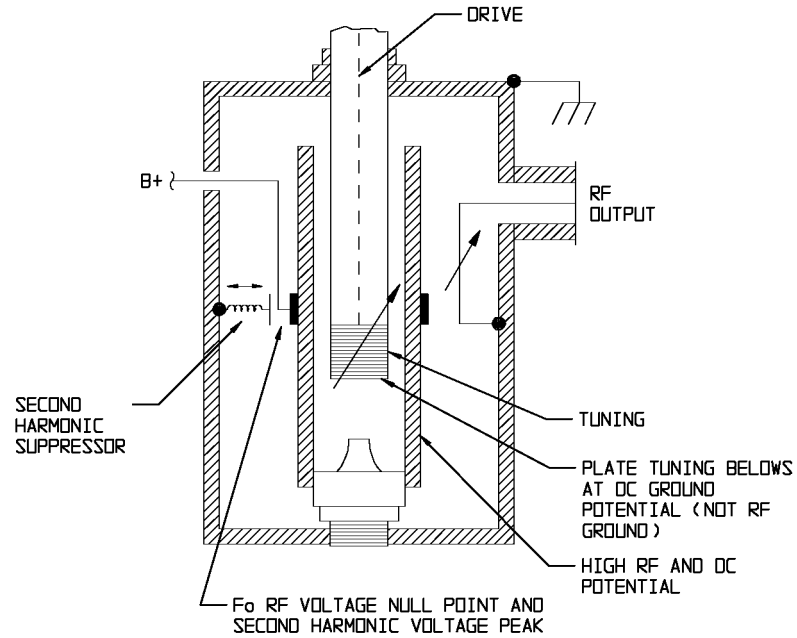
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**FIGURE 4-4.**  
**RF CIRCUIT SIMPLIFIED SCHEMATIC**

(4-17/4-18)

NOTES:

1. TUNING OPERATED AT ZERO RF AND DC POTENTIAL.
2. NO PLATE BLOCKING CAPACITOR.



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**597-0032-32**

**FIGURE 4-5. PA CAVITY**

# SECTION V MAINTENANCE

## 5-1. INTRODUCTION.

5-2. This section provides general maintenance information, electrical adjustment procedures, and troubleshooting information for the FM-5T/FM-5TS transmitters.

## 5-3. SAFETY CONSIDERATIONS.



**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

**WARNING**

5-4. The FM-5T/FM-5TS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built-in safety features, however good judgement, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

5-5. It is very dangerous to attempt to make measurements or replace components with power energized, therefore such actions are not recommended. The design of the equipment provides safety features such that when a door is opened or an access panel is removed, interlock switches will deenergize all dc power supplies and release the fail-safe discharge solenoid across the plate supply. Do not short out or bypass interlock switches as a maintenance short cut.

5-6. The PA cavity access door actuates an interlock switch if the door is opened during transmitter operation. All dc supplies will be deenergized and the plate supply will be shorted to ground. AC power to the entire cabinet may be disconnected with the front panel **AC POWER ON/OFF** circuit breaker.

5-7. A grounding stick is provided as a safety feature. The grounding stick consists of a metal hook with an insulated handle. The metal end is connected to chassis ground. Use the grounding stick to touch every part in the area or circuit on which maintenance is to be performed before attempting maintenance.

5-8. The grounding stick rests on a hook switch. When the grounding stick is removed, the associated hook switch will open the transmitter interlock string and deenergize all transmitter dc potentials until the grounding stick is replaced on its respective hook switch.

5-9. **FIRST LEVEL MAINTENANCE.**



**WARNING**      ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.***

**WARNING**

- 5-10. First level maintenance consists of those precautionary measures applied to the equipment to forestall future failures. These procedures are performed on a regular basis and the results recorded in a maintenance log. Preventive maintenance of the transmitter consists of good housekeeping, lubrication, and checking the performance levels using the meters and various indicators built into the equipment.



**WARNING**      ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

**WARNING**

- 5-11. On a regular basis, clean the equipment of accumulated dust. Check for overheated components, tighten loose hardware, and lubricate mechanical surfaces as required. A lubricant such as “Lubriplate” should be applied sparingly to the tuning drives, cables, the PA tuning line right angle gear mechanism, and the cyclometer drives behind the front panel. The PA output loading screw drive should be opened (four screws) and lubricated every 36 months, or more often if resistance is noted.
- 5-12. **CONTROLLER BATTERY.**
- 5-13. The transmitter controller is equipped with a Lithium battery. The battery has a useful life of approximately two years. After approximately two years of service, replace the controller battery using BEI part number 350-2032.
- 5-14. **AIR FILTER.**
- 5-15. Air filter replacement is accomplished outside the transmitter without interrupting equipment operation. The filter should be checked once each week with replacement done on an as-needed basis. A dirty filter could result in dirt accumulation leaking into the cabinet from seams, door jambs, etc. Never reverse a dirty filter. Always replace the filter.
- 5-16. The transmitter uses one disposable type air filter 1 inch X 16 inches X 20 inches (2.54 cm X 40.64 cm X 50.8 cm) mounted in the rear door of the cabinet. Additional filters may be ordered for replacement (P/N 407-0062) or locally purchased. Always mount the filter with the airflow arrow pointing towards the blower. The exciter is also equipped with an air filter. Refer to the exciter manual for additional information.

5-17. **BLOWER MAINTENANCE.**



**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

**WARNING**

- 5-18. Inspect the blower and the cabinet flushing fans for dust accumulation and periodically clean the blower and fans using a paint brush and vacuum cleaner. Both the fan and blower bearings are sealed and do not permit lubrication. If a bearing fails, the motor must be replaced. The blower and fan mounting bolts should be checked for tightness.
- 5-19. The blower and fan motors are cooled by the air passing around each motor. If the ambient air temperature is too high or if the air flow is restricted, then the lubricant will gradually vaporize from the motor bearings and bearing failure will occur. If very dirty air passes over the motors, accumulated dust will impair the motor cooling unless the accumulation is wiped from and blown out of the motor.
- 5-20. The blower and fan impeller blades should be inspected and cleaned periodically. If the transmitter is operated in a very dusty environment, dust will build up on the concave side of the blower and fan impellers. If this happens, air flow will be reduced and unbalance will result with a possibility of damage to the blower or fans.

5-21. **SECOND LEVEL MAINTENANCE.**

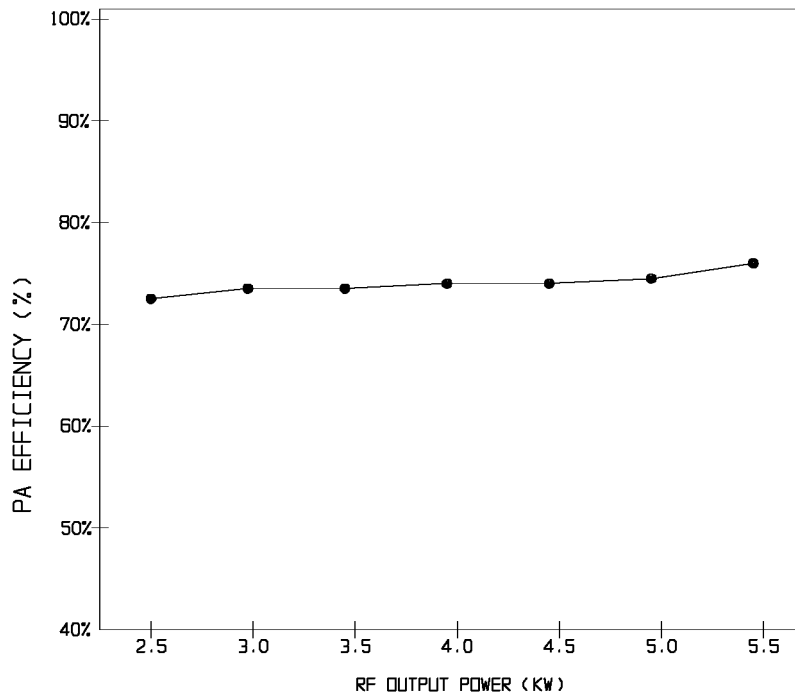


**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

**WARNING**

- 5-22. Second level maintenance consists of procedures required to restore the transmitter to satisfactory operation after a fault has occurred. The maintenance philosophy for the FM-5T/FM-5TS transmitters consists of problem isolation to a specific area. Subsequent troubleshooting provided by each applicable assembly publication in Part II of this manual will assist problem isolation to a replaceable assembly or component. If desired, a replaceable assembly may be returned to the factory for repair or exchange.
- 5-23. **GENERAL.**
- 5-24. **PA STAGE.** Power amplifier tube life is a result of several circuit parameters. Usually, the first indication of the decline of a tube is a slight reduction in power output. This can normally be corrected by a small increase in filament voltage. It may be wise to order a new tube at this time. Further reductions in power output can be compensated in the same manner only a limited number of times. Refer to the Eimac application paper titled "Extending Transmitter Tube Life" included in the "Manufacturers Data" section of this manual. Excess control grid or screen grid dissipation will shorten the life of a tube. Also, excess plate dissipation signals nothing but trouble. PA efficiency versus RF power is plotted on Figure 5-1 and should be referenced to estimate PA efficiency for a particular power level.





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**597-0033-11**

**FIGURE 5-1. TYPICAL PA EFFICIENCY CURVE AT 98.1 MHz  
(Within  $\pm 2\%$  from 87.5 to 108 MHz)**

- 5-25. **PA Tube Warranty.** The FM-5T/FM-5TS PA tube is covered by warranty from the Varian/Eimac Company, the tube manufacturer, not Broadcast Electronics, Inc. However, a tube purchased from Broadcast Electronics which is defective must be returned to Broadcast Electronics with a customer-completed warranty claim service report. A warranty claim service report form is shipped with each tube obtained from Broadcast Electronics, Inc. Following this procedure will expedite immediate shipment of a new tube. Contact the Broadcast Electronics, Inc. Customer Service Department for additional details as required. It is recommended that the warranty report be filled out as soon as the new tube is placed in operation while the nominal voltages are known.

5-26. **ADJUSTMENTS.**



**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.*

- 5-27. Adjustment procedures for controls associated with the transmitter controller are presented in the CONTROLLER section of this manual. Adjustment procedures for the power supply and PA controls are presented as follows:

- A. AM Noise.
- B. Plate Current Meter Calibration.

C. Second Harmonic Suppressor Adjustment.

D. Neutralization.

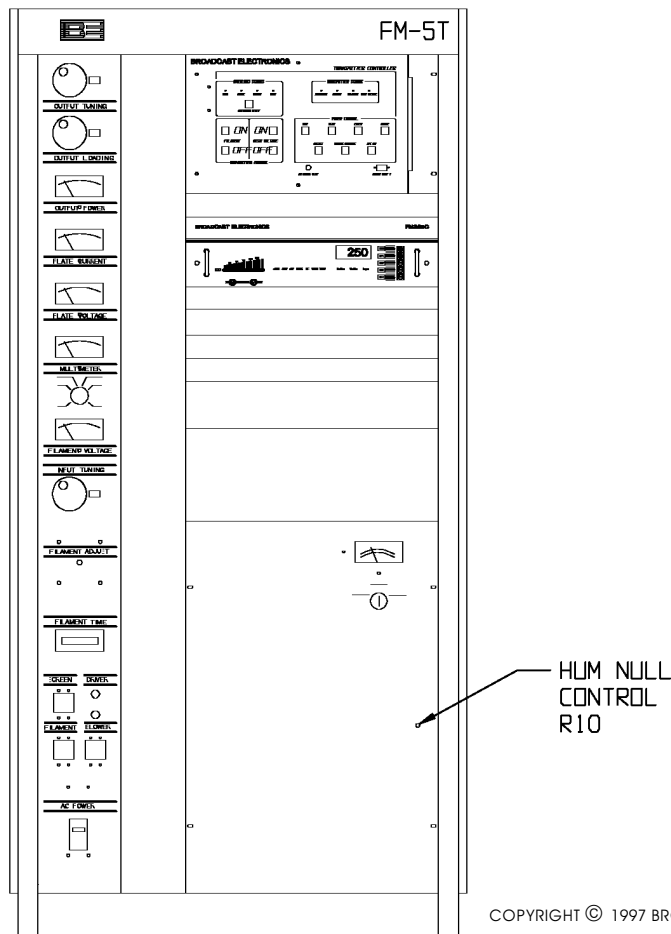
- 5-28. **AM NOISE.** The FM-5T/FM-5TS transmitters are equipped with an **AM NOISE** test receptacle. The test receptacle is located on the transmitter controller and provides a calibrated AM waveform sample for direct measurement of synchronous and asynchronous AM noise parameters. Refer to the following text for procedures to minimize AM noise parameters in the transmitter.
- 5-29. **Synchronous AM Noise.** Synchronous AM noise is incidental amplitude modulation of the carrier by the presence of FM modulation. The synchronous AM noise level is related to: 1) the transmitter overall bandwidth and 2) transmitter tuning. An application paper titled "TECHNIQUES FOR MEASURING SYNCHRONOUS AM NOISE IN FM TRANSMITTERS" is available from Broadcast Electronics, Inc. The paper presents detailed information on AM noise measurements and procedures for tuning the transmitter to minimize the synchronous AM noise level. If adjustment of the transmitter is desired, perform the procedures in the application paper and tune the transmitter for a minimum synchronous AM noise level.
- 5-30. **Asynchronous AM Noise.** Asynchronous AM noise is residual amplitude modulation of the transmitter output due primarily to power supply ripple. The transmitter hum null circuit injects a small 60 Hz voltage into the bias power supply to cancel ac components in the supply and reduce asynchronous AM noise. Adjustment of the circuit will not normally be required in the field. However, if it is certain that hum null circuit adjustment is required, proceed as follows.
- 5-31. **Required Equipment.** The following equipment is required to adjust the hum null circuit.
- A. Distortion analyzer (Tektronics Model AA501 or equivalent).
  - B. One locally fabricated test cable consisting of the following:
    - A. 10 feet (3.05 m) of Belden RG58A/U coaxial cable (BE P/N 622-0050).
    - B. Two BNC connectors (Pomona UG68/U-BE P/N 417-0205).



**WARNING** ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.***

**WARNING**

- 5-32. **Procedure.** To adjust the hum null circuit, proceed as follows:
- 5-33. Refer to Figure 5-2 and connect the distortion analyzer to the controller **AM NOISE** test receptacle using the coaxial test cable (Item B). Configure the distortion analyzer for dBm level indications.
- 5-34. Operate the transmitter at a normal output power level.
- 5-35. Refer to Figure 5-2 and adjust hum null control R10 for a minimum asynchronous AM noise indication on the distortion analyzer.
- 5-36. Disconnect and remove all test equipment.
- 5-37. **PLATE CURRENT METER CALIBRATION.** The plate current meter assembly is equipped with a calibration control. Due to the special equipment required to adjust the calibration control, the control is not considered field adjustable. If it is certain that adjustment of the plate current meter calibration control is required, contact the Broadcast Electronics Customer Service Department for maintenance information on the plate current meter assembly.



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597-0033-401

**FIGURE 5-2. HUM NULL CONTROL LOCATION**

- 5-38. **SECOND HARMONIC SUPPRESSOR.** Adjustment of the second harmonic suppressor in the field will not normally be required, even if the PA tube is replaced. Adjustment should be attempted only when absolutely necessary. Misadjustment of the suppressor could result in sporadic operation, possibly damaging the PA tube, the cavity, or the low-pass filter. It is suggested the customer contact the Broadcast Electronics Customer Service Department before attempting this adjustment. If it is certain that adjustment of the second harmonic suppressor is required, proceed as follows.
- 5-39. **Required Equipment.** The following equipment is required to complete adjustment of the second harmonic suppressor.
- 1/16 inch (1.6 mm) hex wrench.
  - Tektronix Model 492 Spectrum Analyzer or the equivalent capable of displaying frequencies at twice the transmitter frequency of operation.
  - 50 Ohm 10 dB resistive attenuator pad, BNC jack to BNC plug (Texscan FP-50).
  - A cable for the spectrum analyzer comprising the following:
    - 10 feet (3.05 m) of Belden RG 58A/U coaxial cable (BE P/N 622-0050).
    - Two BNC plugs (Pomona UG88/U--BE P/N 417-0205).
  - Six inch scale.



**WARNING**

**WARNING**

***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE.***

- 5-40. **Procedure.** To adjust the second harmonic suppressor, proceed as follows.
- 5-41. Deenergize all primary power to the transmitter.
- 5-42. Open the cabinet rear door.
- 5-43. Connect one end of the spectrum analyzer cable (Item D) to the RF sample port (J2) on the elbow near the cavity.
- 5-44. Connect the attenuator pad (Item C) in series with the cable and attach the attenuator pad to the spectrum analyzer input.
- 5-45. Close the cabinet rear door.
- 5-46. Energize the transmitter primary ac input.
- 5-47. Operate the transmitter at the normal power output and ensure all PA stage tuning and loading controls are correctly adjusted.
- 5-48. Record the level of the second harmonic displayed on the spectrum analyzer \_\_\_\_\_.



**WARNING**

**WARNING**

***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

- 5-49. Disconnect all transmitter primary power.
- 5-50. Open the cabinet rear door.
- 5-51. Loosen the two hex-head lock-screws securing the second harmonic suppressor adjustment rod very slightly--just enough to allow in and out adjustment (see Figure 5-3).



**CAUTION**

**CAUTION**

***THE SECOND HARMONIC SUPPRESSOR IS ADJUSTED BY SLIDING THE ADJUSTMENT ROD IN OR OUT. DO NOT ROTATE THE ROD.***

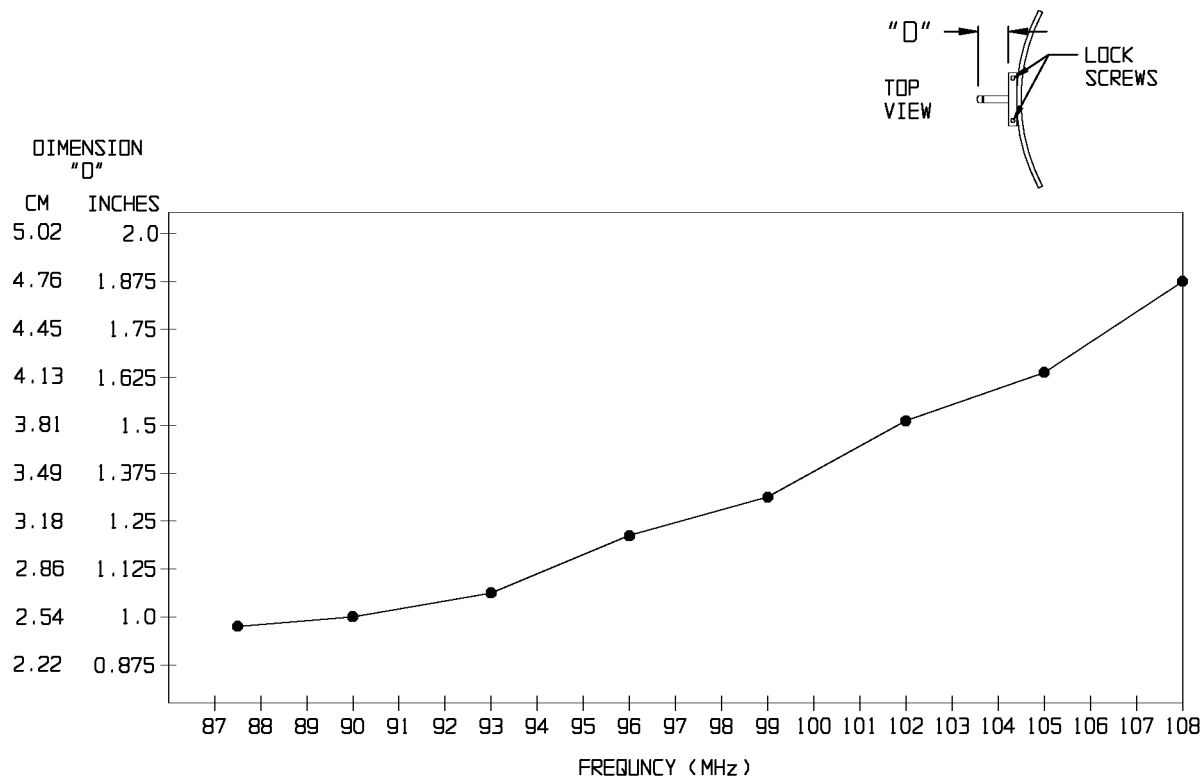


**NOTE**

**NOTE**

***THE ORIGINAL HARMONIC SUPPRESSOR ADJUSTMENT DIMENSION IS RECORDED ON THE FACTORY FINAL TEST DATA SHEETS IF THE DIMENSION MUST BE REFERENCED.***

- 5-52. Move the second harmonic suppressor adjustment rod slightly (approximately 1/16 inch). Record the amount moved and the direction(in or out) \_\_\_\_\_. Slightly tighten the two screws to secure the rod in place.



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**597-0033-33**

**FIGURE 5-3. SECOND HARMONIC SUPPRESSOR COARSE SETTING**

- 5-53. Close the cabinet rear door.
- 5-54. Energize the transmitter primary ac input and operate the transmitter at the normal power output.
- 5-55. Repeat paragraphs 5-49 through 5-55, moving the second harmonic suppressor adjustment rod slightly in or out as required to minimize the second harmonic indication.



**WARNING** *DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.*

**WARNING**

- 5-56. After the correct setting of the second harmonic suppressor is determined, disconnect all transmitter primary power.
- 5-57. Open the cabinet rear door.
- 5-58. Secure both hex-head lock-screws on the second harmonic suppressor bushing (see Figure 5-3).
- 5-59. Disconnect the spectrum analyzer cable from J2 on the transmission line.
- 5-60. Close the cabinet rear door. Record the new harmonic suppressor dimension here

- 5-61. **NEUTRALIZATION.** PA neutralization in the field will not normally be required, even if the PA tube is replaced. If it is certain that adjustment of the neutralization circuitry is required, proceed as follows.



**CAUTION** ***INCORRECT NEUTRALIZATION CAN RESULT IN INSTABILITY WHICH COULD DAMAGE THE PA TUBE, CAVITY, OR LOW-PASS FILTER. CONSULT THE FACTORY BEFORE ATTEMPTING NEUTRALIZATION.***

- 5-62. **Required Equipment.** The following equipment is required to complete PA neutralization.

- A. Spectrum analyzer (Tektronix Model 492 or equivalent).
- B. 25 Watt, 50 Ohm RF attenuator/termination with -20 dB sample output, type N receptacles (Bird Model 8340-030 or equivalent).
- C. Two locally fabricated cables, each comprising the following:
  - 1. 24 inches (61 cm) of Belden RG 58A/U coaxial cable (BE P/N 622-0050).
  - 2. Two BNC plugs (Pomona UG88/U--BE P/N 417-0205).
- D. Three adapters, BNC receptacle to type N plug (Pomona UG201A/U--BE P/N 417-3288).
- E. No. 2 Phillips screwdriver, 4-inch (10.2 cm) blade.
- F. Flat-tip screwdriver, 4-inch (10.2 cm) blade and 1/4 inch (0.64 cm) tip.
- G. Exciter line cord, P/O exciter accessory pack--BE P/N 682-0001).
- H. Electrical extension cord, 3-wire, 12 feet (3.7 m) long;
- I. Six-inch scale, graduated in sixty-fourths of an inch.

- 5-63. **Procedure.** To adjust PA neutralization, proceed as follows:

- 5-64. Operate the transmitter at the normal power output and ensure all PA stage tuning and loading controls are correctly adjusted.

- 5-65. Secure the **INPUT TUNING**, **OUTPUT LOADING**, and **OUTPUT TUNING** control knobs in position with tape. The controls must not be moved until the entire procedure has been completed.



**WARNING** ***ENSURE ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED BEFORE OPENING THE EQUIPMENT.***

- 5-66. Deenergize all primary power to the transmitter.
- 5-67. Open the cabinet door.
- 5-68. Disconnect the coaxial cable from the exciter RF OUTPUT connector.
- 5-69. Connect a BNC-to-type N adapter on each of the RF termination connectors.
- 5-70. Disconnect the cable from the PA RF INPUT (J1) connector.
- 5-71. Connect one cable and one BNC-to-type N adapter between the PA RF INPUT (J1) connector and the RF termination -20 dB output.

- 5-72. Connect one cable between the exciter RF OUTPUT connector and the input to the RF termination.
- 5-73. Disconnect wire No. 5 from TB1-7 on the rear of the exciter and connect a temporary wire jumper from TB1-6 to TB1-7. Flag the temporary jumper with a piece of tape marked "TEMPORARY".
- 5-74. Disconnect the line cord plug and remove the fuse from the AC LINE VOLTAGE SELECTOR on the exciter rear panel. Cover the line cord plug with a piece of tape marked "240 VOLTS".
- 5-75. Remove the AC LINE VOLTAGE SELECTOR circuit board with a small pair of needle-nose pliers and record the circuit board voltage indication \_\_\_\_\_. Reinsert the circuit board so that "115/120V" is visible when the circuit board is inserted into the receptacle.
- 5-76. Replace the fuse with a slow-blow type rated at 10 Amperes.
- 5-77. Connect the accessory exciter line cord to the extension cord. Route the extension cord out through the top or bottom of the cabinet to a source of 110 to 120 Vac.
- 5-78. Connect the accessory exciter line cord (item G) to the exciter.



**WARNING**

***PRIMARY TRANSMITTER POWER MUST REMAIN OFF  
THROUGHOUT THE FOLLOWING PROCEDURE.***

**WARNING**

- 5-79. Assure that the exciter is operating independently of the transmitter.
- 5-80. Connect the spectrum analyzer to the RF sample port (J2) in the transmitter output transmission line. Adjust the analyzer to obtain a reference level display and position the analyzer so that it may be viewed from the rear of the transmitter.
- 5-81. Note the position of the grounding stick in the rear of the cabinet.



**WARNING**

***USE THE GROUNDING STICK PROVIDED TO ENSURE  
NO PA TUBE POTENTIALS ARE PRESENT IN THE FOLLOWING  
STEP BY GROUNDING THE PA TUBE PLATE AND SCREEN  
CONNECTIONS BEFORE PROCEEDING.***

**WARNING**

- 5-82. Open the PA cavity access door and ground the PA tube plate and screen connections to ensure no potentials are present in the cavity before attempting to touch anything within the cavity.
- 5-83. After it has been determined that no PA tube potentials are present, mark the position of the eight neutralization adjustments, (refer to Figure 5-4). Correct neutralization will be found near the original factory position (refer to Figure 5-4).

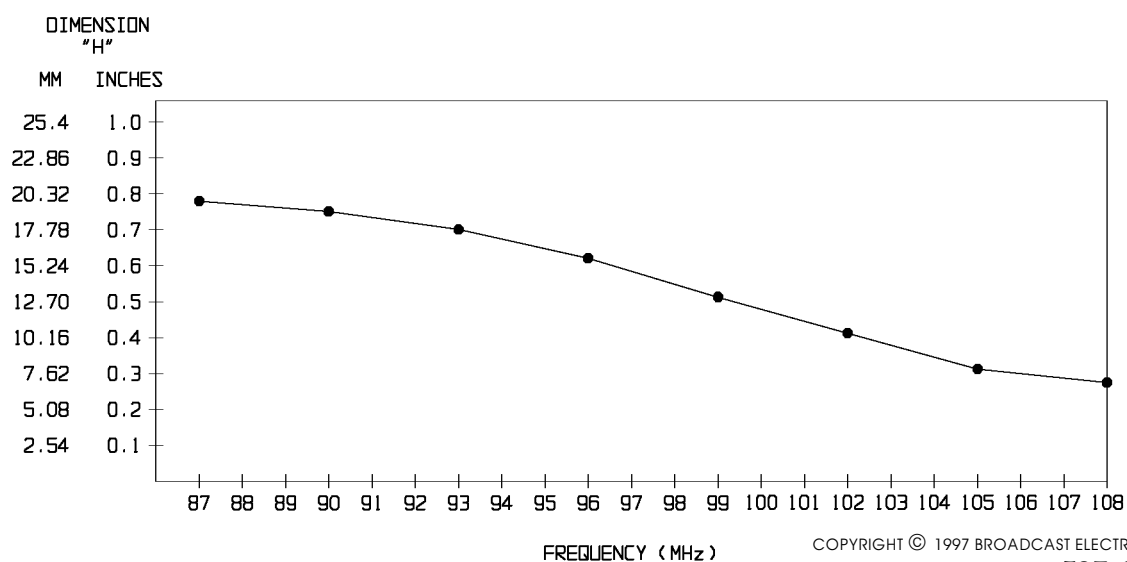
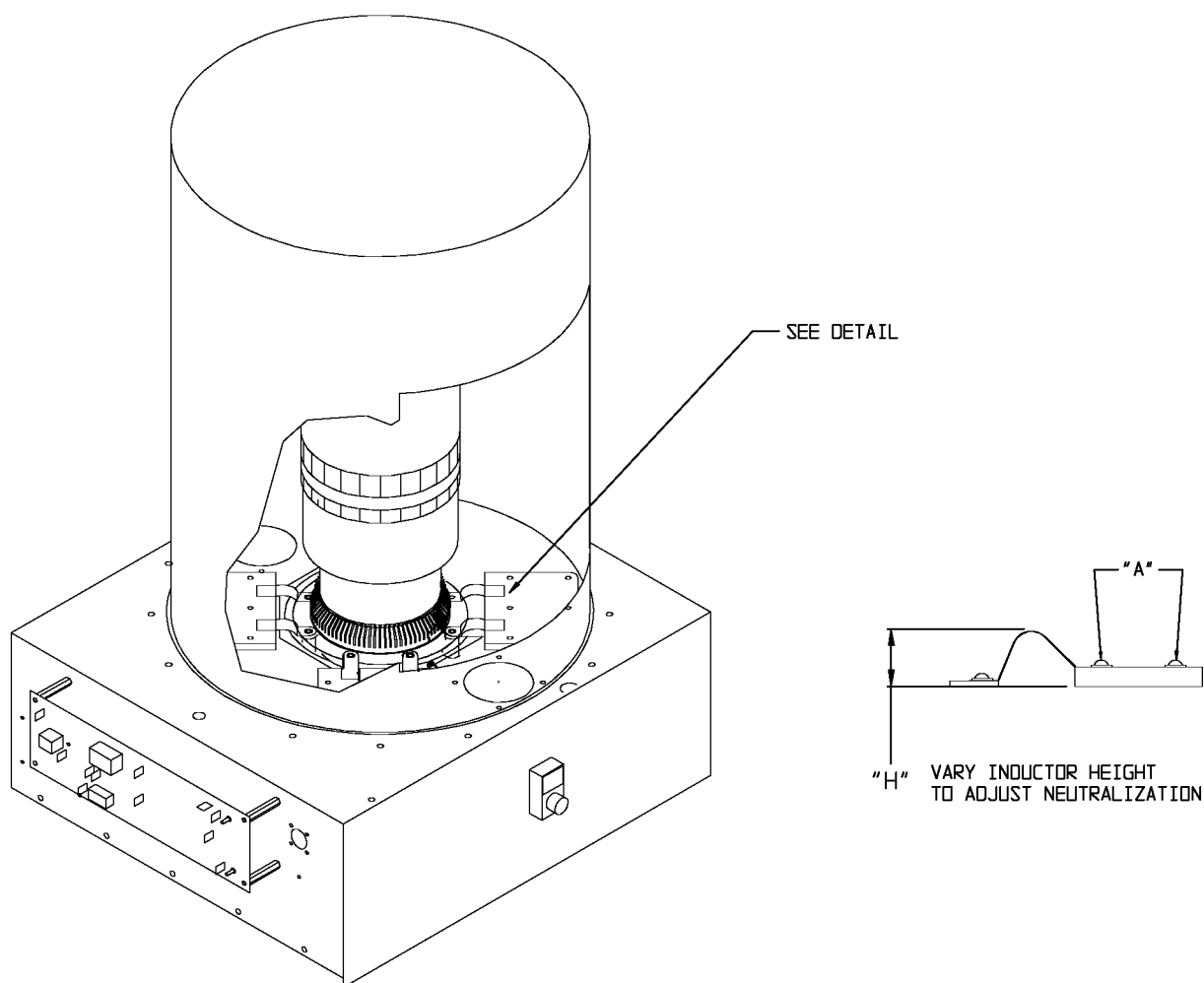


**WARNING**

***BE CAREFUL WHEN ADJUSTING THE NEUTRALIZATION  
STRAPS WITH FINGERS AS THE EDGES OF THE MATERIAL  
ARE VERY SHARP.***

**WARNING**

- 5-84. Loosen the six screws (A, Figure 5-4) on top of each capacitor slightly--just enough to allow adjustment of each pair of inductors. When the neutralization procedure is properly completed, the height of all inductors will be approximately the same, within 1/16 inch (0.16 cm).



**FIGURE 5-4. NEUTRALIZATION STRAP COARSE SETTING**

**597-0032-35**



- 5-85. Neutralization is adjusted in the following manner:
- A. Remove all foreign objects from the cavity then close the cavity access door.
  - B. Note the spectrum analyzer indication.
  - C. Open the cavity access door and adjust one pair of inductors very slightly. The inductors must be adjusted in pairs. Lightly secure the six screws on the capacitor plate.
  - D. Remove all foreign objects from the cavity and close the cavity access door.
  - E. Note the change in the spectrum analyzer indication.
  - F. Repeat steps A through E until a minimum spectrum analyzer indication is noted.
  - G. Repeat steps A through F for the remaining inductor pairs to minimize the spectrum analyzer indication.
  - H. Secure the six screws in each capacitor. When the neutralization procedure is properly completed, the height of all inductors will be approximately equal.
  - I. Ensure all four capacitors are secure before closing the cavity access door.
- 5-86. Close and latch the cavity access door. Replace the grounding stick on the hanger.
- 5-87. Disconnect the spectrum analyzer from the output transmission line.



**CAUTION**

**CAUTION**

***DO NOT CONNECT THE EXCITER TO THE LINE CORD WIRED INTO THE TRANSMITTER IN THE FOLLOWING STEP.***



**WARNING**

**WARNING**

***DISCONNECT ALL EXCITER PRIMARY POWER BEFORE PROCEEDING.***

- 5-88. Remove the electrical extension cord and exciter line cord. Do not connect the exciter to the line cord wired into the transmitter at this time.
- 5-89. Remove the fuse from the exciter rear panel AC LINE VOLTAGE SELECTOR.
- 5-90. Remove the AC LINE VOLTAGE SELECTOR circuit board with a small pair of needle-nose pliers. Reinsert the circuit board so that the voltage recorded in the preceding text is visible when the circuit board is inserted into the receptacle.
- 5-91. Replace the fuse with a slow-blow type rated at 5 Amperes.
- 5-92. Remove the tape from the exciter line cord and connect the plug to the exciter.
- 5-93. Remove the temporary wire jumper from TB1 on the exciter rear panel and reconnect wire No. 5 to TB1-7.
- 5-94. Remove the cabling and test load connected between the exciter RF OUTPUT connector and the PA RF INPUT (J1) connector. Remove the adapter from the PA RF INPUT (J1) connector.
- 5-95. Reconnect the exciter to the PA input.

5-96. **TRANSMITTER POWER LEVEL CHANGE.**



**WARNING**      ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

**WARNING**

5-97. Each transmitter is programmed, operated, and tested at a specific power level at the factory prior to shipment. If at a future date the transmitter is to be operated at a power level other than the original factory programmed level, the following transmitter parameters must be checked and adjusted if required to assure proper transmitter operation. If problems occur during initial operation, contact the Broadcast Electronics Customer Service Department for additional service procedures.

- A. Refer to SECTION III, OPERATION and reset the APC operating reference.
- B. Energize the transmitter primary ac power and operate the transmitter. Adjust the input tuning control for a minimum exciter reflected power indication on the multimeter (for high reflected power conditions, use the multimeter grid current function and maximum grid current information for indications of correct tuning operations).
- C. Refer to CONTROLLER SECTION II, MAINTENANCE and perform the FORWARD POWER CALIBRATION and REFLECTED POWER CALIBRATION adjustment procedures.

5-98. **TRANSMITTER FREQUENCY CHANGE PROCEDURE.**



**CAUTION**      ***CONSULT THE FACTORY BEFORE ATTEMPTING TO CHANGE THE TRANSMITTER OPERATING FREQUENCY.***

**CAUTION**

5-99. **GENERAL.** The following text presents an overall procedure to change the transmitter operating frequency. The procedure specifies operational adjustment procedures located throughout this publication and FM-250C publication 597-1004. To change the transmitter operating frequency, proceed as follows.

5-100. **Procedure.** To change the transmitter operating frequency, proceed as follows:



**WARNING**      ***NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.***

**WARNING**



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

**WARNING**

5-101. Disconnect all transmitter primary power. The primary ac power must remain OFF unless specified by an adjustment procedure.

- 5-102. Refer to Figure 5-5A and adjust the transmitter coarse output tuning by raising or lowering the PA tuning line on top of the PA cavity. Refer to Figure 5-5B and coarse adjust the transmitter input tuning cyclometers.
- 5-103. Refer to Figure 5-3 and coarse adjust the transmitter second harmonic suppressor. The suppressor is adjusted by loosening the two hex-head lock screws and moving the adjustment rod in or out as required. Do not rotate the rod during adjustment.
- 5-104. Refer to Figure 5-4 and coarse adjust the transmitter neutralization.
- 5-105. Refer to FM-250C publication 597-1004, PART II SECTION IV, AFC/PLL ASSEMBLY and perform the FREQUENCY SELECTION procedure. Operate and test the exciter independently from the transmitter.
- 5-106. Refer to SECTION II, INSTALLATION and perform the PRELIMINARY OPERATION AND TUNING procedure to obtain a 10% power indication from the transmitter. Use a spectrum analyzer to monitor spurious activity during tuning. Also, use an in-line wattmeter connected to the transmitter output transmission line for all power output indications.
- 5-107. Refer to the adjustment procedures in the preceding text and perform the NEUTRALIZATION procedure.
- 5-108. Refer to SECTION II, INSTALLATION and complete the PRELIMINARY OPERATION AND TUNING procedure to obtain a 100% power indication from the transmitter.
- 5-109. Refer to the adjustment procedures in the preceding text and perform the SECOND HARMONIC SUPPRESSOR adjustment procedure.
- 5-110. Refer to CONTROLLER SECTION II, MAINTENANCE and perform the FORWARD POWER CALIBRATION and REFLECTED POWER CALIBRATION adjustment procedures.
- 5-111. **TROUBLESHOOTING.**

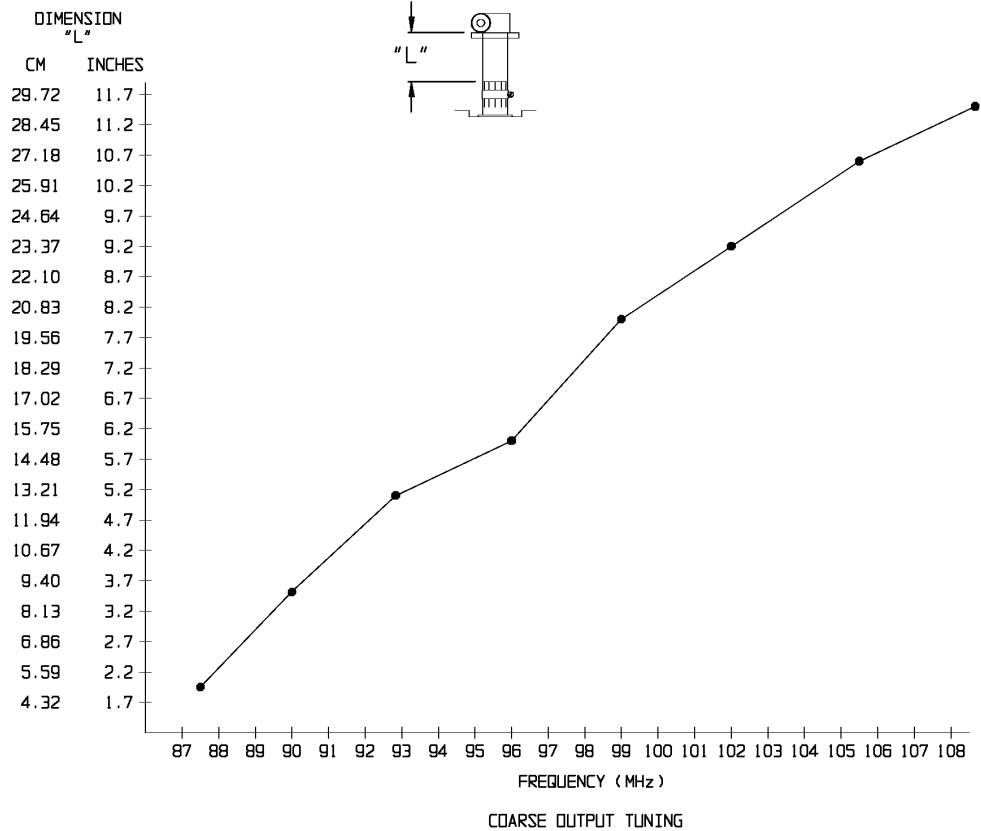


**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

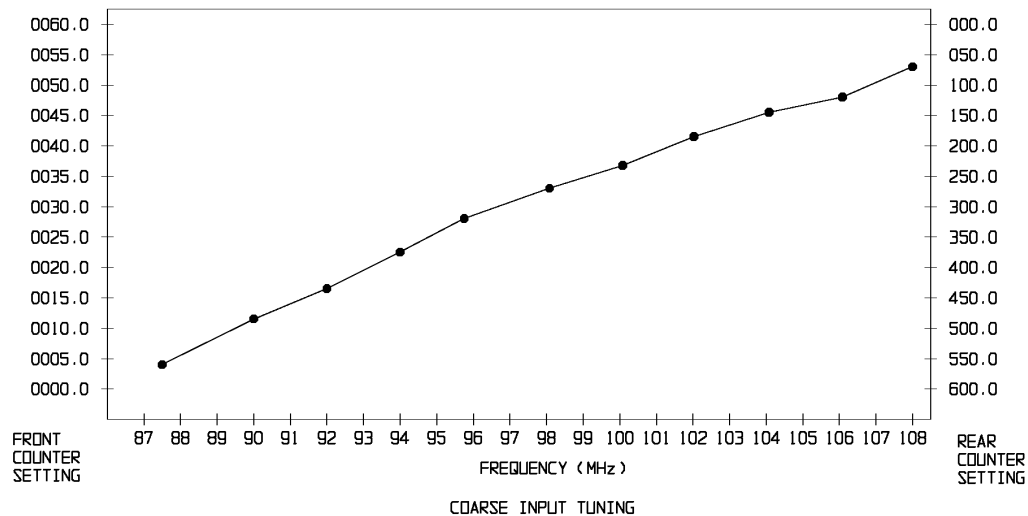
- 5-112. Most troubleshooting consists of visual checks. Due to the dangerous voltages and high currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, fuses, and circuit breakers) should be used to isolate the malfunction to one of the specific areas listed below. Typical meter indications are presented in Table 5-1 and transmitter primary power demand requirements are listed in Table 5-2.

#### **TRANSMITTER TROUBLESHOOTING AREAS**

- A. Power Supplies
- B. Exciter
- C. Power Amplifier
- D. Transmitter Controller
- E. Transmitter Load



NOTE: BOTH FRONT AND REAR COUNTERS MUST BE SET TO COARSE SETTINGS, THEN FINE USING FRONT ONLY.



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**597-0033-25**

**FIGURE 5-5. COARSE TUNING ADJUSTMENTS**

**TABLE 5-1. TYPICAL METER INDICATIONS (5 kW RF OUTPUT)**

METER	SWITCH POSITION/INDICATION	
FM-5T		
	VSWR	FWD
OUTPUT POWER	LESS THAN 1.2	100%
PLATE CURRENT	1.3 A	
PLATE VOLTAGE	5300 V	
SCREEN VOLTAGE	525 V	
SCREEN CURRENT	60 mA	
GRID VOLTAGE	-260 V	
GRID CURRENT	45 mA	
FILAMENT VOLTAGE	5.0 V	
EXCITER FORWARD POWER	140 W	
FM-5TS		
	VSWR	FWD
OUTPUT POWER	LESS THAN 1.2	100%
PLATE CURRENT	1.3 A	
PLATE VOLTAGE	5300 V	
SCREEN VOLTAGE	525 V	
SCREEN CURRENT	60 mA	
GRID VOLTAGE	-260 V	
GRID CURRENT	45 mA	
FILAMENT VOLTAGE	5.0 V	
EXCITER FORWARD POWER	140 W	

**TABLE 5-2. TYPICAL POWER DEMAND (5 kW RF OUTPUT)**

FM-5T			
AC Line Frequency	60 Hz	50 Hz	50 Hz
AC Line Voltage	210 V	224 V	380 V
AC Line Current	28 A	28 A	16 A
FM-5TS			
AC Line Frequency	60 Hz	50 Hz	50 Hz
AC Line Voltage	210 V	224 V	380 V
AC Line Current	48 A	48 A	28 A



**CAUTION**  
**CAUTION**

***MANY COMPONENTS IN THE TRANSMITTER ARE MOUNTED TO HEAT SINKS UTILIZING A FILM OF HEAT-SINK COMPOUND FOR THERMAL CONDUCTION.***



**CAUTION**  
**CAUTION**

***IF ANY SUCH COMPONENT IS REPLACED, ENSURE A THIN FILM OF A ZINC-BASED HEAT-SINK COMPOUND IS USED (BE P/N 700-0028) TO ASSURE GOOD HEAT DISSIPATION.***

- 5-113. Once the trouble is isolated, refer to the applicable assembly publication in Part II of this manual discussing the theory of operation and providing troubleshooting for the respective assembly to assist in problem resolution. Figures 5-6 through 5-10 provide drawings to assist component location.
- 5-114. **COMPONENT REPLACEMENT ON CIRCUIT BOARDS.** All the FM-5T/FM-5TS transmitter circuit boards are double-sided boards with plated through-holes with the exception of the transmitter controller main and front panel circuit boards. Due to the double-sided design, the components on the circuit boards can be replaced without damage if standard soldering techniques are used. The FM-5T/FM-5TS transmitter controller main and front-panel circuit boards are constructed using surface mount technology. Therefore, components on the controller main circuit and front-panel circuit boards can not be replaced without destruction of the circuit board traces.
- 5-115. On all circuit boards, the adhesive securing the copper track to the board melts at almost the same temperature at which solder melts. A circuit board track can be destroyed by excessive heat or lateral movement during soldering. Use of a small iron with steady pressure is required for circuit board repairs.
- 5-116. To remove a component from a circuit board, cut the leads from the body of the defective component while the device is still soldered to the board.
- 5-117. Grip each component lead, one at a time, with long nose pliers. Turn the board over and touch a soldering iron to the lead at the solder connection. When the solder begins to melt, push the lead through the back side of the board and cut off the bent-over outer end of the lead. Each lead may now be heated independently and pulled out of each hole. The holes may be cleared of solder by carefully re-heating with a low wattage iron and removing the residual solder with a soldering vacuum tool.
- 5-118. Install the new component and apply solder from the bottom side of the board. If no damage has been done to the plated through-holes, soldering of the top side is not required.



**WARNING**

**WARNING**

***MOST SOLVENTS WHICH WILL REMOVE ROSIN FLUX ARE VOLATILE AND TOXIC BY THEIR NATURE AND SHOULD BE USED ONLY IN SMALL AMOUNTS IN A WELL VENTILATED AREA, AWAY FROM FLAME, INCLUDING CIGARETTES AND A HOT SOLDERING IRON.***

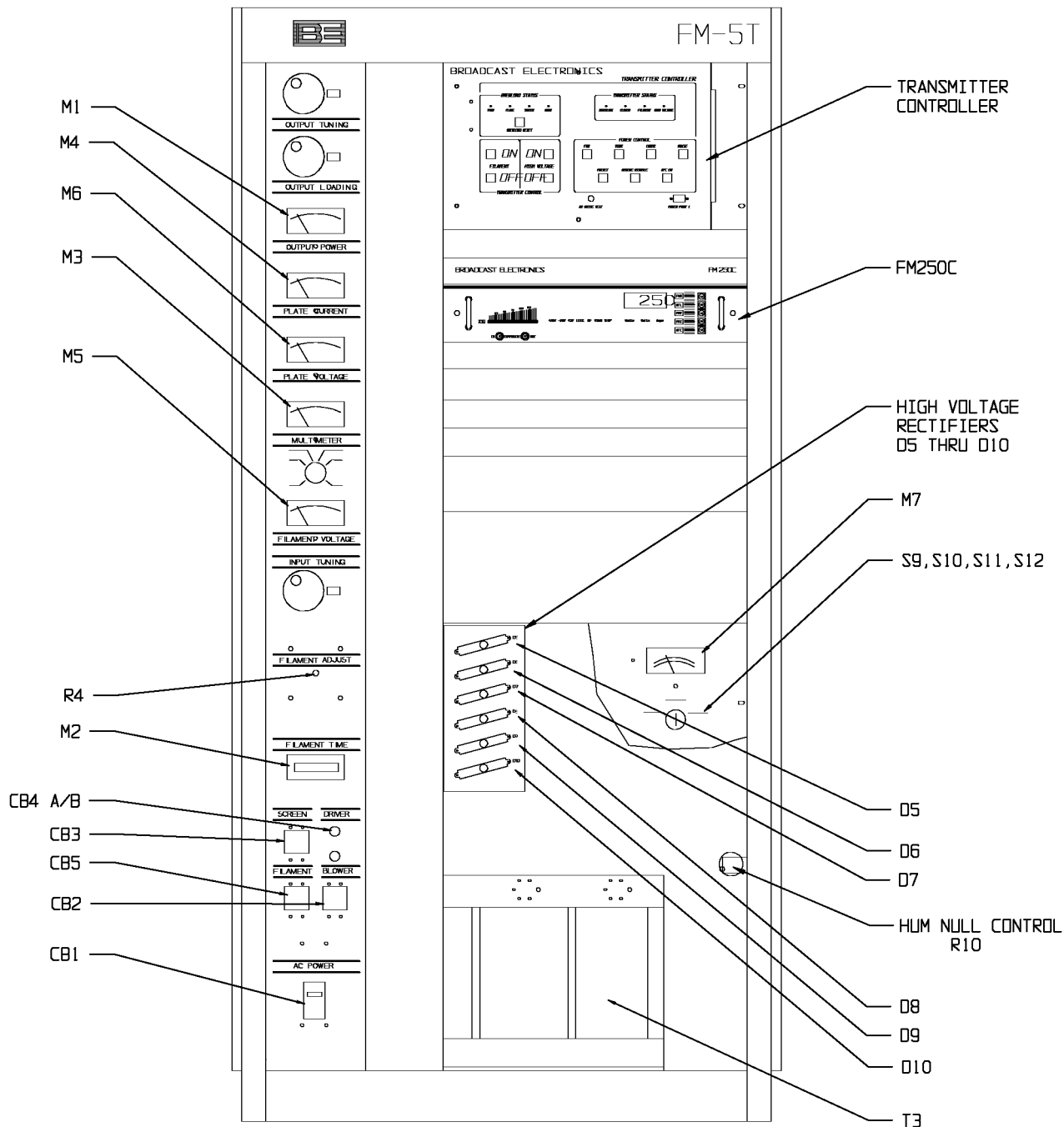


**WARNING**

**WARNING**

***OBSERVE THE MANUFACTURER'S CAUTIONARY INSTRUCTIONS.***

- 5-119. After soldering, remove flux with a cotton swab moistened with a suitable solvent. Rubbing alcohol is highly diluted and is not effective. Solvents are available in electronic supply house which are useful.
- 5-120. The board should be checked to ensure the flux has been removed and not just smeared about. Rosin flux is not normally corrosive, but rosin will absorb enough moisture in time to become conductive and cause problems.

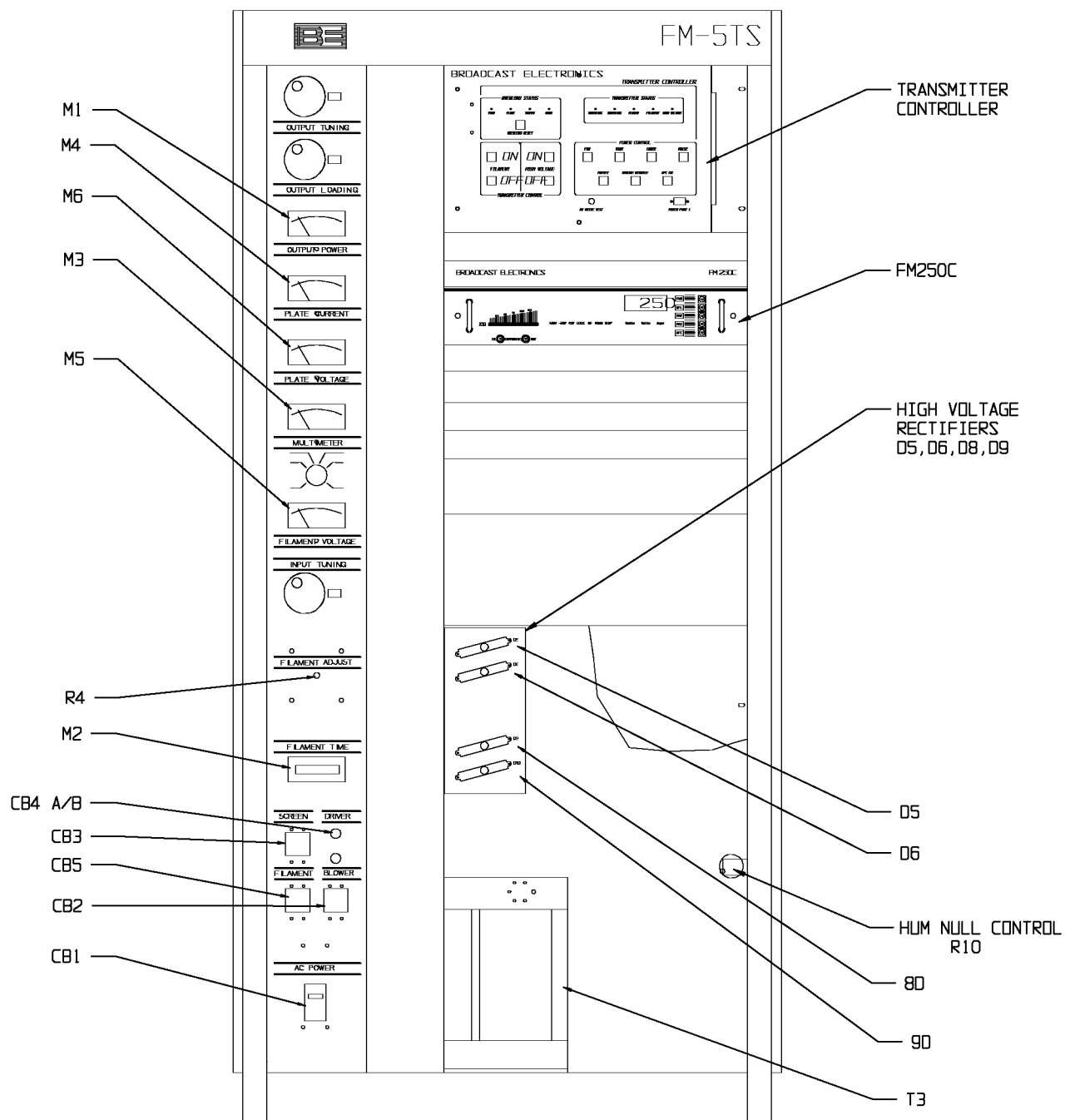


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FIGURE 5-6. FM-5T CABINET COMPONENT LOCATOR, FRONT

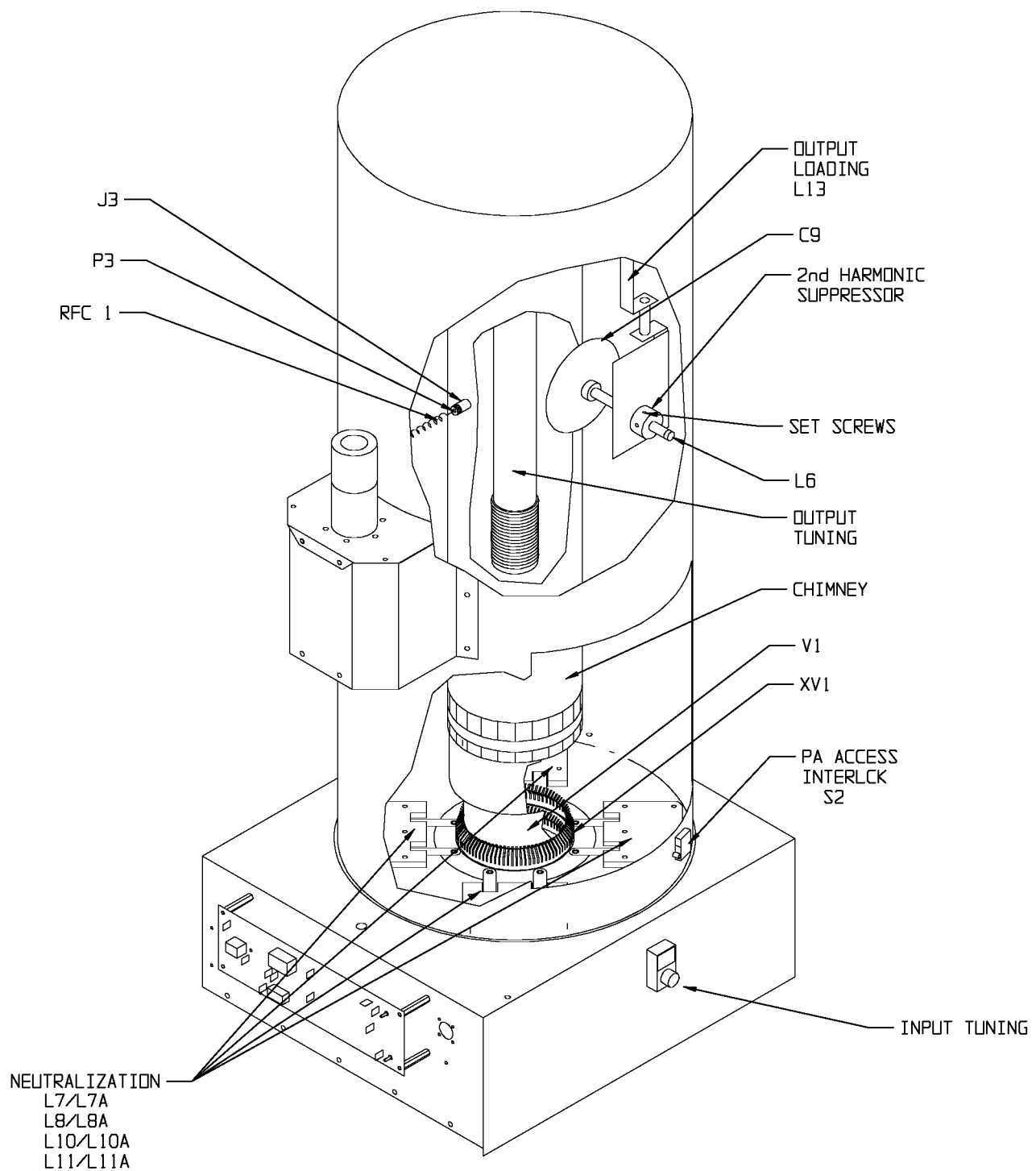




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FIGURE 5-7. FM-5TS CABINET COMPONENT LOCATOR, FRONT

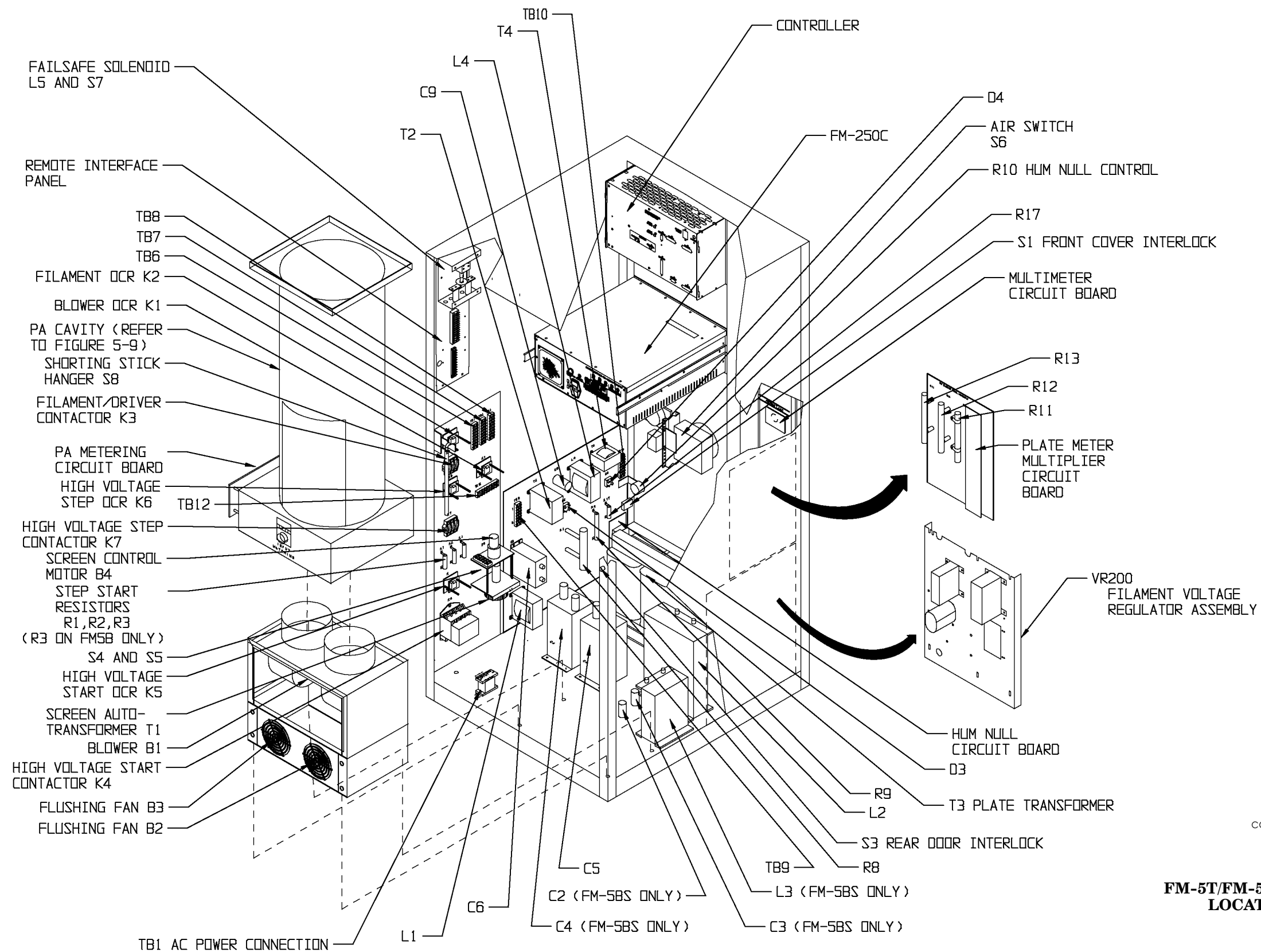


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FIGURE 5-8. PA CAVITY COMPONENT LOCATOR

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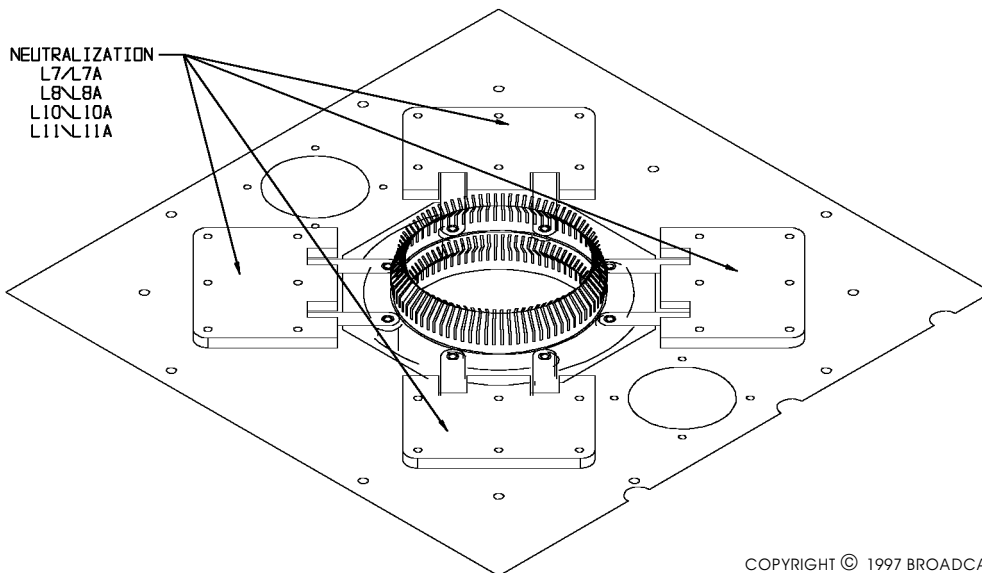
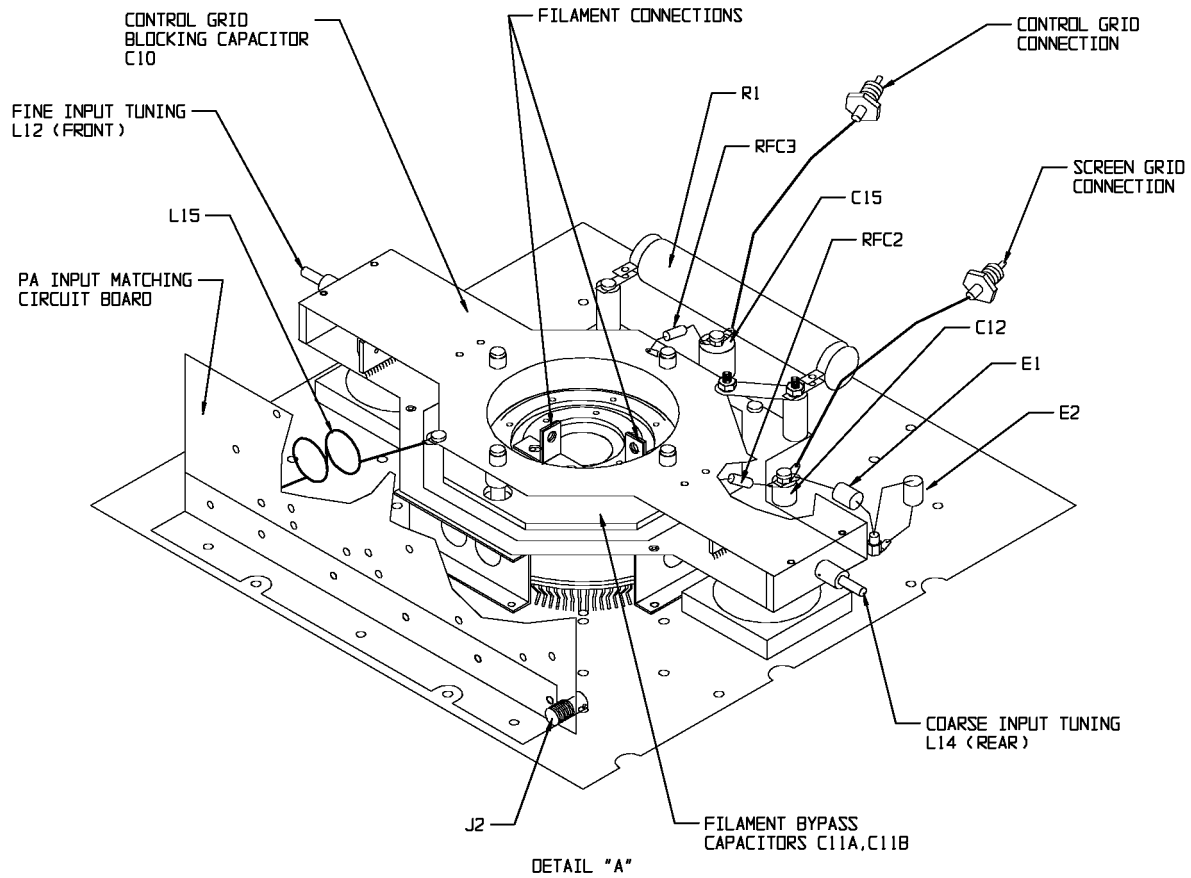
WARNING: DISCONNECT POWER PRIOR TO SERVICING

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**FIGURE 5-9.**  
**FM-5T/FM-5TS CABINET COMPONENT**  
**LOCATOR, REAR**

(5-23/5-24)



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FIGURE 5-10. PA TUBE SOCKET

# SECTION VI

## PARTS LIST

### 6-1. INTRODUCTION.

6-2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM-5T and FM-5TS FM Transmitters. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram. Parts for the transmitter controller are listed in the CONTROLLER section of this manual.

**TABLE 6-1. REPLACEABLE PARTS LIST INDEX**  
(Sheet 1 of 2)

TABLE	DESCRIPTION	PART NO.	PAGE
6-2	FM-5T TRANSMITTER ASSEMBLY	909-5000-215/ -315 -385	6-3
6-3	FM-5TS TRANSMITTER ASSEMBLY	909-5000-255/ -355	6-3
6-4	SCREEN AND BIAS PANEL ASSEMBLY	959-0271-001	6-5
6-5	HUM NULL ASSEMBLY	919-0063	6-5
6-6	BLEEDER PANEL ASSEMBLY	959-0271-003	6-5
6-7	METER MULTIPLIER CIRCUIT BOARD, FM-5T	919-0200	6-6
6-8	METER MULTIPLIER CIRCUIT BOARD, FM-5TS	919-0079	6-6
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6-10	MULTIMETER CIRCUIT BOARD ASSEMBLY	919-0049-001	6-7
6-11	PLATE CURRENT METER ASSEMBLY	959-0300	6-7
6-12	METER PROTECTION CIRCUIT BOARD ASSEMBLY	919-0109-002	6-7
6-13	FAN/BLOWER ASSEMBLY	959-0271-006	6-7
6-14	DIODE STACK PANEL ASSEMBLY, FM-5T	959-0271-008	6-7
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6-17	CONTACTOR PANEL ASSEMBLY, FM-5TS	959-0271-102	6-8
6-18	OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY	919-0096	6-9
6-19	POWERSTAT ASSEMBLY	959-0121	6-9
6-20	THREE-PHASE VOLTMETER ASSEMBLY	959-0271-010	6-9
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6-22	BASIC UNIT CABLE ASSEMBLY	949-0161-100	6-11
6-23	GROUND STICK HANGER ASSEMBLY	955-0038	6-12
6-24	DIRECTIONAL COUPLER ASSEMBLY, 40 db (RFL)	959-0082-040	6-12
6-25	DIRECTIONAL COUPLER ASSEMBLY, 45 db (FWD)	959-0082-045	6-12
6-26	REMOTE INTERFACE PANEL ASSEMBLY	959-0117-100	6-12
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**TABLE 6-1. REPLACEABLE PARTS LIST INDEX**  
(Sheet 2 of 2)

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6-29	TUBE SOCKET AND INPUT TUNING ASSEMBLY	959-0151	6-13
6-30	INPUT MATCHING CIRCUIT BOARD ASSEMBLY	919-0064	6-13
6-31	RF ENCLOSURE ASSEMBLY	959-0272	6-13
6-32	PA CHIMNEY ASSEMBLY	959-0272-002	6-13
6-33	TRANSMISSION LINE ASSEMBLY	959-0272-003	6-14
6-34	SHIELD CELL/TUNING LINE ASSEMBLY	959-0272-101	6-14
6-35	EXHAUST AIR TEMPERATURE CIRCUIT BOARD ASSEMBLY	919-0082	6-14
6-36	ACCESSORY PARTS KIT	969-0013	6-14

**TABLE 6-2. FM-5T TRANSMITTER - 909-5000-215/-315/-385**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C5	Capacitor, Electrolytic, 4 uF, 8 kV, Non-PCB Oil/ Paper	047-0004	1
CB1	Circuit Breaker, 40 Amperes, 3-Pole, 240V (AC POWER)	341-0027	1
L2	Choke, Filter, 6.8 H, 1.8 A Continuous	361-0001	1
<b>FOR 50 Hz TRANSMITTER MODELS ONLY</b>			
M2	Meter, 0 - 99,999.9 Hour, Non-Resetable, 230 Volt, 3.5 Inch (8.89 cm) ( <b>FILAMENT TIME</b> Meter)	310-0000-003	1
S1, S3	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	2
S6	Switch, Pressure, 120-480V ac 60 Hz, 15 Amperes	340-0011	1
T3	Transformer, Plate 3 Ø, 50/60 Hz Primary: 208/240V ±11V ac, Delta Connected; 346V to 433, Wye Connected Secondary: 2300V @ 1.4 Amperes Continuous, Wye Connected	376-0115	1
TB1	Terminal Strip, Consisting of: Terminal Block End Clamp Ground Barrier Mounting Channel, 2.76 Inches (7 cm)	412-0041 412-0042-001 412-0043 412-0044	4 2 1 3
V1	Tube, 4CX3500A EIMAC/SVETLANA	243-3500	1
----	Transformer/Regulator, Filament	370-0056	1
----	Counting Dial, 0-9999, 100 Turn	290-0002	1
----	Air Filter, 16 X 20 X 1 Inch (40.64 X 50.8 X 2.54 cm)	407-0062	1
----	FM-250C Exciter, 50 TO 250 Watt, 220V	909-0251-304	1
----	Screen And Bias Panel Assembly	959-0271-001	1
----	Bleeder Panel Assembly	959-0271-003	1
----	Meter Panel Assembly, FM-5T	959-0271-105	1
----	Fan and Blower Assembly	959-0271-006	1
----	Diode Stack Panel Assembly	959-0271-008	1
----	Contactorm Panel Assembly	959-0271-109	1
----	Three-Phase Voltmeter Assembly	959-0271-010	1
----	PA Metering Circuit Board Assembly, FM-5T	919-0048-008	1
----	Basic Unit Cable Assembly, FM-5T	949-0161-100	1
----	Final Unit Cable Assembly	949-0163	1
----	Ground Stick Hanger Transmitter Assembly	955-0038	1
----	Directional Coupler Assembly, 40DB (RFL)	959-0082-040	1
----	Directional Coupler Assembly, 45DB (FWD)	959-0082-045	1
----	Remote Interface Panel Assembly, FM-10T/FM-5T	959-0117-100	1
----	Ground Stick Shorting Assembly	959-0145	1
----	Tube Socket And Input Tuning Assembly	959-0151	1
----	RF Enclosure Assembly	959-0272	1
----	Transmission Line Assembly	959-0272-003	1
----	Shield Cell/Tuning Line Assembly, FM-5T/FM-10T	959-0272-101	1
----	FM Transmitter Digital Controller Assembly	959-0430	1
----	Accessory Parts Kit	969-0013	1

**TABLE 6-3. FM-5TS TRANSMITTER - 909-5000-255/-355**  
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C2, C3	Capacitor, Polypropylene Film, 0.97 uF ±5%, 2500 VRMS @ 120 Hz	047-0006	2
C4, C5	Capacitor, Electrolytic, 4 uF, 8 kV, Non-PCB Oil/Paper	047-0004	2
CB1	Circuit Breaker, 2-Pole, 240V, 60 Amps	341-0050	1



**TABLE 6-3. FM-5TS TRANSMITTER - 909-5000-255/-355**  
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
L2	Tuned Reactor, 5.06/3.5 H $\pm 5\%$ , 21 Ohms dc Resistance, 1.4 Amperes Continuous	360-0069	1
L3	Choke, 3.5 H, 20 Ohms dc Resistance, 1.4 Amperes Continuous	360-0067	1
M6	Meter, 3.5 Inch (8.89 cm), Taut Band Type, FS = 1 mA dc $\pm 1\%$ , 35 Ohm Resistance ( <b>PLATE VOLTAGE</b> Meter)	310-0051	1
<b>FOR 50 Hz TRANSMITTER MODELS ONLY</b>			
M2	Meter, 0 - 99,999.9 Hour, Non-Resetable, 230 Volt, 3.5 Inch (8.89 cm) ( <b>FILAMENT TIME</b> Meter)	310-0000-003	1
S1, S3	Interlock Switch, SPDT, 15A @ 125V ac, 0.5A @ 125V dc, 0.25A @ 250V dc	346-3302	2
S6	Switch, Pressure, 120-480V ac 60 Hz, 15 Amperes	340-0011	1
T3	Transformer, Plate, Special Construction For Resonant Choke Input Supply Primary: 208/240V $\pm 12V$ ac, 50/60 Hz, Single Phase Secondary: 6200V/5900V @ 1.4 Amperes Continuous, 20 Ohms dc Resistance	370-0091	1
TB1	Terminal Strip Consisting Of:		
	Terminal Block	412-0041	3
	End Clamp	412-0042-001	2
	Ground Barrier	412-0043	1
	Mounting Channel, 2.76 Inches (7cm)	412-0044	2
V1	Tube, 4CX3500A EIMAC/SVETLANA	243-3500	1
----	Transformer/Regulator, Filament	370-0056	1
----	Counting Dial, 0-9999, 100 Turn	290-0002	1
----	Air Filter, 16 X 20 X 1 Inch (40.64 X 50.8 X 2.54 cm)	407-0062	1
----	FM- 250C Exciter, 50 TO 250 Watt, 220V	909-0251-304	1
----	Screen and Bias Panel Assembly	959-0271-001	1
----	Bleeder Panel Assembly	959-0271-003	1
----	Meter Multiplier Circuit Board Assembly	919-0079	1
----	Meter Panel Assembly, FM-5T	959-0271-105	1
----	Fan and Blower Assembly	959-0271-006	1
----	Diode Stack Panel Assembly	959-0271-004	1
----	Contactor Panel Assembly	959-0271-102	1
----	PA Metering Circuit Board Assembly, FM-5T	919-0048-008	1
----	Basic Unit Cable Assembly, FM-5T	949-0161-100	1
----	Ground Stick Hanger Transmitter Assembly	955-0038	1
----	Directional Coupler Assembly, 40DB	959-0082-040	1
----	Directional Coupler Assembly, 45DB	959-0082-045	1
----	Remote Interface Panel Assembly, FM-10T/FM-5T	959-0117-100	1
----	Ground Stick Shorting Assembly	959-0145	1
----	Tube Socket/Input Tuning Assembly	959-0151	1
----	RF Enclosure Assembly	959-0272	1
----	Transmission Line Assembly	959-0272-003	1
----	Shield Cell/Tuning Line Assembly, FM-5T/FM-10T	959-0272-101	1
----	FM Transmitter Digital Controller Assembly	959-0430	1
----	Final Unit Cable Assembly	949-0162	1
----	Accessory Parts Kit	969-0013	1

**TABLE 6-4. SCREEN AND BIAS PANEL ASSEMBLY - 959-0271-001**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C6	Capacitor, Electrolytic, 10 uF, 2 kV, Non-PCB Oil/Paper	047-0002	1
C9	Capacitor, Electrolytic, 80 uF, 450V	028-8076	1
D3, D4	Diode Bridge, Silicon, 4 kV, 0.15 Ampere	239-0440	2
L1, L4	Choke, 10 Henrys, 0.4 Amperes, 2500 Volt Insulation, 92 Ohm dc Resistance	377-0002	2
R8	Resistor, 10 k Ohm $\pm 5\%$ , 100W, WW	132-1053	1
R9	Resistor, 5 k Ohm, 50W, W/W	180-0578	1
R10	Potentiometer, 50 Ohm $\pm 10\%$ , 25W W/W (Hum Null Adjust)	195-0149-001	1
R17	Resistor, 50 Ohm $\pm 5\%$ , 25W W/W	130-5023	1
T2	Transformer, Screen Primary: 208/240V $\pm 11V$ ac, 50/60 Hz, Single Phase Secondary: 1100V @ 0.15 Amperes Continuous, 15 Ohm dc Resistance	370-0009	1
T4	Transformer, Bias Primary: 208/240V $\pm 11V$ ac, 50/60 Hz, Single Phase Secondary: 1: 225V @ 0.2 Amperes Continuous 2: 253V @ 0.2 Amperes Continuous 3: 281V @ 0.2 Amperes Continuous 4: 310V @ 0.2 Amperes Continuous 1500 Volt Insulation, 70 Ohms dc Resistance	370-0006	1
TB9	Barrier Strip, 6 Terminals	412-0008	1
TB10	Barrier Strip, 5 Terminals	412-0005-1	1
----	Hum Null Circuit Board Assembly	919-0063	1

**TABLE 6-5. HUM NULL ASSEMBLY - 919-0063**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Electrolytic, 470 uF, 50V	024-4783	1
D1, D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	1
E1 Thru E3	Terminal Turret, Two Shoulder	413-1597	3
F1, F2	Fuse, AGC3, 250V, 1/2 Ampere	330-0050	2
T1	Transformer, Circuit Board Mount Primary: Dual 115V @ 50/60 Hz, Single Phase Secondary: Dual 6.3V, 1 Ampere	370-0512	1
TB1	Barrier Strip, 4 Terminal	411-0815	1
XF1, XF2	Clip, Fuse, Littlefuse 10207	415-2068	4
----	Blank, Hum Null Circuit Board	519-0063	1

**TABLE 6-6. BLEEDER PANEL ASSEMBLY - 959-0271-003**

REF. DES.	DESCRIPTION	PART NO.	QTY.
R11	Resistor, 22 Ohm $\pm 20\%$ , 150W	139-0220	1
R12, R13	Resistor, 100 k Ohm $\pm 5\%$ , 100W	132-1063	2
FOR FM-5T TRANSMITTERS ONLY			
----	Meter Multiplier Circuit Board Assembly	919-0200	1

**TABLE 6-7. METER MULTIPLIER CIRCUIT BOARD, FM-5T - 919-0200**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V $\pm 5\%$ , 1W	200-0009	1
R1 Thru R6	Resistor, 1 Meg Ohm $\pm 1\%$ , 2W	140-0003	6
R7	Resistor, 4.99 k Ohm $\pm 1\%$ , 1/4W	100-5041	1
----	Blank, Meter Multiplier Circuit Board	519-0200	1

**TABLE 6-8. METER MULTIPLIER CIRCUIT BOARD, FM-5TS - 919-0079**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
D1	Diode, Zener, 1N4739A, 9.1V $\pm 5\%$ , 1W	200-0009	1
R1 Thru R10	Resistor, 1 Meg Ohm $\pm 1\%$ , 2W	140-0003	10
R11	Resistor, 4.99 k Ohm $\pm 1\%$ , 1/4W	100-5041	1
----	Blank, Meter Multiplier Circuit Board	519-0079	1

**TABLE 6-9. METER PANEL ASSEMBLY - 959-0271-105**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1, C10 Thru C12	Capacitor, Ceramic, 0.001 uF, 1 kV	002-1034	4
CB2	Circuit Breaker, 2-Pole, 250 Volt, 5 Amperes ( <b>BLOWER</b> )	341-0010	1
CB3	Circuit Breaker, 2-Pole, 250 Volt, 1 Ampere ( <b>SCREEN</b> )	341-0008	1
CB4A/B	Circuit Breaker, 2-Pole, 250 Volt, 7 Amperes, Push On ( <b>DRIVER</b> )	341-0060	2
CB5	Circuit Breaker, 2-Pole, 250 Volt, 10 Amperes ( <b>FILAMENT</b> )	341-0030	1
M1	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 200 uA $\pm 2\%$ , 230 Ohm Movement ( <b>OUTPUT POWER Meter</b> )	310-0058	1
----- FOR FM-5T AND FM-5TS 60 HZ TRANSMITTER MODELS ONLY -----			
M2	Meter, 0 - 99,999.9 Hour, Non-Resetable, 230 Volt, 3.5 Inch (8.89 cm) ( <b>FILAMENT TIME Meter</b> )	310-0000-002	1
M3	Multimeter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA dc $\pm 2\%$ , 35 Ohm Resistance ( <b>MULTIMETER</b> )	310-0057	1
M4	Meter Assembly ( <b>PLATE CURRENT</b> )	959-0300	1
M5	Meter, 3.5 inch (8.89 cm), Iron Vane Type, 0-10V AC -10V AC $\pm 3\%$ Movement ( <b>FILAMENT VOLTAGE</b> )	310-0024	1
----- FOR FM-5T TRANSMITTER MODELS ONLY -----			
M6	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA $\pm 1\%$ , 35 Ohm Resistance ( <b>PLATE VOLTAGE</b> )	310-0050	1
T5	Transformer, Variable, Superior Electric Type 21, 120V ac 50/60 Hz Input = 0-120V ac @ 5A Output	370-1790-001	1
----	Multimeter Circuit Board Assembly	919-0049-001	1

**TABLE 6-10. MULTIMETER CIRCUIT BOARD ASSEMBLY - 919-0049-001**

REF. DES.	DESCRIPTION	PART NO.	QTY.
E1, E2	Terminal, Male Disconnect PC	410-0025	2
J1	Connector, Ribbon Cable, 10-Pin, PCB Mount	418-1003	1
S1	Switch, Rotary, Panel Mount, 6 Position, Contacts: Single Pole, 28V dc @ 0.5A	340-0119	1
----	Blank, Multimeter Circuit Board Assembly	519-0049-001	1

**TABLE 6-11. PLATE CURRENT METER ASSEMBLY - 959-0300**

REF. DES.	DESCRIPTION	PART NO.	QTY.
M4	Meter, 3.5 inch (8.89 cm), Taut Band Type, FS = 1 mA $\pm$ 2%, 0 - 1.5 A Range, 35 Ohm Resistance ( <b>PLATE CURRENT</b> )	310-0053	1
----	Meter Protection Circuit Board Assembly	919-0109-002	1

**TABLE 6-12. METER PROTECTION CIRCUIT BOARD ASSEMBLY - 919-0109-002**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1, C2	Capacitor, Ceramic, 0.001 uF, 1 kV	002-1034	2
D1	Diode, Zener, 1N4728, 3.3V $\pm$ 5%, 1W	201-4728	1
E1, E2	Terminal, Male Disconnect PC	410-0025	2
R1	Resistor, 680 Ohm $\pm$ 5%, 1W	120-6833	1
R2	Resistor, 182 Ohm $\pm$ 1%, 1/4W	103-1823	1
R3	Potentiometer, 200 Ohm $\pm$ 10%, 1/2W	177-2034	1
----	Blank, Meter Protection Circuit Board	519-0109	1

**TABLE 6-13. FAN/BLOWER ASSEMBLY - 959-0271-006**

REF. DES.	DESCRIPTION	PART NO.	QTY.
B1	Blower, Centrifugal, 600 ft <sup>3</sup> /min Motor: 230V ac, 2.1 Ampere, 50/60 Hz, 3100 R/M, 1/3 hp	380-0005	1
B2, B3	Fan, 6 inch (15.24 cm), 250 ft <sup>3</sup> /min, 220V ac, 50/60 Hz, 40 Watt	380-7650	2
----	Receptacle, Pins	417-0036	4
----	Receptacle, Housing, 6-Pin	418-0006	1
----	Connector, Housing, 9-Pin	418-0055	1

**TABLE 6-14. DIODE STACK PANEL ASSEMBLY, FM-5T - 959-0271-008**

REF. DES.	DESCRIPTION	PART NO.	QTY.
D5 Thru D10	Encapsulated High Voltage Diode Assembly PIV: 18 kV V <sub>F</sub> = 21.0V dc @ 1.5 Amperes Configuration MAX	230-0010	6

**TABLE 6-15. DIODE STACK PANEL ASSEMBLY, FM-5TS - 959-0271-004**

REF. DES.	DESCRIPTION	PART NO.	QTY.
D5, D6, D8, D9	Encapsulated High Voltage Diode Assembly PIV: 18 kV $V_F = 21.0V$ dc @ 1.5 Amperes Configuration MAX	230-0010	4

**TABLE 6-16. CONTACTOR PANEL ASSEMBLY, FM-5T - 959-0271-109**

REF. DES.	DESCRIPTION	PART NO.	QTY.
K1, K2	Optically-Coupled-Relay Assembly (OCR)	919-0096	2
K3	Contactactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
K4	Contactactor, Coil: 110/230V, 50/60 Hz Contacts: 3 Sets SPST, 60 Amperes, 600V	341-0049	1
K5, K6	Optically-Coupled-Relay Assembly (OCR)	919-0096	2
K7	Contactactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
R1, R2, R3	Resistor, 5 Ohm $\pm 5\%$ , 25W, W/W	130-5013	3
TB6 Thru TB8	Barrier Strip, 9 Terminal	412-0090	3
TB12	Barrier Strip, 4 Terminal	412-0011	1
----	Interlock Switch For K4, Normally Open, Contactactor Mounted	341-0058	1
----	Screen Powerstat Assembly	959-0121-100	1

**TABLE 6-17. CONTACTOR PANEL ASSEMBLY, FM-5TS - 959-0271-102**

REF. DES.	DESCRIPTION	PART NO.	QTY.
K1, K2	Optically-Coupled-Relay Assembly (OCR)	919-0096	2
K3	Contactactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
K4	Contactactor, Coil: 110/230V, 50/60 Hz Contacts: 3 Sets SPST, 60 Amperes, 600V	341-0049	1
K5, K6	Optically-Coupled-Relay Assembly (OCR)	919-0096	2
K7	Contactactor, Coil: 208-240V, 60 Hz or 208-220V, 50 Hz Contacts: 3 Sets SPST, 25 Amperes, 600V	341-0033	1
R1, R2	Resistor, 5 Ohm $\pm 5\%$ , 25W, W/W	130-5013	2
TB6 Thru TB8	Barrier Strip, 9 Terminal	412-0090	3
TB12	Barrier Strip, 4 Terminal	412-0011	1
----	Screen Powerstat Assembly	959-0121-100	1

**TABLE 6-18. OPTICALLY-COUPLED-RELAY (OCR) ASSEMBLY - 919-0096**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	1
C2	Capacitor, Electrolytic, 47 uF, 35V	020-4773	1
C3	Capacitor, Ceramic Disc, 0.03 uF, 300V	000-1051	1
C4	Capacitor, Ceramic Disc, 0.001 uF, 1 kV	002-1034	1
D1	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	1
D2	Diode, Zener, 1N5359, 24V, 5W	200-5359	1
D4	Diode, 1N4005, Silicon, 600V @ 1 Ampere	203-4005	1
D5	Bridge Rectifier, MDA970A3, 4 Amps, 50-200V	239-0003	1
E1 Thru E5	Terminal, Male, 0.25 Tab	410-0025	5
F1, F2	Fuse, PCB Mount, 250V, 3 Amperes	330-0055	2
K1	Relay, Coil: 24V dc, 30A, 660 Ohms $\pm 10\%$ dc Resistance Contacts: SPST, 0.5 to 15A @ 12 to 240V dc	270-0054	1
MOV1	Metal Oxide Varistor, V272A60, 27V AC RMS, 120 Joules	140-0023	1
R1	Resistor, 2 k Ohm $\pm 3\%$ , 10W	130-2032	1
R2	Resistor, 560 Ohm $\pm 5\%$ , 1/2W	110-5633	1
R3	Resistor, 820 Ohm $\pm 5\%$ , 1/2W	110-8233	1
R4	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	1
R5	Resistor, 2 k Ohm $\pm 3\%$ , 10W	130-2032	1
U1	Integrated Circuit, 4N33, Optical Isolator, Infared LED-Photo NPN Darlington Transistor Coupled Pair, 1500V Isolation	229-0033	1
XU1	Socket, 6-Pin DIP	417-0600	1
----	Blank Circuit Board	519-0096	1

**TABLE 6-19. POWERSTAT ASSEMBLY - 959-0121**

REF. DES.	DESCRIPTION	PART NO.	QTY.
B4	Motor and Gearhead Assembly, 12V dc @ 235 mA, 9.1 r/min, Torque: 300 oz/in.	381-0001	1
D1, D2	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	2
S4, S5	Microswitch, Modified, SPDT, 125V @ 4 Amperes Inductive	346-6100-1	2
T1	Autotransformer, Variable, 240V, 50/60 Hz, 0.7 Ampere Output	374-0003	1
TB5	Barrier Strip, 4 Terminal	412-0011	1

**TABLE 6-20. THREE-PHASE VOLTMETER ASSEMBLY - 959-0271-010  
(Sheet 1 of 2)**

REF. DES.	DESCRIPTION	PART NO.	QTY.
F1 Thru F3	Fuse, AGC, 1/2 Ampere	330-0050	3
FOR 208/240V TRANSMITTERS			
M7	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0-300V Range 60 k Ohm Resistance ( <b>PRIMARY VOLTAGE</b> )	310-0032	1
FOR 380V TRANSMITTERS			
M7	Meter, 3.5 Inch (8.89 cm), Iron Vane Type, 0-500V Range 45 k Ohm Resistance ( <b>PRIMARY VOLTAGE</b> )	310-0060	1

**TABLE 6-20. THREE-PHASE VOLTMETER ASSEMBLY - 959-0271-010**  
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
S10 Thru S12	Meter Select Switch Assembly Switch: KS46B, Square D	341-0021	1
	Contactactor: KA-1, Square D	341-0020	4
	Cam Assembly: Type F, Square D	341-0019	1
XF1 Thru XF3	Fuseholder, Panel Mount	415-2012	3

**TABLE 6-21. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-008**  
(Sheet 1 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1 Thru C3	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	3
C4, C5	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	2
C6, C7	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	2
C8, C9	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	2
C10	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C11, C12, C13	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	3
C14	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C15, C16	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	2
C17	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C18	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	1
C19	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C20	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	1
C21	Capacitor, Electrolytic, 470 uF, 50V	024-4783	1
D1 Thru D7	Diode, Zener, 1N4739A, 9.1V $\pm 10\%$ , 1W	200-0009	7
E1 Thru E10	Terminal, Male Disconnect PC	410-0025	10
E11, E12	Terminal Turret, Two Shoulder	413-1597	2
E13	Terminal, Male Disconnect PC	410-0025	1
F1, F2	Fuse, AGC, 1 Ampere, Fast Blow	330-0100	2
F3	Fuseable Link, 28 AWG	630-2806	0.208
J1	Connector, 10-Pin	418-1003	1
J2	Connector, 15-Pin	417-0169	1
J3	Connector, 6-Pin	417-0677	1
L1	RF Choke, 2.2 uH $\pm 10\%$ , 0.4 Ohms DC Resistance, 550 mA Maximum	360-2200	1
R1	Resistor, 100 Ohm $\pm 5\%$ , 1/2W	110-1033	1
R2	Resistor, 2 Ohm $\pm 1\%$ , 5W, W/W	130-2011	1
R3	Resistor, 1 Ohm $\pm 1\%$ , 5W, W/W	132-1111	1
R4, R5	Resistor, 0.5 Meg Ohm $\pm 1\%$ , 2W	140-0005	2
R6	Resistor, 4.99 k Ohm $\pm 1\%$ , 1/4W	100-5041	1
R7	Resistor, 5.11 k Ohm $\pm 1\%$ , 1/4W	100-5141	1
R8	Resistor, 4.99 k Ohm $\pm 1\%$ , 1/4W	100-5041	1
R9	Resistor, 0.5 Meg Ohm $\pm 1\%$ , 2W	140-0005	1
R10	Resistor, 5.62 k Ohm $\pm 1\%$ , 1/4W	103-5624	1
R11	Resistor, 49.9 k Ohm $\pm 1\%$ , 1/4W	103-4951	1
R12	Resistor, 26.7 k Ohm $\pm 1\%$ , 1/4W	100-2675	1
R13	Resistor, 49.9 k Ohm $\pm 1\%$ , 1/4W	103-4951	1
R14	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R15	Resistor, 100 Ohm $\pm 5\%$ , 1/2W	110-1033	1
R16	Resistor, 22 Ohm $\pm 1\%$ , 3W	130-2221	1

**TABLE 6-21. PA METERING CIRCUIT BOARD ASSEMBLY - 919-0048-008**  
(Sheet 2 of 2)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R18	Resistor, 1 k Ohm $\pm 1\%$ , 1/4W	100-1041	1
R19	Resistor, 48.7 k Ohm $\pm 1\%$ , 1/4W	103-4875	1
R20	Resistor, 24.3 k Ohm $\pm 1\%$ , 1/4W	103-2435	1
R21	Resistor, 49.9 k Ohm $\pm 1\%$ , 1/4W	103-4951	1
R22	Resistor, 5.49 k Ohm $\pm 1\%$ , 1/4W	103-5494	1
R23	Resistor, 1 k Ohm $\pm 1\%$ , 1/4W	100-1041	1
R24	Resistor, 10 Ohm $\pm 1\%$ , 1W	120-1021	1
R26	Resistor, 1 k Ohm $\pm 1\%$ , 1/4W	100-1041	1
R27	Resistor, 24.3 k Ohm $\pm 1\%$ , 1/4W	103-2435	1
R28	Resistor, 16.2 k Ohm $\pm 1\%$ , 1/4W	103-1625	1
R29	Resistor, 49.9 k Ohm $\pm 1\%$ , 1/4W	103-4951	1
R30	Resistor, 4.99 k Ohm $\pm 1\%$ , 1/4W	100-5041	1
R31	Resistor, 2.43 k Ohm $\pm 1\%$ , 1/4W	103-2434	1
R37, R38	Resistor, 100 k Ohm $\pm 1\%$ , 1/4W	103-1062	2
R39	Resistor, 2.94 k Ohm $\pm 1\%$ , 1/4W	103-2941	1
R41	Resistor, 1 k Ohm $\pm 1\%$ , 1/4W	100-1041	1
TP1	Terminal Turret, Two Shoulder	413-1597	1
U1, U2	Integrated Circuit, LM358N, Dual Operational Amplifier, 8-Pin DIP	221-0358	2
XF1, XF2	Fuse Clip	415-2068	4
XU1, XU2	Socket, 8-Pin DIP	417-0804	2
----	Blank, PA Metering Circuit Board	519-0048-001	1

**TABLE 6-22. BASIC UNIT CABLE ASSEMBLY - 949-0161-100**

REF. DES.	DESCRIPTION	PART NO.	QTY.
P1, P1	Connector, Ribbon Cable, 10-Pin (PA Metering Circuit Board)	417-1003	2
P1, P2	Connector, Housing 6-Pin (on Blower and Fans)	418-0670	2
P2	Connector, Housing, 15-Pin (PA Metering Circuit Board)	417-2379	1
----	Connector, Jack, Type N (IPA: P13, RF Enclosure: P1)	418-0031	2
----	Connector, Housing, 4-Pin	418-0240	1
----	Connector, Plug, BNC APC: P9, P10 Directional Coupler: RFL, FWD Exciter: RF OUTPUT IPA: RF INPUT	417-0094	4
----	Connector, Plug, Type-N (RF Enclosure, PA Input)	417-0076	1
----	Connector, Plug, BNC (RF Enclosure, PA Input)	417-0095	1
----	Pins, Connector	417-0053	20
----	Receptacle, Pins	417-0036	2
----	Connector, 9-Pin	417-0059	1
----	Connector, Housing 6-Pin (PA Metering Circuit Board)	418-0670	2
----	Pins	417-0142	29
----	Plug, 25-Pin 207464-1 Amp	417-0251	2
----	Connector, 37-Pin, Male IDC Dsub	417-2819	1
----	Kit, 25-Pin Cable Clamp	418-2501	2
----	AC Line Cord With Ears, 220V	682-0004	2



**TABLE 6-23. GROUND STICK HANGER ASSEMBLY - 955-0038**

REF. DES.	DESCRIPTION	PART NO.	QTY.
S302	Microswitch, SPDT, 0.5A @ 125V dc	346-6100	1

**TABLE 6-24. DIRECTIONAL COUPLER ASSEMBLY, 40dB (RFL) - 959-0082-040**

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Receptacle, BNC	417-0016	1
----	Resistor, 100 Ohm $\pm 5\%$ , 2W	130-1033	1
----	Choke, 1.5 uH $\pm 10\%$ , 580 mA	360-0032	1

**TABLE 6-25. DIRECTIONAL COUPLER ASSEMBLY, 45 dB (FWD) - 959-0082-045**

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Receptacle, BNC	417-0016	1
----	Resistor, 120 Ohm $\pm 5\%$ , 2W	120-1233	1
----	Choke, 1.5 uH $\pm 10\%$ , 580 mA	360-0032	1

**TABLE 6-26. REMOTE INTERFACE PANEL ASSEMBLY - 959-0117-100**

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Fail-Safe Solenoid Assembly	959-0083	1
----	Remote Interface Circuit Board Assembly	919-0439	1

**TABLE 6-27. FAIL-SAFE SOLENOID ASSEMBLY - 959-0083**

REF. DES.	DESCRIPTION	PART NO.	QTY.
L5	Solenoid, 230V ac 50/60 Hz, DC Resistance: 360 Ohm $\pm 10\%$	281-0004	1
TB11	Barrier Strip, 2-Terminal	412-0002	1
----	Barrier Strip, Insulated, 2-Terminal	407-0122	1

**TABLE 6-28. REMOTE INTERFACE CIRCUIT BOARD ASSEMBLY - 919-0439**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Monolythic, .1 uF $\pm 20\%$ , 50V	003-1054	1
J1	Connector, 40-Pin Ribbon Cable	417-0173	1
TB1	Barrier Strip, 30-Position	412-3000	1
TB2	Barrier Strip, 16-Position	412-1600	1
----	Blank Remote Interface Circuit Board	519-0439	1

**TABLE 6-29. TUBE SOCKET AND INPUT TUNING ASSEMBLY - 959-0151**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Choke, RF Plate 80-200 MC	360-0144	1
C7, C8	Capacitor, Kapton, 1000 pF, 2 kV, Screen Bypass	519-0037	2
C10	Capacitor, Kapton, 2000 pF, 1.5 kV, Grid Blocking	519-0038	1
C12, C15	Capacitor, Ceramic, 500 pF $\pm 20\%$ , 5 kV	008-5024	2
C16, C17	Capacitor, Kapton, 1000 pF, 2 kV, Screen Bypass	519-0037	2
E1, E2	Spark Gap, 630V $\pm 15\%$ DC Surge Voltage Protection	140-0004	2
FL1, FL2	Filter, RFI 2500V 25A Feedthru	339-0012	2
L7, L7A, L8, L8A, L10, L10A, L11, L11A	Strap, Neutralization	463-0040	8
L12, L14	Input Tuning Fingerstock	469-0004	2
L15	Inductor, Input Matching	360-0100	1
R1	Resistor, Power, 750 Ohm $\pm 10\%$ , 50W	139-7532	1
RF	Choke, RF Plate 80-200 MC	360-0144	1
XU1	Tube Socket, 4CX3500A	417-0350	1
----	Input Matching Circuit Board Assembly	919-0064	1

**TABLE 6-30. INPUT MATCHING CIRCUIT BOARD ASSEMBLY - 919-0064**

REF. DES.	DESCRIPTION	PART NO.	QTY.
E1 Thru E8	Terminal Turret, Two Shoulder	413-0025	8
J2	Receptacle, BNC	417-0014	1
----	Blank, PA Input Matching Circuit Board	519-0064	1
----	Matching Capacitor Circuit Board	519-0064-001	1

**TABLE 6-31. RF ENCLOSURE ASSEMBLY - 959-0272**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C9	Capacitor, Plate, Second Harmonic Suppressor	474-0187	1
C13, C14	Capacitor, 700 pF, 1.5 kV, Filament Feedthru:		
	Kapton Dielectric	519-0039	4
	Teflon Spacer	441-0054	2
L6	Inductor, Second Harmonic Suppressor	463-0047	1
S2	Microswitch, SPDT, Roller Activated (PA Interlock)	346-3300	1
----	Connector Assembly, Transmission Line, Modified	427-0009-1	1
----	High Voltage Feed-Thru Capacitor Assembly	955-0049-002	1
----	PA Chimney Assembly	959-0272-002	1

**TABLE 6-32. PA CHIMNEY ASSEMBLY - 959-0272-002**

REF. DES.	DESCRIPTION	PART NO.	QTY.
L9	Chimney, PA	479-0067	1
J3	Receptacle, Binding Post, Banana	417-0074	1

**TABLE 6-33. TRANSMISSION LINE ASSEMBLY- 959-0272-003**

REF. DES.	DESCRIPTION	PART NO.	QTY.
J2	Connector, BNC, Modified	417-0203-2	1
----	Harmonic Low-Pass Filter, 15 kW, 88 MHz to 108 MHz	339-0021	1
----	Elbow, 1 5/8 inch Copper, 90 Degree, EIA Unflanged	427-0006	1
----	Transmission Line Elbow, Modified with Sampling Port	427-0006-002	1
----	Coupling Assembly, 1 5/8 Inch	427-0007	4
----	Transmission Lines:	427-0008-018	1
	Outer, 25.595 Inches (65.0 cm)		
	Inner, 24.72 Inches (62.79 cm)		
----	Transmission Lines:	427-0008-019	1
	Outer, 8.125 Inches (20.64 cm)		
	Inner, 7.25 Inches (18.41 cm)		

**TABLE 6-34. SHIELD CELL/TUNING LINE ASSEMBLY - 959-0272-101**

REF. DES.	DESCRIPTION	PART NO.	QTY.
L10	Assembly, Bellows, Output Tuning Line	463-0043	1
----	Output Tuning Line, 23.62 inches (60 cm) X 1 5/8 inch OD	463-0042	1
----	Exhaust Air Temperature Circuit Board	919-0082	1

**TABLE 6-35. EXHAUST AIR TEMPERATURE CIRCUIT BOARD ASSEMBLY - 919-0082**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1, C2	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	2
C3, C4	Capacitor, Ceramic, 0.001 uF $\pm 10\%$ , 1 kV	002-1034	2
J1	Socket, 4-Pin	418-0255	1
R1	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R2	Resistor, 2.21 k Ohm $\pm 1\%$ , 1/4W	103-2241	1
TP1, TP2	Terminal Turret, Two Shoulder	413-1597	2
U1	Integrated Circuit, LM35DZ, Celsius Temperature Sensor, TO-92 Case	220-0035	1
----	Blank, Exhaust Air Circuit Board	519-0082	1

**TABLE 6-36. ACCESSORY PARTS KIT - 969-0013**

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Cell, Battery, 3V, 190 mAh	350-2032	1
----	Adapter, 1 5/8 Inch EIA Flanged to Unflanged	427-0010	1
----	Hex Key, 5/32 Inch	710-0219	1
----	Binder and Manual, FM-5T/FM-5TS	959-0193-014	1

## SECTION VII DRAWINGS

### 7-1. INTRODUCTION.

7-2. This section provides assembly drawings and schematic diagrams as indexed below for the FM-5T and FM-5TS Transmitters.

FIGURE	TITLE	NUMBER
7-1	OVERALL SCHEMATIC, FM-5T TRANSMITTER, 208/240V	SD909-5000-215/-315
7-2	OVERALL SCHEMATIC, FM-5T TRANSMITTER, 380V	SD909-5000-385
7-3	OVERALL SCHEMATIC, FM-5TS TRANSMITTER	SD909-5000-255/-355
7-4	ASSEMBLY DIAGRAM, PLATE CURRENT METER	AB959-0300
7-5	SCHEMATIC DIAGRAM, METER PROTECTION CIRCUIT BOARD	SB919-0109-002
7-6	ASSEMBLY DIAGRAM, METER PROTECTION CIRCUIT BOARD	AB919-0109-002
7-7	SCHEMATIC DIAGRAM, MULTIMETER CIRCUIT BOARD	SB919-0049-001
7-8	ASSEMBLY DIAGRAM, MULTIMETER CIRCUIT BOARD	AB919-0049-001
7-9	SCHEMATIC, HUM NULL CIRCUIT BOARD	SB919-0063
7-10	ASSEMBLY, HUM NULL CIRCUIT BOARD	AB919-0063
7-11	SCHEMATIC, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5T	SB919-0200
7-12	ASSEMBLY, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5T	AB919-0200
7-13	SCHEMATIC, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5TS	SB919-0079
7-14	ASSEMBLY, PLATE METER MULTIPLIER CIRCUIT BOARD, FM-5TS	AB919-0079
7-15	SCHEMATIC, PA METERING CIRCUIT BOARD	SB919-0048-008
7-16	ASSEMBLY, PA METERING CIRCUIT BOARD	AB919-0048-008
7-17	ASSEMBLY DIAGRAM, PA INPUT CIRCUIT	597-0033-105A/B/ C/D
7-18	SCHEMATIC DIAGRAM, OPTICALLY-COUPLED-RELAY	SB919-0096/-001
7-19	ASSEMBLY DIAGRAM, OPTICALLY-COUPLED-RELAY	AB919-0096/-001
7-20	ASSEMBLY DIAGRAM, DIRECTIONAL COUPLER	597-0032-506
7-21	SCHEMATIC DIAGRAM, REMOTE INTERFACE CIRCUIT BOARD	SB919-0439
7-22	ASSEMBLY DIAGRAM, REMOTE INTERFACE CIRCUIT BOARD	AC919-0439
7-23	ASSEMBLY DIAGRAM, PA MATCHING CIRCUIT BOARD	597-0033-413

# APPENDIX A

## MANUFACTURERS DATA

### A-1. INTRODUCTION.

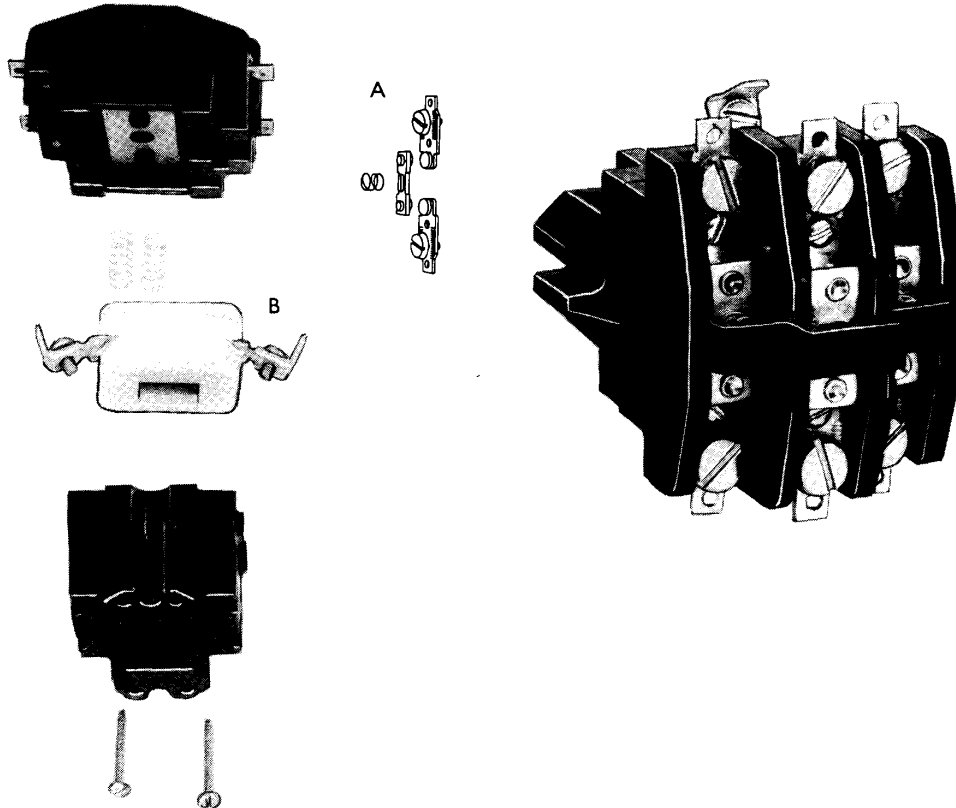
A-2. This appendix provides the following technical data relative to the operation and maintenance of the FM-5T/FM-5TS FM transmitters. Information contained in this appendix is presented in the following order.

- A. Service Bulletin, Furnas Contactor, Size 25 Amp.
- B. Service Bulletin, Furnas Contactor, Size 1 3/4.
- C. Technical Data Sheet, Eimac 4CX3500A Tetrode.
- D. Application Note, Eimac, Extending Transmitter Tube Life.
- E. Schematic Diagram, Power Supply, Computer Products, NFN40-7610.

# REPLACEMENT PARTS

## MAGNETIC CONTACTORS

File No.	<b>41-GNB</b>
Cat. No. or Class Series	<b>41NB</b>
Size	<b>25 Amp</b>
Date	<b>APRIL, 1982</b>



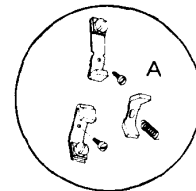
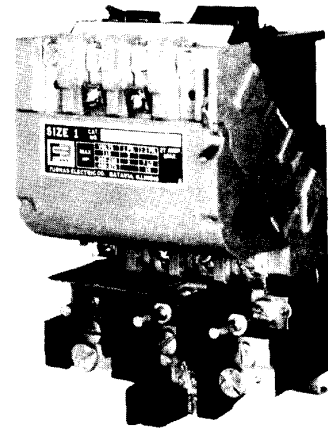
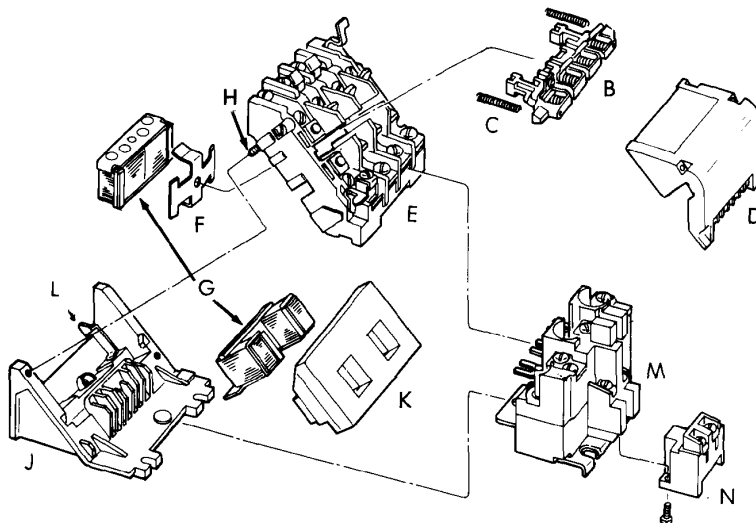
Item	Part Name	Part No.
A	Contacts & Spring, One complete pole	75NB41
B	Coil     60 Hz.	24 Volts     75D54760J 120 Volts    75D54760F 208-240 Volts 75D54760G 440-480 Volts 75D54760H 575-600 Volts 75D54760E

**NOTE:** When ordering replacement parts, give catalog number of control and part name and number.

June, 1983  
Supersedes Issue of  
October, 1982

**Starter & Contactors**  
00, 0, 1, 1P, & 1¾

**Class 14 & 40**  
14BF, 14CF, 14DF, 14EF,  
40BF, 40CF, 40DF, 40EF



Item	Part Name		Part Number				
			Size 00	Size 0	Size 1	Size 1P & 1¾	
A	Contacts & Spring, One Pole	Power Pole	75BF14	75CF14	75DF14	75EF14	
B	Cross Arm (less contacts)	Interlock Pole	75AF14	75AF14	75AF14	75AF14	
C	Cross Arm Springs		D28478001	D28478001	D28478001	D28478001	
D	Contact Board Cover		D24826001	D24826001	D24826001	D24826001	
E	Contact Board (less contacts)		D73062001	D73062001	D73062001	D73062001	
F	Armature Spring Clip		D73116022	D73116022	D73116022	D73116022	
G	Armature Spring Clip		D24817001	D24817001	D24817001	D24817001	
H	Magnet and Armature		D25551001	D25551001	D255551001	D25551001	
H	Contact Board Screw		D24827001	D24827001	D24827001	D24827001	
J	Base		D74400001	D74400001	D74400001	D74400001	
K	Coil						
	60 Hz 110-120/220-240v	50 Hz 110/190-220v	75D73070A	75D73070A	75D73070A	75D73070A	
	220-240/440-480v	190-220/380-440v	75D73070C	75D73070C	75D73070C	75D73070C	
	550-600v	550v	75D73070E	75D73070E	75D73070E	75D73070E	
L	Coil Spring Clip		D24815001	D24815001	D24815001	D24815001	
M	Overload Relays	(Melting Alloy (std.)	{ 1 Pole	48DC11AA2	48DC11AA2	48DC11AA2	48EC11AA2
			{ 3 Pole	48DC31AA2	48DC31AA2	48DC31AA2	48EC31AA2
		Bimetal	{ 1 Pole	48DC17AA2	48DC17AA2	48DC17AA2	48EC17AA2
			{ 3 Pole	48DC37AA2	48DC37AA2	48DC37AA2	48EC37AA2
		Amb. Comp. Bimetal	{ 1 Pole	48DC18AA2	48DC18AA2	48DC18AA2	48EC18AA2
			{ 3 Pole	48DC38AA2	48DC38AA2	48DC38AA2	48EC38AA2
N	Melting Alloy Overload Kit NO Contacts		48ACNO	48ACNO	48ACNO	48ACNO	
P	Auxiliary Interlock Pole NC		49D54682NC	49D54682NC	49D54682NC	49D54682NC	

NOTE: When ordering replacement parts, give catalog number of control and part name and number.

Furnas Electric Company 1000 McKee Street, Batavia, Illinois 60510

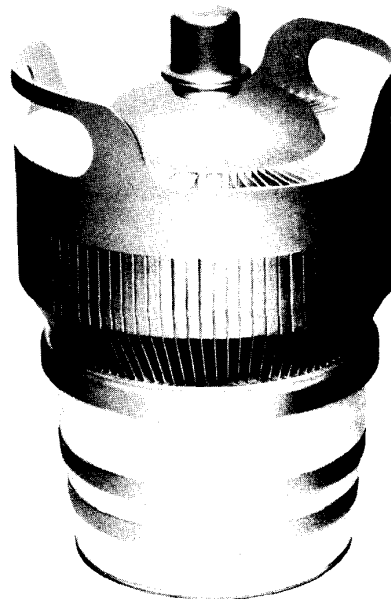


## TECHNICAL DATA

### 4CX3500A VHF RADIAL BEAM POWER TETRODE

The EIMAC 4CX3500A is a compact ceramic/metal radial-beam power tetrode intended for use in VHF power amplifier applications. It features a type of internal mechanical structure which results in high rf operating efficiency. Low rf losses in this structure permit operation at full ratings to 220 MHz.

The 4CX3500A has a gain of over 18 dB in FM broadcast service, and is also recommended for rf linear power amplifier service and for VHF-TV linear amplifier service. The anode is rated for 3500 watts of dissipation with forced-air cooling.



#### GENERAL CHARACTERISTICS<sup>1</sup>

##### ELECTRICAL

Filament: Thoriated Tungsten Mesh

Voltage . . . . .  $5.0 \pm 0.25$  V

Current, at 5.0 volts . . . . . 90 A

Amplification Factor, average

Grid to Screen . . . . . 4.5

Direct Interelectrode Capacitances (cathode grounded)<sup>2</sup>

Cin . . . . . 111 pF

Cout . . . . . 12 pF

Cgp . . . . . 0.5 pF

Direct Interelectrode Capacitances (grids grounded)<sup>2</sup>

Cin . . . . . 58.5 pF

Cout . . . . . 10 pF

Cpk . . . . . 0.4 pF

Frequency of Maximum Ratings (CW) . . . . . 220 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. Varian EIMAC should be consulted before using this information for final equipment design.

2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

##### MECHANICAL

Maximum Overall Dimensions:

Length . . . . . 7.25 in; 18.42 cm

Diameter . . . . . 4.94 in; 12.55 cm

394350 (Effective 30 March 1982)  
VA4520

Printed in U.S.A.





4CX3500A

Net Weight (approximate) . . . . .	5.5 Lbs; 2.5 kg
Operating Position . . . . .	Axis Vertical, Base Up or Down
Cooling . . . . .	Forced Air
Maximum Operating Temperature, Ceramic/Metal Seals & Anode Core . . . . .	250 Deg.C
Base . . . . .	Special, Coaxial
Recommended Air-System Socket . . . . .	HF: EIMAC SK-340 VHF: EIMAC SK-350
Recommended Air Chimney . . . . .	EIMAC SK-346

## RADIO FREQUENCY POWER AMPLIFIER

TYPICAL OPERATION (frequencies to 30 MHz)

Class C Telegraphy or FM (Key-Down Conditions)			Plate Voltage . . . . .	5.0	5.0	kVdc
			Screen Voltage . . . . .	500	500	Vdc
			Grid Voltage . . . . .	-200	-250	Vdc
ABSOLUTE MAXIMUM RATINGS			Plate Current . . . . .	1.32	0.80	Adc
DC PLATE VOLTAGE	5500 VOLTS		Screen Current <sup>1</sup> . . . . .	75	43	mAdc
DC SCREEN VOLTAGE	1500 VOLTS		Grid Current <sup>1</sup> . . . . .	59	21	mAdc
DC GRID VOLTAGE	-500 VOLTS		Peak rf Grid Voltage <sup>1</sup> . . . . .	335	290	v
DC PLATE CURRENT	2.0 AMPERES		Calculated Driving Power . . . . .	25	7	W
PLATE DISSIPATION	3500 WATTS		Plate Dissipation <sup>1</sup> . . . . .	1320	640	W
SCREEN DISSIPATION	165 WATTS		Plate Output Power <sup>1</sup> . . . . .	5280	3360	W
GRID DISSIPATION	50 WATTS		Load Impedance . . . . .	1700	2700	Ohms

<sup>1</sup> Approximate value

## RADIO FREQUENCY POWER AMPLIFIER, FM BROADCAST SERVICE

## ABSOLUTE MAXIMUM RATINGS:

MEASURED DATA AT 100.5 MHz

FILAMENT VOLTAGE	5.0 ± 0.25 VOLTS	Plate Voltage . . . . .	4000	4300	Vdc
DC PLATE VOLTAGE	5500 VOLTS	Plate Current . . . . .	1.5	1.9	Adc
DC SCREEN VOLTAGE	1500 VOLTS	Screen Grid Voltage . . . . .	500	700	Vdc
DC GRID VOLTAGE	-500 VOLTS	Screen Current <sup>1</sup> . . . . .	140	123	mAdc
DC PLATE CURRENT	2.0 AMPERES	Grid Bias Voltage . . . . .	-300	-400	Vdc
PLATE DISSIPATION	3500 WATTS	Grid Current <sup>1</sup> . . . . .	84	63	mAdc
SCREEN DISSIPATION	165 WATTS	Useful Power Out <sup>1,2</sup> . . . . .	3838	5531	W
GRID DISSIPATION	50 WATTS	Efficiency <sup>1</sup> . . . . .	64	68	%
<sup>1</sup> Will vary from tube to tube		Driving Power <sup>1</sup> . . . . .	56	66	W
<sup>2</sup> Delivered to the load		Power Gain <sup>1</sup> . . . . .	18.4	19.2	dB



TYPICAL OPERATION values are obtained by measurement or by calculation from published characteristic curves. To obtain the specified plate current at the specified bias, screen, and plate voltages, adjustment of the rf grid voltage is assumed. If this procedure is followed, there will be little variation in output power when the tube is replaced, even though there may be some variation in grid and screen currents. The grid and screen currents which occur when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no performance degradation providing the circuit maintains the correct voltage in the presence of the current variations. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjusted to produce the required bias voltage when the correct rf grid voltage is applied.

## A P P L I C A T I O N

### MECHANICAL

**MOUNTING** - The 4CX3500A must be mounted with its axis vertical, base up or down at the convenience of the circuit designer.

**AIR-SYSTEM SOCKET & CHIMNEY** - The EIMAC sockets type SK-340 and SK-350 are designed especially for the concentric base terminals of the 4CX3500A. The SK-340 is intended for use at HF, while the SK-350 is recommended for VHF applications. Use of the recommended air flow rates through either socket will provide effective forced-air cooling of the tube. Air forced into the bottom of the socket passes over the tube terminals and through the SK-346 chimney and into the anode cooling fins.

**COOLING** - At full rated anode dissipation, at sea level and with cooling air at 50 Deg.C maximum, for frequencies below 110 MHz, and with the tube mounted in either an SK-340 or SK-350 socket with an SK-346 in place, a minimum of 241 CFM of air must be passed through the socket and the tube anode cooling fins. Air flow should be in the base-to-anode direction. The pressure drop across the tube/ socket/chimney combination with this air flow rate will be approximately 1.87 inches of water.

The blower selected in a given application must be capable of supplying the desired air flow at a back pressure equal to that shown, plus any drop encountered in ducts and filters.

Air flow must be applied before or simultaneously with the application of power, including the tube filament, and may be removed simultaneously with filament voltage. An air interlock system should be incorporated in the design to automatically

remove all voltages from the tube in case of even a partial failure of the tube cooling air.

It is considered good engineering practice to supply more than the minimum required cooling air, to allow for variables such as dirty air filters, rf seal heating, and the fact that the anode cooling fins may not be clean if the tube has been in service for some time.

### ELECTRICAL

**FILAMENT OPERATION** - At rated (nominal) filament voltage the peak emission capability of the tube is many times that needed for communication service. A reduction in filament voltage will lower the filament temperature, which will substantially increase life expectancy. The correct value of filament voltage should be determined for the particular application. It is recommended the tube be operated at full nominal voltage for an initial stabilization period of 100 to 200 hours before any action is taken to operate at reduced voltage. The voltage should gradually be reduced until there is a slight degradation in performance (such as power output or distortion). The filament voltage should then be increased one tenth of a volt above the value where performance degradation was noted for operation. The operating point should be rechecked after 24 hours. Filament voltage should be closely regulated when voltage is to be reduced below nominal in this manner, to avoid any adverse influence by normal line voltage variations.

Filament voltage should be measured at the tube base or socket, using an accurate rms-responding meter. Periodically the procedure outlined above for reduction of voltage should be repeated, with voltage reset as required, to assure best life.



**GRID OPERATION** - The maximum control grid dissipation is 50 watts, determined approximately by the product of the dc grid current and the peak positive grid voltage.

**SCREEN OPERATION** - The maximum screen grid dissipation is 165 watts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and the dc screen current. With screen modulation, dissipation is dependent on rms screen voltage and rms screen current. Plate voltage, plate loading, or bias voltage must never be removed while filament and screen voltages are present, since screen dissipation ratings will be exceeded. A protective spark-gap device should be connected between the screen grid and the cathode to guard against excessive voltage.

**SCREEN CURRENT** - The screen current may reverse under certain conditions and produce negative indications on the screen current meter. This is a normal characteristic of most tetrodes. The screen power supply should be designed with this characteristic in mind, so that the correct operating voltage will be maintained on the screen under all conditions. A current path from the screen to cathode must be provided by a bleeder resistor or a shunt regulator connected between screen and cathode and arranged to pass approximately 10% of the average screen current per connected tube. A series regulated power supply can be used only when an adequate bleeder resistor is provided.

**FAULT PROTECTION** - In addition to the normal plate over-current interlock, screen current interlock, and air-flow interlock, the tube must be protected from internal damage caused by an internal plate arc which may occur at high plate voltage. A protective resistance should always be connected in series with each tube anode, to absorb power supply stored energy if an internal arc should occur. EIMAC's Application Bulletin #17 titled **FAULT PROTECTION** contains considerable detail, and is available on request.

**ABSOLUTE MAXIMUM RATINGS** - The values shown for each type of service are based on the "absolute system" and are not to be exceeded under any service conditions. These ratings are limiting values outside which the serviceability of the tube may be impaired. In order not to exceed absolute ratings the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by a safety factor so that the

absolute values will never be exceeded under any usual conditions of supply voltage variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

**HIGH VOLTAGE** - Normal operating voltages used with this tube are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to discharge high-voltage capacitors whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that **HIGH VOLTAGE CAN KILL**.

**RADIO-FREQUENCY RADIATION** - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 300 MHz most of the energy will pass completely through the human body with little attenuation or heating affect. Public health agencies are concerned with the hazard, however, even at these frequencies, and it is worth noting that some commercial dielectric heating units actually operate at frequencies as low as the 13 MHz and 27 MHz bands.

**INTERELECTRODE CAPACITANCE** - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and Military Services use a standard test procedure as described in Electronic Industries Association Standard RS-191. This requires the use of specially constructed test fixtures which effectively shield all external tube leads from each other and eliminates any capacitance reading to "ground". The test is performed on a cold tube. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of time, even when the tube may be made by different manufacturers. The capacitance values shown in the manufacturer's technical data, or test specifications, normally are taken in accordance with Standard RS-191.



The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in any normal application. Measurements should be taken with the socket and mounting which represent approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATIONS - When it is desired to operate this tube under conditions widely different from those listed here, write to Varian EIMAC; attn:Applications Engineering; 301 Industrial Way; San Carlos, CA 94070 U.S.A.

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#### OPERATING HAZARDS

PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO POWER TUBES ARE THE RESPONSIBILITY OF EQUIPMENT MANUFACTURERS AND USERS OF SUCH TUBES. ALL PERSONS WHO WORK WITH OR ARE EXPOSED TO POWER TUBES OR EQUIPMENT WHICH UTILIZES SUCH TUBES MUST TAKE PRECAUTIONS TO PROTECT THEMSELVES AGAINST POSSIBLE SERIOUS BODILY INJURY. DO NOT BE CARELESS AROUND SUCH PRODUCTS.

The operation of this tube may involve the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel:

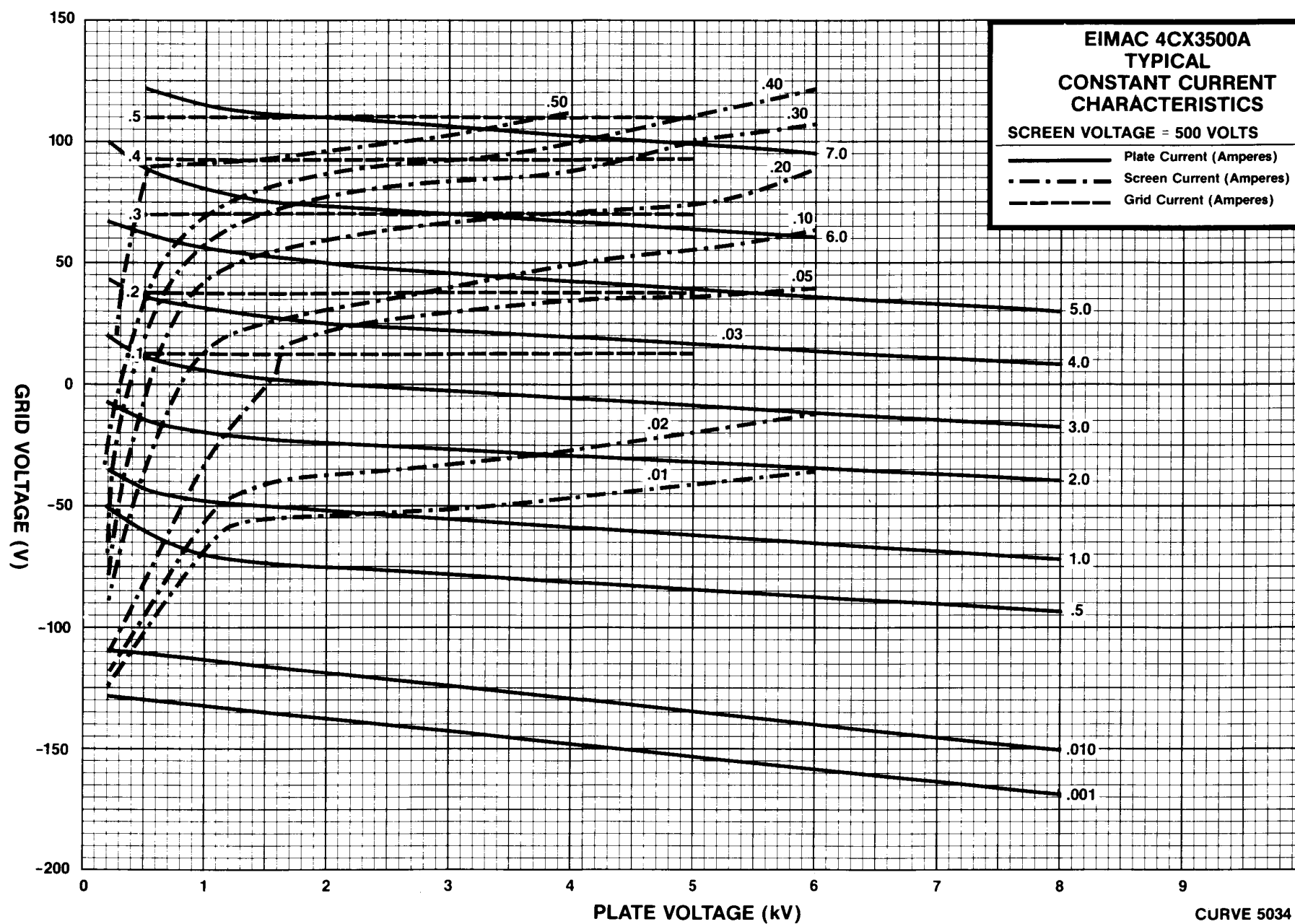
- |  |  |
|--|--|
| a. HIGH VOLTAGE - Normal operating voltages can be deadly.   | and can cause serious bodily and eye injuries. CARDIAC PACEMAKERS MAY BE EFFECTED.   |
| b. RF RADIATION - Exposure to strong rf fields should be avoided, even at relatively low frequencies. The dangers of rf radiation are more severe at UHF and microwave frequencies | c. HOT SURFACES - Surfaces of air-cooled radiators and other parts of tubes can reach temperatures of several hundred Degrees C and cause serious burns if touched for several minutes after all power is removed. |

Please review the detailed operating hazards sheet enclosed with each tube, or request a copy from: Varian EIMAC, Power Grid Tube Division, 301 Industrial Way, San Carlos CA 94070.

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4CX3500A





# ***EXTENDING TRANSMITTER TUBE LIFE***

**EIMAC APPLICATION BULLETIN NO. 18**

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***A carefully followed program of filament voltage management can substantially increase the life expectancy of transmitter power grid tubes. With today's rising operating costs, such a program makes good financial sense.***

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IN RECENT YEARS station managers have seen a substantial increase in replacement costs for power grid tubes. The blame can be placed on higher manufacturing costs due to inflation, volatile precious metal prices, and an uncertain supply of some exotic metals. The current outlook for the future holds little promise for a reversal in this trend toward higher prices.

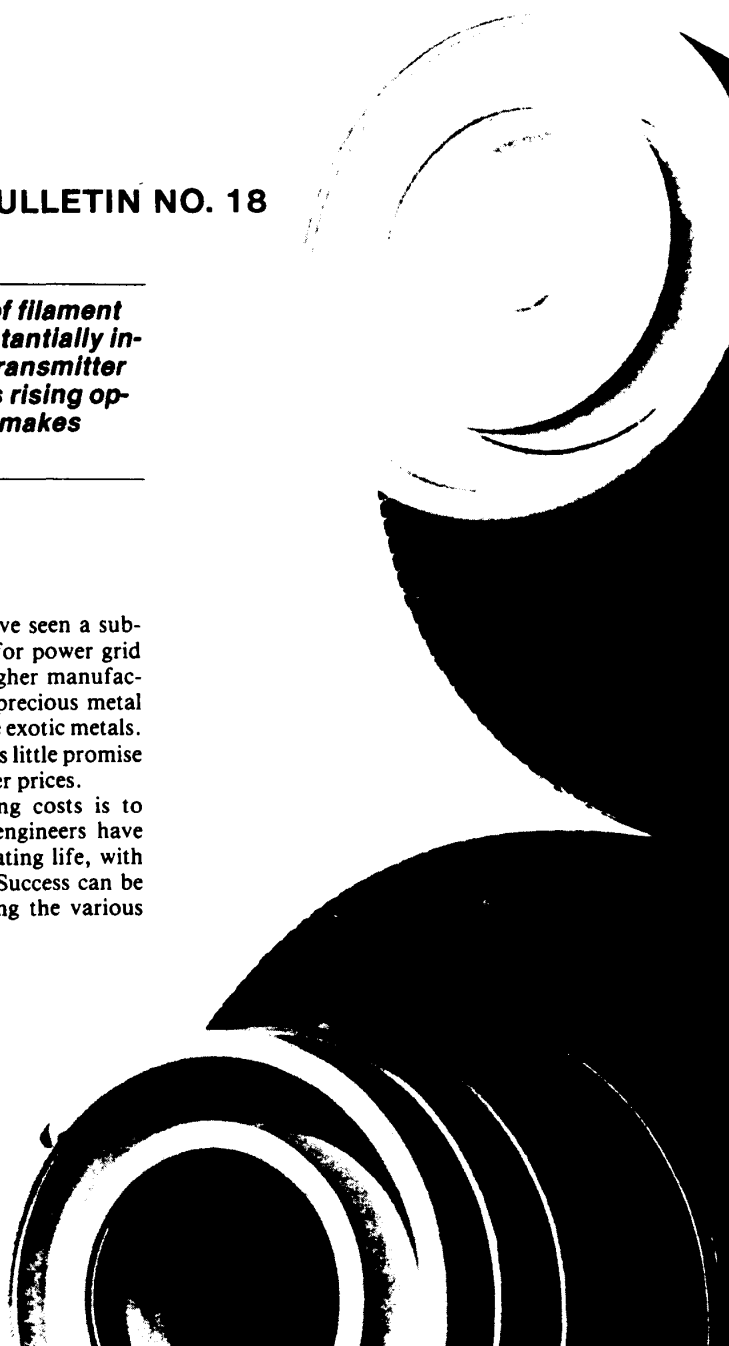
One way to offset higher operating costs is to prolong tube life. For years station engineers have used various tricks to get longer operating life, with greater and lesser degrees of success. Success can be maximized, however, by understanding the various

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EIMAC Application Bulletin AB-18  
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## Extending Transmitter Tube Life

factors that affect tube life and implementing a program of filament voltage management.

A number of factors can aid maximum tube life in your transmitter. For example, are the maximum ratings given on the tube manufacturer's data sheet being exceeded? Data sheets are available upon request from most companies. Most tube manufacturers have an application engineering department to assist in evaluating tube performance for a given application. Make use of these services!

### Headroom

Is the final power tube of the transmitter capable of delivering power in excess of the desired operating level? Or is the demand for performance so great that minimum output power levels can only be met at rated nominal filament voltage?

Figure 1 can be used as a basic guide to determine if a given transmitter and tube combination has a good probability of giving extended life service. Extended life service is defined as useful operating life beyond that normally achieved by operating at rated nominal filament voltage. The amperes/watt ratio is obtained by dividing average plate current by the product of filament voltage and filament current. If the amperes/watt ratio falls in the "good" to "excellent" range, excess emission is sufficient to permit filament voltage derating. At a lower filament voltage, the filament temperature is lowered, thus extending life. A typical FM transmitter on the market today may have an amperes/watt filament ratio of 0.002 to 0.003. This equipment would be considered an excellent choice to achieve extended tube life. On the other hand, if the amperes/watt ratio falls in the "poor" range, it is unlikely that filament derating is possible due to limited

emission. Note that this guideline should be used for thoriated tungsten emitters only, and does not apply to oxide cathode-type tubes.

### Instrumentation

Are all tube elements metered in the transmitter? Elements should be metered for both voltage and current, and meters should be redlined to define operation within safe limits. More modern transmitters may incorporate a microprocessor-controlled circuit to monitor all pertinent parameters.

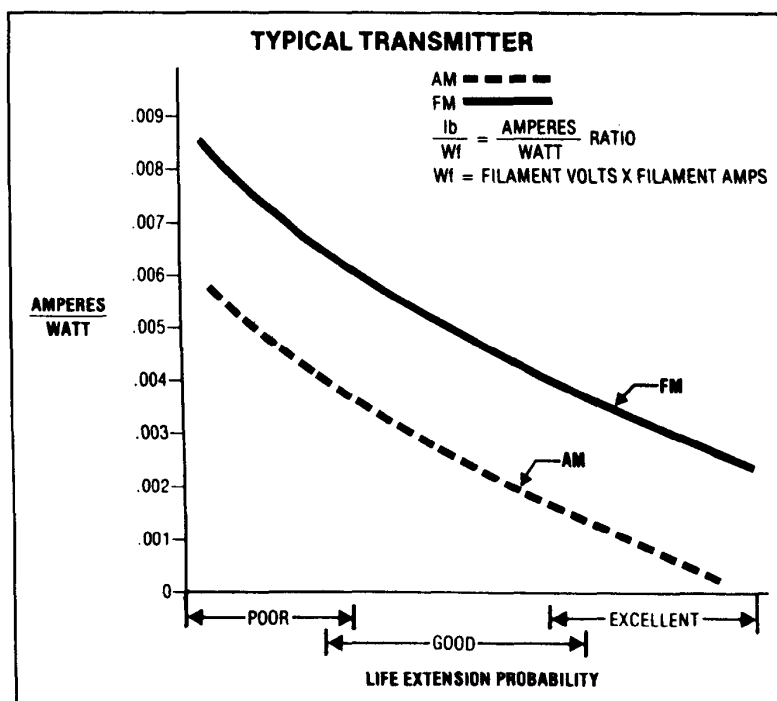
In addition, the following controls are necessary if an effective filament voltage management program is to be undertaken: power output metering for an FM transmitter or a distortion level meter for AM equipment; *accurate* filament voltage metering (an iron-vane instrument is preferred over the more common average responding RMS calibrated type; the filament voltage measurement must be made at the tube socket terminals); filament voltage control, capable of being adjusted to 0.1 V secondary voltage change; and a filament current meter—desirable but optional.

A means must be provided to hold filament voltage constant. If the filament voltage is permitted to vary in accordance with primary line voltage fluctuation, the effect on tube life can be devastating. An acceptable solution is the use of a ferroresonant transformer or line regulator. This accessory is offered by some transmitter manufacturers as an option and should be seriously considered if a tube life extension program is planned.

### Transmitter housekeeping

Once the transmitter has been placed in operation, tube life is in the hands of the chief engineer. The first action to prolong tube life falls into the category of routine maintenance. Most transmitter manufac-

**Fig. 1. Probability of extended life service can be determined from this graph. Divide the average p.a. plate current in amperes by the product of filament voltage and current. The resulting amperes/watt ratio (Y-axis) is projected horizontally to the appropriate curve. The vertical projection to the X-axis indicate the life extension probability.**





## Extending Transmitter Tube Life

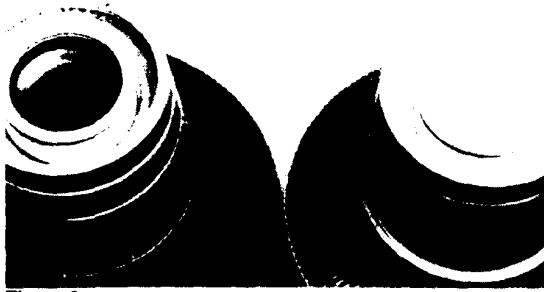


Figure 2



Figure 3



Figure 4



Figure 5

turers have a routine maintenance schedule established in the equipment manual. This procedure must be followed carefully if operating costs are to be held to a minimum. During routine maintenance it is very important to look for tube and socket discoloration, either of which can indicate overheating.

Look for discoloration around the top of the cooler near the anode core and at the bottom of the tube stem where the filament contacts are made. Review Figures 2 and 3 for examples of a tube operating with inadequate cooling. It is possible for discoloration to appear in the areas mentioned if the transmitter has to operate in a dirty environment. If this is the case, the tube should be removed and cleaned with a mild detergent. After cleaning, the tube should be rinsed thoroughly to remove any detergent residue and blown dry with compressed air. If the discoloration remains, this is an indication that the tube has operated at too high a temperature. Check inlet and outlet air ducting and filters for possible air restriction. It may also be necessary to verify that the air blower is large enough to do the job in the present environment and that it is operating at rated capacity.

With the tube removed, the socket should be blown or wiped clean and carefully inspected. Any discoloration in the socket finger stock caused by overheating could contribute to early tube failure. A finger stock that loses its temper through prolonged operation at high temperature will no longer make contact to the tube elements (Figure 4). A well-maintained socket will score the tube contacts when the tube is inserted. If all fingers are not making contact, more current flows through fewer contacting fingers, causing additional overheating and possible burnout (Figure 5).

### Filament voltage management

The useful operating life of a thoriated tungsten emitter can vary widely with filament voltage. Figure 6 describes the relative life expectancy with various filament voltage levels. Obviously, a well-managed filament voltage program will result in longer life expectancy. Improper management, on the other hand, can be very costly.

For a better understanding of this sensitive aging mechanism, the filament itself must be understood. Most filaments in high-power, gridded tubes are a mixture of tungsten and thorium with a chemical com-

*Fig. 2. Improper cooling means short tube life (left). Discoloration of metal around inner filament stem and anode fins indicates poor cooling or improper operation of tube. Properly cooled and operated tube (right) shows no discoloration after many hours of use. In both cases, good socketting is indicated by scoring on circular connector rings.*

*Fig. 3. Dirty and discolored cooler of amplifier tube at left indicates combination of discoloration due to heating and lack of cleaning. Tube has operated too hot and dust has collected in anode louvers.*

*Fig. 4. Minute scoring in base contact rings indicates that socket finger stock has made good, low-resistance contact to tube elements. Well-maintained socket will score the tube contacts when tube is inserted. If all fingers do not make contact, more current will flow through fewer contact fingers, causing additional overheating and burning, as shown in Fig. 5.*

*Fig. 5. High resistance socket contacts has caused severe burning of contact area in the base. Overheated base caused early demise of tube.*

## Extending Transmitter Tube Life

position of  $W + ThO_2$ . A filament made of this wire is not a suitable electron emitter for extended life applications until it is processed. Once the filament is formed into the desired shape and mounted, it is heated to approximately  $2100^{\circ}C$  in the presence of a hydrocarbon. The resulting thermochemical reaction forms di-tungsten carbide on the filament's surface. Life is proportional to the degree of carburization. If the filament is overcarburized, however, it will be brittle and easily broken during handling and transporting. Therefore, only approximately 25% of the cross-sectional area of the wire is converted to di-tungsten carbide. Di-tungsten carbide has a higher resistance than tungsten; thus, the reaction can be carefully monitored by observing the reduction in filament current as the carburizing process proceeds.

As the tube is used the filament slowly decarburizes. At some point in life, all of the di-tungsten carbide layer is depleted and the reduction of thorium to free

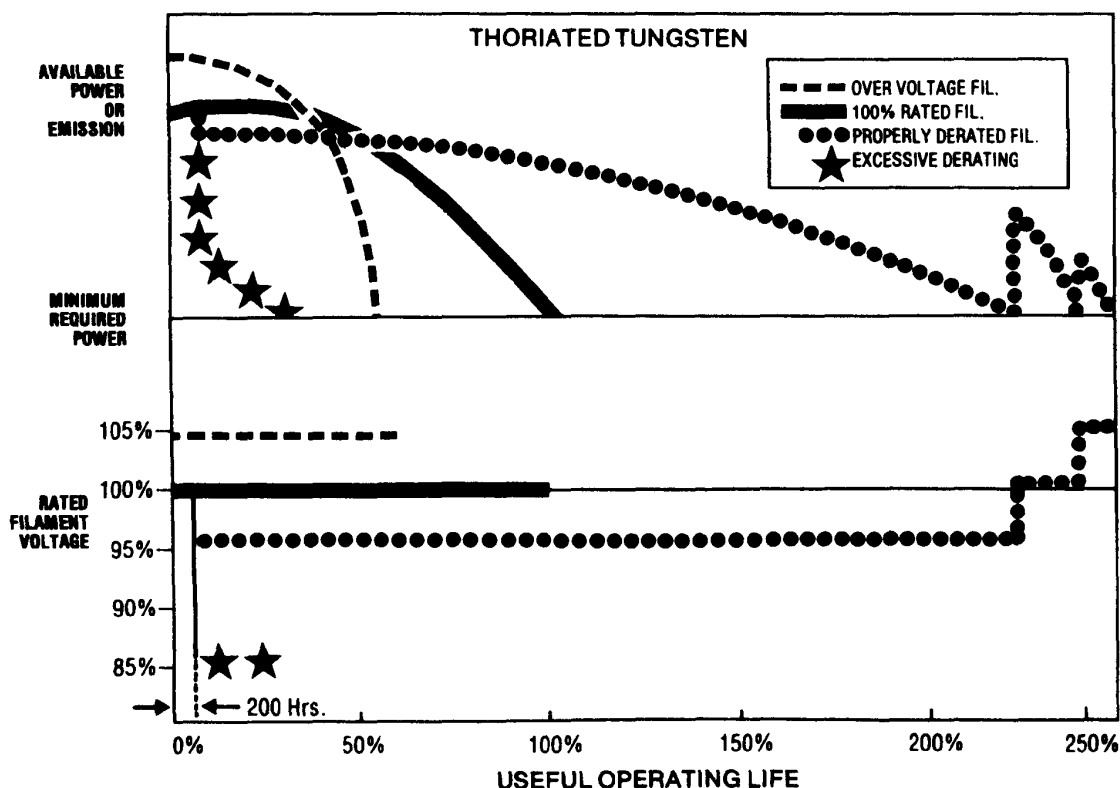
thorium stops. The filament is now decarburized and is no longer an effective electron emitter.

The key to extending the life of a thoriated tungsten filament emitter is to control operating temperature. Emitter temperature is a function of the total RMS power applied to the filament. Thus, filament voltage control is temperature control. Temperature varies directly with voltage. As the emitter temperature rises the de-carburizing process is accelerated and tube life shortened. Figure 6 shows that useful tube life can vary significantly with only a 5% change in filament voltage.

## FILAMENT VOLTAGE MANAGEMENT (Figure 6)

Filament voltage management allows extended tube life when accompanied by a continuing housekeeping program. When filament voltage is too high (dashes), power tube loses emission rapidly and normal operating life is not achieved. When filament is operated at rated voltage (black curve) normal tube life is achieved in a majority of cases. With a filament voltage management program (bullets), extended tube life may be achieved. When the minimum required output power level is finally reached (right-hand portion of curve), the filament voltage may be raised to rated value, or above, to achieve additional useful operating life. If filament is run "cool" (stars), extremely short life will result. Note that filament voltage management program does not take effect until about 200 hours of operating time have passed.

If voltage management program is not undertaken, tube should be run at rated filament voltage.



## Extending Transmitter Tube Life

Of great importance to long tube life is the temperature of the elements and the ceramic-to-metal seals. Element temperature can be held within proper limits by observing the maximum dissipation ratings listed in the data sheet. Seal temperature should be limited to 200°C at the lower anode seal under worst-case conditions. As element temperature rises beyond 200°C, the release of contaminants locked in the materials used in tube manufacturing increases rapidly. These contaminants cause a rapid depletion of the di-tungsten carbide layer of the filament.

When a new power tube is installed in a transmitter, it must be operated at rated nominal filament voltage for the first 200 hours. This procedure is very important for two reasons. First, operation at normal temperature allows the getter to be more effective during the early period of tube life when contaminants are more prevalent. This break-in period conditions the tube for operation at lower filament voltage to obtain longer filament life. Secondly, during the first 200 hours of operation filament emission increases. It is necessary for the life extension program to start at the peak emission point.

A chart recorder or other device should be used to monitor variations in primary line voltage for several days of transmitter operation. The history of line voltage variations during on-air time must be reviewed prior to derating filament voltage. Plan to establish the derated voltage during the time period of historically low line voltage, as this is the worst-case condition. If line variation is greater than  $\pm 3\%$ , filament voltage must be regulated.

Record output power (FM) or distortion level (AM) with the tube operating at rated nominal filament voltage. Next, reduce filament voltage in increments of 0.1 V and record power or distortion levels at each increment. Allow one minute between each increment for the filament emission to stabilize.

When a noticeable change occurs in output power or the distortion level changes, the derating procedure must stop. Obviously, operation at this point is unwise since there is no margin for a drop in line voltage. It is safer to raise the voltage 0.2 V above the critical voltage at which changes are observed to occur. Finally, recheck power output or distortion to see if they are acceptable at the chosen filament voltage level. Recheck again after 24 hours to determine if emission is stable and that the desired performance is maintained. If performance is not repeatable, the derating procedure must be repeated.

### Continuing the program

The filament voltage should be held at the properly derated level as long as minimum power or maximum distortion requirements are met. Filament voltage can

be raised to reestablish minimum requirements as necessary. This procedure will yield results similar to those shown in the illustration, to achieve as much as 10% to 15% additional life extension. When it becomes necessary to increase filament voltage, it is a good time to order a new tube. Filament voltage can be increased as long as the increase results in maintaining minimum level requirements.

When an increase fails to result in meeting a level requirement, filament emission must be considered inadequate and the tube should be replaced. Don't discard it or sell it for scrap! Put it on the shelf and save it. It will serve as a good emergency spare and may come in very handy some day. Also, in AM transmitters, a low-emission RF amplifier tube can be shifted to modulator use where the peak filament emission requirement is not as severe.

Start planning for longer tube life now! Review the following steps you can take:

- Investigate the manufacturer's ratings on the power tubes in your present equipment, or the transmitter you plan to buy.
- Check that your transmitter has sufficient headroom. Is there a margin of safety in tube operation?
- Look for important instrumentation in the next transmitter you buy. Are all tube elements monitored for voltage and current in the transmitter?
- Whether your transmitter is new or old, start a filament life extension program.

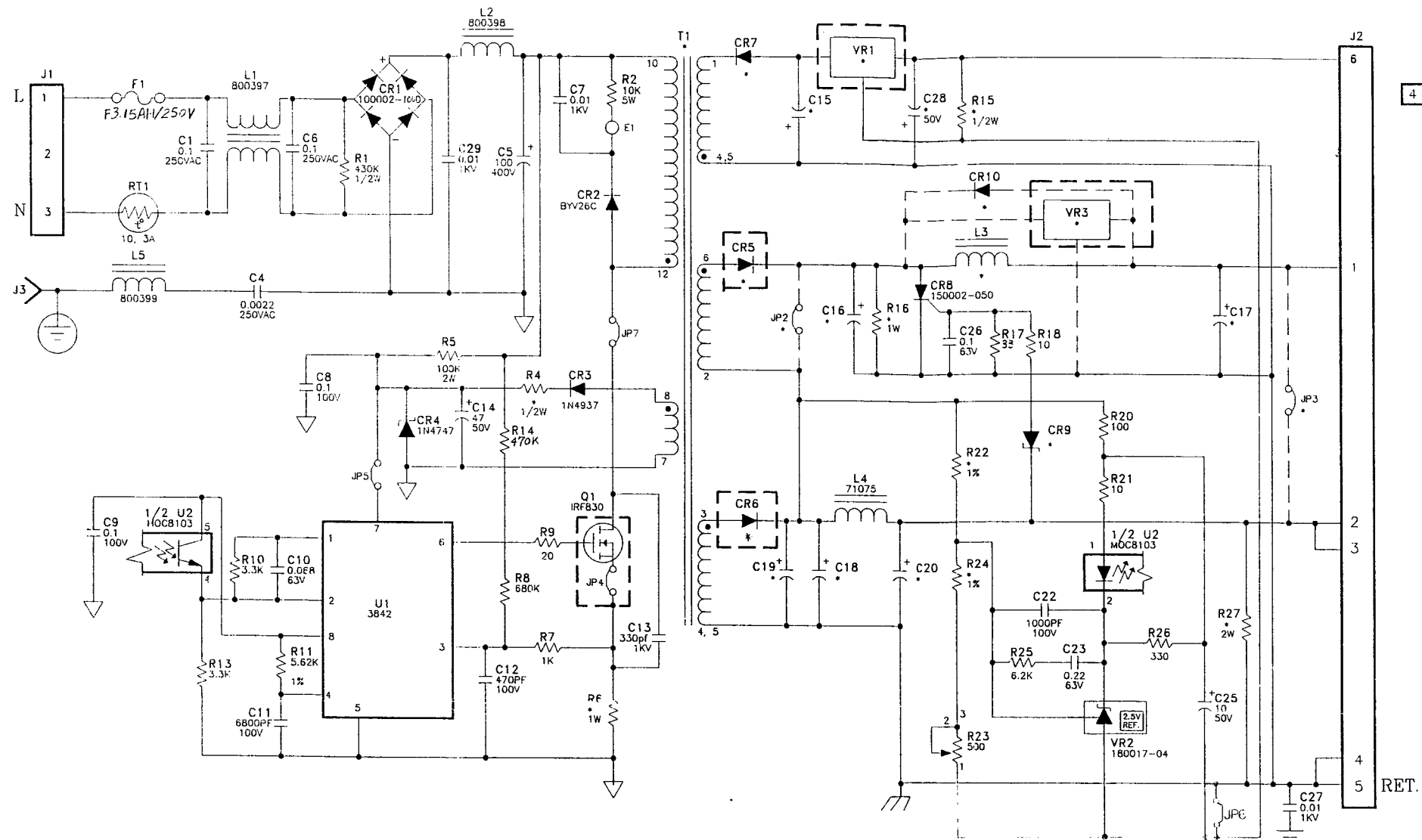
Remember that each time you replace a power tube, the recommended derating procedure must be rerun. Voltage levels required with one tube do not apply to a replacement tube.

When purchasing a tube, insist on a new tube that carries the full, original manufacturer's warranty. Only tubes manufactured by the company of origin have to perform to published data. This is the important reason that transmitter manufacturers buy new, warranted tubes from the original manufacturer.

Thanks to William Barkley, William Orr, William Sain, and Bob Tornoe, all of Varian EIMAC, for their help and suggestions in preparing this paper.

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NOT A CONTROLLED ISSUE  
WILL NOT BE KEPT UP TO DATE

MAY 16 1997

720184-008 NFN40-7628	100UF 50V	10UF	100UF 50V	10UF, 50V	1800uf, 10V	100020-400 3A, 100V	100020-400 3A, 400V	100049-045 16A, 45V	IN4733A	IN4007	N/A	N/A	N/A	24	0.24	680	220	47	2.15K, 1%	1.82K, 1%	800396	160016 NVR - 2V	160017 PVR +12V
720184-007 NFN40-7624	N/A	N/A	N/A	N/A	330uf, 35V	N/A	N/A	BYW29-200	IN4750A	N/A	JUMPER	JUMPER	N/A	15	0.30	JUMPER	N/A	620	35.7K, 1%	3.92K, 1%	800395	N/A	N/A
720184-006 NFN40-7615	N/A	N/A	N/A	N/A	330uf, 35V	N/A	N/A	BYW29-200	IN4746A	N/A	JUMPER	JUMPER	N/A	15	0.30	JUMPER	N/A	220	17.8K, 1%	3.24K, 1%	800394	N/A	N/A
720184-005 NFN40-7612	N/A	N/A	N/A	N/A	330uf, 35V	N/A	N/A	BYW29-200	IN4743A	N/A	JUMPER	JUMPER	N/A	15	0.27	JUMPER	N/A	180	15.8K, 1%	3.92K, 1%	800393	N/A	N/A
720184-004 NFN40-7610	330UF 35V	47UF	680UF 35V	680uf, 35V	1800uf, 10V	100020-400 3A, 100V	BYW29-200	100049-045 16A, 45V	IN4733A	N/A	N/A	N/A	H1565	24	0.30	680	470	47	2.15K, 1%	1.82K, 1%	800392	160035 NVR -15V	N/A
720184-003 NFN40-7607	330UF 35V	47UF	680UF 35V	680uf, 35V	1800uf, 10V	100020-400 3A, 100V	BYW29-200	100049-045 16A, 45V	IN4733A	N/A	N/A	N/A	H1565	24	0.27	100	220	47	2.15K, 1%	1.82K, 1%	800391	160034 NVR -5V	N/A
720184-002 NFN40-7605	N/A	N/A	100UF 50V	N/A	2200uf, 16V	N/A	100020-400 3A, 400V	100049-045 16A, 45V	IN4733A	N/A	470 1W	JUMPER	N/A	20	0.27	JUMPER	750	47	2.15K, 1%	1.82K, 1%	800390	N/A	N/A
720184-001 NFN40-7608	330UF 35V	47UF	680UF 35V	680uf, 35V	1800uf, 10V	100020-400 3A, 100V	BYW29-200	100049-045 16A, 45V	IN4733A	N/A	N/A	N/A	H1565	24	0.30	680	220	47	2.15K, 1%	1.82K, 1%	800389	160010 NVR - 2V	N/A
PART NO. MODEL NO.	C15	C28	C16	C17	C18, C19, C20	CR7	CR5	CR6	CR9	CR10	JP2	JP3	L3	R4	R6	R15	R16	R27	R22	R24	T1	VR1	VR3

COMPONENTS VALUE TABLE

PIN No.	720184-001 NFN40-7608	720184-002 NFN40-7605	720184-003 NFN40-7607	720184-004 NFN40-7610	720184-005 NFN40-7612	720184-006 NFN40-7615	720184-007 NFN40-7624	720184-008 NFN40-7628
1	+12V		+12V	+15V				+12V
2,3	+5V	+5V	+5V	+5V	+12V	+15V	+24V	+5V
4,5	RET	RET	RET	RET	RET	RET	RET	RET
6	-12V		-5V	-15V				-12V

4. SEE J2 OUTPUT CHART.

3. \* SEE COMPONENTS VALUES TABLE.

2. ALL CAPACITANCE VALUES ARE IN MICROFARADS, VOLTAGES ARE IN D.C..

1. ALL RESISTANCE VALUES ARE IN OHMS, 1/4W, 5%.

NOTES: UNLESS OTHERWISE SPECIFIED.

F1	RT1
JP1, (2,3 OPTION)	JP7
RT1 (OPTION)	RT1
	J3
	T1
	U2
	Q1
	L4
VR3 (OPTION)	VR3
CR10 (OPTION)	CR10
C2,3,21,24	C29
R3,R12,R19	R27
NOT USED	LAST USED

ENVIRONMENTAL TESTS COMPLETE  
DATE 5-16-97 BY [Signature]

720184-008 NFN40-7628 720184-007 NFN40-7624 720184-006 NFN40-7615 720184-005 NFN40-7612 720184-004 NFN40-7610 720184-003 NFN40-7607 720184-002 NFN40-7605 720184-001 NFN40-7608 USED ON MODEL NO.		UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS .005 .010 .015 .020 .030 .040 .050 .060 .070 .080 .090 .100 .125 .150 .175 .200 .250 .300 .350 .400 .450 .500 .600 .700 .800 .900 1.000 1.125 1.250 1.500 1.750 2.000 2.500 3.000 3.500 4.000 4.500 5.000 6.000 7.000 8.000 9.000 10.000	APPROVALS DATE DRAWN J.MICHAEL 6-28-91 CHECKED ENG. HSB MFG. ENG. S.A. ENR. RELEASED	COMPUTER PRODUCTS SCHEMATIC POWER SUPPLY NFN40-76XX SIZE D DRAWING NO. 730184-001 THRU -008 P SCALE NONE SHEET 1 OF 1
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# SECTION I

## TRANSMITTER CONTROLLER THEORY OF OPERATION

### 1-1. INTRODUCTION.

- 1-2. The following text provides theory of operation with supporting diagrams for the FM-5T/FM-5TS transmitter controller.

### 1-3. GENERAL DESCRIPTION.

- 1-4. All transmitter control and monitoring functions are performed by a microprocessor based controller (refer to Figure 1-1). The controller is designed to monitor the status of several transmitter parameters and perform control actions when required. The controller will interface with almost any remote control device such as the Broadcast Electronics VMC-16 remote control system.
- 1-5. The controller is equipped with 12 switch/indicators, 4 overload indicators, and 5 status indicators. Controller processing power is provided by a Z-Soft microcontroller. The microcontroller is housed on a small plug-in circuit board. The microcontroller circuit board is designed to plug directly into a header on the controller main circuit board.
- 1-6. The controller circuitry includes a front-panel modem port, one rear-panel modem port, one rear-panel local port, and a printer port. The modem ports and the printer port are designed to be used with a future remote monitoring and diagnostic system. The rear-panel local port is for interfacing to a future dual/main/alternate transmitter control system.
- 1-7. A Lithium battery back-up system is included in the controller design. The battery back-up system will maintain the controller memory and other parameters during a power failure. This system allows the transmitter to return to operation after the power failure in the exact same operating conditions.
- 1-8. A modular switching power supply provides operating potentials for the controller circuitry. Power supply status indications are provided by +15V, -15V, and +5 V indicators.

### 1-9. FUNCTIONAL DESCRIPTION.

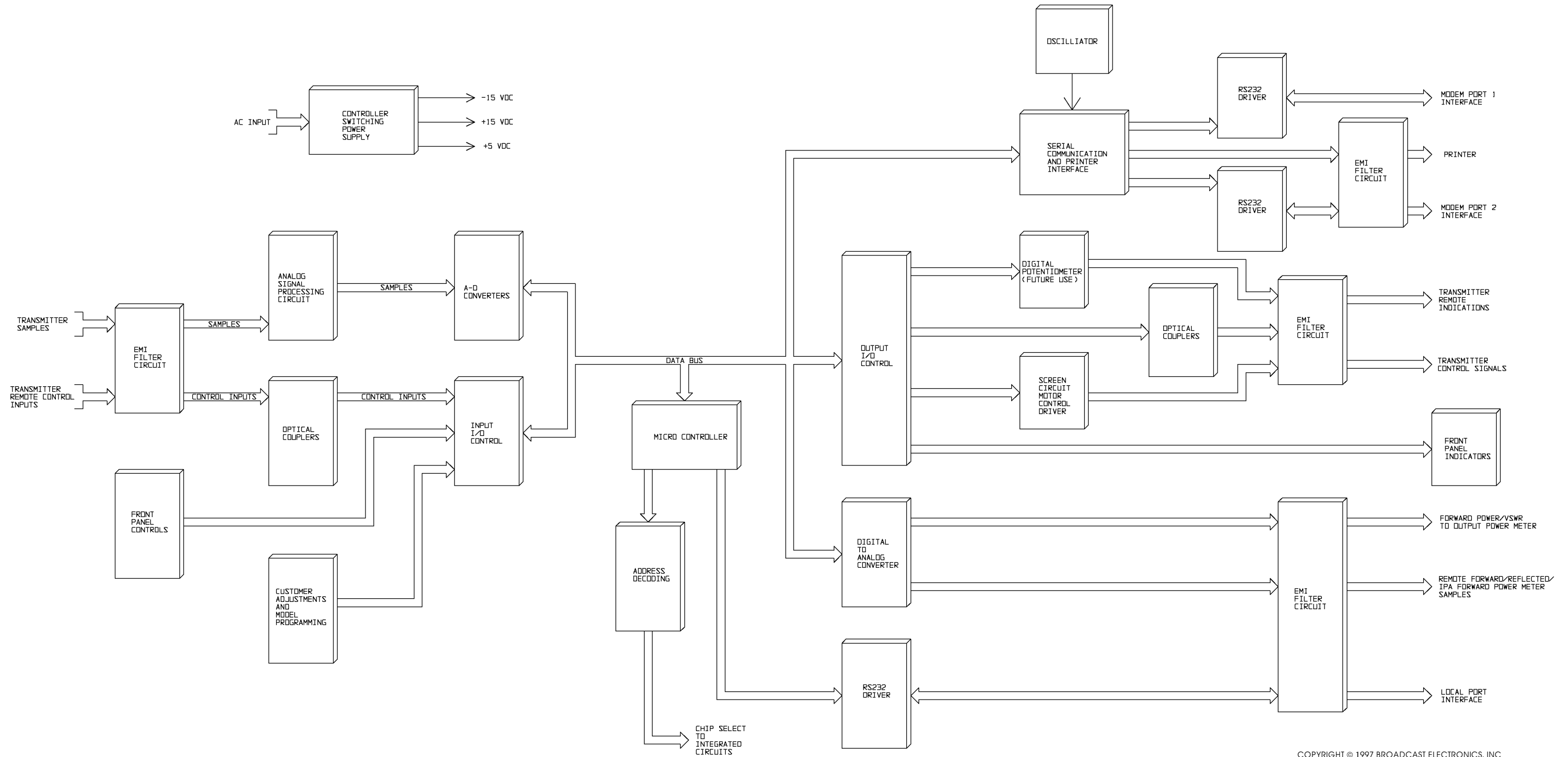
- 1-10. The following text presents a description of the major functions performed by the transmitter controller. The text describes controller operations during major transmitter functions such as turn-on and automatic power control.

### 1-11. TRANSMITTER TURN-ON.

- 1-12. Commands such as filament on and high voltage on are initiated by the front-panel **FILAMENT ON** and **HIGH VOLTAGE ON** switch/indicators. A one-button-start may be selected by depressing only the **HIGH VOLTAGE ON** switch/indicator. As each switch is depressed, the associated switch/indicator will illuminate to indicate that the selected command has been received and stored.
- 1-13. Assuming the **FILAMENT ON** and/or **HIGH VOLTAGE ON** switch/indicators have been depressed and all internal interlocks are closed, the blower will start. The internal interlock closed condition is identified by the illumination of the front-panel **INTERLOCK** indicator.

- 1-14. When the air pressure switch closes: 1) the **BLOWER** indicator will illuminate, 2) the filament warm-up timer will start, 3) filament voltage will be applied to the PA tube, and 4) the **FILAMENT** indicator will illuminate. A high-voltage on signal will be output to the high voltage step-start circuitry and the mute command will be removed from the FM exciter: 1) after the filament warm-up delay expires, 2) no overloads exist, 3) all internal interlocks remain closed, 4) the failsafe interlock is closed, 5) the air switch remains closed, and 6) the exciter AFC signal lock status is obtained. The failsafe interlock closed condition is identified by the illumination of the front-panel **FAILSAFE** indicator. The **HIGH VOLTAGE** indicator will illuminate to indicate that a high voltage on command has been output from the controller.
- 1-15. The high voltage on signal is applied to the step driver. The driver will energize the plate supply step relay to apply primary voltage to the plate supply transformer through three limiting resistors. After a 100 millisecond delay, the controller will enable the start driver. The start driver will energize the start contactor and apply the full primary potential to the plate supply transformer. The step circuit will deenergize after being energized for 160 milliseconds. In this manner, the plate supply inrush is limited and the current limiting resistors are subject to heating only during a 100 millisecond interval before start contactor closure. For added reliability, the limiting resistors are disconnected after 160 milliseconds.
- 1-16. Simultaneous with generation of the high voltage on start signal, the exciter will be enabled and the **HIGH VOLTAGE** status indicator will illuminate to indicate that the plate supply control signal has been output. The high voltage supply is prevented from step-starting under full load in this manner.
- 1-17. **TRANSMITTER TURN-OFF.**
- 1-18. When the **HIGH VOLTAGE OFF** switch/indicator is depressed, the controller will: 1) deenergize the high voltage supply, 2) extinguish the **HIGH VOLTAGE ON** switch/indicator, and 3) extinguish the **HIGH VOLTAGE STATUS** indicator. A one-button-stop feature is provided when the **FILAMENT OFF** switch/indicator is depressed. When the switch/indicator is depressed, the controller will perform the following operations:
1. Mutes the exciter.
  2. De-energize the high voltage supply.
  3. De-energize the filament supply.
  4. Extinguish the **FILAMENT ON** switch/indicator and the **FILAMENT STATUS** indicator.
  5. Initiate a filament cool-down interval.
  6. When the filament cool-down timer delay expires, the blower will de-energize and the **BLOWER STATUS** indicator will extinguish.
- 1-19. **REMOTE CONTROL OPERATION.**
- 1-20. Transmitter remote control operation is enabled whenever the **REMOTE DISABLE** switch/indicator is extinguished. Local control of the transmitter is enabled at all times. Remote control inputs are routed: 1) through the controller EMI I/O filter circuit board, 2) through optical isolators, and 3) connected in parallel with the local inputs. The remote control inputs can be enabled by a HIGH or a ground with proper circuit board programming of header J6 on the main circuit board. Remote metering and status outputs are active at all times.





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**597-0220-423**

**FIGURE 1-1. TRANSMITTER CONTROLLER  
BLOCK DIAGRAM**

(1-3/1-4)

- 1-21. **INTERLOCKS.**
- 1-22. The internal interlock circuitry consists of a series string of normally closed switches mounted in areas which contain electrical or mechanical hazards. Each switch is mechanically activated by a door or panel to deenergize the entire transmitter when opened. If an internal interlock opens, the transmitter will deenergize immediately. The transmitter must be manually restored to operation after the open interlock is closed. The controller front-panel **INTERLOCK** indicator will extinguish to indicate an open interlock. If the opened internal interlock is closed before the filament cool-down timer interval expires, the blower will re-energize for the remaining duration of the cool-down cycle and then de-energize. If the air pressure interlock opens, the power supplies will de-energize immediately. When the interlock closes, the transmitter will return to operation automatically.
- 1-23. The failsafe interlock circuitry consists of an external switch such as from a test load or remote control failsafe circuit connected to the failsafe interlock terminals on the remote interface circuit board. If the failsafe interlock is opened, only the high voltage plate supply will be deenergized. The controller **FAILSAFE** and **HIGH VOLTAGE** indicators will extinguish to indicate an open interlock. When the failsafe interlock is closed, the transmitter will return to operation automatically.
- 1-24. **OVERLOAD OPERATION.**
- 1-25. Plate current, screen current, control grid bias supply current, and PA reflected power are monitored for overload conditions. If an overload occurs, the overload initiate an overload control sequence.
- 1-26. Any overload will illuminate the **OVERLOAD** indicator and initiate two timed intervals. A timer and counter monitors the number of times an overload occurs during a 60 second interval. A second overload recycle timer delays restoration of the transmitter to operation to allow the condition that prompted the overload to dissipate.
- 1-27. When the timed interval delaying restoration of the transmitter to operation has expired, the transmitter will recycle back into operation. If no further overloads occur during the 60 second interval following the first overload, the 60 second timer will clear the overload counter. If four overload recycles occur during the 60 second counter/timer interval, the transmitter will deenergize and must be manually reset. This can be done by depressing the **OVERLOAD** switch/indicator, the **FILAMENT ON** switch/indicator, and the **HIGH VOLTAGE ON** switch/indicator. The overload can also be cleared by remote control if remote control is enabled.
- 1-28. If an overload persists in duration for longer than 0.22 seconds, the controller will consider the overload a short circuit and immediately deenergize the transmitter. The transmitter must then be manually restored to operation after the fault is repaired.
- 1-29. The overload reset sequence is initiated when the **OVERLOAD RESET** switch/indicator is depressed. When the switch/indicator is depressed, the following actions will occur.
1. The **OVERLOAD RESET** switch/indicator and the overload diagnostic indicator (**PLATE, SCREEN, GRID, or VSWR**) indicator will extinguish.
  2. The overload timer/counter will be reset.
  3. The overload recycle timer will be reset.
- 1-30. **EMI I/O CIRCUIT BOARD.**
- 1-31. All controller inputs and outputs are routed through connectors J1, J2, and J3 mounted to the EMI I/O circuit board. The circuitry consists of PI-section low-pass LC filters effective to 108 MHz and connected in series with each input and output to prevent RF leakage into the controller. Each input/output also contains a transzorb. The transzorb limits the input/output signal to  $\pm 15$  volts.

1-32.     **AC POWER FAILURE.**

1-33.     The controller is equipped with a battery back-up system. When ac power is lost, the following actions will occur:

1. The filament restart delay timer is set as soon as ac power is lost. If ac power is removed long enough for the filament restart delay timer interval to expire, the filament timer will reset. When power returns, a new filament heating delay will be initiated before the plate supply is energized. If the ac power outage is momentary and the timer does not expire, high voltage will energize immediately upon restoration of ac power.
2. The overload feature will be inhibited.
3. The battery back-up system will maintain the controller memory. This system allows the transmitter to return to operation after the power failure in the exact same operating conditions.

1-34.     **POWER CONTROL OPERATION.**

1-35.     The controller is designed with two power control modes: 1) manual and 2) automatic. Manual/automatic power control operation is controlled by the **APC ON** switch/indicator. The controller is configured for manual power control when the **APC ON** switch/indicator is extinguished. The controller is configured for automatic power control when the **APC ON** switch/indicator is illuminated.

1-36.     The controller manipulates the RF output power using the screen supply. The primary of the screen power transformer is controlled by variable autotransformer which is driven by dc servo motor B4. The controller manipulates the RF output power by routing raise/lower commands B4. A raise command rotates the motor in a manner which increases the screen voltage. As a result of the increase in screen voltage, the RF output power will increase. A lower command rotates the motor in a manner which decreases the screen voltage. Limit switches on the motor prevent possible damage to the autotransformer by disconnecting the drive signal at the end of travel for each direction.

1-37.     **MANUAL POWER CONTROL OPERATION.**

1-38.     Manual operation refers to operation of the transmitter with the APC feature off. In this mode, RF power output is not automatically controlled, but responds only to manual raise and lower commands. In the manual mode, the **RAISE** and **LOWER** switch/indicators directly control the dc servo motor which varies the screen voltage supply.

1-39.     **AUTOMATIC POWER CONTROL (APC) OPERATION.**

1-40.     When the controller is in the automatic mode, the **RAISE** and **LOWER** switch/indicators control a power control reference point. When the **RAISE** switch/indicator is depressed, the power control reference point is raised and the transmitter output power level will increase. When the **LOWER** switch/indicator is depressed, the power control reference point is lowered and the transmitter output power level will decrease.

1-41.     The transmitter output power level will respond to the changes in the power control reference point. The controller manipulates the RF output power using the screen supply dc servo motor. Once the desired output level is established using the **RAISE/LOWER** switch/indicators, the controller will automatically maintain the established RF output power level.

- 1-42. The controller is equipped with circuitry which rectifies and calibrates the PA directional coupler forward and reflected power signals. These signals serve as control inputs. In addition to the forward and reflected power signals, PA screen current, and IPA forward power allow automatic control of the PA screen voltage using a dc servo motor. If excessive PA reflected power, excessive screen current, or low IPA power is measured, the “raise power” function will be inhibited to prevent an overload condition. The absence of plate voltage will inhibit the raise function and signal the controller to adjust the screen voltage to minimum. Excessive transmitter RF output or a high PA reflection will first inhibit the raise function. If the condition exceeds the limits, the circuit will initiate a sequence which lowers power proportionately in response to the condition.
- 1-43. **VSWR FOLDBACK.**
- 1-44. In the automatic power control mode, PA power will be automatically reduced if PA reflected power becomes excessive enough to overload the transmitter. As the condition which caused the high VSWR returns to normal, RF power will be proportionally raised until full output is restored. A similar circuit for PA forward power will reduce power if the output is excessive.
- 1-45. A dead-band window is used to prevent the controller from hunting. If reflected power is below the lower limit of the dead-band, the controller will perform no correction. If reflected power increases beyond the lower limit, the raise feature will be inhibited to prevent the forward power control function from raising power to avoid a transmitter overload. If the PA reflected power continues to rise and is within the dead-band, no lowering of power will occur. If the upper limit of the dead-band is reached, a lower command will be applied.
- 1-46. **SOFT START.**
- 1-47. Soft start operation is when APC is enabled, the controller monitors the plate voltage and reduces the screen voltage to zero upon the absence of plate voltage. When the plate supply is energized such as during power-on, the controller will perform the following:
1. Gradually increase the screen voltage until the APC power level reference is achieved unless limited by low IPA drive, excessive screen current, or a high VSWR condition. This prevents inadvertent cycling of the VSWR overload at turn-on if the load is not optimal such as during an ice storm.
  2. When the plate voltage sample decreases below the fixed level, the following events will occur:
    - A. The raise function will be inhibited.
    - B. The controller will output a lower command to: 1) lower the screen voltage and 2) stop lowering the screen voltage at a minimum level. Once the minimum level is achieved, the lower command will remain.
    - C. When the HIGH VOLTAGE ON switch/indicator is depressed, the plate voltage sample from the plate meter multiplier circuit board will rise above the fixed reference. The raise inhibit will be removed along with the power lower signal and the APC mode will be allowed to re-establish the transmitter RF power.

1-48. **OUTPUT POWER CONTROL.**

- 1-49. The controller uses a dead-band to determine how the PA forward power control circuit will react when PA forward power increases or decreases beyond the established level. When power is within the dead-band, the controller will take no control action. If the PA forward power decreases by 2% or more from 100%, the controller will start corrective action by applying the raise power command. If PA forward power then increases by 2% or more from 100%, the raise function is to be inhibited. This is the upper edge of the dead-band. If PA power should continue to increase to a point which is 2% above the desired power level reference, the controller will lower the power. As the PA power is lowered to the normal level, the controller will remove the power lower command. The power will remain at this point within the power level reference point deadband. If the power should drop below the lower limit, the unit will again apply the raise command. The circuit will now function normally to control power and maintain operation within the deadband.



**NOTE**

***PRESET POWER IS ONLY USED FOR EMERGENCY OPERATION AT LESS THAN LICENSED POWER OPERATION.***

**NOTE**

1-50. **PRESET POWER.**

- 1-51. Preset power is normally used to automatically switch the transmitter to a predetermined power output level such as half-power for periods of auxiliary generator operation. The following events are to occur during preset power operation.
1. The APC functions as before, only the preset power reference is used to determine the APC power level reference. The transmitter power output will now be determined by the preset power level reference.
  2. If ac power is momentarily removed from the controller, the preset power command will be automatically maintained.
  3. When the APC ON and PRESET switch/indicators are illuminated, any adjustment of the RAISE and LOWER switch/indicators will adjust the preset power level reference.

1-52. **CONTROLLER POWER SUPPLY MODULE.**

- 1-53. The transmitter controller is equipped with a modular switching power supply assembly. The assembly is not manufactured by Broadcast Electronics. Therefore, no theory of operation can be provided.

## SECTION II

# TRANSMITTER CONTROLLER MAINTENANCE

### 2-1. INTRODUCTION.

2-2. This section provides maintenance information for the FM-5T/FM-5TS transmitter controller.

### 2-3. SAFETY CONSIDERATIONS.

2-4. The FM-5T/FM-5TS transmitters contain high voltages and currents which, if regarded carelessly, could be fatal. The transmitter has many built-in safety features, however; good judgment, care, and common sense are the best accident preventives. The maintenance information contained in this section should be performed only by trained and experienced maintenance personnel.

### 2-5. MAINTENANCE.



**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED.*

**WARNING**

2-6. The maintenance philosophy consists of preventative maintenance such as cleaning applied to the equipment of forestall future failures and second level maintenance consisting of procedures required to restore the equipment to operation after a fault. The following text presents the controller adjustments.

### 2-7. MAIN CIRCUIT BOARD CONTROL ADJUSTMENTS.

2-8. **OVERLOAD CONTROLS.** The following text presents the overload adjustment procedures. If more than one control is adjusted, adjust the controls as follows: 1) VSWR, 2) PLATE, 3) SCREEN, and 4) GRID.

2-9. **VSWR OVERLOAD THRESHOLD ADJUST.** To adjust the VSWR overload threshold, proceed as follows.

2-10. **Required Equipment.** The following equipment is required to adjust the VSWR overload threshold.

A. 7 dB attenuator, BNC connections.

B. 5/16 inch nut-driver.



**CAUTION** *THE OVERLOAD THRESHOLD LEVEL ADJUSTMENTS DETERMINE WHEN THE TRANSMITTER INITIATES ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED THE CONTROLLER MAY NOT SENSE THE FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.*

**CAUTION**

2-11. **Procedure.** To adjust the control, proceed as follows.

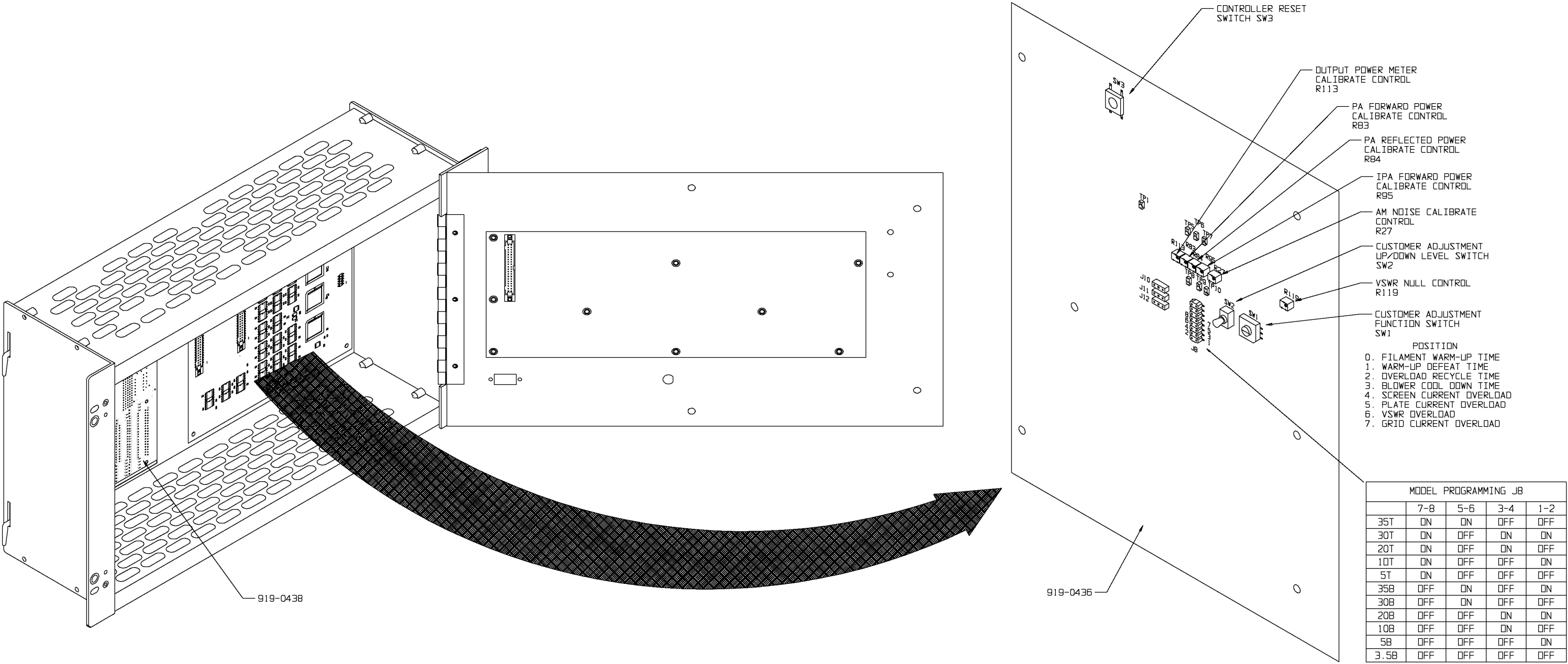
2-12. Check and adjust reflected power meter calibration control R84 before proceeding (refer to REFLECTED POWER CALIBRATION in the following text).

- 2-13. Apply power to the transmitter.
- 2-14. Refer to Figure 2-1 and select VSWR OVERLOAD as follows:
  - 1. Operate customer adjustment function switch SW1 to position 6.
  - 2. Depress and hold customer adjustment up/down switch S2 in the up position to raise the threshold.
- 2-15. Disconnect cable 131 from the reflected power directional coupler (↓ port) on the transmitter low-pass filter.
- 2-16. Using the nut-driver, loosen the clamps securing the reflected power directional coupler to the low-pass filter.
- 2-17. Rotate the reflected power directional coupler 180 degrees so the arrow on the coupler is up (↑). Secure the clamps.
- 2-18. Connect the 7 dB attenuator to the reflected power directional coupler and connect cable 131 to the attenuator.
- 2-19. Apply power and operate the transmitter at the normal RF power output as indicated by the front panel **OUTPUT POWER** meter.
- 2-20. Depress the **VSWR** switch/indicator to illuminate the switch/indicator.
- 2-21. Refer to Figure 2-1 and use up/down switch S2 to lower the VSWR overload threshold until the **VSWR OVERLOAD** indicator and the **OVERLOAD RESET** switch/indicator illuminate and the transmitter cycles off.
- 2-22. Depress the **HIGH VOLTAGE OFF** switch then depress the **LOWER** switch/indicator for approximately 4 seconds to lower the transmitter power.
- 2-23. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.
- 2-24. Depress the **RAISE** switch/indicator to raise power. The transmitter will cycle off at a VSWR indication of 2.8 : 1. If not, repeat the adjustment.



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***  
**WARNING**

- 2-25. Disconnect all transmitter primary power.
- 2-26. Remove the test equipment and replace the reflected power directional coupler. Ensure the reflected power directional coupler arrow is down (↓). Ensure cable 131 is re-connected to the reflected power directional coupler port.
- 2-27. **PLATE OVERLOAD ADJUSTMENT.** The plate overload control can be adjusted from 0.1 A to 0.75 A above a normal plate current level. The factory default is 0.2 A. To adjust the PLATE overload threshold, proceed as follows.



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597-0220-417

FIGURE 2-1. CONTROLLER MAIN CIRCUIT BOARD CONTROLS

(2-3/2-4)





**CAUTION**  
**CAUTION**

***THE OVERLOAD THRESHOLD LEVEL ADJUSTMENTS DETERMINE WHEN THE TRANSMITTER INITIATES ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED THE CONTROLLER MAY NOT SENSE THE FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.***

- 2-28. **Procedure.** To adjust the threshold level of the plate overload circuit, proceed as follows:
- 2-29. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load. Record the **OUTPUT LOADING** control cyclometer indication
- 
- 2-30. Refer to Figure 2-1 and select PLATE OVERLOAD as follows:
1. Operate customer adjustment function switch SW1 to position 5.
  2. Depress and hold customer adjustment up/down switch S2 in the up position to raise the threshold.
- 2-31. Operate the **APC ON** switch/indicator to extinguish the switch/indicator.
- 2-32. Operate the **OUTPUT LOADING** control clockwise and the **RAISE** switch/indicator to detune the transmitter until plate current is increased by 0.2 Amperes as indicated on the **PLATE CURRENT** meter.
- 2-33. Refer to Figure 2-1 and use up/down switch S2 to lower the plate overload threshold until the **PLATE OVERLOAD** indicator and the **OVERLOAD RESET** switch/indicator illuminate and the transmitter cycles off.
- 2-34. Depress the **HIGH VOLTAGE OFF** switch then depress and hold the **LOWER** switch/indicator for approximately four seconds.
- 2-35. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.
- 2-36. Observe the **PLATE CURRENT** meter and operate the **RAISE** switch/indicator until the transmitter deenergizes. Correct adjustment is obtained when the transmitter deenergizes and plate current is 0.2 amperes above normal. Repeat the procedure if required.
- 2-37. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.
- 2-38. Restore the **OUTPUT LOADING** control to the cyclometer indication recorded in the preceding text and operate the **APC ON** switch/indicator to illuminate the switch/indicator.
- 2-39. **SCREEN OVERLOAD ADJUSTMENT.** The screen overload control can be adjusted from 100 mA to 190 mA. The factory default is 145 mA. To adjust the SCREEN overload threshold, proceed as follows.
- 2-40. **Required Equipment.** The following equipment is required to adjust the screen overload threshold.

- A. Insulated adjustment tool, flat-tip (BE P/N 407-0083).



**CAUTION**  
**CAUTION**

***THE OVERLOAD THRESHOLD LEVEL ADJUSTMENTS DETERMINE WHEN THE TRANSMITTER INITIATES ACTION. IF A CONTROL IS INCORRECTLY ADJUSTED THE CONTROLLER MAY NOT SENSE THE FAULT AND DAMAGE TO THE TRANSMITTER MAY RESULT.***

- 2-41. **Procedure.** To adjust the threshold level of the screen overload circuit, proceed as follows:

- 2-42. Apply power and operate the transmitter within specifications at the rated RF output into a proper 50 Ohm load. Record the **OUTPUT LOADING** control cyclometer indication \_\_\_\_\_.
- 2-43. Refer to Figure 2-1 and select **SCREEN OVERLOAD** as follows:
1. Operate customer adjustment function switch SW1 to position 4.
  2. Depress and hold customer adjustment up/down switch S2 in the up position to raise the threshold.
- 2-44. Operate the **APC ON** switch/indicator to extinguish the switch/indicator.
- 2-45. Operate the **MULTIMETER** to the **SCREEN CURRENT** position.
- 2-46. Operate the **OUTPUT LOADING** control counterclockwise and the **RAISE** switch/indicator to detune the transmitter for a screen current of 145 milliamperes as indicated on the **MULTIMETER**. If 145 milliamperes can not be obtained, increase the exciter power as follows:
1. Depress the exciter FWD switch/indicator to illuminate the switch/indicator and record the forward power indication \_\_\_\_\_.
  2. Pull the exciter out of the cabinet to expose the **RF OUTPUT ADJ.** control.
  3. Adjust the control until the exciter multimeter indicates approximately 250 watts.
- 2-47. Refer to Figure 2-1 and use up/down switch S2 to lower the screen overload threshold until the **SCREEN OVERLOAD** indicator and the **OVERLOAD RESET** switch/indicator illuminate and the transmitter cycles off.
- 2-48. Depress the **HIGH VOLTAGE OFF** switch/indicator then depress and hold the **LOWER** switch/indicator for approximately four seconds.
- 2-49. Depress the **OVERLOAD RESET** and the **HIGH VOLTAGE ON** switch/indicators.
- 2-50. Observe the **MULTIMETER** and operate the **RAISE** switch/indicator until the transmitter deenergizes. Correct adjustment is obtained when the transmitter deenergizes and the **MULTIMETER** indicates 145 milliamperes. Repeat the procedure if required.
- 2-51. Depress the **HIGH VOLTAGE OFF** switch and **OVERLOAD RESET** switch/indicator.
- 2-52. Restore the **OUTPUT LOADING** control to the cyclometer indication recorded in the preceding text, re-adjust the exciter output level if required, and operate the **APC ON** switch/indicator to illuminate the switch/indicator.
- 2-53. **GRID OVERLOAD ADJUSTMENT.** Position 7 on customer adjustment function switch SW1 adjusts the grid overload threshold. The control is adjusted at the factory and will not require re-adjustment. The control is designed in a manner which does not permit mis-adjustment in the field.
- 2-54. **FILAMENT WARM-UP ADJUSTMENT.** The warm-up adjustment controls the filament heating delay prior to high voltage on. The warm-up time can be adjusted from 10 seconds to 4.5 minutes. A minimum interval is preset so that incorrect adjustment cannot damage the PA tube. To adjust the warm-up time, proceed as follows.
- 2-55. **Required Equipment.** The following equipment is required to adjust warm-up time.
- A. Wristwatch with seconds hand or stopwatch function.
- 2-56. **Procedure.** To adjust the warm-up time, proceed as follows.
- 2-57. Depress the **FILAMENT OFF** switch/indicator to illuminate the switch/indicator.

- 2-58. Wait approximately 15 seconds. Note the time and depress the **HIGH VOLTAGE ON** switch/indicator.
- 2-59. Again note the time when the plate contactor energizes.
- 2-60. Refer to Figure 2-1 and select the warm-up feature by operating customer adjustment function switch SW1 to position 0.
- 2-61. Refer to Figure 2-1 and use up/down switch S2 to increase or decrease the time delay. Check the adjustment by repeating the procedure. The control is factory set for 10 seconds.
- 2-62. **COOL-DOWN ADJUSTMENT.** The cool-down adjustment controls the blower run-down interval after the filament voltage is off. The cool-down time can be adjusted from 30 seconds to 4.5 minutes. A minimum interval is preset so that incorrect adjustment cannot damage the PA tube. To adjust the cool down time, proceed as follows.
- 2-63. **Required Equipment.** The following equipment is required to adjust cool down time.
- A. Wristwatch with seconds hand or stopwatch function.
- 2-64. **Procedure.** To adjust the cool-down time, proceed as follows.
- 2-65. Apply power and operate the transmitter.
- 2-66. Simultaneously depress the **FILAMENT OFF** switch and note the time.
- 2-67. Again note the time when the blower halts operation.
- 2-68. Refer to Figure 2-1 and select the cool-down feature by operating customer adjustment function switch SW1 to position 3.
- 2-69. Refer to Figure 2-1 and use up/down switch S2 to increase or decrease the blower run-down interval. Check the adjustment by repeating the procedure. The control is factory set for 30 seconds. Each click of S2 is equal to 1 second.
- 2-70. **RECYCLE ADJUSTMENT.** The recycle adjustment controls the amount of time the transmitter will remain deenergized to allow an overload to dissipate. The recycle time can be adjusted from 100 milliseconds to 15 seconds. The factory default is 2 seconds. To adjust the recycle time, proceed as follows.
- 2-71. **Required Equipment.** The following equipment is required to adjust cool down time.
- A. Wristwatch with seconds hand or stopwatch function.
- 2-72. **Procedure.** To adjust the recycle time, proceed as follows.
- 2-73. Apply power and operate the transmitter.
- 2-74. Simulate a screen or plate overload using the **OUTPUT LOADING** control and note the time when the transmitter attempts to return to operation.
- 2-75. Refer to Figure 2-1 and select the recycle feature by operating customer adjustment function switch SW1 to position 2.
- 2-76. Refer to Figure 2-1 and use up/down switch S2 to increase or decrease the recycle time. Check the adjustment by repeating the procedure. The control is factory set for 2 seconds. Each click of S2 is equal to 1 second.
- 2-77. **WARM-UP DEFEAT ADJUSTMENT.** The warm-up defeat adjustment controls the length of the interval the filaments can be off before initiating a new filament warm-up cycle. The warm-up defeat time can be adjusted from 1 second to 15 seconds. A 3 second delay is preset so that momentary power fluctuations will not initiate a new filament warm-up cycle. To adjust the warm-up defeat time, proceed as follows.

- 2-78. **Required Equipment.** The following equipment is required to adjust the warm-up defeat time.
- A. Wristwatch with seconds hand or stopwatch function.
- 2-79. **Procedure.** To adjust the warm-up defeat time, proceed as follows.
- 2-80. Apply power and operate the transmitter.
- 2-81. Check the current warm-up defeat time as follows:
- 1. Depress the **FILAMENT OFF** switch/indicator to illuminate the switch/indicator.
  - 2. Wait approximately 3 seconds and depress the **HIGH VOLTAGE ON** switch/indicator to illuminate the switch/indicator. With the warm-up defeat time configured at 3 seconds, the filaments will automatically re-energize.
- 2-82. Refer to Figure 2-1 and select the warm-up defeat feature by operating customer adjustment function switch SW1 to position 1.
- 2-83. Refer to Figure 2-1 and use up/down switch S2 to increase or decrease the warm-up time. Check the adjustment by repeating the procedure. The control is factory set for 3 seconds. Each click of S2 is equal to 1 second.
- 2-84. **FORWARD POWER CALIBRATION.** Potentiometer R83 calibrates the forward power sample circuit. Adjustment is required only if repairs have been made to the directional coupler forward port, controller main circuit board, or low-pass filter. To adjust the control, proceed as follows.
- 2-85. **Required Equipment.** The following equipment is required to adjust the forward power calibration control.
- A. 1/16 inch jewelers screw-driver, flat-tip.
  - B. Digital multimeter (Fluke 77 or equivalent).
  - C. Test load and connecting line (50 Ohm non-inductive, 1 5/8 inch line input, 5 kW minimum).
  - D. Calibrated in-line wattmeter with 1 5/8 inch sampling section and cables (Bird 4720 Thruline with 5 kW element or equivalent).
- 2-86. **Procedure.** To adjust the control, proceed as follows.



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER  
BEFORE PROCEEDING.***

**WARNING**

- 2-87. Disconnect the transmitter primary power.
- 2-88. Connect the test load and wattmeter to the transmitter output.
- 2-89. Connect the multimeter between TP-5 (signal) and TP-1 (ground) or to the chassis.
- 2-90. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** extinguished) at the desired 100% RF power output as indicated by the in-line wattmeter.
- 2-91. Depress the **FWD** switch/indicator to illuminate the switch/indicator.
- 2-92. Refer to Figure 2-1 and adjust forward power calibrate control R83 until the multimeter indicates +4.25 volts dc.

- 2-93. Refer to OUTPUT POWER METER CALIBRATION in the following text and perform the procedure to calibrate the output power meter.
- 2-94. Remove the test equipment and return the transmitter to service.
- 2-95. **OUTPUT POWER METER CALIBRATION.** This adjustment will be required only if the **OUTPUT POWER** meter or potentiometer R113 is replaced. To adjust output meter calibrate control R113, proceed as follows.
- 2-96. **Required Equipment.** The following equipment is required to adjust the output meter calibrate control.
- A. 1/16 inch jewelers screw-driver, flat-tip.
  - B. Test load and connecting line (50 Ohm non-inductive, 1 5/8 inch line input, 5 kW minimum).
  - C. Calibrated in-line wattmeter with 1 5/8 inch sampling section and cables (Bird 4720 Thruline with 5 kW element or equivalent).
- 2-97. **Procedure.** To adjust the control, proceed as follows:
- 2-98. Check and adjust forward power calibration control R83 before proceeding (refer to FORWARD POWER CALIBRATION in the preceding text).



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***

**WARNING**

- 2-99. Disconnect the transmitter primary power.
- 2-100. Connect the test load and wattmeter to the transmitter output.
- 2-101. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** extinguished) at the desired 100% RF power output as indicated by the in-line wattmeter.
- 2-102. Refer to Figure 2-1 and adjust meter calibration control R113 to obtain a 100% **OUTPUT POWER** meter indication.



**WARNING**      ***ASSURE ALL PRIMARY POWER IS DISCONNECTED BEFORE PROCEEDING.***

**WARNING**

- 2-103. Disconnect primary power.
- 2-104. Remove the test equipment and reconnect the transmitter output to the antenna load.
- 2-105. **REFLECTED POWER CALIBRATION.** Potentiometer R84 calibrates the reflected power sample circuit and potentiometer R119 nulls the VSWR meter. Adjustment is required only if repairs have been made to the directional coupler reflected port, controller main circuit board, or low-pass filter. To adjust the control, proceed as follows.
- 2-106. **Required Equipment.** The following equipment is required to adjust the controls.
- A. 1/16 inch jewelers screw-driver, flat-tip.
  - B. 10 dB attenuator, BNC connections.
  - C. 5/16 inch nut-driver.

- D. Test load and connecting line (50 Ohm non-inductive, 1 5/8 inch line input, 5 kW minimum).
  - E. Calibrated in-line wattmeter with 1 5/8 inch sampling section and cables (Bird 4720 Thruline with 5 kW element or equivalent).
- 2-107. **Procedure.** To adjust the controls, proceed as follows.
- 2-108. Check and adjust output power meter calibration control R113 before proceeding (refer to OUTPUT POWER METER CALIBRATION in the preceding text).
- 2-109. Adjust the VSWR null control as follows:



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***  
**WARNING**

1. Disconnect the transmitter primary power.
2. Ensure the test load and wattmeter are connected to the transmitter output.
3. Refer to Figure 2-1 and connect the multimeter between TP-6 (signal) and TP-1 (ground) or to the chassis.
4. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** extinguished) at the desired 100% RF power output as indicated by the in-line wattmeter.
5. Refer to Figure 2-1 and adjust VSWR null control R119 for a 0.0 volt dc indication on the multimeter.



**WARNING**      ***DISCONNECT ALL TRANSMITTER PRIMARY POWER BEFORE PROCEEDING.***  
**WARNING**

- 2-110. Disconnect the transmitter primary power.
- 2-111. Disconnect cable 131 from the reflected power directional coupler (↓ port) on the transmitter low-pass filter.
- 2-112. Using the nut-driver, loosen the clamps securing the reflected power directional coupler to the low-pass filter.
- 2-113. Rotate the reflected power directional coupler 180 degrees so the arrow on the coupler is up (↑). Secure the clamps.
- 2-114. Connect the 10 dB attenuator to the reflected power directional coupler and connect cable 131 to the attenuator.
- 2-115. Apply power and operate the transmitter at the normal RF power output as indicated by the in-line wattmeter.
- 2-116. Depress the **VSWR** switch/indicator to illuminate the switch/indicator.
- 2-117. Refer to Figure 2-1 and adjust reflected power calibrate control R84 until the **OUTPUT POWER** meter indicates a VSWR condition of 1.9 : 1.



**WARNING**

***DISCONNECT ALL TRANSMITTER PRIMARY POWER  
BEFORE PROCEEDING.***

**WARNING**

- 2-118. Disconnect the transmitter primary power.
- 2-119. Remove the test equipment and replace the reflected power directional coupler. Ensure the reflected power directional coupler arrow is down (↓). Ensure cable 131 is re-connected to the reflected power directional coupler port.
- 2-120. **AM NOISE TEST RECEPTACLE CALIBRATION.** Potentiometer R27 calibrates the signal at the AM noise test receptacle. Adjustment is required only if repairs have been made to the AM noise circuitry. To adjust the control, proceed as follows.
- 2-121. **Required Equipment.** The following equipment is required to adjust the AM noise calibration control.
- A. 1/16 inch jewelers screw-driver, flat-tip.
  - B. Digital multimeter (Fluke 77 or equivalent).
- 2-122. **Procedure.** To adjust the control, proceed as follows.
- 2-123. Check and adjust output power meter calibration control R113 before proceeding (refer to OUTPUT POWER METER CALIBRATION in the preceding text).
- 2-124. Disconnect the transmitter primary power.
- 2-125. Connect the multimeter between the center conductor of the AM noise test receptacle and chassis ground.
- 2-126. Apply power and operate the transmitter in the local manual mode (**REMOTE DISABLE** illuminated, **APC ON** extinguished) at the desired 100% RF power output as indicated by the front panel **OUTPUT POWER** meter.
- 2-127. Refer to Figure 2-1 and adjust AM noise calibration control R27 for a 1.09 volt dc indication on the multimeter.
- 2-128. Disconnect the transmitter primary power.
- 2-129. Remove the test equipment and return the transmitter to service.
- 2-130. **IPA FORWARD POWER CALIBRATION.** Potentiometer R95 calibrates the IPA forward power sample circuit. This circuit is not used in an FM-5T/FM-5TS.
- 2-131. **CONTROLLER RESET.** The controller is equipped with reset switch SW3. However, the microcontroller is equipped with a circuit to automatically reset the processor in the event of a lock-up condition. As a result, the switch will typically not be used.
- 2-132. **CUSTOMER ADJUSTMENTS - RESET.** The customer adjustments and the 100% power programming can be reset to the factory defaults if required. The reset operation is required only if the customer adjustments have been mis-adjusted. To reset the controller programming to the factory defaults, proceed as follows:
- 1. Depress the **HIGH VOLTAGE OFF** switch/indicator.
  - 2. Refer to Figure 2-1 and remove the model programming jumpers from model programming header J8.
  - 3. Refer to Figure 2-1 and re-install the model programming jumpers. Ensure the jumpers are correctly programmed for the transmitter model.

4. Depress the **HIGH VOLTAGE ON** switch/indicator and return the transmitter to service.

## 2-133. TROUBLESHOOTING.



**WARNING** *NEVER OPEN THE EQUIPMENT UNLESS ALL TRANSMITTER PRIMARY POWER IS DISCONNECTED. USE THE GROUNDING STICK PROVIDED TO ENSURE ALL COMPONENTS AND ALL SURROUNDING COMPONENTS ARE DISCHARGED BEFORE ATTEMPTING ANY MAINTENANCE ON ANY AREA WITHIN THE TRANSMITTER.*

**WARNING**

- 2-134. Most troubleshooting consists of visual checks. Because of the high voltages and currents in the equipment, it is considered hazardous to work with power energized. Therefore, the various transmitter indicators (meters, LEDs, and fuses) should be used to isolate the malfunction to one specific area.
- 2-135. Troubleshooting within the controller circuit board enclosure is not considered hazardous due to the low potentials and currents involved. Once the trouble is isolated and power is totally deenergized, it is suggested that the exact problem be located with resistance checks using the schematic diagrams and theory of operation presented throughout the text.
- 2-136. If a circuit is diagnosed as faulty, the circuit fault may be isolated and repaired locally or the entire device may be returned to Broadcast Electronics, Inc. for exchange, alignment, or replacement.
- 2-137. **CONTROLLER COMPONENT LOCATIONS.** Figure 2-2 presents the controller component locations. Refer to Figure 2-2 as required during the troubleshooting procedures to locate components within the controller.



**CAUTION** *TO PREVENT DAMAGE TO THE MAIN CIRCUIT BOARD, DO NOT REMOVE POWER SUPPLY CONNECTOR P5 WITH POWER ENERGIZED.*

**CAUTION**

- 2-138. **MAIN CIRCUIT BOARD POWER SUPPLY CONNECTOR P5.** The controller main circuit board is equipped with power supply connector P5. The main circuit board may be destroyed if the connector is removed with power energized. Therefore, disconnect the transmitter ac power before removing the connector.
- 2-139. **MICROPROCESSOR MODULE.** The transmitter controller is equipped with a microprocessor module. Figure 2-2 presents the location of the module. The module is designed to plug directly into header J1 on the main circuit board. In the event of a microprocessor failure, the module can be replaced by performing the following procedure.

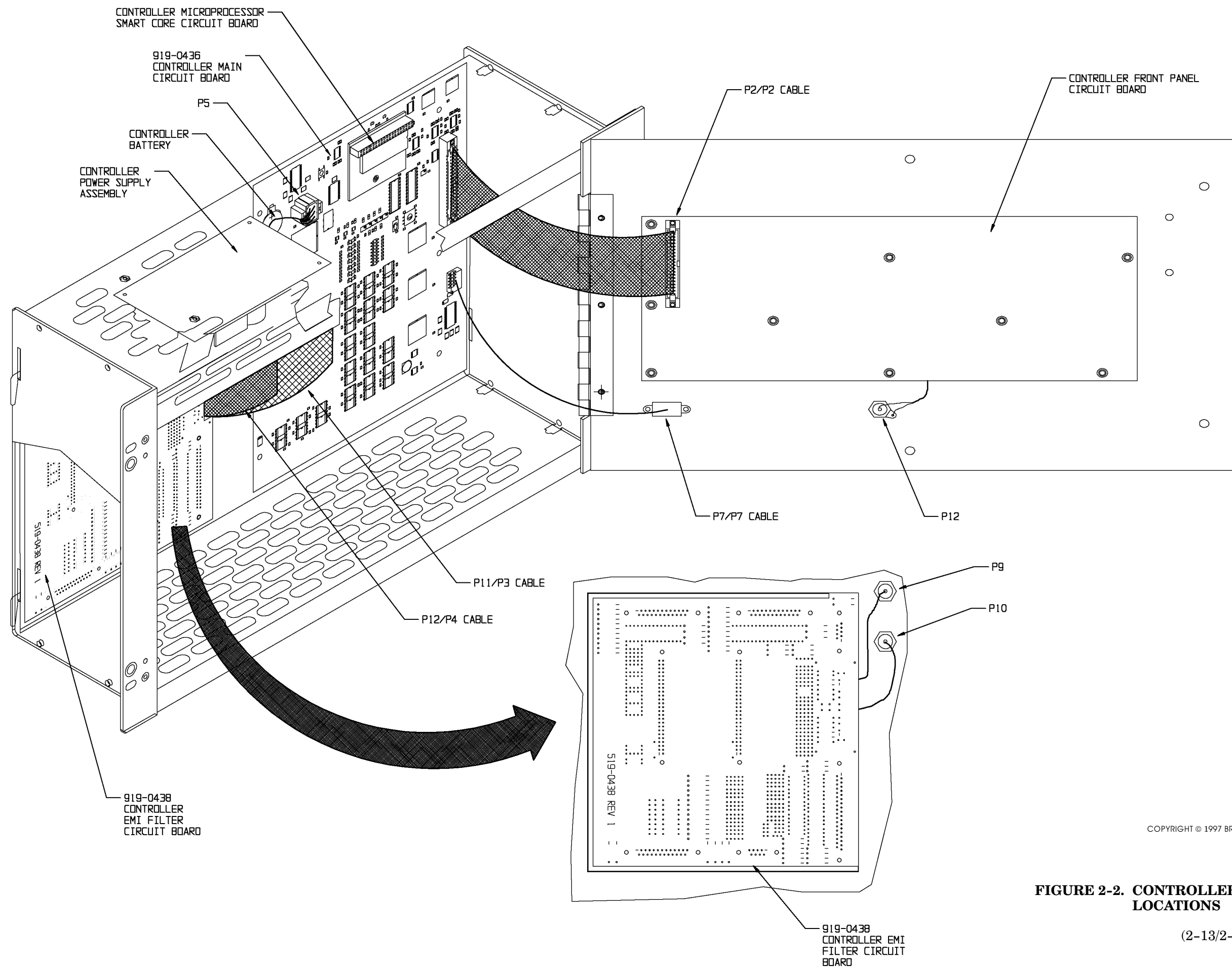


**CAUTION** *DO NOT REMOVE THE MICROPROCESSOR MODULE WITH THE TRANSMITTER PRIMARY AC POWER ENERGIZED.*

**CAUTION**

- 2-140. Disconnect the transmitter primary power.
- 2-141. Open the controller door and locate the microprocessor module.
- 2-142. Using a Phillips screwdriver, remove the microprocessor mounting screw.





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**FIGURE 2-2. CONTROLLER COMPONENT LOCATIONS**

(2-13/2-14)

- 2-143. Using your hands, gently pull the module from the header.
- 2-144. Orient the new microprocessor module as shown and insert the module in header J1.
- 2-145. Re-install the mounting screw, close the controller door, and return the transmitter to service.
- 2-146. **POWER SUPPLY INDICATORS.** The controller main circuit board is equipped with three LEDs. The LEDs present the status of the power supply +15V, -15V, and +5V power supplies. Use the indicators to check the status of the power supply module.
- 2-147. **CONTROLLER POWER SUPPLY MODULE.** The transmitter controller is equipped with a modular switching power supply assembly. The power supply module is equipped with an ac line fuse and is not manufactured by Broadcast Electronics.
- 2-148. If the power supply is suspected as being faulty, check the power supply fuse. If the power supply fuse has not blown, contact the Broadcast Electronics Customer Service Department. If desired, refer to APPENDIX A and the Computer Products power supply schematic diagram for additional power supply troubleshooting information.

## SECTION III

### PARTS LIST

#### 3-1. INTRODUCTION.

3-2. This section provides descriptions and part numbers of electrical components, assemblies, and selected mechanical parts required for maintenance of the Broadcast Electronics FM-5T/FM-5TS Transmitter Controller. Each table entry in this section is indexed by reference designators appearing on the applicable schematic diagram.

**TABLE 3-1. TRANSMITTER CONTROLLER PARTS LIST INDEX**

TABLE	DESCRIPTION	PART NO.	PAGE
3-2	FM TRANSMITTER DIGITAL CONTROLLER ASSEMBLY	959-0430	3-2
3-3	MAIN BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY	919-0436	3-2
3-4	FRONT PANEL CONTROLLER CIRCUIT BOARD ASSEMBLY	919-0437	3-5
3-5	I/O BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY	919-0438	3-5
3-6	HARNESS, FM DIGITAL CONTROLLER ASSEMBLY	949-0423	3-7

**TABLE 3-2. FM TRANSMITTER DIGITAL CONTROLLER ASSEMBLY - 959-0430**

REF. DES.	DESCRIPTION	PART NO.	QTY.
XU3	Software, FM Control, Programmed Kit	979-0443-003	1
Z1	Smartcore Z1B Circuit Board Assembly	544-0006	1
----	Power Input Connector/RFI Filter, 3 Amperes, 250V ac, 50/60 Hz	339-0008	1
----	Fuse, 313001, 3AG, 1 Amp, Slow-Blow, 250V	334-0100	1
----	Fuse Holder, AGC	415-2012	1
----	Connector, BNC	417-0016	1
----	Receptacle, BNC	417-0017	2
----	Power Supply, NFN40-7610, SMPS, 3 Output 40W	540-0006	1
----	Main Board, Controller Circuit Board Assembly	919-0436	1
----	Front Panel, Controller Circuit Board Assembly	919-0437	1
----	I/O Board, Controller Circuit Board Assembly	919-0438	1
----	Harness, FM Digital Controller Assembly	949-0423	1

**TABLE 3-3. MAIN BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0436  
(Sheet 1 of 3)**

REF. DES.	DESCRIPTION	PART NO.	QTY.
BT1	Battery, 3 Volts, 190 mAh, Lithium	350-2032	1
C1, C2	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	2
C3	Capacitor, Tantalum, 15 uF $\pm 10\%$ , 35V, SMD	070-1564	1
C4 thru C8	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	5
C9	Capacitor, Tantalum, 15 uF $\pm 10\%$ , 35V, SMD	070-1564	1
C10, C11	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	2
C12 thru C15	Capacitor, Ceramic, 390 pF $\pm 5\%$ , 100V, SMD	007-3923	4
C16 thru C30	Capacitor, Ceramic, 1 uF $\pm 10\%$ , 50V, SMD	007-1054	15
C31, C32	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	2
C33	Capacitor, Ceramic, 1 uF $\pm 10\%$ , 50V, SMD	007-1054	1
C34	Capacitor, Electrolytic, 330 uF $\pm 20\%$ , 25V, SMD	007-0331	1
C35, C36	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	2
C37 thru C52	Capacitor, Ceramic, 390 pF $\pm 5\%$ , 100V, SMD	007-3923	16
C53	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	1
C54, C55	Capacitor, Tantalum, 15 uF $\pm 10\%$ , 35V, SMD	070-1564	2
C56, C57	Capacitor, Ceramic, 0.1 uF $\pm 10\%$ , 50V, SMD	007-1044	7
C59 thru C63			
D1	Transzorb, P6SMB27CAT3, Case 403A-03, 27V, SMD	204-0027	1
D2	Transzorb, P6SMB15CAT3, Case 403A-03, 15V, SMD	204-0015	1
D3	Diode, Switching, MMBD914LT1, SMD	204-0914	1
DS1 thru DS3	LED, HSMF-C655, Dual Red/Green, Low Profile, SMD	325-0250	3
J1	Receptacle, 40-Position, Two Row, PCB	417-4042	1
J2	Header, 40-Pin, .100 Centers, SMD	408-0040	1
J3, J4	Header, 50-Pin, .100 Centers, SMD	408-0050	2
J5	Receptacle, 6-Pin	417-0677	1
J6	Header, 3-Pin, .100 Centers, SIP	408-0300	1
J7	Header, 10-Pin, .100 Centers, DIP	408-1000	1
J8	Header, 16-Pin, .100 Centers, DIP	408-1600	1
J9 thru J14	Header, 3-Pin, .100 Centers	408-0300	6
OSC1	Oscillator, Crystal, 1.8432 Mhz, SMD	390-0054	1
P6, P8A thru P8H, P9 thru P14	Switch, Jumper Programmable, 65474-002	340-0004	15
Q1, Q2	Transistor, MMBT3904LT1, NPN, SMD	216-3904	2
R1, R2	Resistor, Chip, 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	2
R3 thru R19	Resistor, Chip, 471 Ohm $\pm 1\%$ , 1/10W, SMD	102-4711	17
R20 thru R25,	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	6
R26	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	1
R27	Potentiometer, 100 k, Top Adjust, SMD	198-0104	1

**TABLE 3-3. MAIN BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0436**  
(Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R31 thru R45	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	15
R46	Resistor, Chip 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	1
R47 thru R59	Resistor, Chip, 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	13
R60	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R61	Resistor, Chip 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	1
R62	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R63	Resistor, Chip, 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	1
R64 thru R74	Resistor, Chip, 471 Ohm $\pm 1\%$ , 1/10W, SMD	102-4711	11
R75	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R76	Resistor, Chip, 41.2 k Ohm $\pm 1\%$ , 1/10W, SMD	102-4122	1
R77, R78	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R79	Resistor, Chip, 100 k Ohm $\pm 1\%$ , 1/10W	102-1003	1
R80	Resistor, Chip, 20.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2002	1
R81, R82	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R83, R84	Potentiometer, 100 k, Top Adjust, SMD	198-0104	1
R85	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R86	Resistor, Chip, 100 k Ohm $\pm 1\%$ , 1/10W	102-1003	1
R87	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	1
R88, R89	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R90, R91	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	2
R92	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R94	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	1
R95	Potentiometer, 100 k, Top Adjust, SMD	198-0104	1
R96	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R99	Resistor, Chip, 768 Ohm $\pm 1\%$ , 1/10W, SMD	102-7680	1
R100	Resistor, Chip, 1.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1001	1
R101, R103	Resistor, Chip, 332 k Ohm $\pm 1\%$ , 1/10W, SMD	102-3323	2
R104	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R106	Resistor, Chip, 20.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2002	1
R107	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R109, R110	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R112	Resistor, Chip, 33 k Ohm $\pm 1\%$ , 1/10W, SMD	102-3353	1
R113	Potentiometer, 100 k, Top Adjust, SMD	198-0104	1
R114	Resistor, Chip, 2.00 k Ohm, 1/10W, SMD	102-2001	1
R115, R116	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R117	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	1
R118	Resistor, Chip, 100 k Ohm $\pm 1\%$ , 1/10W	102-1003	1
R119	Potentiometer, 50k, Top Adjust, SMD	198-0503	1
R120	Resistor, Chip, 100 k Ohm $\pm 1\%$ , 1/10W	102-1003	1
R125 thru R131	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	7
R133 thru R140	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	8
R141 thru R143	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	3
R144	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	1
R145	Resistor, Chip, 20.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2002	1
R146, R147	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	2
R148	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	1
R149, R150	Resistor, Chip, 10.0 k Ohm $\pm 1\%$ , 1/10W, SMD	102-1002	2
R151 thru R156	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	6
R159	Resistor, Chip, 2.00 k Ohm $\pm 1\%$ , 1/10W, SMD	102-2001	1
R162	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	1

**TABLE 3-3. MAIN BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0436**  
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R165	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	1
R168	Resistor, Chip, 49.9 Ohm $\pm 1\%$ , 1/10W	102-4991	1
SW1	Switch, 94HCB08W, Rotary, BCD, 8 Position, SMD	342-9410	1
SW2	Switch, ETO5SD1CBE, Toggle, SPDT, MOM/OFF/MOM	340-0510	1
SW3	Switch, TL3304F160, TACT, SPST, N.O., SMD, Recessed	342-3304	1
TP1 thru TP10	Chip, Test Point, 1206, SMD	413-1206	10
U1, U2	Integrated Circuit, 82C55A, Peripheral Interface, 44-Pin PLCC Package	229-8255-001	2
U3	Voltage Regulator, LM79L05AC, Negative Voltage, 100mA, SMD	231-7905	1
U4	Integrated Circuit, 82C55A, Peripheral Interface, 44-Pin PLCC Package	229-8255-001	1
U7, U8	Integrated Circuit, ADC0808CCV, A/D Converter, 8-BIT, 8-Channel Multiplexer, 28-Pin Molded Chip Carrier Package	224-0808	2
U9	Integrated Circuit, MAX351, Quad Analog Switch, 16-Pin, SO Package, SMD	224-0351	1
U10A thru U17A, U10B thru U17B	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, Response: 30 kHz Maximum, Current: 50 mA Maximum, 6-Pin DIP	229-0033	16
U18	Integrated Circuit, ST16C552CJ68, PLCC Package, 68-Pin, Dual Universal Asynchronous Receiver/Transmitter with FIFO and Parallel Printer Port With Power Down Capability, SMD	224-0552	1
U19A thru U22A, U25A	Integrated Circuit, H11AA1, AC Input Opto-Isolator, 6-Pin DIP	229-0111	10
U19B thru U22B, U25B			
U24A, U25A, U26A thru U28A, U24B, U26B thru U28B	Integrated Circuit, 4N33, Optical Isolator, NPN Photo Transistor/Infared Emitting Diode Type, 1500V Isolation, Response: 30 kHz Maximum, Current: 50 mA Maximum, 6-Pin DIP	229-0033	9
U29, U31	Integrated Circuit, LT1491CS, OP Amp, Quad Micropower Rail-To-Rail Input and Output, 14-Pin, SO Package, SMD	224-1491	2
U32 thru U34	Integrated Circuit, SP241ACT, RS-232 Multi-Transceiver, +5V, 28-Pin SOIC Package, SMD	224-2410	3
U35	Integrated Circuit, X9312WS, Nonvolatile Trimmer Pot, 10 k, 0-15V dc, 8-Pin SOIC Package, SMD	198-9312	1
U36	Integrated Circuit, Si9986CY, 1 Amp, Buffered Full-Bridge, 8-Pin SOIC Package, SMD	224-9986	1
U37	Integrated Circuit, LT1491CS, OP Amp, Quad Micropower Rail-To-Rail Input and Output, 14-Pin SO Package, SMD	224-1491	1
U38	Integrated Circuit, MAX505ACWG, QUAD, 8-BIT DAC, Volt Out, +5V, 24-Pin Wide SO Package, SMD	224-0505	1
U39	Integrated Circuit, N74F74D, Dual Positive Edge Triggered D-Type Flip-Flop, 14-Pin SO, SMD	224-0074	1
U40, U41	Integrated Circuit, LT1491CS, Op Amp, Quad Micropower Rail-To-Rail Input and Output, 14-Pin, SO Package, SMD	224-1491	2
XBT1	Holder, Battery For CR-2032, SMD	415-2032	1
XU5, XU6	Socket, 20-Pin, DIP, SMD	431-2000	2
XU5	Software, FM Control Programmed Kit	979-0436-005	1
XU6	Software, FM Control Programmed Kit	979-0436-006	1
XU10 thru XU17	Socket, 14-Pin, DIP, SMD	431-1400	8
XU18	Socket, 68-Pin, PLCC, SMD	431-6800	1
XU19 thru XU22	Socket, 14-Pin, DIP, SMD	431-1400	4
XU24 thru XU28	Socket, 14-Pin, DIP, SMD	431-1400	5
----	Blank, Main Board, Controller Circuit Board	519-0436	1

**TABLE 3-4. FRONT PANEL CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0437**

REF. DES.	DESCRIPTION	PART NO.	QTY.
C2	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C3	Capacitor, Ceramic, Monolythic, .1 uF $\pm 20\%$ , 50V	003-1054	1
DS1 thru DS4	LED, LN322GP, Green, Diffused Chimney	320-0322	4
DS5 thru DS8	LED, LN222RP, Red Diffused Chimney, P424, 70 mW, 20 mA, 4V	320-0037	4
DS9	LED, LN322GP, Green, Diffused Chimney	320-0322	1
J2	Connector Header, 40-Pin	417-0173	1
J12	Receptacle, Male, 8-Pin In-Line, Right Angle	417-0080-001	1
L1	RF Choke, 4.7 uH $\pm 10\%$ , 430 mA, DC Resistance: 0.55 Ohms, 0.43 Amperes Maximum, Resonant at 115 MHz	360-0022	1
R1, R2	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	2
R3	Resistor, 17.8 Ohm $\pm 1\%$ , 1/4W	103-1782	1
R4	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	1
R5	Resistor, 17.8 Ohm $\pm 1\%$ , 1/4W	103-1782	1
R6	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	1
R7	Resistor, 17.8 Ohm $\pm 1\%$ , 1/4W	103-1782	1
R8	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	1
R9	Resistor, 267 Ohm $\pm 1\%$ , 1/4W	103-2673	1
R10	Resistor, 10k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R11 thru R14	Resistor, 536 Ohm $\pm 1\%$ , 1/4W	103-5363	4
R15 thru R18	Resistor, 150 Ohm $\pm 1\%$ , 1/4W	100-1531	4
R19 thru R27, R30, R32	Resistor, 10k Ohm $\pm 1\%$ , 1/4W	100-1051	11
R28	Resistor, 267 Ohm $\pm 1\%$ , 1/4W	103-2673	1
R29	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	1
R31	Resistor, 10 Ohm $\pm 1\%$ , 1/4W	103-1021	1
R33	Resistor, 536 Ohm $\pm 1\%$ , 1/4W	103-5363	1
R34	Resistor, 150 Ohm $\pm 1\%$ , 1/4W	100-1531	1
R35	Resistor, 442 Ohm $\pm 1\%$ , 1/4W	103-4423	1
SW1	Switch, TL-1251-G, Pushbutton, Momentary, LED Illuminated, Green	340-0140	1
SW2	Switch, TL-1251-Y, Pushbutton, Momentary, LED Illuminated, Yellow	340-0139	1
SW3	Switch, TL-1251-R, Pushbutton, Momentary, LED Illuminated, Red	340-0143	1
SW4	Switch, TL-1251-G, Pushbutton, Momentary, LED Illuminated, Green	340-0140	1
SW5, SW6	Switch, TL-1251-Y, Pushbutton, Momentary, LED Illuminated, Yellow	340-0139	2
SW7	Switch, TL-1251-G, Pushbutton, Momentary, LED Illuminated, Green	340-0140	1
SW8	Switch, TL-1251-R, Pushbutton, Momentary, LED Illuminated, Red	340-0143	1
SW9	Switch, TL-1251-Y, Pushbutton, Momentary, LED Illuminated, Yellow	340-0139	1
SW10	Switch, TL-1251-R, Pushbutton, Momentary, LED Illuminated, Red	340-0143	1
SW11, SW12	Switch, TL-1251-Y, Pushbutton, Momentary, LED Illuminated, Yellow	340-0139	2
----	Blank, Front Panel Controller Circuit Board	519-0437	1

**TABLE 3-5. I/O BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0438**  
(Sheet 1 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C1	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	1
C2 thru C12	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	11
C13	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	1
C14 thru C24	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	11

**TABLE 3-5. I/O BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0438**  
(Sheet 2 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
C25 thru C33	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	9
C34, C35	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	2
C36	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	1
C37	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	1
C38 thru C45	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	8
C46, C47	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	2
C48 thru C52	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	5
C53 thru C57	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	5
C58	Capacitor, Mica, 390 pF $\pm 5\%$ , 100V	042-3922	1
C59	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	1
C60	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	1
C61 thru C69	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	9
C70	Capacitor, Polyester, 0.0022 uF $\pm 10\%$ , 100V	031-2033	1
C71 thru C83	Capacitor, Monolythic Ceramic, 0.1 uF $\pm 20\%$ , 50V	003-1054	15
C85, C86			
C87	Capacitor, Mica, 1000 pF $\pm 1\%$ , 100V	041-1031	1
D1 thru D4	Diode, HP5082-2800, High Voltage, Schottky Barrier Type, 70V, 15 mA	201-2800	4
D5 thru D73,	Bidirectional Zener Transient Voltage Suppressor, P6KE15CA-RL, +/-15V	201-0015	69
D74, D75	Bidirectional Zener Transient Voltage Suppressor, P6KE27CA-RL, +/-27V	201-0027	2
D76, D77	Bidirectional Zener Transient Voltage Suppressor, P6KE15CA-RL, +/-15V	201-0015	2
D78, D79	Bidirectional Zener Transient Voltage Suppressor, P6KE15CA-RL, +/-15V	201-0015	2
D80	Diode, HP5082-2800, High Voltage, Schottky Barrier Type, 70V, 15 mA	201-2800	1
D81	Diode, 1N4005, Silicon, 600V, 1 Ampere	203-4005	1
FL1 thru FL46	Filter, EMI, 10,000 pF, 3-Pin	411-0001	71
FL47 thru FL71			
J1	Receptacle, 37-Pin D, Female	417-3704	1
J2, J3	Receptacle, 25-Pin D, Female	417-2502	2
J5, J6	Receptacle, 9-Pin D, Male	417-0902	2
J7	Receptacle, 25-Pin D, Female	417-2502	1
J11, J12	Header, 50-Pin, Right Angle, .100 Centers	417-5017	2
L1 thru L8	RF Choke, 4.7 uH $\pm 10\%$ , 430 mA, DC Resistance: 0.55 Ohms, 0.43 Amperes Maximum, Resonant at 115 MHz	360-0022	8
R1	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R2 thru R6	Resistor, 100 Ohm $\pm 1\%$ , 1/4W	100-1031	5
R7	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	1
R8, R9	Resistor, 100 Ohm $\pm 1\%$ , 1/4W	100-1031	2
R10, R11	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	2
R12	Resistor, 100 Ohm $\pm 1\%$ , 1/4W	100-1031	1
R13 thru R21	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	9
R24 thru R31	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	8
R34	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R37 thru R39	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	3
R40	Resistor, 499k Ohm $\pm 1\%$ , 1/4W	103-4996	1
R41	Resistor, 162k Ohm $\pm 1\%$ , 1/4W	103-1626	1
R42	Resistor, 499k Ohm $\pm 1\%$ , 1/4W	103-4996	1
R43, R44	Resistor, 10k Ohm $\pm 1\%$ , 1/4W	100-1051	2
R45	Resistor, 56 Ohm $\pm 5\%$ , 2W	130-5621	1
R46 thru R48	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	3
R54	Resistor, 475 Ohm $\pm 1\%$ , 1/4W	103-4753	1



**TABLE 3-5. I/O BOARD CONTROLLER CIRCUIT BOARD ASSEMBLY - 919-0438**  
(Sheet 3 of 3)

REF. DES.	DESCRIPTION	PART NO.	QTY.
R55, R56	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	2
R57	Resistor, 475 Ohm $\pm 1\%$ , 1/4W	103-4753	1
R58	Resistor, 56 Ohm $\pm 5\%$ , 2W	130-5621	1
R60	Resistor, 21 k Ohm $\pm 1\%$ , 1/4W	103-2105	1
R64 thru R66	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	3
R67	Resistor, 8.66 k Ohm $\pm 1\%$ , 1/4W	100-8641	1
R68	Resistor, 4.32 k Ohm $\pm 1\%$ , 1/4W	103-4324	1
R73, R75	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	2
R76, R77	Resistor, 10 k Ohm $\pm 1\%$ , 1/4W	100-1051	1
R79	Resistor, 4.32 k Ohm $\pm 1\%$ , 1/4W	103-4324	1
R82	Resistor, 8.66 k Ohm $\pm 1\%$ , 1/4W	100-8641	1
R90 thru R92	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	3
R94 thru R98	Resistor, 51.1 Ohm $\pm 1\%$ , 1/4W	103-5112	5
----	Blank, I/O Board Controller Circuit Board	519-0438	1

**TABLE 3-6. HARNESS, FM DIGITAL CONTROLLER ASSEMBLY - 949-0423**

REF. DES.	DESCRIPTION	PART NO.	QTY.
----	Connector, Male, 9-Pin	417-0181	1
----	Socket, Connector, 50-Pin	417-0228	4
----	Housing, SL-156, 3 Position	417-0306	1
----	Plug, Housing, 2-Pin	417-0499	3
----	Housing, SL-156, 6 Position	417-0606	1
----	Pins, Crimp Type	417-8766	6
----	Connector Housing, 6-Pin	418-0670	1
----	Plug, 40-Pin Dual In-Line	418-4001	2
----	Varistor, V250LA20A GE, Model Size 14	140-0008	2
----	Socket, Connector, 641294-1 Amp	417-0053	6
----	Socket, Connector, 10-Pin	417-1003	1

## SECTION IV DRAWINGS

### 4-1. INTRODUCTION.

- 4-2. This section provides assembly drawings, schematic diagrams, and wiring diagrams as indexed below for the FM-5T/FM-5TS transmitter controller.

FIGURE	TITLE	NUMBER
4-1	OVERALL SCHEMATIC, TRANSMITTER CONTROLLER	SB959-0430
4-2	SCHEMATIC DIAGRAM, EMI FILTER CIRCUIT BOARD	SB919-0438
4-3	ASSEMBLY DIAGRAM, EMI FILTER CIRCUIT BOARD	AC919-0438
4-4	SCHEMATIC DIAGRAM, MAIN CIRCUIT BOARD	SB919-0436
4-5	ASSEMBLY DIAGRAM, MAIN CIRCUIT BOARD	AC919-0436
4-6	SCHEMATIC DIAGRAM, FRONT PANEL CIRCUIT BOARD	SB919-0437
4-7	ASSEMBLY DIAGRAM, FRONT PANEL CIRCUIT BOARD	AC919-0437
4-8	ASSEMBLY DIAGRAM, TRANSMITTER CONTROLLER	597-0220-429
		-430
		-431
		-432