UHF 250 WATT POWER AMPLIFIER

USER Manual

EAGLE WIRELESS INTERNATIONAL

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Preface

Scope

This user manual contains a high level description of the UHF 250 Watt Power Amplifier as well as a detailed technical description. The scope of this document is to provide the reader with a general understanding, system description, and operation of the UHF 250 Watt Power Amplifier.

Section 1 – Presents a general introduction of the UHF 250 Watt Power Amplifier who are familiarizing themselves with the system for the first time.

Section 2 – Highlights the major features and specifications of the power amplifier.

Section 3 – Outlines the major system components.

Section 5 – Appendices and Schematics.

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For after hours emergencies, call (281) 538-6000 for instructions. If you reach voice mail, please leave a message and your call will be returned promptly.

Customers should maintain a stock of replacement parts or units for emergency backup.

Eagle Wireless International's factory trained field service engineers are available for system installation and optimization. For assistance, write or call:

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Cautions & Safety Regulations

All RF power transistor and RF termination resistors in this power amplifier contain the toxic substance beryllium oxide. These assemblies are located on the combiner, splitter and power amplifier boards. The fumes and dust of beryllium oxide is also toxic and should only be treated by trained personnel using proper precautions. Federal law and most state laws strictly prohibit disposal of beryllium oxide as a public waste.

FCC Requirements

FCC regulations state that:

1. Radio transmitters may be tuned or adjusted only by persons holding a general class commercial radiotelephone operator's license, a registered engineer or by personnel working under their immediate supervision.

2. The RF power output of a radio transmitter shall be no more than that required for satisfactory technical operation considering the area to be covered and local conditions.

3. The frequency, deviation, and power of a base station transmitter must be maintained within specified limits. It is recommended, therefor, that these three parameters be checked before the station is placed in service.

4. The power input to the final radio frequency stage shall not exceed the maximum figure specified on the current station authorization. This power input shall be measured and the results recorded:

    a. When the transmitter is initially installed.
    b. When any change is made in the transmitter, which may increase the power input.
    c. At intervals not to exceed on year.

FCC Interference Warning

FCC regulations state that:

This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation it has not been tested for compliance with the limits for Class A computing devices pursuant to Sub-part J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own

expense will be required to take whatever measures may be required to correct the interference.

OSHA Safety Standards

The United States Department of Labor, through the provisions of the Occupational Safety and Health Act, has established an electromagnetic energy safety standard with applies to the use of this equipment. Proper use of this radio equipment will result in exposure below the OSHA limit. The following precautions are recommended:

DO NOT operate the transmitter of a fixed radio (base station, radio paging transmitter RF equipment) when someone is within two feet (0.6 meters) of the antenna.

DO NOT operate the transmitter of any radio unless all RF connectors are secure and any open connectors are properly terminated.

In addition, all equipment must be properly grounded according to National & Local Electrical Codes.

Lightning Protection Considerations

The Transmitters and Power Amplifiers have protection against high voltages but for all external connections, added protection against lightning attack should be considered. For Transmitters used for high power applications with tower antennas, the following measures will provide sufficient protection against minor lighting attacks.

- Keep the antenna tower grounding resistance as low as possible.
- The ground rods should be made of copper and be at least eight feet long. Multiple rods should be used over a single rod, if possible.
- All transmission line bends should be made according to manufacturer's exact specifications. All ground line bend should be made as large as possible.
- Ground the transmission line sheath at every opportunity. Also, ground the transmission line where it is supported on poles and where it enters the building.
- Whenever possible, run at least a part of the transmission line through a length of ground conduit.
- Tie all equipment grounds together to a single point. Then, ground that point to a grounding rod using as short and as straight a ground wire as possible.
- The ground wire must never be bundled with other wires in the system. Also, ground wires must not run along a metal plane.

Integrated Circuit Handling Procedure

Care should be taken in handling the circuit boards during installation and service. A number of IC's (Integrated Circuits) used in the equipment are from the MOS (Metal Oxide Semiconductor) family and are vulnerable to damage from static discharges.

Exercise the following precautions when handling these components.

- Before handling components, ground yourself by touching a ground rod or the grounded chassis of the equipment momentarily.

- Whenever, either installing or servicing the equipment, take proper static protection (e.g. wearing a conductive wrist-strap) and stand on a conductive mat, which is connected to the ground through a 100K ohm resistor.

- Ground all test equipment and soldering stations that are electrically powered.

Always connect the ground lead of the test equipment to the Base Station, Extend-A-Page, and/or Power Amplifier, (which ever is being serviced) first and then the test probe. While disconnecting, remove the test probe prior to the ground lead.

Equipment Unpacking and Inspecting

Remove all hardware from the shipping carton and inspect the unit for damage. If shipping damage has occurred, contact the carrier immediately. Obtain an RMA number from Eagle Wireless International and return the damaged unit. Use the original customized package for shipment. All damages must be reported within 15 days of shipment.

Limited Warranty

1. The product line of paging and mobile equipment, base stations/power amplifiers, receivers, transmitters, security and transmitter control equipment sold by **EAGLE WIRELESS INTERNATIONAL, INC.** is warranted to the original buyer to meet the then current published specifications, drawings and/or such modifications thereof as Buyer and Seller have agreed to in writing and to be free from defects in workmanship and materials. Seller's entire warranty obligations are limited to making adjustments by repairing or replacing any product which fails to meet this warranty and which is returned to Seller. Replacement, repairs, or adjustment under this warranty shall be **F.O.B. League City, Texas and does not reinstate the warranty set forth herein.** Under all circumstances, the warranty will expire not later than one (1) year after date of such first shipment.

2. This warranty is void and adjustment will not be allowed for products which have been subjected to abuse, improper application or installation, unauthorized alteration, or accidental/negligent damage in use, storage, transportation or handling.

3. This warranty does not apply to:

   a. Incandescent lamps, LEDs, batteries, fuses and other consumable type goods, operable upon arrival only.

   b. Parts and accessories (other than those in the equipment) sold by Eagle Wireless International, Inc.

   c. Service calls and/or shipping charges necessary to transport the equipment between customer's location and the factory.

   d. Routine checkout and/or tuning equipment.

   e. Equipment damaged by an act of God and/or nature, war or terrorism.

   f. Equipment that has been sold, rented, or acquired in bankruptcy proceedings.

   g. Equipment where the serial number has been removed, defaced, or changed.

4. The Seller shall have the right of final determination as to the following: (a) existence of cause and defect, (b) whether adjustment will be allowed, and (c) if allowed, whether adjustment will be by repair or replacement. When adjustment is not allowed, a reasonable charge will be made to the Buyer to cover the Seller's cost of inspection and handling. During the first 30 days from the date of original shipment the seller may elect to accept a returned item for full credit less all shipping charges. After this thirty day period the buyer will be required to pay a restocking fee of twenty five percent of the invoice amount if the Seller elects to accept the returned item.

5. In the event the Seller determines that any product claimed to be defective is not subject to the warranty provisions set forth herein, the Buyer will be notified that the product is not subject to adjustment. Unless the Buyer furnishes disposition instructions for the product within thirty (30) days after such notification, Seller may return product "as is" to Buyer, transportation collect.

6. In returning products under this warranty, Buyer shall comply with terms set forth in the Warranty Return Procedures. Buyer shall comply with terms set forth in the Warranty Return Procedures. Buyer in all cases will obtain and comply with Seller's packaging and shipping instructions. Buyer will pay for packing, transportation and transit insurance costs for return of products. Where adjustment is not allowed, products will be returned to the Buyer, transportation collect.

7. Replacement parts may be secured on an immediate exchange basis, with the Buyer being billed F.O.B. League City, Texas for parts and shipping. Credit will be issued for exchange items and shipping upon their receipt, shipping prepaid, at **Eagle Wireless International, Inc**.

8. There are no warranties, express or implied, that extend beyond the description on the face of this contract. Seller shall not be liable for consequential damages. No change in this warranty shall be binding upon the Seller unless it shall be in writing and signed by a duly authorized representative of **Eagle Wireless International, Inc**.

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Section 1 – Introduction

UHF 250 WATT POWER AMPLIFIER

INTRODUCTION

EAGLE WIRELESS INTERNATIONAL is pleased to introduce its newest state-of-the-art technically advanced UHF 250 WATT POWER AMPLIFIER. The UHF 250 WATT POWER AMPLIFIER is fully solid-state design and built with the most advanced and rugged LDMOS power transistors. The POWER AMPLIFIER is designed for continuous duty operation for the paging and link application. The POWER AMPLIFIER has a modular design approach, thus making it easy to operate and maintain the unit. The heat sink design is rated well above the requirement for a 500 watt power amplifier operating on a continuous basis. The heat sink cooling is provided by three high capacity cooling fans. All adjustments are factory preset and require no field adjustments. The POWER AMPLIFIER is fully operationally compatible with the EAGLE and other manufacturer's made UHF exciters.

Section 2 – Features and Specifications

UHF 250 WATT POWER AMPLIFIER

Major features of the UHF 250 Watt Power Amplifier:

- Advanced State-of-the-Art Technology
- 100% Solid State Continuous Duty
- Extensive Front Panel Monitoring & Display
- Modular Design
- Multi-channel Capability

Specification of the UHF 250 Watt Power Amplifier:

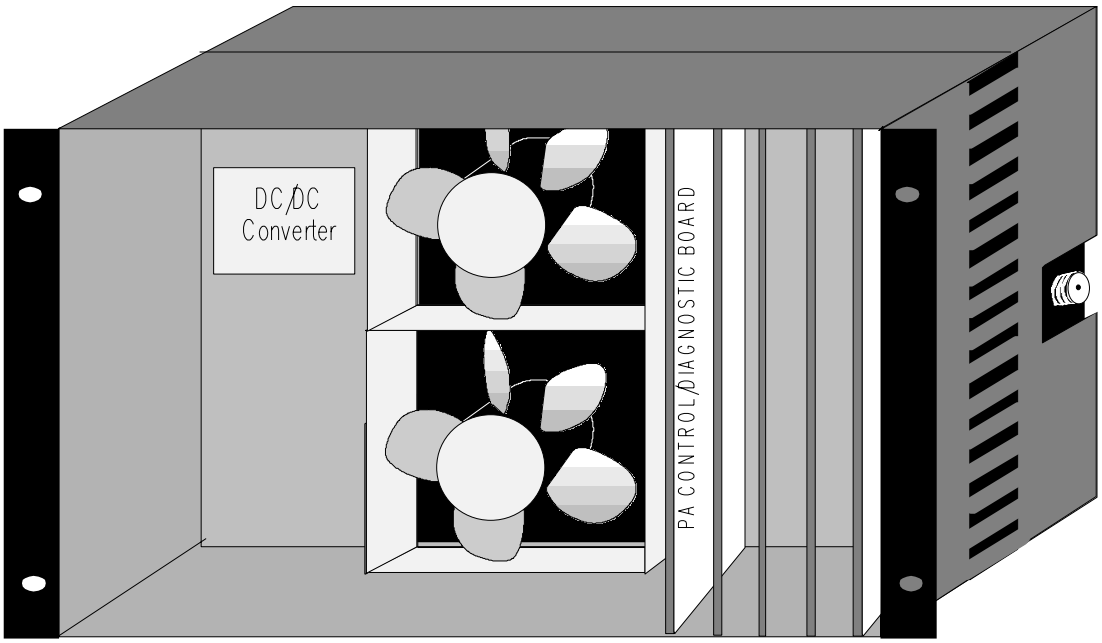
Frequency Range	450-470 MHz
Power Output	250 Watt
RF Input Impedance	50 Ohm (BNC Female)
RF Output Impedance	50 Ohms (Type N Female)
Emission Designators	F1D, F3D, F3E
Duty Cycle	100% at full rated power
Primary Power	26-28 VDC at 25 Amps
Spurious and Harmonics	-70 dBc or better
Adjacent Channel Noise	-70 dBc or better
Operating Temperature	0ºc to 45ºc (Full Power)
Operating Humidity	0% to 95% relative, non-condensing

Section 3 – SYSTEM COMPONENTS

UHF 250 WATT POWER AMPLIFIER

Power Amplifier Configuration

The high power amplifier is mounted to the heat sink and is accessible from the backside of the transmitter. All components of the power amplifier are contained in an RF tight enclosure such that only the input and output R.F. coaxial connectors directly penetrate the enclosure. All other penetrations are by filtered feed through which is designed for the R.F. environment. A packaging view of the front and rear of the transmitter is shown in Figures 1 and 2. The power amplifier functional bock diagram is shown in Figure 3.



FRONT VIEW

Figure 1 – Power Amplifier Unit Front Packaging View

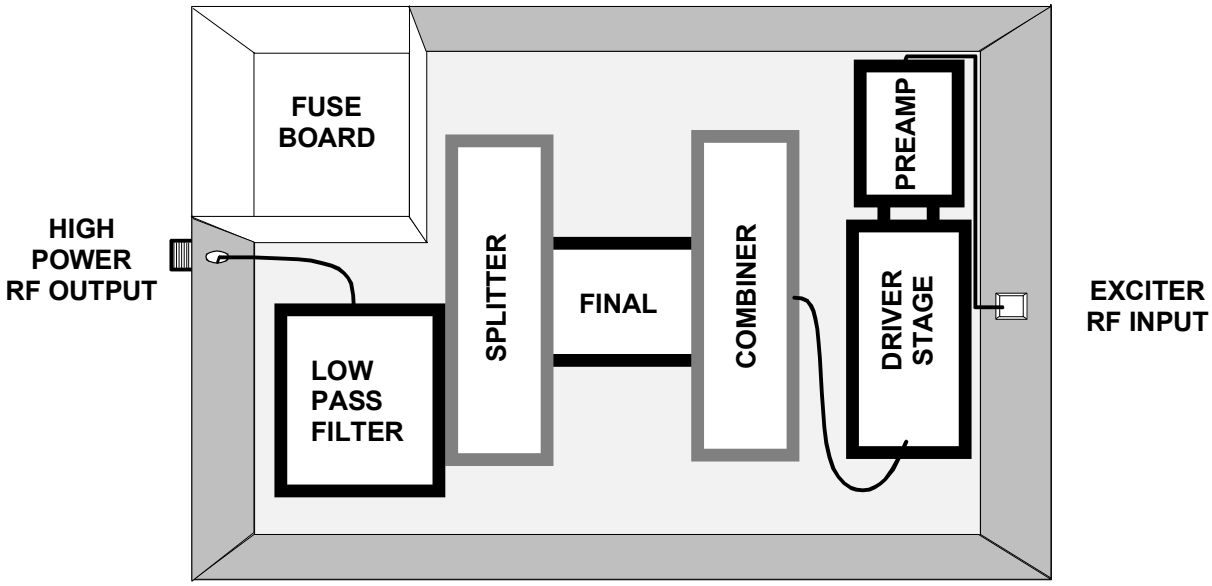


Figure 2 –Power Amplifier Rear View

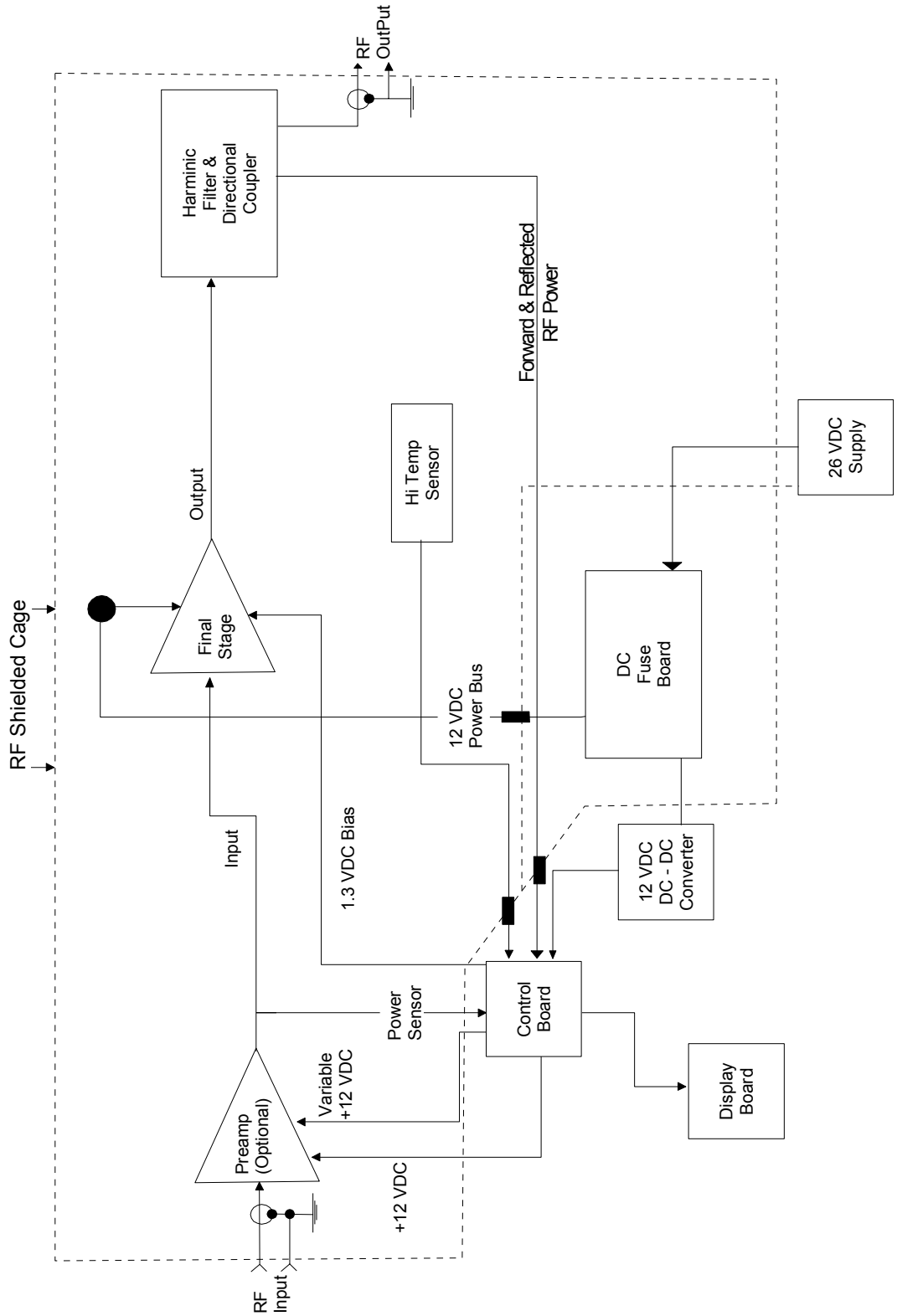


Figure 3 – Power Amplifier Functional Block Diagram

Power Amplifier – Control Section

The Power Amplifier Control Board provides all of the Power Amplifier control functions necessary to operate any of the Eagle Power Amplifier configurations.

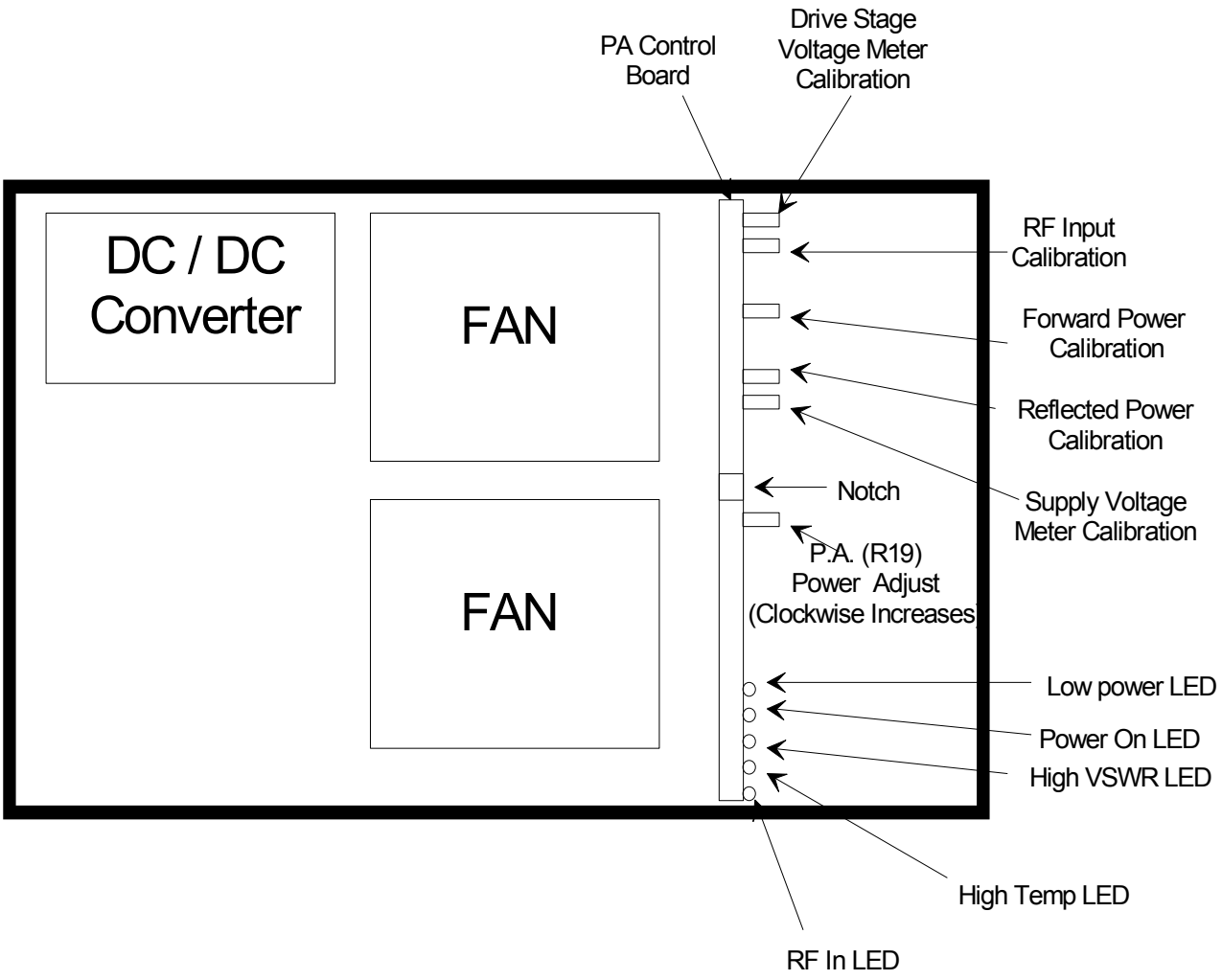


Figure 4 – Power Amplifier Control Board

Power Amplifier (PA) Control Board

1. The P.A. control board contains all of the hardware and software necessary to provide the following control functions. See Figure 3 for block diagram.

a. Variable DC control voltage that drives the P.A. pre-amp to control the output power level of the P.A.

b. Bias supply generation for amplifier configurations requiring external bias.

c. Monitoring of forward power, reflected power, temperature, VSWR conditions, D.C. power levels, and various alarm conditions.

d. Fan control and sensing.

e. DC power regulation.

f. Input power detection.

g. P.A. keying and deactivation.

h. Front panel Meter display.

Power Amplifier Control Functions

The Power Amplifier Control Functions on the Power Amplifier Control Board are accomplished by the 87C552 master processor located on this board in conjunction with a variety of support circuitry. All of the major power amplifier parameters such as forward and reflected power, heat sink temperature, input drive RF. power, drive stage voltage, and the master power supply voltage are monitored in this board by the processor. The 87C552 has a built in A/D converter for these analog signals and they are sampled after suitable scaling in the operational amplifier stages of U6 through U8. The gain of most of these operational amplifiers is controlled by a potentiometer located in one of the feedback stages as can be observed on the schematic located in Appendix. Each of these adjustment points can also be located in Figures 4 and 5. All of these adjustments are factory preset and should not require field adjustment. However, for convenience, the following is a summary of these potentiometers and their function.

R24	Driver Voltage Meter Calibration	Adjust for proper reading on meter with external voltmeter.
R33	Input RF Threshold Adjustment	Sets the input RF level at which the fan circuit is activated.
R43	Forward Output Power Calibration	Sets the gain between the forward power sensor and the input to the microprocessor. Setting depends on frequency and power options and is factory preset. This input is used to control the VSWR protection circuit.
R18	Input DC Voltage Meter Calibration	This control is used in conjunction with a voltmeter to set the input DC voltage reading on the display meter.
R19	Output RF Power Level Adjustment	This control is used to adjust a control voltage to the pre-amp stage that ultimately controls the level of the output forward RF power

The microprocessor, U1, on the Power Amplifier Control Board also provides the monitoring of the VSWR using the forward and reflected power levels and will automatically shut the amplifier down if the VSWR exceeds the threshold level set in the software.

In addition, the microprocessor also continuously monitors the temperature of the heat sink near the high power final stage and will shut the amplifier down if this temperature reaches 70 degrees centigrade. Should this event occur, the fan will continue to run and should the temperature drop to 50 degrees centigrade, the processor will automatically re-enable the amplifier for full power.

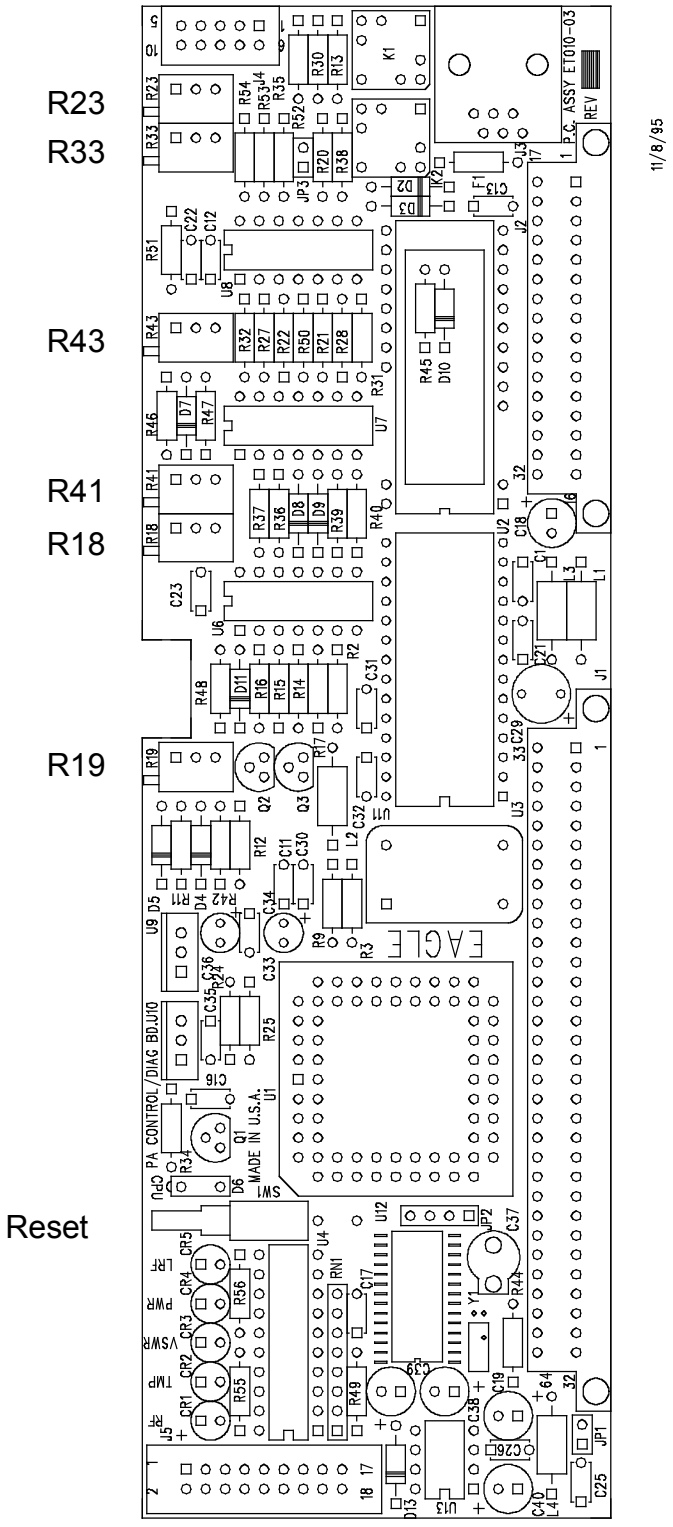


Figure 5 – Transmitter Unit – Power Amplifier Control Board

There is, however, a built in delay of two minutes and twenty seconds before the reset condition can occur to allow adequate cooling for an excessively hot ambient condition. The microprocessor also has a software threshold to determine the minimum acceptable output power for a normal transmit condition. When the output power is below this limit a fault indications provided (i.e. low power), but otherwise the amplifier operates normally. This low power threshold is normally set in software to 50% of full rated power unless the customer makes a special request.

In addition to its normal control functions, the Power Amplifier Control Board also contains all the drive circuitry for the on-board displays as well as the circuitry for the front panel display.

Power Amplifier – RF Section
General Description

The Power Amplifier circuitry is primarily located in the rear R.F. compartment that provides R.F. shielding for all of the higher power R.F. circuitry. The basic configuration of the Power Amplifier RF Section is shown in Figure 6. This configuration consists of a pre-amp module that drives an intermediate stage amplifier (the driver stage) followed by the high power amplifier stage. The high power stage consists of four separate transistors. The particular transistor configuration is chosen to maximize the performance and reliability of the products. All power transistors are mounted on special high thermal performance board material and employ copper heat spreaders. The output of the power transistor is fed into a low pass harmonic filter to eliminate unwanted harmonics. The output of this harmonic filter also serves as the RF output connector mount and support. The individual boards and preamp in the power amplifier are all fused on an independent basis. This fuse board is also located in the RF cavity in its own shielded compartment. Each fuse is also instrumented with a LED indicator to provide easy visibility as to the health and status of the fuse for that circuit. The back of the RF cavity enclosure also serves as the mount for an auxiliary cooling fan.

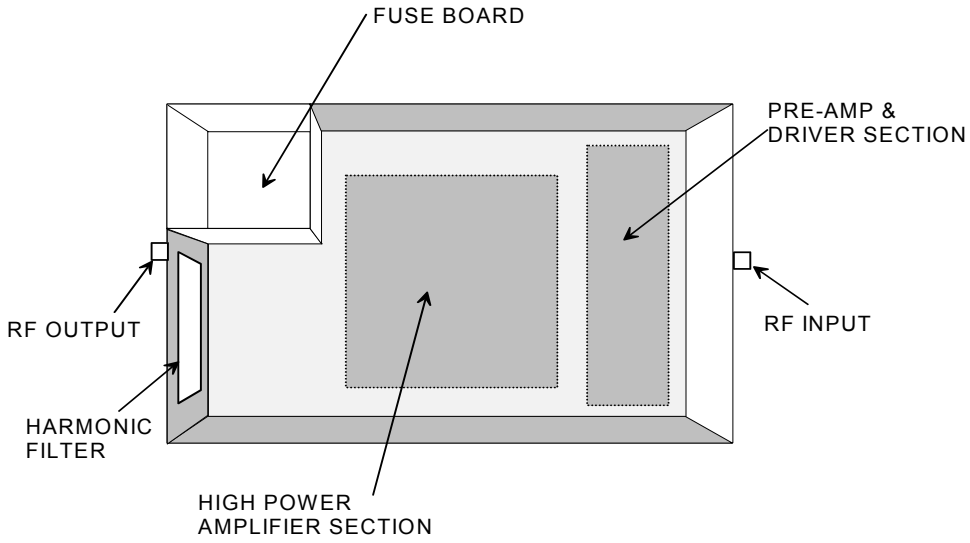


Figure 6 – Back View of the Power Amplifier

Technical Description

The 250-watt version of the 450 MHz power amplifier utilizes a very conservative and simplified design. Like all of the EAGLE power amplifier designs, the exciter output is fed directly through the heat sink and into the RF. cavity on the back of the transmitter unit as shown in Figure 7 below:

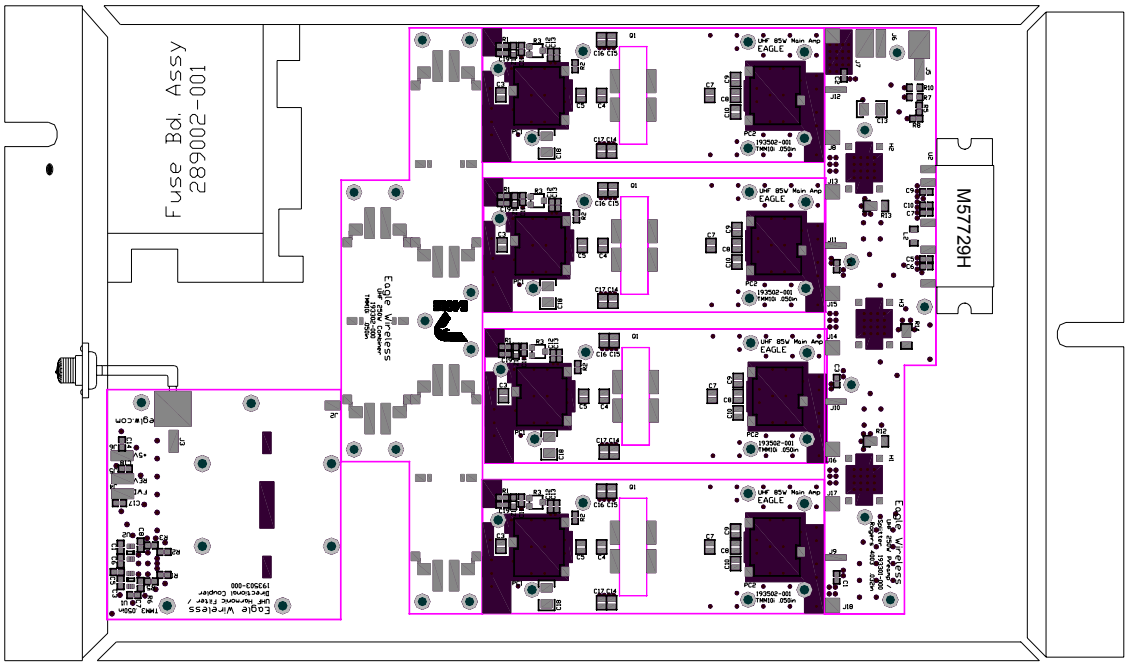


Figure 7

The block diagram of this configuration is also shown below:

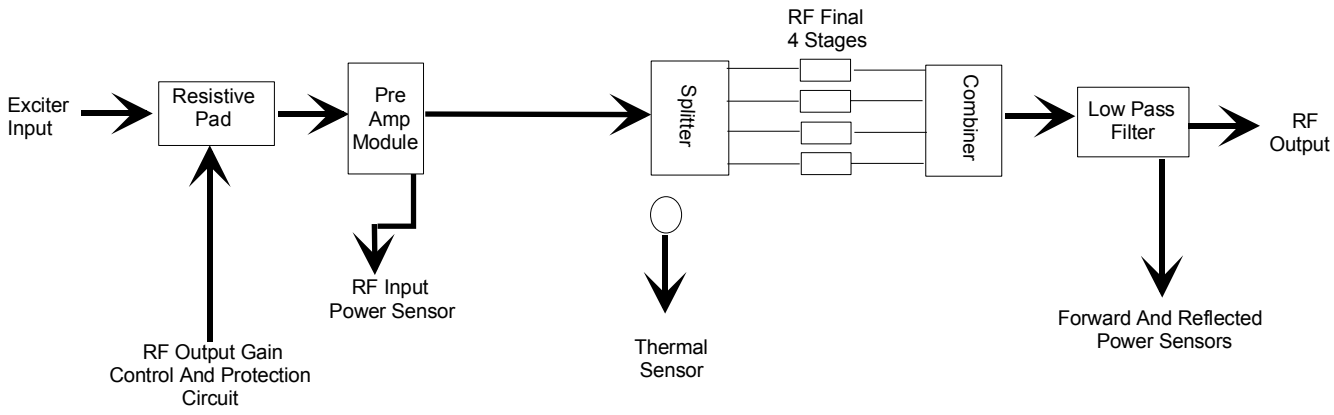


Figure 8 – Power Amplifier Block Diagram

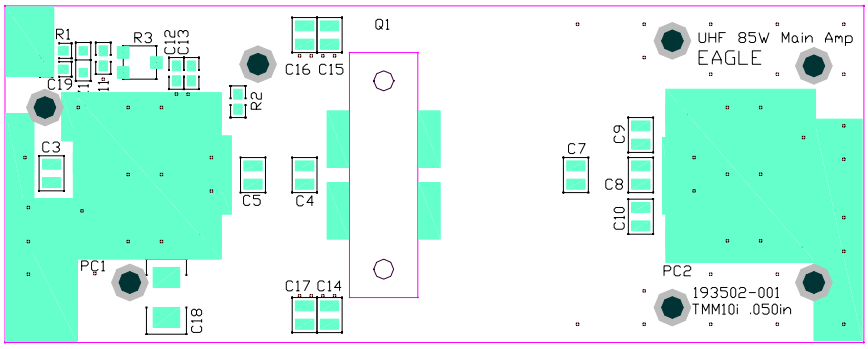
The input from the exciter (approximately 750 milli-watts and 1.0 Watts) is fed directly into the Pre-Amp module. The 6dB pad is a resistive pi-attenuator, which lowers the input power to meet the preamp input requirement as well as provide optimal input impedance for the amplifier. The pre-amp module is a high gain amplifier with positive gain control through the use of its bias voltage. This bias voltage is provided by the PA Control board and is manually adjustable from the front of the transmitter as well as being controlled by the PA Control board main processor for VSWR and thermal shutdown. This information is utilized for a variety of purposes such as fan control and VSWR validation.

The driver stage is a hybrid module used to provide the required input power levels to the final stages of the amplifier. It is a self-contained module and is the final stage of the driver board. Its output is connected to a network of three hybrid splitters used to provide one to four split. Each output of the splitter drives the input to a final stage amplifier.

There are four final stage amplifiers used in the amplifier. All four amplifiers are of equal gain, phase and output power levels. The purpose of these final stages is again to provide additional gain to the amplifier. The output of each final stage amplifier is fed to an output combiner, which is used to re-combine all four signals into one higher power signal.

Each RF. final stage consists of a transistor with a board/copper heat spreader assembly. This circuit board material is thermally bonded to a heavy-duty copper heat spreader for added thermal capacity. The heat sink is instrumented to allow the microprocessor on the Power Amplifier Control board to continually monitor the thermal performance of the unit.

Figure 9 – RF Final Circuit Board Layout



The RF. final Circuit board layout for an individual module is shown in Figure 9. Should the Final Stage ever require replacement, the entire assembly, including the heat spreader, is easily replaced as a subassembly.

This combined output signal is fed to a low pass filter, which also incorporates RF detector circuit to determine voltages from the forward and reflected power levels at the output of PA. These detector outputs are used to provide an alarm in the event that a high VSWR is present at the output of the power amplifier.

The output of the low pass filter attenuates high frequency components of the desired signal, (i.e. harmonics). The output of the low pass filter is connected to semi-rigid coaxial cable, which is attached to the RF output N connector of the amplifier.

The pre-amp stage generates about 12-16 Watts. The Pre-amp RF power then passes through a dual splitter assembly to drive four final stages; each is capable of generating up to 80 Watts to a total of 320 Watts of RF. power. This output is then passed through a dual combiner stage and then through a low pass filter to generate up to 250 watts of RF. power.

The design of the low pass filter utilizes special low loss high dielectric constant materials with high thermal conductivity. The back of the low pass board also employs a heat spreader to minimize the board surface temperature. The inductive elements of the filter are simple half-loop elements that are soldered directly to the circuit board. The directional couplers for forward and reflected power measurement are etched into the filter board design. The final output connector is soldered directly into the filter assembly. The geometry of the low pas filter board is shown in Figure 10.

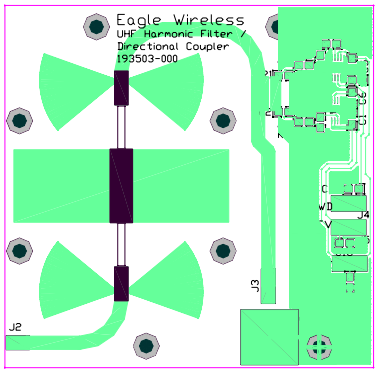


Figure 10 – Low Pass Filter Board

The final item in the UHF 250 watt power amplifier is the fuse board located in the fuse compartment as shown in Figure 25. This fuse board is utilized in all models of EAGLE power amplifiers up to 500 watts. Therefore, in the 250-watt version there are a number of unused fuse locations as shown in Figure 11 below.

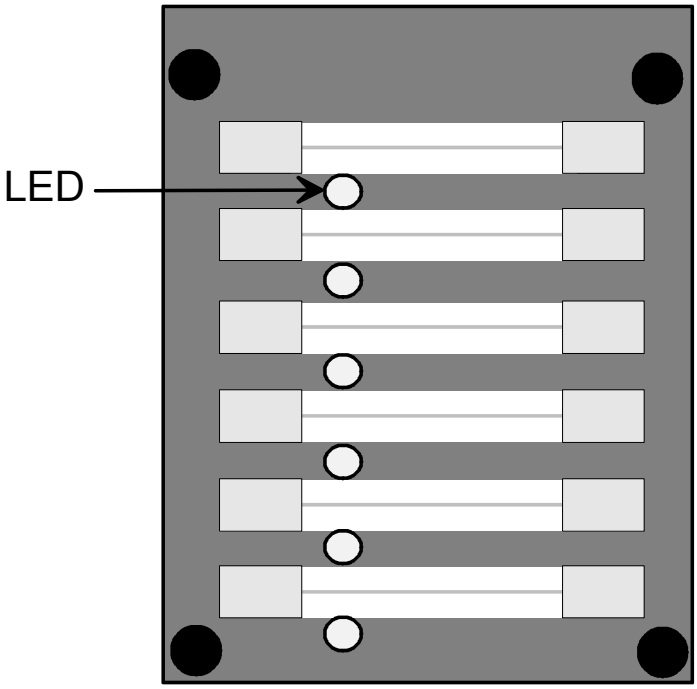


Figure 11 – Fuse Board

Each of these fuse locations is instrumented with an LED to provide a quick visual indication of the health and status of that particular fuse.

Backplane Mother Board

The Backplane Mother Board mechanical and electrical details are shown in Figure 12. The schematic for the Mother Board may be found in the Appendix of this manual. There are four separate card slots on the mother board and any of the slots can be used for the PA control board. However, the PA control board is usually installed in last slot on the left. Also contained on the mother board is a regulator required to provide the +5 VDC supply to the PA control board and the display monitor. A 12VDC variable regulator is also located at the motherboard to provide the drive voltage requirement for the pre-amp.

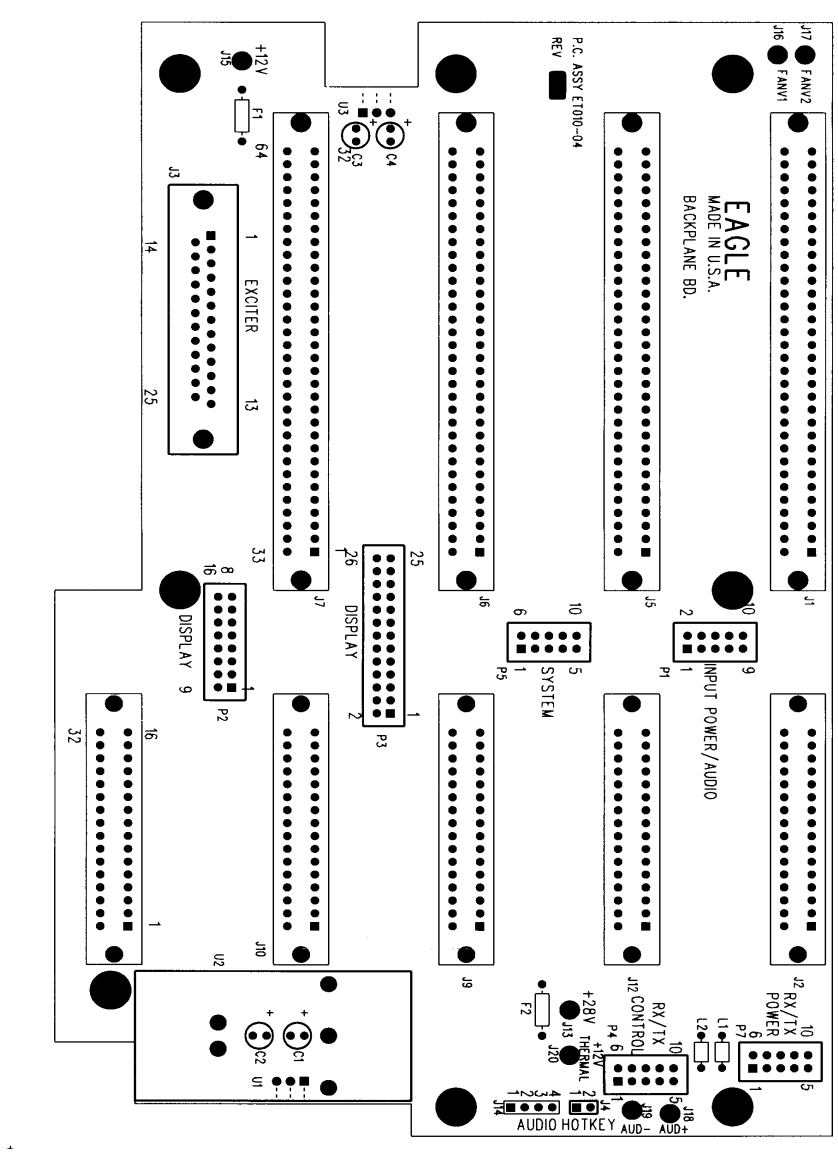


Figure 12 – Transmitter Backplane Board

Power Supply

The power supplies are switch mode type supplies. Depending on the requirement, it is capable of supplying 40 amps of DC current at 28 VDC from 115 or 220 VAC line voltage. Each supply is made up of four 28 VDC modules. The modules are assembled in parallels to meet the desired current rating. Each module is individually fused and contains its own temperature controlled fan.

The supply is protected against overload and short circuit conditions by fold-back current limiting. The load is protected against over voltage by a "crowbar circuit" which initiates latched current limiting upon over voltage, dropping the output voltage to safe levels.

Power Amplifier – Installation

Equipment Required: Wattmeter with RF sample output, Spectrum Analyzer and Oscilloscope.

Please read and follow instructions carefully before installing the Power Amplifier.

1. Upon removing the unit from its package, it should be inspected for any obvious signs of physical damage and loose hardware. If there is damage, call Eagle to obtain a RMA number to return the unit.
2. Verify that all cabling and DC power connections are in place. If not, tighten any screw or cables that may have come loose during shipment.
3. Connect a known good Isolator/Circulator to the RF output of the unit.
4. Connect a known good dummy load to the output of the Isolator/Circulator with a wattmeter in line between them.
5. Connect the Power Amplifier unit to a correct ampere rated AC outlet. For most applications 10 amps rated outlet will support a 250 watt system.
6. Turn power on. The system will perform its internal diagnostic tests, the HI VSWR and the HI TEMP LED will blink sequentially for about 22 seconds and then stop with both HI VSWR and the HI TEMP LED off and a "CPU OK" green LED will blink in the PA control board at the rate once every second. The system is now ready for operation.
7. Check DC voltage at the DC power input terminal located at the rear of the transmitter unit. This should be at 26 volts.
8. Check that the exciter output is correctly adjusted to meet the input power requirement (the maximum input power requirement is shown either at the front or back of the unit) of the PA and the spurious and harmonics from the exciter should be at 65dBc or better.

9. All adjustments are factory preset; no field adjustments are necessary. Allow the PA to warm up for a period of 5 minutes before taking measurements. Key the Exciter and check forward Power (factory adjusted), reflected power (close to zero) at the wattmeter and also at the Display meter. Also available at the display panel are: DC supply voltage, Drive voltage and temperature. Rotate the knob on the display panel to read their values. Check measured data against the Test Data sheet provided; they should be within 5% of each other.
10. Check forward output power with the desired input power level. Check results against the Test Data sheet provided. If RF Out power is more or less than the required output, adjust exciter output.
11. In the Power Amplifier unit itself there are three cooling fans. One at the rear of the unit, which stays ON as long as the DC power is applied and the other two fans at the front of the unit turns ON when the Power Amplifier is keyed and RF Input power is detected. These fans will turn OFF at about 2 minutes and 20 seconds after the system is unkeyed.
12. Check spurious and harmonics taken from the sampled output of the wattmeter on a Spectrum Analyzer. These should be at least 65dBc.
13. Un-key the Exciter.
14. Turn Power Off.
15. Remove the dummy load. Leave the Isolator/Circulator and the wattmeter connected as before.
16. Connect the antenna to the Isolator/Circulator output through the wattmeter. Before connecting the antenna to the RF Output, have the antenna and RF cables thoroughly checked by a professional.
17. Apply Power to the system. Wait for the internal diagnostic test time period to elapse.
18. Manually key the exciter as before. Check reflected power, it should be no more than 0-3% of the forward power. For reflected power more than 5% of the forward power, unkey the system and have the antenna and RF cables checked. Systems running with high reflected power will cause irreversible damage to RF transistors and/or the Isolator/Circulator.
19. Check display meter readings as before.
20. Unkey the transmitter. Monitor the system operation with actual paging data for a short period of time. Check spurious and harmonics as before.
21. The Power Amplifier is now ready to be put in service.

Section 4 – Appendices

UHF 250 Watt Power Amplifier