ADVANCED ENERGY®

RFX 600A

April 2003 5706059-F

User Manual

User Manual

RFX 600 A

5706059-F

ADVANCED ENERGY®

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Introduction

READ THIS SECTION!

To ensure safe operation, you should read and understand this manual before you attempt to install or operate this unit. At a minimum, read and heed the “Safety” section in this chapter.

INTERPRETING THE MANUAL

Type Conventions

To help you quickly find what is being discussed, the manual presents certain words and phrases in type that are different from the rest of the text. We use the following type conventions:

- Pin and signal names appear in capitalized italics (*DUTY CYCLE.A*).
- Labels that are on the unit (switches, indicators, etc.) generally appear in boldface capital letters (**MODIFY**); however they appear as you see them on the unit. Exceptions are port names, which simply begin with a capital letter (User port).
- Functions appear in boldface lowercase letters (**analog input filtering**).
- Commands appear in small, bold capital letters (**START**)

Icons (Symbols)

This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. It is found whenever needed in the manual.

We include this symbol in Danger, Warning, and Caution boxes to identify specific levels of hazard seriousness.

DANGER:

This box identifies hazards that could result in severe personal injury or death.

WARNING:
This box identifies hazards or unsafe practices that could result in personal injury.

CAUTION:
This box identifies hazards or unsafe practices that could result in product or property damage.

The following symbols could appear on labels on your unit.

- Hazardous Voltage

1332

- Short circuit protected

1024

- High voltage

1028

- Protective earth ground

1029

- Chassis ground

1069

- Warning (refer to manual)

- CE label

- Non-ionizing radiation

- Hot surface

SAFETY

Do not attempt to install or operate this equipment if you have not first acquired proper training.

- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper ESD precautions.
- BE CAREFUL AROUND THIS EQUIPMENT.

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

PRODUCT SAFETY/COMPLIANCE

Certain options of this unit have been tested for and comply with the following Electromagnetic Compatibility (EMC) standards.

Directives

The following tables list the Electromagnetic Compatibility (EMC) and Safety directives.

Table 1-1. *Electromagnetic Compatibility (EMC)*

Directive	Description
89/336/EEC 92/31/EEC	EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).

Table 1-2. *Safety Directives*

Directive	Description
73/23/EEC	EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive).
SEMI S2-93	Safety Guidelines for Semiconductor Manufacturing Equipment

Table 1-3. *SEMI Guidelines*

Directive	Description
SEMI S2-0200	Environmental, Health and Safety Guideline for Semiconductor Manufacturing
SEMI S8-0600	Safety Guidelines for Ergonomics Engineering of Semiconductor Manufacturing

Standards

This device has been designed to meet the following Safety and EMC standard(s):

- EN 61000-6-2
- EN 55011 (Class A, Group 2)(CISPR 11)
- 47 CFR Part 18

This device must be installed and used only in compliance with the standards listed in addition to VDE 0113, EN 60204 (IEC 204), and applicable requirements.

For more information, refer to the letter of conformance (US) or declaration of conformity (EU) accompanying the product.

Installation Requirements

WARNING:
Operating and maintenance personnel must receive proper training before installing, troubleshooting, or maintaining high-energy electrical equipment. Potentially lethal voltages could cause death, serious personal injury, or damage to the equipment. Ensure that all appropriate safety precautions are taken.

Conditions of Use

To be in compliance with the stated directives and standards, you must meet the following conditions of use.

- This device must be used in an over voltage category II installation only. Install and operate this device with an approved isolation transformer on the ac input.
- Before making any other connection, connect the auxiliary Protective Earth ground conductor on the rear panel.
- The RFX 600A generator should be properly grounded through its input power ac ground. Additionally, for proper operation, you must ensure the power and ground connections between the generator and tool are adequate.
- Use only a shielded cable on the input power connector.
- Use only a shielded power cable on the output power connector.
- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, depending on the working environment, a temporary conductivity caused by condensation may occur when the device is not operating.

- Non-standard connectors for input and/or output power must be inaccessible to the user.
- To provide the required over-current protection, install and operate this device with an AE-approved circuit breaker on the ac input.

Theory

FLEXIBLE POWER REGULATION AND FLEXIBLE CONTROL

With these units, you can choose one of three methods for regulating RF output:

- Forward power
- Load power
- DC bias (some options)

With the RFX 600A, you have the flexibility to control from the unit's front panel (with specific options) or from an analog User port connector, and because control settings are stored in non-volatile memory, you will not lose them if input power is interrupted. You can also order your RFX 600A with a passive front panel. With this option, you can control and monitor the unit remotely through a standard 25-pin, parallel analog/digital interface.

GENERAL DESCRIPTION

The RFX 600A generator introduces innovative power amplifier design and instrumentation providing superior repeatability, stability, linearity, and accuracy. Its small size (1/2 rack) allows it to be mounted within a system, eliminating the need for long interconnect cables and separate generator racks. The RFX 600A can be rack mounted together with another RFX 600A or Tuner Controller to fit in a full-rack size mount without a special adapter.

The RFX 600A is a three-stage power generator using a class AE power amplifier, a switchmode dc power supply for main power and control, and a Power Factor Correction (PFC) circuit to reduce current harmonic distortion. The RFX 600A can handle up to 400 W reflected power.

The RFX 600A generator's features allow it to be used alone or in combination with other supplies (through the common exciter mode) in such configurations as RF with RF bias, RF with dc bias, and dc with RF bias.

The RFX 600A provides 600 W at 13.56 MHz power into a non-reactive, 50 Ω load and is designed to work in system environments with the output controlled by signals through the User port.

The RFX 600A uses a 25-pin parallel User port for communication with the host system. The RFX 600A's interlock loop uses electro-mechanical devices only and is designed for simple contact closure provided by the user's system. The RFX 600A meets the European regulatory requirements pertaining to safety, emissions, immunity, and power factor correction.

The RFX 600A can be configured with an active front panel, allowing you to manually control and monitor the generator's performance. The front panel includes a membrane-style panel for high reliability.

The RFX 600A permits power regulation based on either forward power, load power (forward power minus reflected power), or dc bias regulation (using an externally supplied, normalized signal representing dc bias).

The RFX 600A supports common exciter (CEX) operation where the CEX output of one unit may be connected to the CEX input of another unit causing the second unit to frequency lock its output to the frequency of the first unit.

The RFX 600A is air cooled. In the event of an over temperature condition, you are alerted by an indicator on the front panel and the RF output is stopped.

THEORY OF OPERATION

There are four main sections within the RFX 600A. Figure 2-1 and Table 2-1 outline the theory of operation of this efficient source of power.

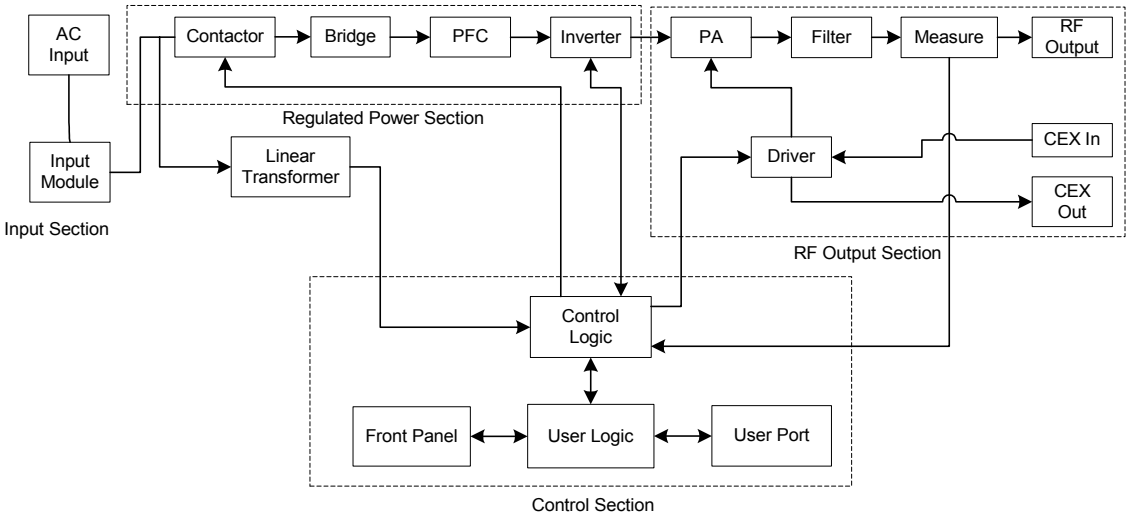


Figure 2-1. *Simplified functional block diagram*

Table 2-1. *Functional Block Diagram Explanation*

Input Section	
Input Module	The Input Module consists of a fused ac input, an ac power switch and an ac line filter for suppression of electromagnetic and radio frequency emissions.
Regulated Power Section	
Contactor	The Contactor is engaged through an interlock string. The Contactor includes a *soft-start resistor* that limits current until the desired bus voltage is reached. When the voltage is reached, the resistor is shorted and no longer limits current.
Bridge	The Bridge Rectifier converts the incoming ac line voltage to dc.
Power Factor Converter (PFC)	The PFC actively keeps the voltage and current in phase and boosts the bus voltage from 300 to 400 V across the bus capacitor.
Inverter	The Inverter chops the dc bus at 100 kHz, transforms it through an isolation transformer, and then rectifies the 100 kHz output. The inverter dc output is controlled by a PWM (pulse width modulation) technique.
RF Output Section	
Driver	The Driver provides the 13.56 MHz drive to the PA
Power Amplifier (PA)	The PA is powered by the dc output from the inverter and amplifies the 13.56mhz signal from the driver to produce the RF output
Filter	The Filter takes the output from the PA, filters out the harmonics, and stabilizes the power.
Measurement	The Measurement section measures power out and provides feedback to the Control Logic. This provides the closed loop for forward and load power regulation.
CEX Out	The CEX Output is a low voltage signal whose frequency matches the frequency of the RF output. This signal can be connected to another generator's CEX input to frequency lock it to this generator's RF signal.
CEX In	The CEX Input can be used. The RF Output of this generator must be frequency locked to another generator or to a system clock. This input is connected to a phase lock loop circuit in the RFX 600A.
Output	The Output section provides the final output to the system the RFX 600A generator is installed in.

Table 2-1. *Functional Block Diagram Explanation*

Control Section	
Linear Transformer	This transformer provides the housekeeping supply for the generator.
Control Logic	The Control Logic section provides the following: • Active protection circuitry for operation in abnormal load conditions, such as an open or short circuit • Controlled regulation when operating in forward power or load power modes
Front Panel	The Front Panel provides the controls, indicators, and displays for manual operation of the generator. The RFX 600A is available with an active front panel which permits control and monitoring function or a passive front panel (monitoring only).
User Port	The User port provides the communication port for remote control of the generator.
User Logic	The User Logic takes your input and makes it usable for the User port.

CEX Mode of Operation

In the common exciter (CEX) mode of operation, two generators are coupled into the same plasma. In this type of operation, slight differences in output frequency can create *beat* frequencies that may even be visible in the plasma. This may have adverse effects on the plasma process. To prevent unwanted beat frequencies, two RFX 600A generators can be locked together so that they run at the same frequency. This ensures repeatable RF characteristics within the plasma.

RFX 600A generators are extremely easy to operate in the CEX mode. One unit is chosen as the *master* and the other as the *slave*. The CEX output of the master is connected to the CEX input of the slave. If the slave unit receives a signal of the proper frequency and amplitude at its CEX input, it automatically frequency locks to that signal and tracks the master unit's oscillator.

More than two generators can be locked together to a single master unit by *daisy chaining* the CEX outputs and inputs. That is, the CEX output of the master is connected to the CEX input of the first slave; the CEX output of the first slave is connected to the CEX input of the second slave; and so on. Also, any number of generators may be locked to a single system oscillator as slave units by supplying each RFX 600A generator with a signal of the proper frequency and amplitude at its CEX input. See Chapter 6 for more information on CEX operation modes.

The phase relationship between the RF outputs of the generators is affected by the length of the cable used to interconnect the CEX outputs and inputs of the generators. At 13.56 MHz, a single wavelength (360° of phase rotation) is approximately 48′ in

typical 50 Ωcoaxial cable. Use of a very short CEX interconnecting cable (as supplied in the hardware kit) between two RFX 600A generators results in little phase shift. Varying this length or using commercially available phase shifters inserted in the interconnection path can provide more control of this relationship, if required.

Specifications

PHYSICAL SPECIFICATIONS

Table 3-1. *Physical Specifications*

Size	17.7 cm (H) x 21.6 cm (W) x 40.6 cm (D) 6.97″ (H) x 8.5″ (W) x 16″ (D)
Weight	15 kg (33 lb)
Connector Specifications	
RF Output	Type N, coaxial, female
AC Input Power	Male, IEC 320 style
User Port	25-pin shielded, female, subminiature-D
CEX Input	Female, type BNC
CEX Output	Female, type BNC

ELECTRICAL SPECIFICATIONS

Table 3-2. *Input Power Options*

Nominal Voltage	Voltage Range	Frequency	Maximum Line Current	Overcurrent Protection
115 VAC single phase	104 to 126V	47/63 Hz	12 amps	15 amp fuse
200 VAC single phase	180 to 229V	47/63 Hz	6.5 amps rms	8 amp fuse
230 VAC single phase	207 to 253V	47/63 Hz	5.3 amps rms	6.3 amp fuse

Table 3-3. *Electrical Specifications*

Frequency	13.56 MHz, ±.01%
Output Power	6 to 600 W operator-selectable setpoint
Regulation	±2% of setpoint or ±3 W, whichever is greater, as measured at the output of the generator when terminated in a non-reactive, 50 Ω load
Transient Regulation	±0.1% change for a 10% disturbance in the ac line voltage within the line voltage operating range
Load Impedance	50 Ω, ±2 Ω
Reflected Power Limit	Automatic foldback (forward power limiting) occurs if the reflected power at the generator output exceeds 400 W or if other internal preset limits are exceeded.
Harmonics	At full-rated output, all harmonics are 50 dB (or more) below the RF output signal when operated into a 50 Ω, non-reactive load impedance.
Spurious Noise	All spurious (non-harmonic) outputs are 45 dB (or more) below the RF output signal when operated into a 50 Ω, non-reactive load impedance.
CEX Specifications	
CEX Input	
Signal Amplitude	-1 dBm (288 mV_{pk}) minimum, +10 dBm (1.012 V_{pk}) maximum
Frequency	13.56 MHz, 0.005%
Impedance	50 Ω, ±2 Ω

Table 3-3. *Electrical Specifications (Continued)*

CEX Output	
Signal Amplitude	+3 dBm minimum, +7 dBm maximum
Impedance	50 Ω, ±2 Ω

COOLING SPECIFICATIONS

The RFX 600A generator is air cooled and requires clearance of at least 1″ on its sides and 6″ at the front and rear. There are no minimum requirements for clearance above and below the generator.

ENVIRONMENTAL SPECIFICATIONS

Table 3-4. *Climatic Specifications*

	Temperature	Relative Humidity	Air Pressure
Operating	Class 3K3 +5°C to +40°C +41°F to +104°F	Class 3K2 15% to 85% [a] +2 g/m^3 to +25 g/m^3	Class 3K3 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Storage	Class 1K4 -25°C to +55°C -13°F to +131°F	Class 1K3 35% to 95% [a] +1 g/m^3 to +29 g/m^3	Class 1K4 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Transportation	Class 2K3 -25°C to +70°C -13°F to +158°F	Class 2K3 95% [b] +60 g/m^3 [c]	Class 2K3 66 kPa to 106 kPa 660 mbar to 1060 mbar (approximately 3265 m above sea level)

a. Non-condensing
b. Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25°C to +30°C

c. Maximum absolute humidity when the unit temperature directly decreases from +70°C to +15°C

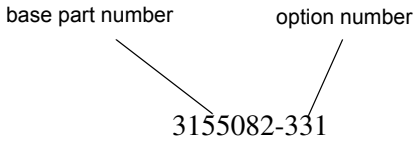
Connectors, Indicators and Controls

UNDERSTANDING THE INFORMATION IN THIS CHAPTER

The RFX 600 A product line provides several customer-selectable control and communication options as well as a choice of input power specifications. These options can be combined into many different configurations, all of which are covered by this manual. The available options include four different user port configurations, three input voltage configurations, and two front panel configurations. In order to identify the correct information for your unit, use the following configuration chart.

RFX 600 A Configuration Information

Each RFX 600 A model is assigned a part number which includes both a seven-digit base number and a three-digit *option number*, as in the following example:



The base part number for all RFX 600 A models is the same (3155082). The three-digit option number identifies the customer-selected options on your unit, with each digit representing an option category.

- The most significant digit of the option number represents the ac input line voltage.
- The middle digit represents the User port.
- The least significant digit represents the type of front panel.

The following table shows how to interpret the option number on your RFX 600 A, which indicates the options on your unit. It also provides references to the sections of this chapter that apply to those options.

User Port Options

Your RFX 600 A unit has one of four User ports. Use the information in the preceding section to determine which User port your unit has. All four User ports utilize the same connector, a female, 25-pin, subminiature-D connector, as shown in the following illustration. All four ports provide both analog and digital signals. The following sections describe each of the User ports and their signals in detail.

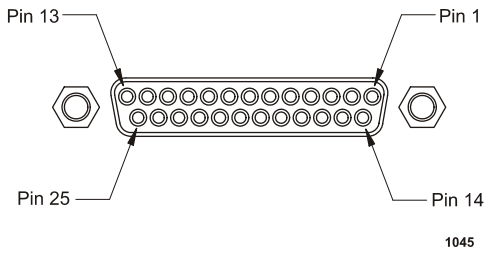


Figure 4-1. *User Port Connector*

Table 4-1. *RFX 600 A Option Number Configurations*

Digit	Category	Configuration and Description	Manual Page Number
1	AC input line voltage	1 = 104 to 126 Vac (nominal 115 V, 1ϕ) 2 = 207 to 253 Vac (nominal 230 V, 1ϕ) 3 = 180 to 229 Vac (nominal 200 V, 1ϕ)	Table 3-3, “Electrical Specifications,” on page 3-2

Table 4-1. *RFX 600 A Option Number Configurations*

Digit	Category	Configuration and Description	Manual Page Number
2	User port	Option 0 = RFX 600 compatible Option 1 = 0 to 10V Option 2 = 0 to 5V Option 3 = RFG compatible	“Option 0 User Port (RFX 600 Compatible)” on page 4-4 “Regulation Mode Select” on page 4-8 “” on page 4-14
3	front panel	0 = active front panel 1 = passive front panel 2 = passive front panel (custom configuration)	“Front Panel” on page 4-25 “Passive Front Panel” on page 4-33

Option 0 User Port (RFX 600 Compatible)

User port uses a female, shielded 25-pin subminiature-D connector.

All analog signals are 0 to 5 V. All digital input signals are CMOS level (10 to 18 V required for logic high), and all digital output signals are open-collector signals with return lines non-referenced to ground, 45VC and 12mA maximum. The following table contains the pins and their descriptions.

Table 4-2. *Option 0 User Port Pin Descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1	2	*DC BIAS*	Analog Input	Differential input for scaled feedback from the chamber. This signal can also be used for DC bias regulation. 0-5V = 0-1000V DC bias. The maximum working voltage for this connection is 5V above chassis ground. The more positive of the two feedback leads should be connected to pin 1.
3	19	*RF OFF/RESET*	Digital Input	This signal, in conjunction with the ON signal (pin 4), is used to enable or disable the RF output of the generator. A logic high on this pin disables the RF output, regardless of the state of the ON signal. A logic low is required on this pin either at the time of or prior to the leading edge of the ON signal (pin 4) to activate RF power. Once RF power is activated, the power shall remain on until the OFF/RESET signal goes high. This signal is referenced to pin 19. The OFF/ RESET signal can be tied to the ON signal (pin 4) to allow “single signal” control of the RF power.

Table 4-2. *Option 0 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
4	19	*RF ON*	Digital Input	The remote digital ON command duplicates the RF ON function of the front panel, when remote control has been selected at the front panel. A momentary contact closure of this pin to POWER COMMON (pin 19) will cause the generator drive to turn on if RF OFF/RESET has been overridden. A two-wire on command is possible with RF ON and RF OFF/RESET connected together. To accomplish this both must be connected to POWER COMMON (pin 19) simultaneously to turn the generator drive on.
5		*RESERVED*	N/A	Reserved for future use
6	19	*CEX ENABLE*	Digital Input	This signal enables the common exciter feature in the RFX 600A generator. A logic low enables the CEX mode. A logic high causes the unit to ignore the CEX input signal and use only its free-running internal oscillator.
7	19	*MODE SELECTION 0*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
8	19	*MODE SELECTION 1*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
9	19	*RESERVED*	N/A	
10		*RESERVED*	N/A	Reserved for future use

Table 4-2. *Option 0 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
11	18	*REMOTE SETPOINT*	Analog Input	When the generator is operating in remote mode, this signal is used to establish the desired output power level (set-point). When the generator is regulating its output based on forward or load power, this signal is scaled 0-5V = 0 to 600 watts. When DC bias regulation mode is selected, this signal is scaled to 0-5V = 0 to the maximum expected DC bias voltage (see descriptions for pin 1).
12		*RESERVED*	N/A	Reserved for future use
13	23	*SERIES INTERLOCK A*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 23 satisfies the interlock criteria. The RFX 600A's interlock circuitry is designed for use with simple contact closure devices (switches and/or relays).
14	18	*REFLECTED POWER*	Analog output	This signal represents the reflected power from the generator and is scaled such that 0-5V represents 0 to 600 watts.
15	18	*LOAD POWER*	Analog output	This signal represents the delivered power from the generator (forward minus reflected) and is scaled such that 0 to 5 represents 0 to 600 watts.
16	18	*DC BIAS*	Analog output	This signal represents the DC bias input from the match network (if used). This buffered readback signal provides a positive (0 to 5 V) analog representation of the differential signal found on pins 1 and 2 and uses the same scaling, which represents 0 to 1000V.
17	18	*FORWARD POWER*	Analog Output	This signal represents the forward power from the generator and is scaled such that 0 to 5 V represents 0 to 600 watts.

Table 4-2. *Option 0 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
18		*SIGNAL COMMON*	Signal Reference	Ground reference for all analog signals.
19		*POWER COMMON*	Digital input/ output	Ground reference for all digital and control signals.
20		*RESERVED*	N/A	Reserved for future use.
21	19	*-15 VDC*	Supply Voltage	- 15 V supply provided by the generator, limited to 50 mA.
22	19	*+15 VDC*	Supply Voltage	+15 V supply provided by the generator, limited to 50 mA.
23	13	*INTERLOCK B*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 13 satisfies the interlock criteria. The generators interlock circuitry is designed for use with simple contact closure devices (switches and/or relays.)
24	19	*POWER LIMIT*	Digital output	Indicates whether or not the generator is producing the requested output power. When high, this signal indicates that the generator is unable to supply the requested amount of power (set-point) due to some internal protection limit. The RFX 600A generator protects itself from abnormal operating conditions through the use of current, voltage, and power dissipation limits.
25	19	*RF ON STATUS*	Digital output	Indicates the state of the generator's RF output. When high, this signal indicates that the generator's output is enabled.

REGULATION MODE SELECT

Mode Select 1 (pin 8)	Mode Select 0 (pin 7)	Regulation Mode
Logic Low	Logic Low	Forward Power
Logic Low	Logic High	Load Power
Logic High	Logic Low	DC Bias
Logic High	Logic High	Forward Power

Table 4-3. *Regulation Mode Select for Option 0 RFX Compatible*

User Port Electrical Characteristics

The 25-pin User Port on the RFX 600A generator provides analog and digital signals for control and monitoring of the generator functions. Figure 1 shows the electrical diagrams for the interface circuitry in the generator. The following are descriptions of the signal types used:

Analog Outputs
The analog readback signals from the generator (pins 14, 15, 16 and 17) are driven by precision operational amplifiers (industry type OP400). These devices are capable of driving high-capacitance loads such as those expected in shielded interface applications. The user's receiver must present a 10k ohm (or greater) impedance to these signals. The readback signals, which represent the forward and reflected power as measured at the output of the generator, are scaled as defined in the signal description table above.

Analog Input
The analog signals from the user (pins 1 and 11) is a 0 to 5 volt signal scaled to represent the desired forward power from the generator (refer to the signal description table for details).

Signal common (pin 18)
Must be connected to the user's controllers chassis common for proper operation.

Digital Inputs
The digital input signals (pins 3, 4, 6, 7 and 8) are opto-coupled (industry type 4N37). The user's signal drives the LED in the opto-coupler through a 1.5K Ohm resistor. A signal level of 10 volts to 18 volts applied to the input pin activates the signal.

Interlock
The interlock signals (pins 13 and 23) provide the dc power to close the ac contactor in the generator. Pin 13 is tied to the generator's +24V supply. Pin 23 is series wired with the interlock (Standby) switch on the front panel and then ties to the coil of the contactor relay. Connecting pin 13 to pin 23 closes the contactor, enabling ac power to

the RF circuits (assuming that the front panel standby switch is closed). Safety interlock status (pins 24 and 25) indicate this circuit has been satisfied by presenting a low impedance (contact closure) between these pins.

Interface Cabling Requirements

The cable used to connect the generator's 25-pin User Port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring is highly recommended but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 35 feet. To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's D connectors. Additionally, the chassis of the RFX 600A generator must be tied to a local earth ground through an adequately sized grounding strap.

The following table gives descriptions for the User port 0 pins.

Option 1 User Port (0 to 10 V I/O)

The User port for option 1 uses a female, shielded 25-pin subminiature-D connector.

All analog signals are 0-10V unless otherwise specified. All digital input signals drive opto-coupled LEDs through a series current limiting resistor (22-28VDC required for LED turn-on), and all digital output signals are opto-coupled (open-collector signals with return lines non referenced to ground, 45VDC and 10 mA maximum). Signal pins are tied to the opto-coupler diode anode for digital inputs or opto-coupler Table 3-2, “Input Power Options,” on page 3-2.

The following table contains pin description for User port option 1.

Table 4-4. *Option 1 User Port Pin Descriptions for Option 1*

Signal Pin	Return Pin	Name	Signal Type	Description
1	*2*	*DC BIAS*	Analog Input	Differential input for scaled feedback from the chamber. This signal can also be used for DC bias regulation. 0-10V = 0-2000V DC bias. The maximum working voltage for this connection is 10V above chassis ground. The more positive of the two feedback leads should be connected to pin 1.
3	*19*	*RF OFF/RESET*	Digital Input	This function overrides all other commands and forces the generator drive to turn off, opens the main contactor and resets the interlock. A continuous digital high command (contact closure to external +24V, referenced to pin 19) is required to override the off command.

Table 4-4. *Option 1 User Port Pin Descriptions for Option 1 (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
4	*19*	*RF ON*	Digital Input	A momentary contact closure of this pin to external +24V (referenced to pin 19) will cause the generator drive to turn on if RF OFF/RESET has been overridden. A two-wire on command is possible with RF ON and RF OFF/RESET connected together. To accomplish this both must be connected to external +24V (referenced to pin 19) simultaneously to turn the generator drive on.
5		*RESERVED*		Reserved for future use
6	*19*	*CEX TOGGLE*	Digital Input	The digital common exciter toggle command enable the CEX in port, on the back of the generator. This command simultaneously disables the exciter within this power supply allowing for a common exciter signal to drive both supplies in synchronization through the CEX port.
7	*19*	*MODE SELECTION 0*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
8	*19*	*MODE SELECTION 1*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
9		*RESERVED*	N/A	Reserved for future use
10		*RESERVED*		Reserved for future use

Table 4-4. *Option 1 User Port Pin Descriptions for Option 1 (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
11	*18*	*REMOTE SETPOINT*	Analog Input	When the generator is operating in remote mode, this signal is used to establish the desired output power level (set-point). When the generator is regulating its output based on forward or load power, this signal is scaled 0-10V = 0 to 600 watts. When DC bias regulation mode is selected, this signal is scaled to 0-10V = 0 to the maximum expected DC bias voltage (see descriptions for pin 1).
12		*RESERVED*		Reserved for future use
13	*23*	*SERIES INTERLOCK A*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 23 satisfies the interlock criteria. The RFX 600A's interlock circuitry is designed for use with simple contact-closure devices (switches and/or relays)
14	*18*	*REFLECTED POWER*	Analog Output	This signal represents the reflected power from the generator and is scaled such that 0-10V represents 0 to 400 watts.
15	*18*	*LOAD POWER*	Analog Output	This signal represents the delivered power from the generator (forward minus reflected) and is scaled such that 0-10V represents 0 to 600 watts.

Table 4-4. *Option 1 User Port Pin Descriptions for Option 1 (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
16	*18*	*DC BIAS*	Analog Output	This signal represents the DC bias input from the match network (if used). This buffered readback signal provides a positive (0-10V) analog representation of the differential signal found on pins 1 and 2 and uses the same scaling.
17	*18*	*FORWARD POWER*	Analog Output	This signal represents the forward power from the generator and is scaled such that 0-10V represents 0 to 600 watts.
18	*NA*	*SIGNAL COMMON*	Signal Reference	Ground reference for all analog signals.
19	*NA*	*POWER COMMON*	Signal Reference	Ground reference for all digital and control signals
20		*RESERVED*	N/A	Reserved for future use
21	*19*	*-15 VDC*	Supply Voltage	-15 V supply provided by the generator, limited to 50 mA
22	*13*	*+15 VDC*	Supply Voltage	+15 V supply provided by the generator, limited to 50 mA
23	*13*	*INTERLOCK B*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 13 satisfies the interlock criteria. The generators interlock circuitry is designed for use with simple contact-closure devices (switches and/or relays).

Table 4-4. *Option 1 User Port Pin Descriptions for Option 1 (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
24	*25*	*SAFETY INTERLOCK STATUS*		Dry switch contact, used with pin 25 to indicate status of safety interlock. When interlock is satisfied a switch closure is provided between this pin and pin 25.
25	*24*	*SAFETY INTERLOCK B STATUS*		Dry switch contact, used with pin 24 to indicate status of safety interlock. When interlock is satisfied a switch closure is provided between this pin and pin 24.

Table 4-5. *Regulation Mode Select for Option 1 User Port (0 to 10 V I/O)*

Mode Select 1 (pin 8)	Mode Select 0 (pin 7)	Regulation Mode
Logic Low	Logic Low	Forward Power
Logic Low	Logic High	Load Power
Logic High	Logic Low	DC Bias
Logic High	Logic High	Forward Power

User Port Electrical Characteristics

The 25-pin User Port on the RFX 600A generator provides analog and digital signals for control and monitoring of the generator functions. Figure 1 shows the electrical diagrams for the interface circuitry in the generator. The following are descriptions of the signal types used:

Analog Outputs

The analog readback signals from the generator (pins 14, 15, 16 and 17) are driven by precision operational amplifiers (industry type OP400). These devices are capable of driving high-capacitance loads such as those expected in shielded interface applications. The user's receiver must present a 10k ohm (or greater) impedance to these signals. The readback signals, which represent the forward and reflected power as measured at the output of the generator, are scaled as defined in the signal description table above.

Analog Input

The analog signals from the user (pins 1 and 11) is a 0 to 10 volt signal scaled to represent the desired forward power from the generator (refer to the signal description table for details).

Signal common (pin 18) must be connected to the user's chassis common for proper operation.

Digital Inputs

The digital input signals (pins 3, 4, 6, 7 and 8) are opto-coupled (industry type 4N37). The user's signal drives the LED in the opto-coupler through a 3.4K Ohm resistor. A signal level of 22 volts to 28 volts applied to the input pin activates the signal.

Interlock

The interlock signals (pins 13 and 23) provide the dc power to close the ac contactor in the generator. Pin 13 is tied to the generator's +24V supply. Pin 23 is series wired with the interlock (Standby) switch on the front panel and then ties to the coil of the contactor relay. Connecting pin 13 to pin 23 closes the contactor, enabling ac power to the RF circuits (assuming that the front panel standby switch is closed). Safety interlock status (pins 24 and 25) indicate this circuit has been satisfied by presenting a low impedance (contact closure) between these pins.

Interface Cabling Requirements

The cable used to connect the generator's 25-pin User Port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring is highly recommended but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 35 feet. To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's D connectors. Additionally, the chassis of the RFX 600A generator must be tied to a local earth ground through an adequately sized grounding strap.

Option 2 User Port (0 to 5V I/O)

This User port uses a female, shielded 25-pin subminiature-D connector.

All analog signals are 0-5V unless otherwise specified. All digital input signals drive opto-coupler LEDs through a series current limiting resistor (10-18VDC required for LED turn-on), all digital output signals are opto-coupled (open-collector signals with return lines non referenced to ground, 45VDC and 10 mA maximum) Signal pins are tied to the opto-coupler diode anode for digital inputs or opto-coupler transistor collector for digital outputs. Return pins are tied to the opto-coupler diode cathode for digital inputs or opto-coupler transistor emitter for digital outputs.

Table 4-6. *Option 2 User Port Pin Descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1	*2*	*DC BIAS*	Analog Input	Differential input for scaled feedback from the chamber. This signal can also be used for DC bias regulation. 0-5V = 0-2000V DC bias. The maximum working voltage for this connection is 10V above chassis ground. The more positive of the two feedback leads should be connected to pin 1.
3	*19*	*RF OFF/ RESET*	Digital Input	The remote digital OFF/RESET command duplicates the RF off of the front panel. This function overrides all other commands and forces the generator drive to turn off, opens the main contactor and resets the interlock. A continuous digital low command (contact closure to power common, pin 19) is required to override the off command. The internal circuit has a 15V pull-up on it to provide the OFF command when contact closure to pin 19 is interrupted.

Table 4-6. *Option 2 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
4	*19*	*RF ON*	Digital Input	The remote digital ON command duplicates the RF ON function of the front panel, when remote control has been selected at the front panel. A momentary contact closure of this pin to POWER COMMON (pin 19) will cause the generator drive to turn on if RF OFF/RESET has been overridden. A two-wire on command is possible with RF ON and RF OFF/RESET connected together. To accomplish this both must be connected to POWER COMMON (pin 19) simultaneously to turn the generator drive on.
5		*RESERVED*		Reserved for future use
6	*19*	*CEX TOGGLE*	Digital Input	The digital common exciter toggle command enable the CEX in port, on the back of the generator. This command simultaneously disables the exciter within this power supply allowing for a common exciter signal to drive both supplies in synchronization through the CEX port.
7	*19*	*MODE SELECTION 0*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
8	*19*	*MODE SELECTION 1*	Digital Input	Digital input used to determine mode of regulation when in user port control mode. See regulation table below.
9		*RESERVED*	N/A	Reserved for future use
10		*RESERVED*		Reserved for future use

Table 4-6. *Option 2 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
11	*18*	*REMOTE SETPOINT*	Analog Input	When the generator is operating in remote mode, this signal is used to establish the desired output power level (set-point). When the generator is regulating its output based on forward or load power, this signal is scaled 0-5V = 0 to 600 watts. When DC bias regulation mode is selected, this signal is scaled to 0-5V = 0 to the maximum expected DC bias voltage (see descriptions for pin 1).
12		*RESERVED*		Reserved for future use
13	*23*	*ANALOG SERIES INTERLOCK*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 23 satisfies the interlock criteria. The generators interlock circuitry is designed for use with simple contact-closure devices (switches and/or relays).
14	*18*	*REFLECTED POWER*	Analog Output	This signal represents the reflected power from the generator and is scaled such that 0-5V represents 0 to 400 watts.
15	*18*	*LOAD POWER*	Analog Output	This signal represents the delivered power from the generator (forward minus reflected) and is scaled such that 0-5V represents 0 to 600 watts.
16	*18*	*DC BIAS*	Analog Output	This signal represents the DC bias input from the match network (if used). This buffered readback signal provides a positive (0-5V) analog representation of the differential signal found on pins 1 and 2 and uses the same scaling.
17	*18*	*FORWARD POWER*	Analog Output	This signal represents the forward power from the generator and is scaled such that 0-5V represents 0 to 600 watts.
18	*NA*	*SIGNAL COMMON*	Signal Reference	Ground reference for all analog signals.
19	*NA*	*POWER COMMON*	Signal Reference	Ground reference for all digital and control signals

Table 4-6. *Option 2 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
20		*RESERVED*	N/A	Reserved for future use
21	*19*	*-15 VDC*	Supply Voltage	-15 V supply provided by the generator, limited to 50 mA
22	*13*	*+15 VDC*	Supply Voltage	+15 V supply provided by the generator, limited to 50 mA
23	*13*	*INTERLOCK B*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 13 satisfies the interlock criteria. The generator's interlock circuitry is designed for use with simple contact closure devices (switches and/or relays).
13	*23*	*INTERLOCK A*	Series Interlock	Interlock string. A low impedance connection between this pin and pin 13 satisfies the interlock criteria. The generator's interlock circuitry is designed for use with simple contact closure devices (switches and/or relays).
24	*25*	*SAFETY INTERLOCK STATUS*		Dry switch contact, used with pin 25 to indicate status of safety interlock. When interlock is satisfied a switch closure is provided between this pin and pin 25.
25	*24*	*SAFETY INTERLOCK B STATUS*		Dry switch contact, used with pin 24 to indicate status of safety interlock. When interlock is satisfied a switch closure is provided between this pin and pin 24.

Table 4-7. *Regulation Mode Select for Option 2 User Port (0 to 5 V I/O)*

Mode Select 1 (pin 8)	Mode Select 0 (pin 7)	Regulation Mode
Logic Low	Logic Low	Forward Power
Logic Low	Logic High	Load Power
Logic High	Logic Low	DC Bias
Logic high	Logic High	Forward Power

User Port Electrical Characteristics

The 25-pin User Port on the RFX 600A generator provides analog and digital signals for control and monitoring of the generator functions. Figure 1 shows the electrical diagrams for the interface circuitry in the generator. The following are descriptions of the signal types used:

Analog Outputs

The analog readback signals from the generator (pins 14, 15, 16 and 17) are driven by precision operational amplifiers (industry type OP400). These devices are capable of driving high-capacitance loads such as those expected in shielded interface applications. The user's receiver must present a 10k ohm (or greater) impedance to these signals. The readback signals, which represent the forward and reflected power as measured at the output of the generator, are scaled as defined in the signal description table above.

Analog Input

The analog signals from the user (pins 1 and 11) is a 0 to 5 volt signal scaled to represent the desired forward power from the generator (refer to the signal description table for details).

Signal common (pin 18) must be connected to the user's controllers chassis common for proper operation.

Digital Inputs

The digital input signals (pins 3, 4, 6, 7 and 8) are opto-coupled (industry type 4N37). The user's signal drives the LED in the opto-coupler through a 1.5K Ohm resistor. A signal level of 10 volts to 18 volts applied to the input pin activates the signal.

Interlock

The interlock signals (pins 13 and 23) provide the dc power to close the ac contactor in the generator. Pin 13 is tied to the generator's +24V supply. Pin 23 is series wired with the interlock (Standby) switch on the front panel and then ties to the coil of the contactor relay. Connecting pin 13 to pin 23 closes the contactor, enabling ac power to the RF circuits (assuming that the front panel standby switch is closed). Safety interlock status (pins 24 and 25) indicate this circuit has been satisfied by presenting a low impedance (contact closure) between these pins.

Interface Cabling Requirements

The cable used to connect the generator's 25-pin User Port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring is highly recommended but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 35 feet. To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's D connectors. Additionally, the chassis of the RFX 600A generator must be tied to a local earth ground through an adequately sized grounding strap.

Option 3 User Port (RFG Compatible I/O)

This User port uses a 25-pin, subminiature-D, shielded, female connector.

All analog signals are 0-10V unless otherwise specified. All digital input signals drive opto-coupler LEDs through a series current limiting resistor (4-30VDC required for LED turn-on), and all digital output signals are opto-coupled (open-collector signals with return lines non referenced to ground, 45VDC and 10 mA maximum). Signal pins are tied to the opto-coupler diode anode for digital inputs or opto-coupler transistor collector for digital outputs. Return pins are tied to the opto-coupler diode cathode for digital inputs or opto-coupler transistor emitter for digital outputs. The 25-pin User port for option 3 provides analog and digital signals for control and monitoring of the generator functions.

Table 4-8. *Option 3 User Port Pin Descriptions*

Signal Pin	Return Pin	Signal Name	Signal Type	Signal Description
14	*1*	*SETPOINT STATUS*	Digital Output	A low-impedance path between these pins indicates that an internal power limit has been encountered. When RF power is enabled, a high impedance path between these pins indicates that the generator is “at setpoint”.
2	*15*	*REFL PWR MONITOR*	Analog Output	This 0-10V signal represents the reflected power as measured at the output of the generator. This signal is scaled to represent 0-400 watts.
3	*16*	*FWD/DELV PWR MONITOR*	Analog Output	This 0-10V signal represents the forward or delivered power as measured at the output of the generator. See pin 8 for power regulation mode selection. This signal is scaled to represent 0-600 watts.
4	*17*	*RF PWR ON*	Digital Input	This signal is used to control the RF output of the generator. A voltage level of 4V to 30V on pin 4 enables the RF power. If pin 4 is open or grounded, RF power is disabled.
5	*18*	*SETPOINT*	Analog Input	This 0-10V signal defines the desired setpoint for the generator's RF output. It is scaled to represent 0-600 watts.

Table 4-8. *Option 3 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Signal Description
6	*19,21*	*+24V DC*	Reference Voltage	This unregulated dc voltage may be used for controlling the RF power via pin 4 (pin 6 may be tied to pin 4 to enable the RF power). The maximum current capacity for this signal is 50 milliamperes.
20	*7*	*RF STATUS*	Digital Output	A low impedance path between these pins indicates that the RF power is present at the output of the generator. The interlock loop must be closed and the RF PWR ON signal must be active to enable RF power.
8	*19, 21*	*PWR REG MODE*	Input	This signal is used to control the desired power regulation mode. If pin 8 is open or grounded, the generator will regulate on forward power. A voltage level of 4V to 30V on pin 8 selects delivered power mode. Delivered power is defined as “forward power minus reflected power”.
9	*22*	*OVERTEMP*	Digital Output	A low impedance path between these pins indicates that an over temperature condition has been detected by the generator. Refer to the troubleshooting section of the user manual for detailed information on this fault condition.
10	*23*	*INTERLOCK*	Input	These pins are part of a series interlock string which must be closed to enable ac power in the generator. A contact resistance of 15 ohms or less across these pins will close the loop. Pin 10 is connected to +24V in the generator via a current limiting circuit.
24	*11*	*AC ON*	Digital Output	A low impedance path between these two pins indicates that ac power is available within the generator. AC power cannot be enabled unless the interlock loop is closed.

Table 4-8. *Option 3 User Port Pin Descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Signal Description
12	*25*	*CEX LOCK*	Digital Output	A low impedance path between these two pins indicates that the generator is frequency locked to the CEX input signal. A high impedance path indicates that there is either no input signal or it does not meet the required specifications.
13	*19,21*	*+15V DC*	Reference Voltage	This is a regulated dc voltage has a maximum current capacity of 50 milliamperes. This signal can be used for controlling RF power (pin 13 can be jumpered to pin 4). The voltage on this pin may vary between 13 and 16 volts.
19,21	*N/A*	*GROUND*	Ground Reference	These two pins are referenced to the signal and chassis grounds in the generator.

User Port Electrical Characteristics

The 25-pin User Port on the RFX 600A provides analog and digital signals for control and monitoring of the generator functions. Figure 1 shows the electrical diagrams for the interface circuitry in the generator. The following are descriptions of the signal types used.

Analog Outputs

The analog readback signals from the generator (pins 2 and 3) are driven by precision operational amplifiers (industry type OP400). These devices are capable of driving high-capacitance loads such as those expected in shielded interface applications. The user's receiver must present a 10k ohm (or greater) impedance to these signals. The readback signals, which represent the forward and reflected power as measured at the output of the generator, are scaled as defined in the signal description table above.

Analog Input

The setpoint signal from the user (pin 5) is a 0 to 10 volt signal scaled to represent the desired forward power from the generator (refer to the signal description table for details).

Digital Outputs

The status signals provided by the generator (pins 14, 20, 22, 24, and 12) are opto-coupled with NPN transistor outputs (industry type 4N37). The collector and emitter of each transistor are provided to the user interface. Each transistor can provide a

minimum of 8 milliamperes of collector current and may be operated with a collector-to-emitter voltage of up to 30 volts. Refer to the attached signal description table for signal definitions.

Digital Inputs

The RF PWR ON control signal (pin 4) and the PWR REG MODE signal (pin 8) are opto-coupled (industry type 4N37). The user's signal drives the LED in the opto-coupler through a 510 Ohm resistor. A signal level of 4 volts to 30 volts applied to the input pin activates the signal.

Interlock

The interlock signals (pins 10 and 23) provide the dc power to close the ac contactor in the generator. Pin 10 is tied to the generator's +24V supply. Pin 23 is series wired with the interlock (Standby) switch on the front panel and then ties to the coil of the contactor relay. Connecting pin 10 to pin 23 closes the contactor, enabling ac power to the RF circuits (assuming that the front panel Standby switch is closed).

Interface Cabling Requirements

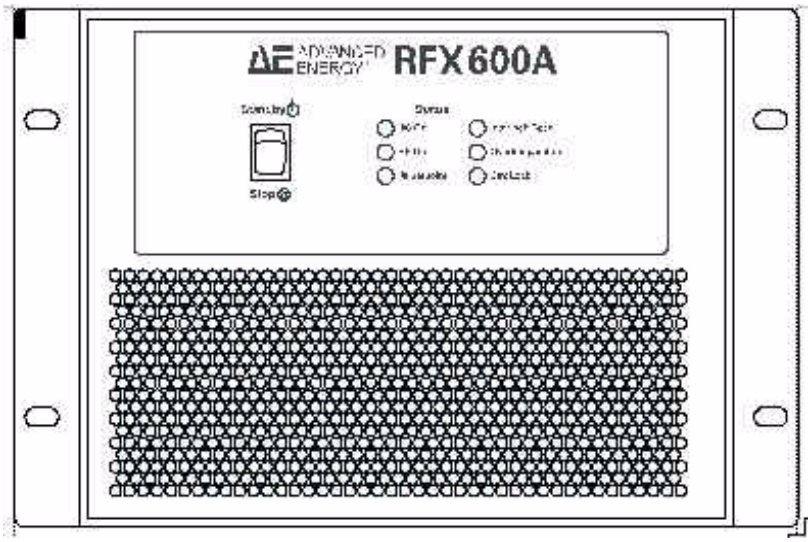
The cable used to connect the generator's 25-pin User Port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring is highly recommended but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 35 feet. To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's D connectors. Additionally, the chassis of the RFX 600A must be tied to a local earth ground through an adequately sized grounding strap.

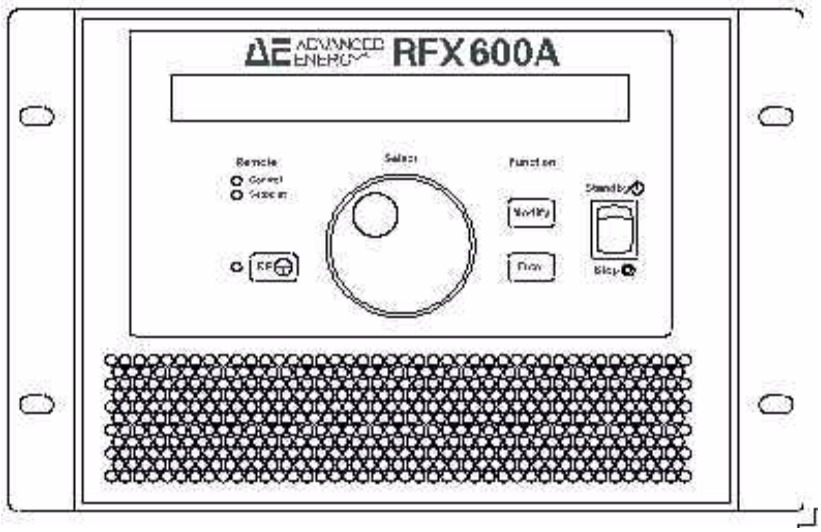
INTERFACE CABLE REQUIREMENTS

The cable used to connect the generator's 25-pin User port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring is highly recommended but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 35 feet. To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's D connectors. Additionally, the chassis of the RFG 600A generator must be tied to a local earth ground through an adequately sized grounding strap.

FRONT PANEL

The RFX 600 A has two front panel options, passive and active. To determine which front panel you have, see “Passive Front Panel” on page 4-38 and “Dimensions” on page 5-2. The following information will guide you to specific information on both options.





Active Front Panel

The RFX 600A active front panel allows you to both control and monitor the generator's functions. The panel includes an LCD display for indicating the status of the generator and displaying the operational parameters you select. The panel employs membrane style switches for high reliability. The following functions are available from the active front panel:

Table 4-9. *Active Front Panel Functions*

Indicators *Note:* The Control and Setpoint functions are independent and can be configured for either remote or local operation (they do not have to match one another). These modes are selectable by the front panel only (the modes cannot be selected or altered from the User Port).	
Remote Control	When lit, this green LED indicates that the User Port has been granted authority to control the generator's RF output (RF on and off). If the LED is not lit, the unit is in Local Control mode and RF is enabled by the front panel.
Remote Setpoint	When lit, this green LED indicates that the User Port has been assigned as the source for the setpoint value. If the LED is not lit, the setpoint value is supplied by the generator's active front panel.

Table 4-9. *Active Front Panel Functions (Continued)*

Switches	
Standby/Stop	This rocker switch enables the internal contactor which routes ac power to the RF circuits in the generator. In the STANDBY position, the contactor is closed. In the STOP position, the contactor opens, inhibiting the RF output. *Note:* Your generator option may include interlock loop connections at the User Port connector. If so, the contactor will not close unless the rocker switch is in the STANDBY position and the interlock pins are connected together.
RF	This membrane style switch is used for enabling the RF output when the generator is in Local Control mode. If the generator is configured for local control and the interlock loop is closed, subsequent depressions of this button enable and disable the RF output. A green LED indicator, located to the left of this switch, illuminates whenever RF power is enabled. The LED indicates the state of the RF output regardless of the control mode.
Modify	This membrane style switch is used for altering the currently selected generator configuration. See “Front Panel” on page 4-25.
Enter	This membrane style switch is used for selecting parameters to be stored in the RFX 600A’s non-volatile memory. See “Front Panel” on page 4-25 for a description of the uses for this button.
Select Rotary Knob	This knob is a rotary digital encoder used to increase or decrease the setpoint value or select different user fields.
LCD Display	
The RFX 600A incorporates a two-line by 40-character, LCD display which is divided into the fields shown in the following illustration.	

Table 4-9. *Active Front Panel Functions (Continued)*

```
char pos          1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 4

1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0

+-------------------------------------------------------------------------------------------------+
line 1 |<---setpoint--> |<-----control----->|    |MAXPWR| |OT| |CEX| IIL|
line 2 |<-----fwd pwr-----> |<------ref pwr------>| |<---dc bias/ld pwr-->|

+-------------------------------------------------------------------------------------------------+
```

Table 4-9. *Active Front Panel Functions (Continued)*

User-Modified Fields	
Setpoint Field Values	During normal operation, the Setpoint Field displays the currently selected setpoint parameter. This field is also used to display the desired setpoint parameter when you are configuring the generator from the front panel. The setpoint value is reported using one of the following formats: **Stpt=nnnW**—Used when either forward power or load power regulation mode is selected. **Stpt=nnnV**—Used when dc bias regulation mode is selected.
Control Field Values	During normal operation, the Control Field displays the currently selected power regulation mode (forward power, load power, or dc bias). This field is also used to select the desired control mode when you are configuring the generator from the front panel. See "Active Front Panel" on page 4-26. The following is a list of the allowable Control Field values: see "Readout of Front Panel" on page 4-35.
Fwd Pwr Reg	Displayed when forward power regulation mode is either selected (during normal operation) or is the desired mode (during configuration mode).
Ld Pwr Reg	Displayed when load power regulation mode is either selected (during normal operation) or is the desired mode (during configuration mode).
DC Bias Reg	Displayed when dc bias regulation mode is either selected (during normal operation) or is the desired mode (during configuration mode).
CONTROL SRC	This message is displayed only during the selection of the desired control source for the generator. The available menu options are local and remote ("Active Front Panel" on page 4-26.)
Local Ctrl	This message is displayed only during CONTROL SRC configuration mode and indicates that LOCAL (front panel) control of the generator is desired.
Remote Ctrl	This message is displayed only during CONTROL SRC configuration mode and indicates that REMOTE (User Port) control of the generator is selected.
SETPNT SRC	This message is displayed only during the selection of the desired setpoint source for the generator. The available menu options are local and remote (refer to the "Front Panel Configuration Modes" section on next page for details).

Table 4-9. *Active Front Panel Functions (Continued)*

Local Stpt	This message is displayed only during SETPOINT SRC configuration mode and indicates that LOCAL (front panel) control of the generator's setpoint is selected.
Remote Stpt	This message is displayed only during SETPOINT SRC configuration mode and indicates that REMOTE (User Port) control of the generator's setpoint is selected.
Status Fields:	
MAXPWR	This message is displayed when the generator is unable to achieve the selected setpoint. This fault condition indicates that an internal limit (voltage, current, of power) is preventing the generator from reaching the desired setpoint. This can result from load mismatches or interconnection problems.
OT	This message is displayed when the generator has detected an over-temperature condition. RF power is stopped when an over temperature condition is detected. RF power is re-enabled when the unit cools down. With User Port Type D, the RF ON signal must be toggled off and then back on to restore power following an over temperature shutdown.
CEX	This message is displayed to indicate that the generator has detected a valid CEX input signal and has synchronized its RF output to this signal (common exciter mode).
IL	This message is displayed when the generator's interlock has been satisfied. RF power cannot be enabled when the interlock string is open.

Passive Front Panel

The RFX 600A passive front panel allows you to monitor the generator's status. The passive front panel does not allow you to control the generator. The following table describes the passive front panel in more detail. To view a diagram of the passive front panel, refer to Figure 4-3 on page 4-38.

Table 4-10. *Passive Front Panel Indicators and Switches*

Indicators	
AC ON	When lit, this green LED indicates that AC power is present within the unit. (This is LED is not available on the option 211 and 212).
RF ON	When lit, this green LED indicates that RF power is on. Depending on the selected setpoint value, RF power may or may not be present at the output connector.
AT SETPOINT	When lit, this green LED indicates that the unit is delivering the requested power. Absence of this light indicates that the unit is unable to deliver the requested setpoint due to some limit or alarm condition in the generator. The conditions that can cause an out-of-setpoint condition are high reflected power and internal power/current limits
INTERLOCK OPEN	When lit, this green LED indicates that the main contactor (the relay that supplies power to the RF circuitry) is de-energized, indicating that the series interlock string is not satisfied. To obtain closure of the interlock loop, the front panel rocker switch must be in the STANDBY position and the interlock pins on the user port connector must be jumpered together. The interlock criteria must be satisfied before the generator's RF output is enabled.
OVERTEMP	When lit, this yellow LED indicates that the internal temperature has exceeded a maximum allowable level for operation of RF output power. During this condition the output will be disabled. After the temperature has been reduced to an acceptable level, the RF ON command will need to be toggled to enable RF output.
CEX LOCK	When lit, this green LED indicates that the RF output frequency is locked onto the external RF signal source. Criteria for locking onto the external signal source include external frequency and magnitude being within the defined ranges. Details are in "Input Power Options" on page 3-2 and in "Electrical Specifications" on page 3-2.

Table 4-10. *Passive Front Panel Indicators and Switches*

Switches	
STANDBY/STOP	This rocker switch enables or disables the internal contactor. In the STANDBY position, the contactor will be closed if the series interlock loop is closed at the user port (low impedance connection between pins 10 and 23). In the STOP position, the contactor will be disabled (RF power will be inhibited).

FRONT PANEL CONFIGURATION MODES

The active front panel permits you to display and/or alter the generator's operational parameters. These parameters are viewable on the LCD display which offers nested, menu-driven selections for the operator.

Enter the configuration mode by depressing the Modify button once. Then, using the rotary Select knob, you can select which type of parameter you wish to alter; the setpoint value or a control parameter. The designated field blinks on the display to indicate which parameter type is selected. Each rotation of the Select knob toggles between the two fields.

After choosing the desired parameter type to change, depress the Modify button once. The selected field can now be altered as the following paragraphs describe.

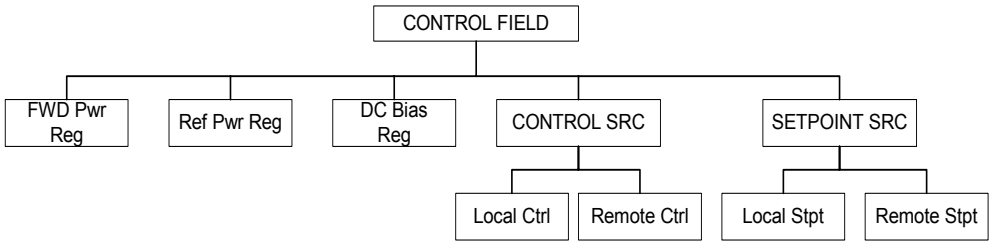
If the Setpoint Field is selected, the Select knob may now be used to change the setpoint parameter. The new setpoint parameter can be stored in the generator by depressing the Enter button once. After entering the parameter, the display returns to its normal (pre-configuration) mode.

If the Control Field is selected as the field to change, you are presented with five possible selections as illustrated in the diagram below. The rotary Select knob is used to cycle through the available options. Three of the options define the desired power regulation mode (forward, load, or dc bias). Depressing the Enter button while one of these modes is displayed changes the regulation mode for subsequent operations. The other two available options permit you to change either the control source for the generator's RF output (RF on/off) or change the control source for the setpoint (local or remote) as follows.

To change the control source for the RF output, rotate the Select knob until the Control Field displays the "CONTROL SRC" message. Then, depress the Modify button once to go to the selection menu. Use the Select knob to choose either Local Ctrl (front panel) or Remote Ctrl (User Port). With the desired mode shown on the display, depress the Enter button to store this mode for use during subsequent operations.

To change the control source for the setpoint, rotate the Select knob until the Control Field displays the “SETPOINT SRC” message. Then, depress the Modify button once to go to the selection menu. Use the Select knob to choose either Local Ctrl (front panel) or Remote Ctrl (User Port). With the desired mode shown on the display, depress the Enter button to store this mode for use during subsequent operations.

Readout of Front Panel



The RFX 600A provides a special mode where you can lock out the front panel to prevent unwanted manual entries during system operation. With the generator in its normal operating mode, this special mode is selected by depressing both the Modify and Enter buttons simultaneously. The currently selected mode (lock or unlock) is displayed in the Control Field portion of the LCD display. The rotary Select knob is then used to change the mode. Once selected, the Enter button is used to store the new mode.

The RFX 600A incorporates diagnostic and error logging features that can be accessed from the front panel. These diagnostic features are intended for use by trained Customer Service representatives. With the generator in its normal operating mode, the diagnostic mode is entered by depressing the Modify button once, using the Select knob to highlight the Control Field, and then depressing both the Modify and Enter buttons simultaneously. You may then choose between the ERROR and DIAGNOSTIC menus. The error parameters must be interpreted by a trained technician and are not discussed in this document. The available diagnostic parameters are listed below:

- Software part number and revision
- +15 Vdc measurement
- -15 Vdc measurement
- +5 Vdc measurement
- +24 Vdc measurement
- Inverter voltage
- Inverter current

- Bus voltage
- PAED

FRONT VIEWS

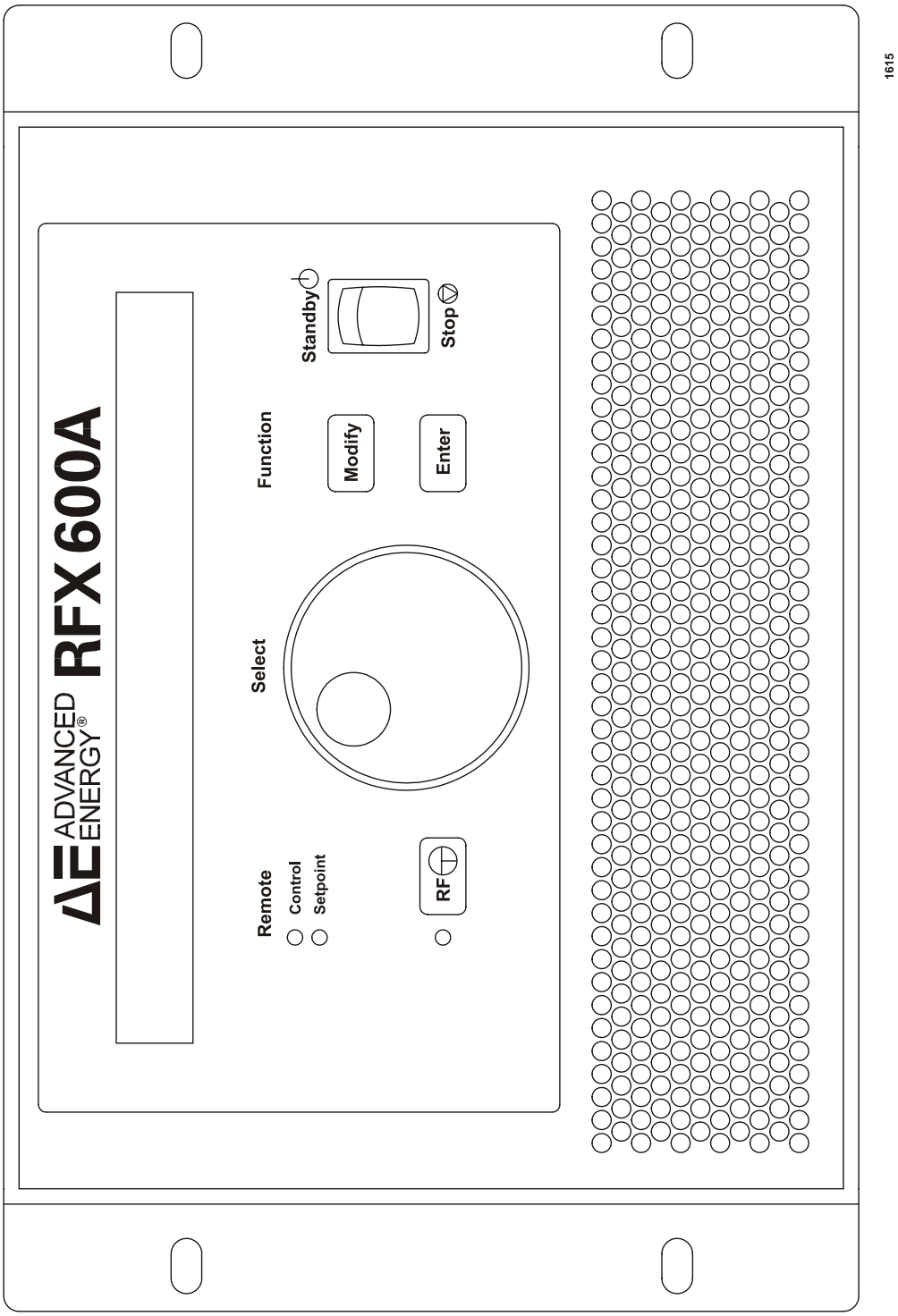


Figure 4-2. *Front View Active Front Panel*

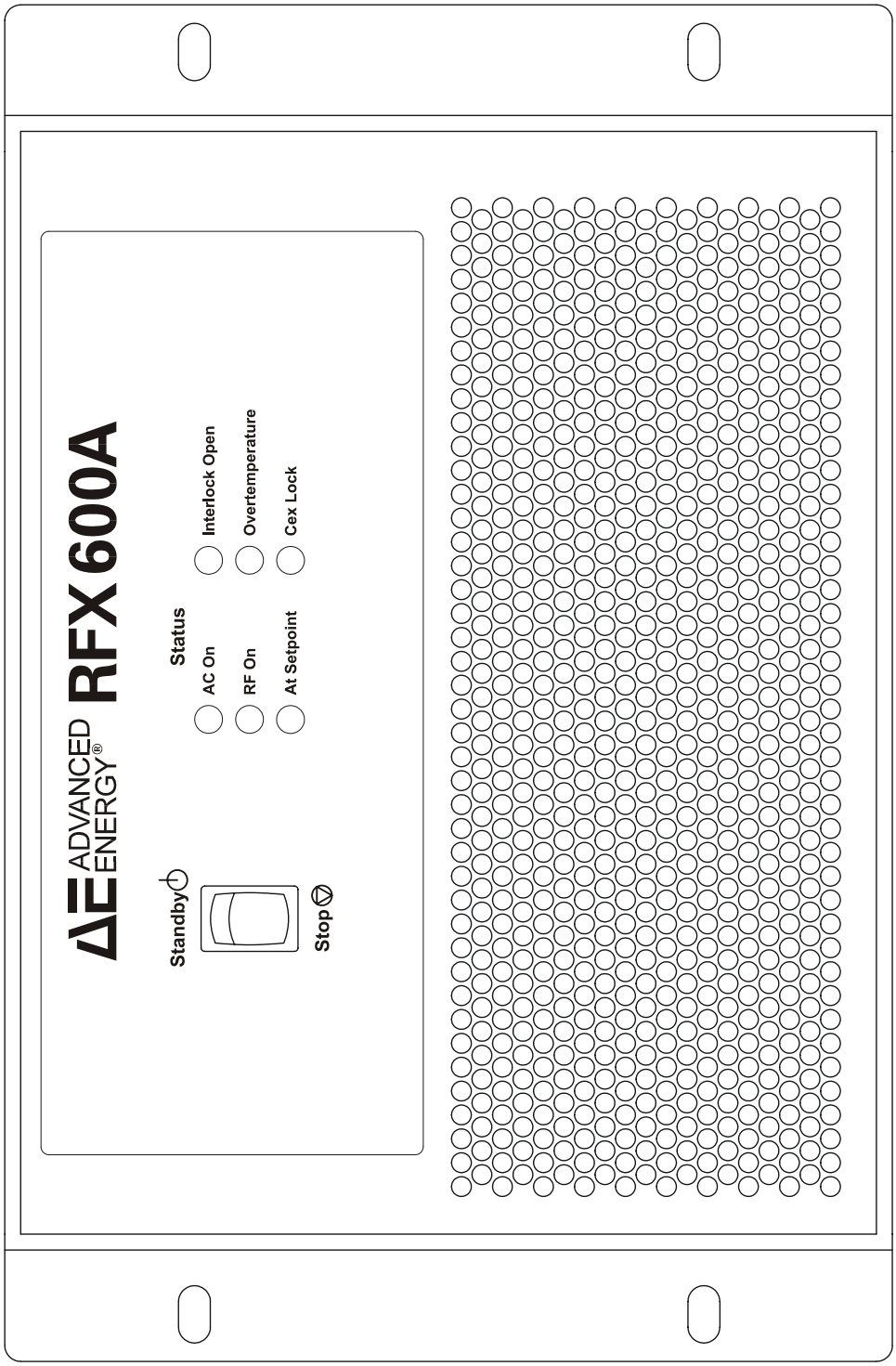


Figure 4-3. *Passive Front Panel*

REAR VIEW

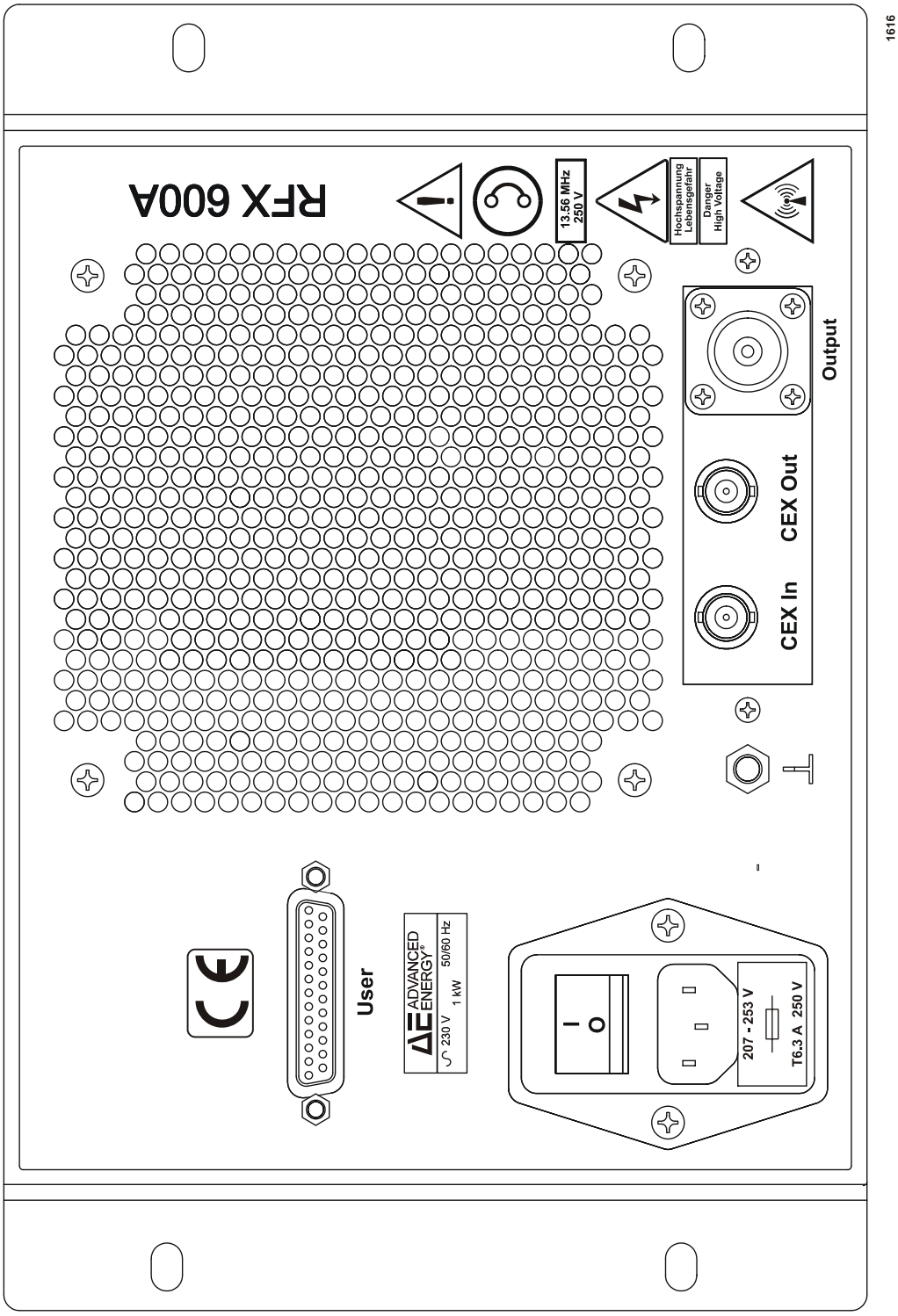


Figure 4-4. *Rear View*

Installation

UNPACKING

Unpack and inspect your RFX 600A generator carefully. Check for obvious physical damage. If no damage is apparent, proceed with the unit connections. If you do see signs of shipping damage, contact Advanced Energy Industries, Inc., and the carrier immediately. Save the shipping container for submitting necessary claims to the carrier.

GROUNDING

The unit provides an RFI ground stud. A suitable chassis ground connection made to this stud prevents or minimizes radio frequency interference.

Note: .Meeting Spacing Requirements

Mount the unit so that there is at least 1″ clearance on the sides and 6″ on the front and rear panels. Any blockages could cause overheating to occur.

CONNECTING FOR CEX MODE OPERATION

Connect the type BNC male connector on one end of a CEX interconnect cable to the connector labeled CEX OUT on the RFX 600A that has been designated as the master unit. Connect the other end of the CEX interconnect cable to the connector labeled CEX IN on the RFX 600A that has been designated as the slave unit. See the rear panel illustration at the end of Chapter 4 for the location of the CEX connectors.

DIMENSIONS

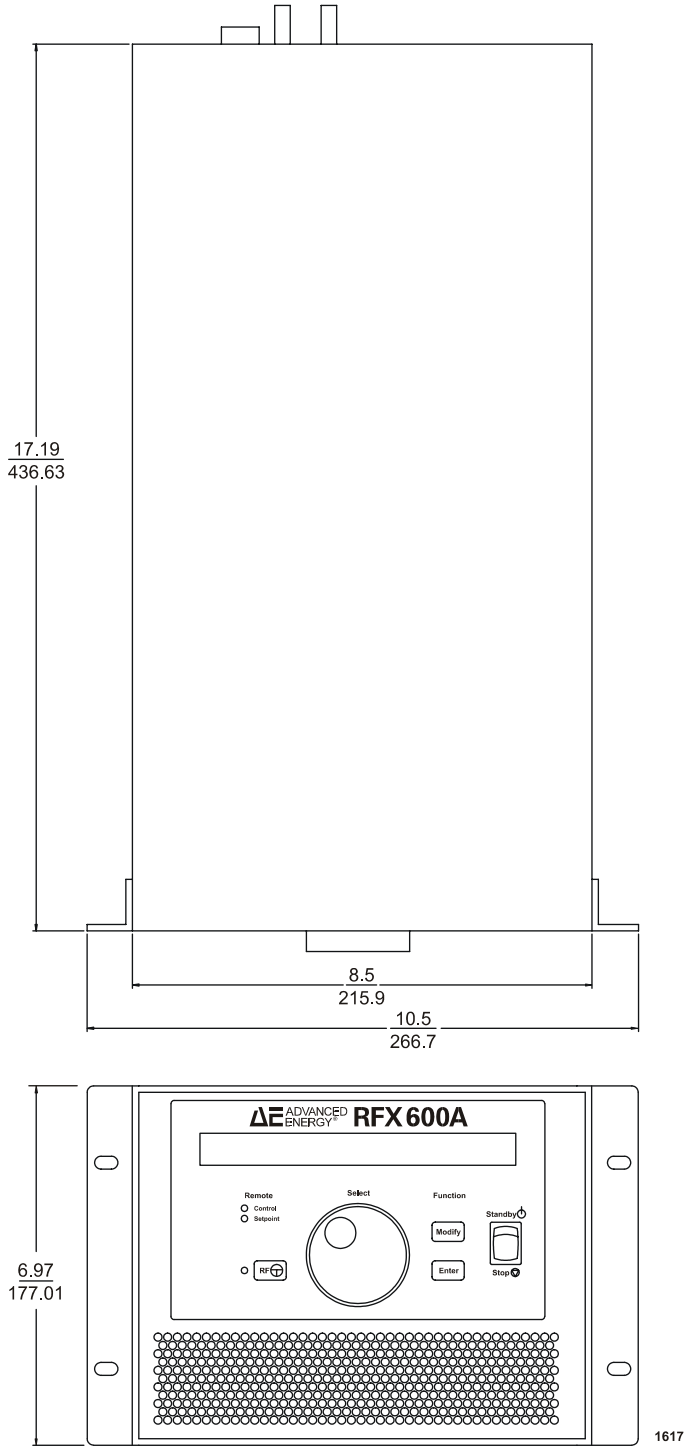


Figure 5-1. *Dimensions*

CONNECTING INPUT POWER

The AC input utilizes a type IEC 320 connector located at the rear of the generator. To connect the generator to the ac input line, simply plug the input power cord with its IEC 320 type connector into the generator input connection. Be sure to follow the ac line ratings and specifications found in Chapter 3 as well as the Conditions of Use in Chapter 1.

CONNECTING OUTPUT POWER

The RF output, a type N female connector, is located on the rear of the generator. To connect the output of the generator, simply connect the output coaxial cable with its type N male connector to the generator output connection. Verify that the connection is tight and properly mated to prevent damage to the connectors.

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

Troubleshooting and Customer Support

BEFORE CALLING AE CUSTOMER SUPPORT

WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect all sources of input power before working on this unit or anything connected to it.

Checks with the Power Off

1. Ensure the power to the unit is off.
2. Check for visible damage to the unit, cables, and connectors.
3. Ensure all unit connectors are installed correctly and are fastened tightly.
4. Check to determine whether any system-related circuit breakers have been tripped.
5. Ensure there is input power to both the unit control (if used) and the RFX 600A to verify the input power meets specifications.
6. Ensure ground connections are adequate and secure.

Checks with the Power On

1. Ensure there is input power to both the unit control (if used) and the RFX 600A to verify the input power meets specifications.
2. Check the LEDs on all units to determine that the proper ones are lit.

Troubleshooting Guide

1. Does the fan come on and the front panel LEDs light?

Yes Go to the next step.

No Go to the INPUT POWER section.

2. Does the front panel show any errors (active front panel units only)?

Yes Go to the error message table.

No Go to the next step.

3. Connect the generator to a 50 Ohm RF load or the tuning network. Select Forward Power Regulation. Set the setpoint to 100 Watts and enable the RF output. Does the output turn on and go to 100 Watts?

Yes go to the next step.

No Go to the NO RF OUTPUT section.

4. Does the output power match the setpoint power level that was set?

Yes Go to the next step.

No Go to the OUT OF SETPOINT section.

5. Increase the setpoint to 600 watts or the maximum power level for the system. Does the generator output match the setpoint.

Yes Go to the next step.

No Go to the OUT OF SETPOINT section.

5. Does the generator have less than 10 watts of reflected power?

Yes The generator has tested good

No Go to the HIGH REFLECTED POWER section.

INPUT POWER

When the front panel LEDs do not light and the fan does not come on check to see if the input power is supplied to the unit and that it is within specification. Check to see if the fuse in the rear panel is good. Check to see if the rear panel power switch is in the ON position. After verifying these items and the problem persists call Advanced Energy Customer support.

NO RF OUTPUT

Check to see if any error messages are displayed on the Active Front Panel of the generator. If any messages are displayed refer to the Error message table. Check to verify if a 100 Watt setpoint had been set on either the front panel or on the remote user port if the generator is being controlled by a remote system.

Is the generator displaying a OT (overtemperature fault)? If the unit is displaying an OT, check if the fan is functioning correctly. Check the spacing around the unit to ensure free air flow. Check the ambient intake air to ensure that it is within specification. If one of these items is found to be out of specification correct the fault and allow the unit to cool down. Once the unit is cooled down try to enable the RF output and test the generator for proper function. After verifying these items and the problem persists contact Advanced Energy Customer Support.

OUT OF SETPOINT

If the forward power and the setpoint power levels do not match this is an indication that the unit is unable to supply the requested power. This may be caused by the unit having an internal limit or the reflected power being too high and the unit hitting the reflected power limit which is set at 400 watts. If the reflected power is lower than 200 watts and the unit cannot achieve the desired setpoint then call Advanced Energy Customer Support. If the unit has more than 200 watts of reflected power see the *HIGH REFLECTED POWER SECTION* below.

HIGH REFLECTED POWER

Reflected power is caused be a load mismatch on the output of the generator. Possible causes of this are the tuner is unable to match the plasma, the cable between the generator and the tuner is bad, or a bad connector at the generator or the tuner. If the problem persists after these items are checked contact Advanced Energy Customer Support.

FIRST TIME OPERATION

1. Inspect the unit for physical damage. If some damage is visible contact Advanced Energy Customer Support.

2. Connect the unit to the correct input power.

3. Connect the unit to a 50 Ohm RF load rated for at least 600 Watts or to the matching network mounted on the system.

4. Install the factory supplied connector on the user I/O port on the rear of the unit or if the unit is a passive front panel unit connect the system interface to the I/O port.

5. Turn the rear breaker of the unit on.

6. Observe that the front panel LEDs light. If the front panel does not light check the input power to see if it is present and within the specifications.

7. If the unit is an active front panel place the unit into the local control and local setpoint modes. If the unit is a passive front panel it will default to the remote control and remote setpoint modes and must be controlled from the User port.

8. Enable the RF OUTPUT.

9. Adjust the setpoint level to 100 Watts.

10. The front panel should read 100 Watts of forward power and 0 Watts reflected power if the generator is connected to a 50 Ohm RF load or a properly functioning matching network. Up to 100 Watts of reflected power could be seen depending on the load at the output of the generator. If the unit has a passive front panel monitor the FWD PWR out and the RFL PWR out at the user port for this information.

11. If the unit does not reach 100 Watts of forward power at this time see "Troubleshooting Guide" section of the manual.

12. If the unit produces 100 Watts increase the setpoint to 600 watts or the maximum power of the system.

13. The unit will produce 600 Watts if the reflected power is below 400 watts. If the reflected power is 400 Watts, the unit will limit the forward power to protect itself.

14. If any error messages appear on the front panel of the generator, see "Error Messages" Operating the Active Front Panel.

Only the setpoint and control fields can be modified. This can be done using the MODIFY push-button. Pushing MODIFY when the user fields are inactive (i.e., no field information blinking) causes the words "SETPOINT" and "CONTROL" to be displayed in their respective fields—one of which blinks to indicate that the field can be modified. Selection between the two fields is changed by rotating the Select knob. When the desired field has been selected, pressing "MODIFY" allows either setpoint to be modified or control functionality to be chosen. In the control field, menu items can be viewed by rotating the encoder knob until the desired item blinks. In all cases, modification is completed by pressing the "ENTER" push-button.

Note: If a menu item is shown in capital letters, there is another sub-level of menus under it that can be modified.

Setpoint Modification (local setpoint mode)

If the RF power is on, the setpoint can be modified by rotating the Select knob clockwise to increase the setpoint value and counterclockwise to decrease the setpoint value.

If RF power is not on, the setpoint can only be modified by the LCD menu. In order to do this, the user fields must be inactive. Pressing MODIFY displays both field headers, SETPOINT and CONTROL in their respective field location. One of the headers blinks to indicate that the respective field can be modified. Rotating the knob counter clockwise or clockwise causes SETPOINT or CONTROL, respectively, to blink. (If at this point the decision is made not to change the setpoint value, pressing ENTER terminates the process without making any changes.) When SETPOINT is blinking, press MODIFY to select setpoint modification. The field displays "stpt=xxxW" (forward or load power regulation) or "Stpt=xxxxV" (DC bias regulation). The numerical value "xxx" blinks to indicate that it can be modified. (Again at this point if you decide that do not want to change the setpoint, pressing ENTER terminates the process without making any changes.) When "xxx" is

blinking, rotating the knob clockwise or counterclockwise increases or decreases the setpoint value. Pressing ENTER captures the new setpoint value and returns the LCD to its inactive state.

Control Modification

When the user fields are inactive, the control field displays the generator's current regulation mode. The control field can be activated for the purpose of modifying regulation mode, control source (local/remote), and setpoint source (local/remote). Select the control field by pressing MODIFY and rotating the knob until "CONTROL" blinks. Pressing ENTER at this time returns the LCD to its inactive state without making any changes to any of the control parameters. Pressing MODIFY causes "Fwd Pwr Reg" to blink. Control field menu items can be viewed by rotating the knob one click per item.

Pressing ENTER when any of the regulation modes are blinking modifies the generator's regulation and returns the LCD to its inactive state. Pressing ENTER when either CONTROLSRC or SETPNTSRC is blinking returns the LCD to its inactive state without making any changes to the generator. Pressing MODIFY when either CONTROLSRC or SETPNTSRC is blinking allows local/remote menu items to be viewed. Rotating the knob in either direction alternates between the local/remote entries. The control source defines the interface from which the generator's RF power can be commanded on (local=front panel; remote=user port). The setpoint source defines the interface from which the setpoint is received. Pressing ENTER at this level modifies the generator's operation and returns the LCD to its inactive state.

Front Panel Security

The front panel can be *locked* rendering all buttons and knob inactive. You can lock the front panel only when the user fields are inactive. To lock or unlock the front panel, press both the MODIFY and ENTER push-buttons simultaneously and hold for one second. This causes either *Lock Front Panel* (front panel is unlocked) or *Unlock Front Panel* (front panel is locked) to blink in the LCD top row. The encoder knob can be rotated either left or right to toggle between these two choices. Pressing ENTER selects the appropriate lock/unlock function and returns the LCD to its inactive state.

Note: Except for being shown as an error message, there is no indication on the panel whether the panel is locked or unlocked.

Error Messages

Error messages are displayed whenever an erroneous front panel operation has occurred. This information blinks in the top row of the LCD for approximately three seconds and then the top row is restored to its normal display. Following is a list of the possible messages and respective descriptions.

Table 6-1. *Front Panel Error Messages*

Error Message	Description
FRONT PANEL LOCKED	Either the knob was rotated or one of the push-buttons was pressed while the front panel was locked. When the front panel is locked, only the MODIFY and ENTER buttons can be pressed simultaneously to unlock the unit.
USER PORT SETUP ONLY	An attempt was made to select the SETPOINT field when the generator's setpoint source was configured for remote user setup. In this mode, variations in the setpoint can only occur from the analog user port setpoint.
USER PORT CONTROL ONLY	An attempt was made to turn RF on from the front panel when the generator was configured for remote control. In remote control mode, only the user port can command RF on.
NO INTERLOCK DETECTED	An attempt was made to turn RF power on from the front panel while the interlock circuitry was not satisfied.
USER PORT CMDING RF OFF	An attempt was made to turn RF power on from the front panel while the remote user port OFF/RESET signal was active.
RF MUST BE TURNED OFF	An attempt was made to change the control source while RF power was on.

COMMON EXCITER (CEX) OPERATION

In applications where multiple RF supplies are coupled into the same plasma (e.g., RF bias and RF flux source), it may be important to synchronize the frequencies of the generators and to control the phase relationship between them. It is possible to see *beat note*, or interference patterns in plasmas supplied by generators with slightly different frequencies. If the generators are driven by a common exciter, however, the frequencies are identical and the interference pattern disappears.

In addition, some applications are sensitive to the phase difference that may be present in the two sources. For instance, you may see varying voltage or current peaks as the two signals add vectorially.

Phase shift can occur at a number of points:

- The coaxial cable used to provide the common exciter signal (varies with length of cable)

- The generator from the common exciter input to the RF output (varies as a function of power output)
- The coaxial cable connecting the generator to the matching network (varies with length of cable)
- The reactive elements of the matching network (varies as a function of variable values if automatic matching network)
- The connection from the matching network to the chamber input

If necessary, you can adjust the aggregate phase shift between the RF sources by varying the length of the coaxial cable or inserting a commercially available phase shifter in the line used to provide the common exciter signal.

RFX 600A generators are extremely easy to operate in the CEX mode. Choose one unit as the *master* and the other as the *slave*. Connect the CEX output of the master to the CEX input of the slave. The RFX CEX output provides a signal of the proper frequency and amplitude to the CEX input, automatically phase-locking to the signal and tracking the master unit's oscillator. In some options, CEX toggle on the User port must be active.

More than two generators can be synchronized with a single master unit by *daisy-chaining* the CEX outputs and inputs. That is, connect the CEX output of the master to the CEX input of the first slave; connect the CEX output of the first slave to the CEX input of the second slave; and so on.

AE CUSTOMER SUPPORT

Please contact one of the following offices if you have questions:

Table 6-2. *Customer Support Locations*

Office	Telephone
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA	Phone: 970.221.0108 or 970.221.0156 Fax: 970.221.5583 Email: technical.support@aei.com
AE, Voorhees, NJ 1007 Laurel Oak Road Voorhees, NJ 08043 USA	Phone: 856.627.6100 Fax: 856.627.6159

Table 6-2. *Customer Support Locations*

Office	Telephone
AE, California 491 Montague Expressway Milpitas, CA 95035 USA	Phone: 408.263.8784 Fax: 408.263.8992
AE, GmbH Raiffeisenstrasse 32 70794 Filderstadt (Bonlanden) Germany	Phone: 49.711.77927.0 Fax: 49.711.7778700
AE, Japan KK TOWA Edogawabashi Bldg. 347 Yamabuki-cho Shinjuku-ku, Tokyo Japan	Phone: 81.3.32351511 Fax: 81.3.32353580
AE, Korea Ltd. Gongduk Building, 4th floor 272-6 Seohyun-Dong, Bundang-Gu, Sungam Si Kyunggi, 463-050 Korea	Phone: 82.342.705.2100 Fax: 82.342.705.2766
AE, United Kingdom Unit 5, Minton Place, Market Court, Victoria Road Bichester, Oxon OX6 7QB UK	Phone: 44.1869.320022 Fax: 44.1869.325004

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, ***first follow all troubleshooting procedures***. If, after following these procedures, you still have a problem or if the procedure instructs you to, call AE Customer Support and discuss the problem with a representative. Be prepared to give the model number and serial number of the unit as well as the reason for the proposed return. This consultation call allows Customer Support to determine whether the problem can be corrected in the field or if the unit needs to be returned. Such technical consultation is always available at no charge.

If you return a unit without first getting authorization from Customer Support and that unit is found to be functional, you will be charged a re-test and calibration fee plus shipping charges.

To ensure years of dependable service, Advanced Energy® products are thoroughly tested and designed to be among the most reliable and highest quality systems available worldwide.

WARRANTY

Advanced Energy® (AE) products are warranted to be free from failures due to defects in material and workmanship for 12 months after they are shipped from the factory (please see warranty statement below, for details).

In order to claim shipping or handling damage, you must inspect the delivered goods and report such damage to AE within 30 days of your receipt of the goods. Please note that failing to report any damage within this period is the same as acknowledging that the goods were received undamaged.

For a warranty claim to be valid, it must:

- Be made within the applicable warranty period
- Include the product serial number and a full description of the circumstances giving rise to the claim
- Have been assigned a return material authorization number (see below) by AE Customer Support

All warranty work will be performed at an authorized AE service center (see list of contacts at the beginning of this chapter). You are responsible for obtaining authorization (see details below) to return any defective units, prepaying the freight costs, and ensuring that the units are returned to an authorized AE service center. AE will return the repaired unit (freight prepaid) to you by second-day air shipment (or ground carrier for local returns); repair parts and labor will be provided free of charge. Whoever ships the unit (either you or AE) is responsible for properly packaging and adequately insuring the unit.

Authorized Returns

Before returning any product for repair and/or adjustment, call AE Customer Support and discuss the problem with them. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Customer Support to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Units that are returned without authorization from AE Customer Support and that are found to be functional will not be covered under the warranty (see warranty statement, below). That is, you will have to pay a retest and calibration fee, and all shipping charges.

Warranty Statement

The seller makes no express or implied warranty that the goods are merchantable or fit for any particular purpose except as specifically stated in printed AE specifications. The sole responsibility of the Seller shall be that it will manufacture the goods in accordance with its published specifications and that the goods will be free from defects in material and workmanship. The seller's liability for breach of an expressed warranty shall exist only if the goods are installed, started in operation, and tested in conformity with the seller's published instructions. The seller expressly excludes any warranty whatsoever concerning goods that have been subject to misuse, negligence, or accident, or that have been altered or repaired by anyone other than the seller or the seller's duly authorized agent. This warranty is expressly made in lieu of any and all other warranties, express or implied, unless otherwise agreed to in writing. The warranty period is 12 months after the date the goods are shipped from AE. In all cases, the seller has sole responsibility for determining the cause and nature of the failure, and the seller's determination with regard thereto shall be final.

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