MODEL FFPA8689-120

INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS FOR FEED FORWARD POWER AMPLIFIER

PREPARED
SEPTEMBER 1, 1999

M P D T E C H N O L O G I E S , I N C .
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1. Publication # & Edition

Warning - If the equipment appears to be damaged in any way, remove all power to the unit and it serviced as soon thereafter as possible. The use of an earth ground is required to ensure safety.

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1. GENERAL DESCRIPTION

1.1 Introduction

This manual provides information for the installation, operation and maintenance of MPD Technologies, Inc. model FFPA8689-120 feed forward linear power amplifier. The manual is organized in 5 sections as follows:

- Section 1. General Description

- Section 2. Installation
- Section 3. Operating Instructions
- Section 4. Principles of Operation
- Section 5. Maintenance

1.2 General Description

The FFPA8689-120 (Figure 1-1) is a microprocessor-controlled linear power amplifier (FFPA) which operates over the frequency range of 869 to 894 MHz with a rated output power of 120 watts total (average). At rated output, the amplifier provides intermodulation products of better than 65 dBc. The design of the FFPA is entirely solid state, providing trouble free operation and a minimum of maintenance. The FFPA8689-120 includes a high-speed I/O port to receive commands from the host controller. An internal transmitter sends data to the host controller regarding the performance and health of the FFPA8689-120. The FFPA8689-120 is equipped with microprocessor controlled status monitoring and control circuitry which monitors key FFPA operating conditions and provides remote status output via the rear panel I/O connector. Local operating status is provided via front panel LED indicators. The FFPA8689-120 is powered by an external (customer supplied) 24-28 vdc power supply.

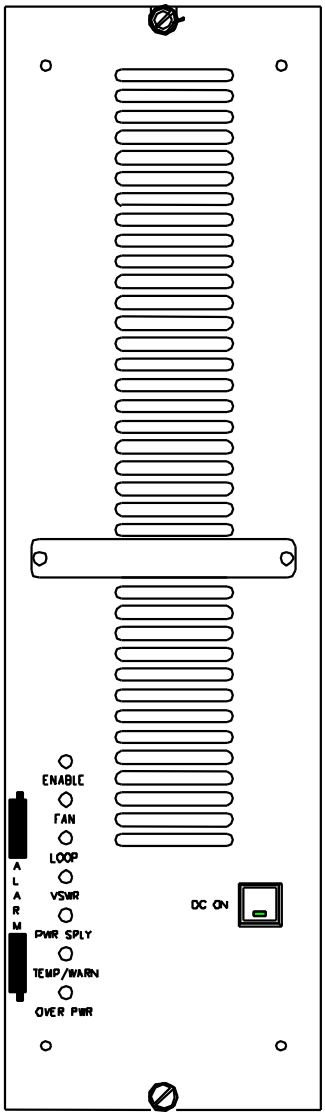


Figure 1. Model FFPA8689-120 Feed Forward Power Amplifier

1.3 Equipment Functional and Physical Specifications

Table 1 lists the functional and physical specifications of the FFPA8689-120 linear power amplifier.

Table 1. Performance Characteristics
Model FFPA8689-120 Linear Power Amplifier

PERFORMANCE CHARACTERISTICS	
Parameter	**Specification**
Frequency	869 - 894 MHz
RF Output Power	120 Watts Average
Intermodulation Distortion	65 dBc minimum when measured with 50 random phase sets.
Gain	61±0.25 dB
Modulation Format	Any
Input Return Loss	18 dbr Minimum
Load Stability	VSWR unconditional, all phases
Current Consumption	50 amperes nominal @ 27 Vdc
DC Input	Fully operational from 24 to 28 VDC
Operating Temperature	0° to 50° C
Operating Humidity	20% to 80% RH, non condensing
Storage Humidity	20% to 95% RH, non condensing
Dimensions	349.5 mm H x 130 mm W x 422.4 mm D (Optional Configuration Available)
RF, DC, and I/O interface	Blindmate 24W7 Sub-miniature connector
LED Status Monitoring	Loop Alarm, VSWR Alarm, Temperature Alarm, Power Supply Alarm, Fan Alarm, Over Power Alarm, and DC On

1.4 Mechanical Description

The FFPA8689-120 is contained in a 19-inch rack mountable enclosure. A central heatsink is permanently mounted as part of the assembly (casting/housing). Cooling is provided by 2 integral rear mounted fans which are easily replaced without the need for chassis disassembly. Airflow through the FFPA is from front through the rear of the unit.

2. INSTALLATION

Figure 2, is the outline/installation drawing for the FFPA8689-120 linear power amplifier.

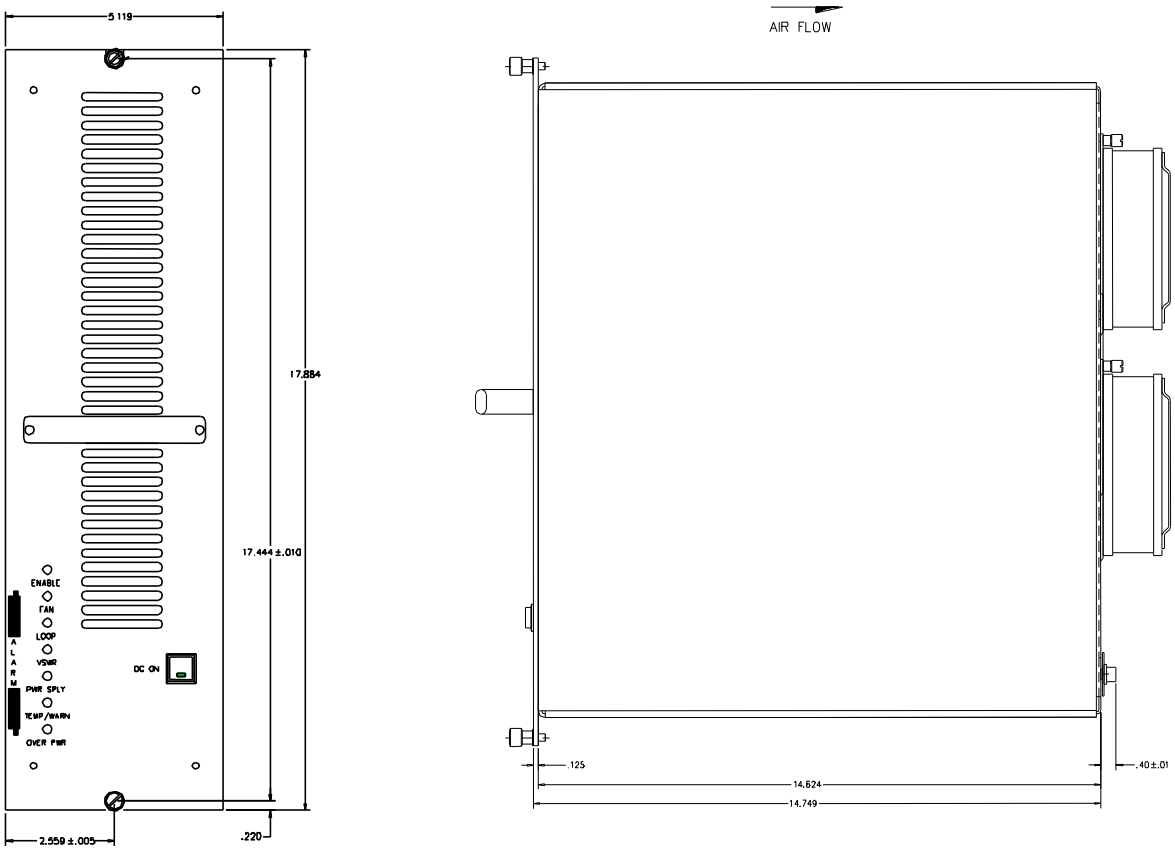


Figure 2. MPD Technologies, Inc.
Model FFPA8689-120
Outline/Installation Drawing

INSTALLATION (cont.)

2.1 Introduction

This section contains receiving, unpacking and installation recommendations for the model FFPA8689-120 feed forward linear power amplifier. Carefully read and review all

of the information contained in this section before attempting to install or operate the FFPA. In addition, read and review the operating instructions contained in Section 3 before operating the equipment.

2.2 Electrical Service Recommendations

MPD Technologies strongly recommends the use of AC line conditioning and surge suppression devices at the primary AC input to the power source for the FFPA. All electrical connections should be in accordance with National Electric Code, and any applicable state and local codes. In addition, lightning protection for all systems is strongly recommended. Lightning arrestors are recommended at the service entrance as well. The electric service must be well grounded.

The amplifier power source should be equipped with a separate circuit breaker, installed in a load center with a separate mains switch or breaker. This arrangement permits service and maintenance of the FFPA without the necessity for removing power to the entire site.

2.3 Receiving, Unpacking and Inspection

The FFPA has been tested and calibrated at the factory prior to shipment. No additional readjustment is required prior to installation.

The FFPA is shipped in a single container. Check the exterior of the shipping container for any visible signs of damage. If possible, open the container in the presence of the delivery agent. Carefully unpack the FFPA and save all packing material for possible reshipment. After removal from the container, check the FFPA for physical damage such as scratched panels, damaged connectors, etc. If damage is noted, immediately file claim with the delivery agent or freight carrier.

2.4 Repackaging for Shipment

Should it ever become necessary to return the FFPA for service or repair, the following procedure should be followed.

a. Use the original container, if possible.

b. Wrap the item in heavy paper or plastic before placing it in the shipping container.

c. Use packing material around all sides of the item.

d. Use a heavy cardboard box or a wooden container to house the item. Seal the container with heavy duty tape (Fiberglas) or strap the container with metal bands.

e. Mark the container: "FRAGILE - DELICATE INSTRUMENT". If the item is to be shipped to MPD for service or repair, attach a tag identifying the owner and include a description of the difficulty. Refer to the Notification of Returned Goods at the rear of this manual. In all correspondence regarding the unit, identify the assembly by both model and serial number, noting the difficulty in detail.

2.5 Environmental Limitations

The FFPA is designed to operate in an environment as noted in Table 1 of this manual. The FFPA must be installed in an area where an adequate and unrestricted supply of air is available for cooling. Adequate clearance must be provided to prevent obstruction of airflow. Confirm that proper dc power is available for the equipment.

2.6 Installation

Refer to the outline and installation drawing contained in Appendix A and the following paragraphs for installation details.

The FFPA is designed for rack mounting in a standard 19-inch rack. It is secured in the rack at each corner of the front panel. Install the FFPA in the desired location in the rack, making sure that an unrestricted supply of air is available at the front and rear of the enclosure.

2.7 Cable Interconnections

!! CAUTION !!

DO NOT CONNECT AC POWER TO FFPA UNTIL PROPER AC POWER OUTPUT HAS BEEN VERIFIED. DAMAGE TO THE FFPA CAN OCCUR IF IMPROPER VOLTAGES ARE APPLIED.

2.8 J1 – I/O Connector and Wiring

The RF, DC, and I/O interface is incorporated on one connector. It is a 24W7 Blind Mate "D" sub-miniature connector. Connections are as shown in the Table 4.

2.9 Verify Connections

Recheck all connections. Make certain that all connections are correct and secure.

2.10 Verify DC Supply Voltage

Measure the DC supply voltage which will power the FFPA. The voltage must be 27 vdc ±0.5 vdc. Refer to Section 3 for operating instructions.

!! CAUTION !!

DO NOT OPERATE FFPA WITH A DC SUPPLY VOLTAGE OUTSIDE OF THESE LIMITS. DAMAGE WILL OCCUR TO THE FFPA FROM IMPROPER SUPPLY APPLICATION.

3 OPERATING INSTRUCTIONS

3.1 Safety Precautions

During normal FFPA operation, personnel must be cognizant of the intrinsic hazards related to electronic equipment in general, and RF power amplifiers in particular. This amplifier subsystem generates high RF power (120 watts) which is dangerous and can cause serious RF burns if contacted. Caution must be exercised when working with this amplifier. While every practicable safety precaution has been incorporated into this amplifier, the following rules must be strictly observed:

!! WARNING !!

Keep Away From Live Circuits

Operating personnel must observe all safety regulations at all times. Do not make adjustments inside equipment with hazardous voltages present. Do not operate the amplifier without proper RF termination.

Do Not Service or Adjust Alone

Under no circumstances should any person reach within or enter any enclosure for purposes of servicing or adjustment without the immediate presence and assistance of another person capable of rendering aid. Knowledge of first aid for electrical shock and burns is necessary.

Personnel

Only trained personnel are to service and adjust the amplifier. Personnel must be trained in the maintenance of equipment with hazardous RF power, and must be familiar with this amplifier. In addition, the following precautions must be observed during operation.

!! WARNING !!

Maintain proper termination at the output port of the FFPA. Do not remove or exchange RF cables of the output load circuit while the FFPA is in operation. Dangerous RF voltage may exist at the foremost terminal of the interrupted load circuit during operation.

!! CAUTION !!

All interconnecting cables must be connected prior to application of RF power. Although the FFPA is designed to withstand all output load conditions including open and short circuit conditions, it is recommended to connect an appropriate RF load to the output port of the FFPA prior to application of RF power.

!! CAUTION !!

Maintain proper RF input to the amplifier. Damage to the amplifier may occur if excessive RF input is applied.

3.2 Controls and Indicators

The FFPA is equipped with local controls and indicators on the front panel, and a rear panel I/O interface for remote status monitoring and control. The following paragraphs detail these features.

3.2.1 Local Controls and Indicators

Figure 3 is the front view of the FFPA, and the following controls and indicators:

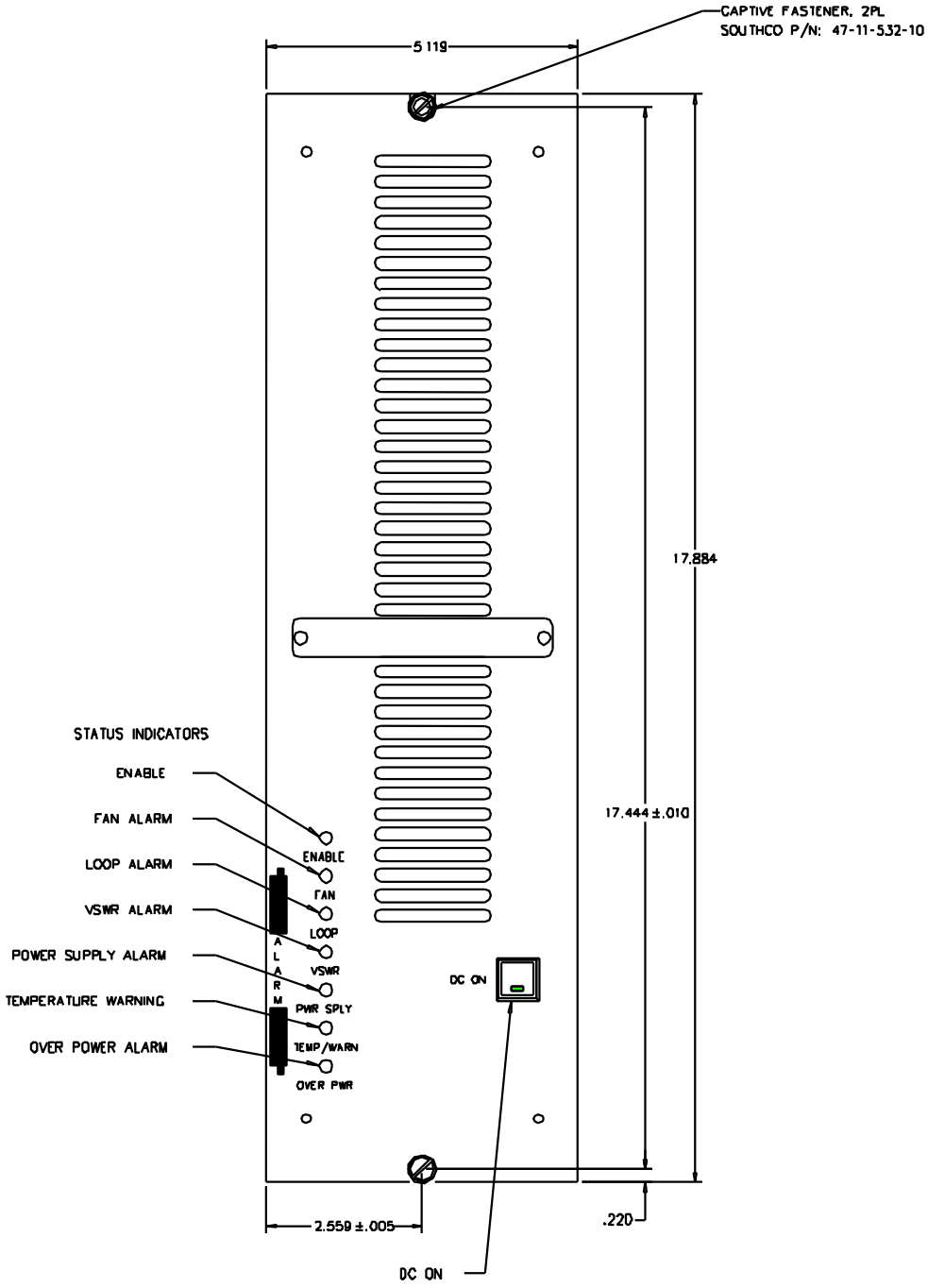


Figure 3 Model FFPA8689-120
Local Controls and Indicators

FFPA Status & Alarms

POWER ON/OFF** - line switch/circuit breaker, turns on high power +27V power supply circuitry.

DC ON** - Green LED indicating presence of DC from high power +27V power supply. This is located on the ON/OFF switch.

ENABLE ON** - Green LED indicates unit is ENABLED and biased on.

FAN ALARM - Yellow LED indicating a blocked or non-functioning fan.

LOOP ALARM - Red LED indicating control loops can no longer minimize IMD performance.

VSWR ALARM - Red LED indicating load VSWR is greater than 3.0:1.

POWER SUPPLY ALARM - Red LED indicating a power supply generated voltage is out of range.

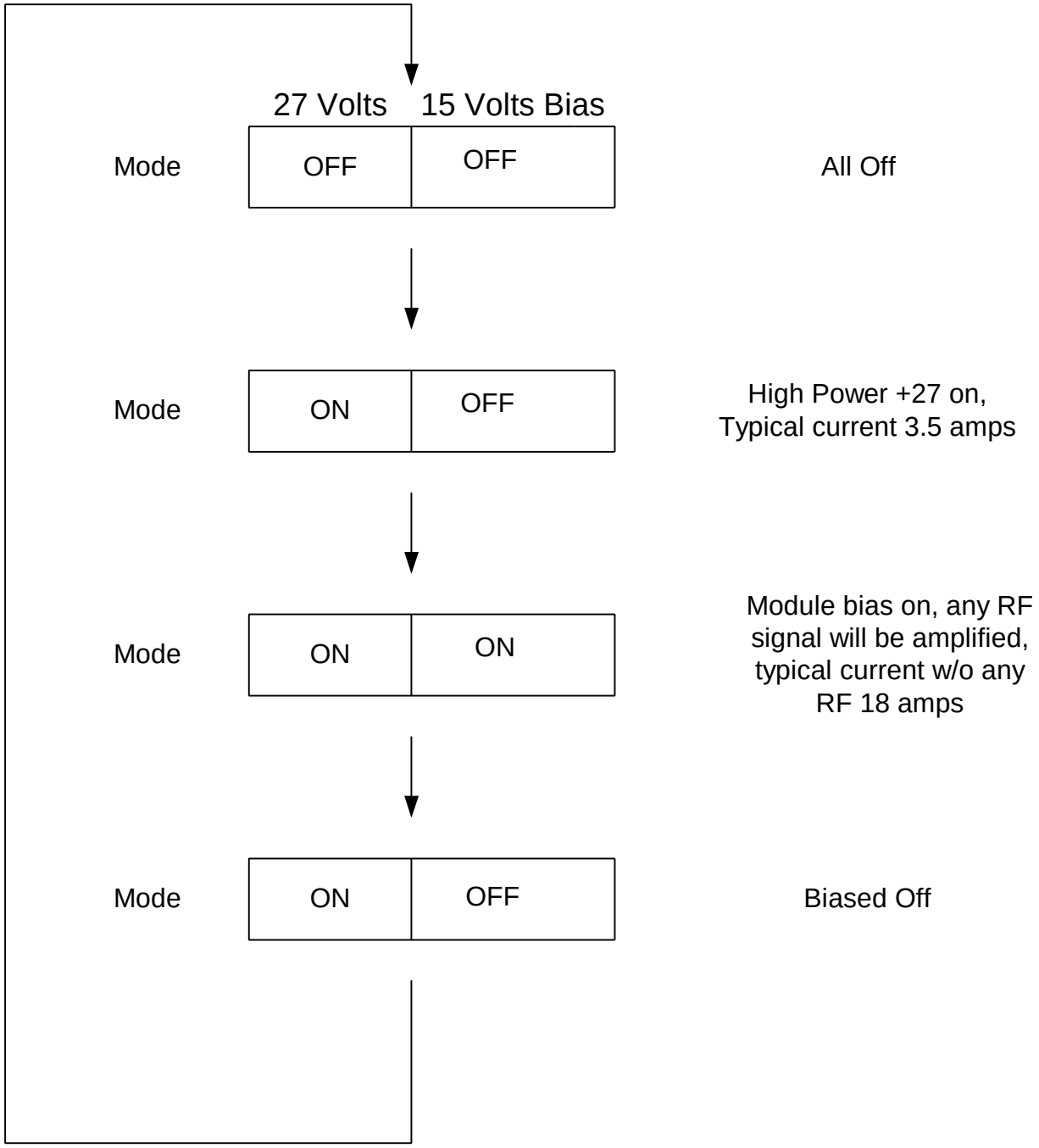
TEMP WARNING/ALARM – Bi-Polar LED. Yellow indicating excessive temperature of approximately 80ºC as monitored on the heatsink. Red indicating excessive temperature of approximately 90ºC as monitored on the heatsink.

OVERPOWER ALARM - Red LED indicating that the RF output power from the FFPA is greater than 2 dB above nominal operating power level.

NOTE: *Loop, VSWR, Power Supply, Temperature, and Overpower alarms will shut the FFPA down.*

See the note on the following page regarding the ON/OFF sequence of the FFPA

ON/OFF Sequence of the FFPA Module



ON/OFF Sequence Summary: First, the FFPA module's high power +27 VDC and +15 VDC bias are both off. After depressing the On/Off switch once, the high power +27 VDC is on while +15 VDC bias voltage is off. Typical current is 3.5 amps. After depressing the On/Off switch a second time, both the +27 VDC and +15 VDC bias are on. Typical current without any RF applied to the FFPA is 18 amps. Pressing the On/Off switch a third time will bias off the Module. Pressing the On/Off switch a fourth time will turn off the FFPA module completely.

3.22 Remote Control/Status Interface

The FFPA is equipped with control inputs as well as built-in-test (BIT) status outputs at I/O connector J4. Table 3 details the interface and describes the signals.

3.3 Initial Turn On Procedure

The following procedure is intended to verify operation of the FFPA following installation or repair/replacement.

!! WARNING !!

Equipment operators must be familiar with all safety precautions outlined at the beginning of this section prior to operating the FFPA. Operator injury and/or equipment damage will result from improper operation.

a. Verify that all connections to the FFPA have been properly made in accordance with Section 2 of this manual, and the outline and installation drawing, Figure 2.

b. With no RF applied to the FFPA, press the POWER ON/OFF switch once. The DC ON LED on the ON/OFF switch will be illuminated, and the fans will be activated.

c. Observe that only the following indicators are illuminated on the front panel of the FFPA:

DC ON

d. Press the ON/OFF switch a second time. The DC on and Enable LEDs will both be illuminated.

e. Observe that the following indicators are illuminated on the front panel of the FFPA:

DC ON

ENABLE

f. Apply reduced RF input (-60 dBm) to the FFPA RF IN connector within the 869-894 MHz frequency range, and observe that all indicators remain as in step e.

!! CAUTION !!

Maintain proper RF input level within the 869-894 MHz operating band. Improper RF input may cause severe FFPA damage.

g. Increase input level to between -15 and -11 dBm, and observe that only the following indicators are illuminated on the front panel of the FFPA:

DC ON

ENABLE

3.4 Normal Operation

The FFPA requires minimum attention during normal operation. Monitoring of the BIT status output and output meter provides an overall indication of FFPA health.

3.5 Shut Down Procedure

a. Reduce RF input signal level to minimum (-60 dBm).

b. Press the PWR ON/OFF switch once to disable the bias voltage, two times to shut down the module altogether.

c. If maintenance or service is to be performed on the FFPA, deactivate prime dc power to the FFPA.

4.0 PRINCIPLES OF OPERATION

4.1 Introduction

This section contains a functional description of the Feed Forward linear SMR Power Amplifier. Refer to the block diagram of the FFPA8689-120 FFPA, Figure 4.

4.2 RF Input Signal

The maximum input signal for all carrier frequencies should not exceed the limits specified in the electrical specifications. The input VSWR should be 2:1 maximum (or better).

4.3 RF Output Load

The load impedance should be as good as possible (1.5:1 or better) in the operating frequency band for good RF power transfer to the load.

4.4 System Functional Description

The FFPA8689-120 amplifier is a linear, feed forward power amplifier which operates from 869 to 894 MHz with a rated output power of 120W total (average). The amplifier produces better than 65 dBc intermodulation products. The amplifier operates from a 24-28 vdc input power source, and provides a rear I/O interface to report all faults and alarms. The front panel of the amplifier contains the DC ON/OFF switch, and the status LEDs.

The amplifier is comprised of the following:

Carrier Cancellation
Main/Error Driver Amplifier
Main Amplifier
Error Amplifier
DC/DC Function
Microprocessor Control
Loop Processor
Pre-distorter

The main amplifier employs class AB amplification for maximum efficiency and low intermodulation distortion. The error amplifier and main/error driver amplifiers operate class A mode. The input RF signal is amplified by the carrier cancellation and then split into a signal and a reference path. The signal path is sent through the main driver amplifier where the amplitude and phase are modified based on the reference signal, and then amplified by the main amplifier. The signal is coupled off to the carrier cancellation where the 180 degree converted amplified signal meets the reference signal. At this point the combined signal which has a canceled carrier (called the IMD signal) is sent to the IMD leg of the feed forward amplifier.

The IMD signal is sent to the error driver amplifier and error amplifier. The signals amplitude and phase are adjusted from the input by the loop processor. The signal is re-injected into the main amplifier output signal and the combined signal yields intermodulation suppression of 65 dBc minimum.

4.4.1 Main Amplifier

The main amplifier operates class AB that provides approximately 22 dB of gain over the operating frequency band of 869-894 MHz. The main amplifier operates on 27.0 VDC, and utilizes 15V DC to derive bias. The main amplifier is directly mounted to the heatsink. Within the main amplifier are the temperature sensors, which detect the baseplate temperature.

4.4.2 Error Amplifier

The main function of the error amplifier is to amplify the distortion products generated by the main amplifier, so they can be canceled when the signal is coupled onto the main signal at the output of the amplifier. The error amplifier operates class A, has 47 dB of gain, and produces a 2W output. The amplifier operates on 27.0 VDC, and

utilizes 15V DC to derive bias. The error amplifier is mounted to the heatsink, and utilizes an output circulator to protect the error amplifier output. The load port of the circulator is connected to a detector to monitor reverse power. This analog voltage is monitored by the microprocessor to determine the safe reverse power levels during operation. If the detector level is too high (greater than a 3:1 mismatch), the amplifier goes into a fault mode and bias is turned off for protection.

4.4.3 Amplitude and Phase Adjustment

The two loops are controlled via the microprocessor through the main and error driver amplifiers. The amplifiers include a vector control circuitry to adjust amplitude and phase of the RF signals. The microprocessor controls the amplitude and phase adjustment for the two loops. The loop processor responds to the amplitude and phase of the IMD loops.

4.4.4 Amplifier Module Cooling

The amplifier is cooled via forced air through the heatsink. Two rear fans are used to draw air through the heatsink. The fans are field replaceable and are monitored for fan faults.

4.5 Power Distribution

The amplifier employs a DC/DC converter to regulate the amplifier sub-circuits to the required voltage, based on a 22-29V DC input. The power supply board converts the input voltage to +/-5V, and +/-15V used by the loop processor and microprocessor.

4.6 Intermodulation

The FFPA8689-120 amplifier is designed to deliver 120W average power, multicarrier signal, operating over the passband of 869-894 MHz.

4.6.1 Two Tone Intermodulation

When measured with two equal CW tones, spaced anywhere from 30 kHz to 25 MHz apart, and at any power level up to the peak power, the third order intermodulation products are below -65 dBc.

4.7 Alarms

The amplifier reports various alarms, indicated via a front panel LED, and via the I/O connector on the rear.

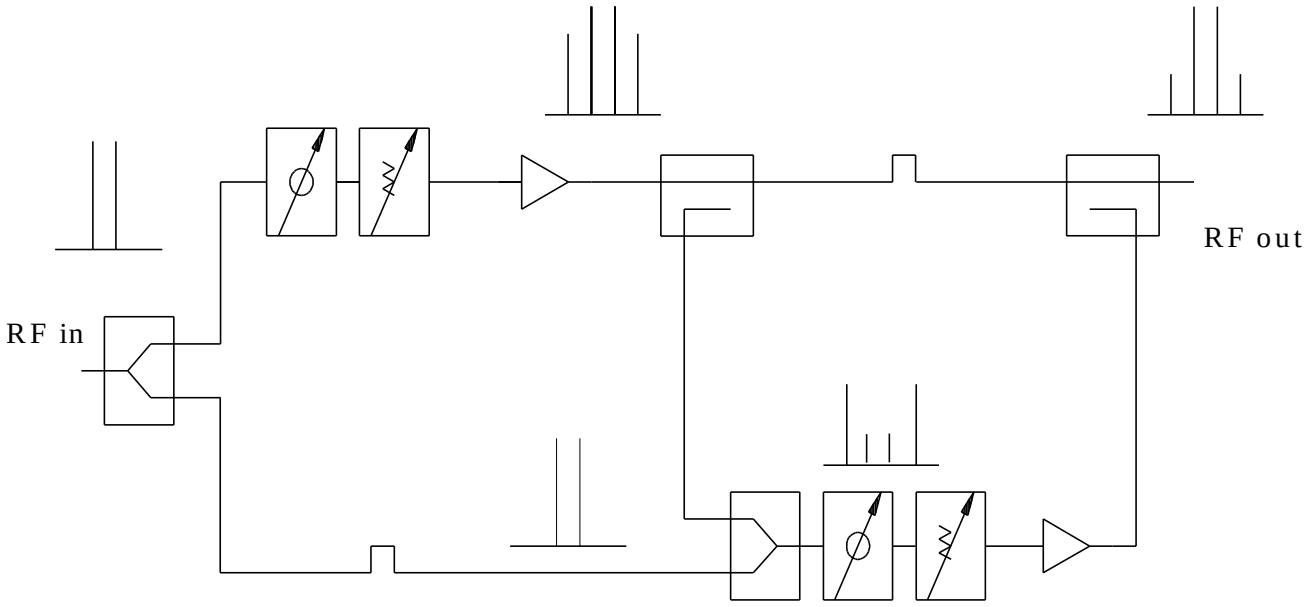


Figure 4. Block Diagram, Model FFPA8689-120 FFPA

5.0 MAINTENANCE

5.1 Introduction

This section provides information for periodic maintenance of the FFPA, as well as tests which are recommended in order to evaluate performance of the amplifier.

NOTE

Do not attempt to repair the FFPA. The amplifier contains no user-serviceable components, with the exception of the fans. Do not break the seals on the equipment, as this will void the warranty. A Return Authorization Number must be obtained from the factory prior to returning any equipment. Refer to the Notification of Returned Goods form at the rear of this manual for further instructions.

5.2 Periodic Maintenance

Periodic maintenance tasks and recommended intervals are listed in Table 4.

Table 4. Periodic Maintenance Tasks

TASK	INTERVAL	ACTION
Cleaning		
Air Inlets/Outlets	30 Days	Inspect and clean in accordance with paragraph 2.3.
Inspection		
Cables and Connectors	12 Months	Inspect all cables for any signs of damage or wear. Check and verify that all connections are secure.
Performance Tests	12 Months	Perform tests as outlined in paragraph 2.5.

5.3 Cleaning Air Inlets/Outlets

The air inlets and outlets are located at the front and rear of the unit. Air is drawn in from the front, and exhausted through the rear of the FFPA. These areas should be cleaned at 30 day intervals, or sooner, if the equipment is operated in a severe dust environment. Use dry, low pressure compressed air or a brush with soft bristles to loosen remove and clean off any accumulated dust from the air inlet and outlet areas.

5.4 Test Equipment Required

Table 5 lists the test equipment required for evaluating FFPA performance. Suitable equivalents may be substituted.

Table 5. Test Equipment Required

NOMENCLATURE	QTY	MANUFACTURER	MODEL
Signal Generator	1	H/P	ESG
Attenuator, 40 dB, 250 Watt	1	Weinschel	S3-40-43
Attenuator, 20 dB, 20 Watt	2	Weinschel	AT20
Spectrum Analyzer	1	H/P	8560E
Directional Coupler, 30 dB	1	RF Power	DDC-901-931-R5-30
Power Meter/Sensor	1	H/P	437B/8481A
Power Supply	1	H/P	6673A

5.5 Performance Tests

Performance tests should be performed at 12 month intervals, or as directed by the resident maintenance authority, to ensure that the FFPA is functioning properly and within expected specification limits.

Figure 5, Front View FFPA 8689-120

Figure 6, Back View FFPA 8689-120

Table 2. J1 – Blind mate 24W7 D Sub-miniature Connector

J1-Connector Pin	Signal Name	Description
1-6	N/C	
7	Data Out 1	RS-232
8	Data In 1	RS-232
9	Signal Ground	
10	Reserved	Internal usage
11	Data Out 2	RS-232
12	Data In 2	RS-232
13-14	Reserved	Internal usage
15-17	N/C	
A1	RF in	
A2	N/C	
A3, A4	+DC Power In	
A5, A6	DC Power Return	
A7	RF out	