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Paramount® MF 2 kW Generator

User Manual

January 2018 57020114-00E

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PRODUCT USAGE STATEMENT

WARNING:

Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment might be impaired. All personnel who work with or who are exposed to this equipment must take precautions to protect themselves against serious or possibly fatal bodily injury.

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Safety and Product Compliance Guidelines

IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy Paramount MF 2 kW unit, read and understand this manual before attempting to install and operate this unit. At a minimum, read and follow the safety guidelines, instructions, and practices.

DANGER, WARNING, AND CAUTION BOXES



This symbol represents important notes concerning potential harm to people, this unit, or associated equipment. Advanced Energy includes this symbol in danger, warning, and caution boxes to identify specific levels of hazard seriousness.



DANGER:

DANGER indicates an imminently hazardous situation that, if not avoided, will result in death or serious injury. DANGER is limited to the most extreme situations.



WARNING:

WARNING indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury, and/or property damage.



CAUTION:

CAUTION indicates a potentially hazardous situation that, if not avoided, could result in minor or moderate injury, and/or property damage. CAUTION is also used for property-damage-only accidents.

SAFETY GUIDELINES

Review the following information before attempting to install and operate the product.

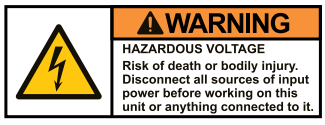
Rules for Safe Installation and Operation

Please note the following rules:

- Do not attempt to install or operate this equipment without proper training.
- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.
- Verify that input voltage and current capacity are within specifications before turning on the power supplies.
- Use proper electrostatic discharge (ESD) precautions.

INTERPRETING PRODUCT LABELS

The following labels may appear on your unit:

	CE label Complies with applicable European directives.
	Protective conductor terminal This terminal must be connected first and be of proper type and size for the circuit with the highest voltage and current carrying capacity. Note that other connections may have higher requirements than that of the MAINS connection.
	Hazardous voltage
	Hazardous voltage Voltage > 30 V_{rms}, 42.4 V peak, or 60 VDC
	Nonionizing radiation Radio Frequency emissions may be harmful.
	Certified by CSA to North American Safety Standards for both Canada and the United States



Refer to manual for more information



SEMI® F47 compliant



Heavy object—can cause muscle strain or back injury



Environmentally Friendly Use Period of 25 years per China RoHS—recycle responsibly at end of life

PRODUCT COMPLIANCE

The following sections include information about unit compliance and certification, including the conditions of use required to be in compliance with the standards and directives.

Product Certification

Certain options of this product may be certified according to the list below.

For more information, refer to the Certificate or Letter of Conformity (US) or Declaration of Conformity (EU) accompanying the product.

- NRTL – Safety certified by CSA International, a Nationally Recognized Testing Laboratory
- CE Marking – Self-declaration, assessed by AE Corporate Compliance
- EMC measurements – Verified by AE Corporate Compliance
- SEMI guidelines – Verified by AE Corporate Compliance

Safety and EMC Directives and Standards

For information concerning compliance to applicable EU requirements, refer to the EU Declaration of Conformity for this unit. The Declaration of Conformity may also include a supplementary section covering compliance to non-EU regulatory requirements and/or industry standards or guidelines.

Conditions of Use

To comply with the stated directives and standards, you must meet the following conditions of use:

- For corner-grounded delta configuration installation, excessive leakage occurs. Secondary Protective Earth (ground) must be connected.
- The AC power cordset used must comply with local codes and regulations.
- Before making any other connection to this product, connect the primary Protective Earth (ground), and secondary Protective Earth (ground) if applicable, to a local earth ground using wire that is sized according to the applicable requirements.
- To prevent condensation, install and operate this device with an external water solenoid valve so that water flow is interrupted when the device is not operating.
- Install and operate this unit in an overvoltage category according to environmental specifications.
- Install and operate this unit in a pollution degree environment according to environmental specifications.
- Operate this device within the ambient temperature and water specifications declared in the specifications.
- If this unit does not have a circuit breaker, you must install and operate it with a circuit breaker switch on the AC input. The circuit breaker switch must be easily accessible and near the unit. The circuit breaker must be marked as the disconnecting device for the equipment.
- You must install and operate this device with a disconnect switch that conforms to the applicable requirements. The switch must be easily accessible and near the device.
- Use only a shielded cable for the input power connections.
- Use only a shielded cable for the output process power connections.
- Use only a shielded cable for communications and/or control connections.

Environmental Compliance

- **EU REACH – European Union Regulation (EC) No. 1907/2006**

  Registration, Evaluation, Authorization and Restriction of Chemicals

  Advanced Energy manufactures articles subject to Article 33 of REACH and, upon request, will provide information regarding Substances of Very High Concern (SVHC) currently identified by the European Chemical Agency (ECHA) that are contained in this product, at concentrations greater than 0.1% by weight.

- **China RoHS - People's Republic of China (PRC) Ministry of Industry and Information Technology (MIIT) Order #32 (China RoHS 2)**

  Management Methods for the Restriction of the Use of Hazardous Substances Electrical and Electronic Products

  This product contains hazardous substances listed in PRC Standard GB/T 26572, above the maximum concentration limits stipulated. In compliance to PRC Standard SJ/T 11364, AE provides a disclosure of hazardous substance content and this product is marked with an Environmentally Friendly Use Period (EFUP) of 25 years.

INTERLOCKS

WARNING:

Advanced Energy products only include interlocks when required by product specification. Interlocks in Advanced Energy products are not intended to meet or satisfy safety requirements. Where interlocks exist, you must still meet and satisfy safety requirements. The presence of interlocks does not imply operator protection.

Hardware Interlocks and Interlock Circuit

Table 1-1. Hardware interlocks

Mechanism	Detection Method	Equipment Condition When Interlock is Open
Interlock relay disables DC power to the gate drivers of the RF section, which results in RF output being disabled.	An interlock condition occurs when: • The **User** port interlock circuit is not satisfied • The RF output interlock switch detects when the RF cable is not fully attached.	Green **Interlock** LED is not lit, interlock is not satisfied, and as a result RF out cannot be enabled.

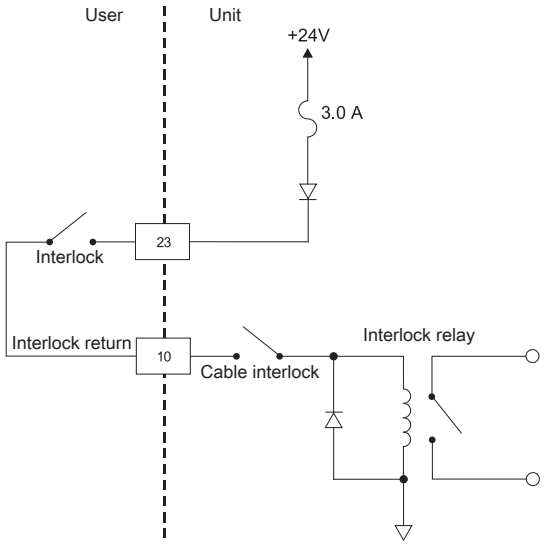


Figure 1-1. *Interlock circuit*

Product Overview

PRODUCT DESCRIPTION

General Description

The Advanced Energy Paramount MF 2 kW generator is a 360 kHz to 440 kHz midfrequency generator designed to regulate on one of the following:

- Forward power
- Load power
- Voltage with an optional AE peak voltage sensor

The Paramount MF 2 kW generator provides up to 2000 W into a 50 Ω, nonreactive load. The generator is capable of delivering 100% of its rated power into a 4.79:1 VSWR load, making it an ideal choice for applications with a fixed match.

The Paramount MF 2 kW generators incorporate Direct Digital Synthesis (DDS) technology for control of the operating frequency. This technology can be useful when the application requires that the selected generator operate into an impedance mismatch. The frequency can be programmed to dither over a predetermined range to minimize the load mismatch to the generator. The DDS operating parameters on each generator are configured via the generator's serial communications interface and are stored indefinitely in nonvolatile RAM.

The Paramount MF 2 kW generators are water and air cooled, 7" high, 19" rack-mountable units. Front panels with numeric displays and six status LEDs provide basic generator monitoring. Primary control is accomplished through the generator's serial and user communications interfaces.

THEORY OF OPERATION

Operation Overview

The Paramount MF 2 kW generator efficiently creates sinusoidal voltage waveforms by switching rectified DC power through a filter and an isolation transformer. A directional coupler/detector samples the RF power signal and uses the signal to control the switch waveforms and therefore, the output power. Depending upon the method of regulation, either the forward or load power can be used as a control

signal. The Paramount MF 2 kW generator can also control the voltage at the load with proper voltage feedback and setting the unit to voltage control mode.

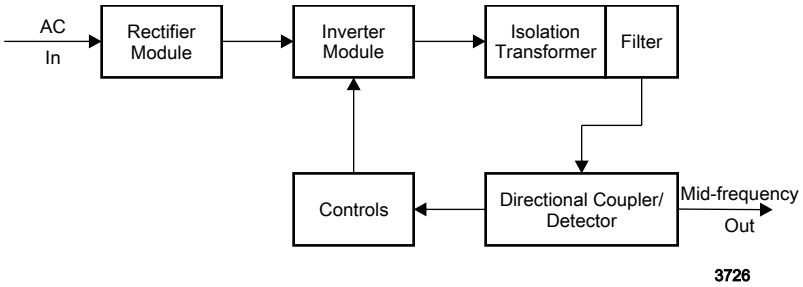


Figure 2-1. Paramount MF 2 kW generator block diagram

Rectifier Module

The full-wave bridge rectifier converts the AC input voltage into a steady DC signal. This power is provided directly into the inverter module.

Inverter Module

The inverter module is composed of a set of MOSFETs which are either fully on or fully off. When the FETs are on, very little voltage drop occurs across them. When they are off, virtually no current flows through them. Since the power dissipated in a FET is the product of the voltage across and the current through the device, neither case represents a large power loss. This makes the generator very efficient.

Isolation Transformer

The inverter module produces a waveform with substantial energy at the fundamental switching frequency, which is set to the desired output frequency. This waveform goes to the isolation transformer.

The isolation transformer isolates RF output of the generator from the inverter module which is directly connected to the AC power line. The transformer also transforms the impedance to bring the output impedance of the generator to a standard 50 Ω level.

Filter

The filter is a combination of inductors and capacitors especially designed to pass only the frequency of interest and reject high frequency harmonics (a lowpass filter). The output of the filter is nearly a perfect sine wave. This wave is then delivered to the directional coupler/detector.

Directional Coupler/Detector

The directional coupler/detector samples the voltage and current of the RF power line and a digital signal processor (DSP) is used to calculate the forward and reflected power. The forward and reflected power can be thought of as the power flowing toward the load and the power reflected back from the load. Forward power minus reflected power is the power dissipated in the load and is called the load power. The DSP uses the calculated values in the feedback control loop to control the power supply output.

The Paramount MF 2 kW generator uses sophisticated signal processing to compensate for or eliminate offsets and nonlinearities inherent in the generator. As a result, the output power of the generator is accurate and linear. Forward, reflected, and load power levels are displayed on the front panel and are provided to, or can be accessed through, the generator's serial and user communication ports.

Voltage Control Mode

The Paramount MF 2 kW generator has the capability to control the amplitude of RF output voltage at the load with the use of the AE Low Frequency Fixed Match and voltage peak detector. The voltage from the peak detector is supplied to the generator and used to control the inverter.

Controls

The control section controls the inverter that regulates the output power. This section has limits and trip thresholds that prevent inverter failure.

POWER REGULATION

Regulation Overview

The Paramount MF 2 kW generator can regulate power based on either forward or load power measurements. The method used by the generator is determined by **User** port pin 8, referenced to pin 21 (*FWD/LOAD POWER REGULATION*). You can also use command **3**, set regulation mode, at the Host port to select the regulation mode. The front panel display screen allows you to view operating data for forward, reflected, and load power parameters.

Forward and Reflected Power

In a mismatched system, the load impedance does not match the connecting cable impedance, which means there will always be a standing wave on the connecting cable. Think of this standing wave as being created by the interference of two

travelling waves, one moving toward the load and one returning to the generator. The power in the imagined wave moving toward the load is the forward power, and the power in the imagined return wave is the reverse, or reflected, power.

Mathematically, in a system with a reference (cable) impedance Z_0, forward and reflected voltages ($V_{f/r}$) and current ($I_{f/r}$) can be defined as:

$$\mathcal{V}_{f/r} = \mathcal{V} \pm (\mathcal{Z}_0 I)/2$$

$$I_{f/r} = (\mathcal{V}/\mathcal{Z}_0) \pm I/2$$

The plus sign is used for forward voltage and current and the minus sign is used for reflected voltage and current. The forward and reflected powers are the product of the voltages and currents:

$$\mathcal{P}_f = \mathcal{V}_f \times I_f$$

$$\mathcal{P}_r = \mathcal{V}_r \times I_r$$

Neither the forward nor the reflected power directly determine the process results.

Load Power

The load power is the power actually dissipated in the load. If the load is not reactive, the load power is simply the voltage times the current. If the load is reactive, there will be phase angle between the voltage and current, and the load power will be equal to: V * I * cos (phase angle).

In terms of forward and reflected power, the load power is the forward power minus the reflected power. Generally, the important factor in a process is the load power, because by definition that is the actual power delivered to the load.

Specifications

PHYSICAL SPECIFICATIONS

Table 3-1. Physical specifications

Description	Specification
Size	178 mm (H) x 434 mm (W) x 501 mm (D) 7″ (H) x 17.1″ (W) x 19.7″ (D) ☞ **Important** These measurements do not include handles, connectors, and switches.
Weight	35.38 kg (78 lb) maximum
Mounting	Standard 19″ rack; optional custom mounting
Clearance	A clearance of 13 mm (0.5″) minimum is required at the right side of the unit for proper cooling. A clearance of 102 mm (4″) is required at the rear of the unit for connections.
Connectors/Cable Specifications	
RF output connector	HN coaxial female (TRU-8371-SNT). Connector has an interlock which engages when output cable is fully connected.
AC power input	HARTING Han® Modular, 4-pin, 70 A male connector: • Frame: 09140060303 • Housing: 09300060301 • Insert (70 A): 09140022642
User port connector	25-pin subminiature-D, female
Host port connector	9-pin subminiature-D, female
E-Net port	Reserved for AE use only
Pulse In connector	SMA
Pulse Out connector	SMA
Bias voltage input **Sense V-In** connector	SMA
Scaled analog output for bias compensation	SMA

Table 3-1. Physical specifications (Continued)

Description	Specification
Bias V-Out connector	
Coolant connectors (water in and water out)	SS female Swagelok® 3/8″ on nickel plated brass panel
Chassis ground terminal	10-32 stud with nut and star washer

ELECTRICAL SPECIFICATIONS

☞ **Important**
AE Host command **7** restores all nonvolatile RAM values to factory preset values. See individual product specifications for factory default parameters. For more information, contact AE Global Services.

Table 3-2. Electrical specifications

Description	Specification
Input Power	
Standard operation	• Nominal: VAC = 208 V, 60 Hz; Low line AC: VAC = 187 V, 60 Hz • Output power = 2000 W • Frequency = 400 kHz • Load = 50 Ω
AC facility requirements • Line voltage • Line frequency • Phase	Facility requirements specification: • Line voltage: 208 VAC ± 10% (187 VAC to 229 VAC) • Line frequency: 50 Hz to 60 Hz nominal (47 Hz to 63 Hz) • Phase: 3φ with ground, no neutral
AC to RF efficiency	Nominal: 78% Low line AC: 79%
AC input power factor	Nominal: 0.67 Low line AC: 0.69
AC power consumption	Nominal: 2556 W Low line AC: 2514 W
AC line current	< 16 A_{RMS} per phase at 2000 W, 208 VAC < 18 A_{RMS} per phase at 2000 W, low AC line
Overcurrent protection	50 A circuit breaker with lockout pin
RF Output Power	
Warm-up time	Generator minimum warm-up time of 2 minutes after AC on
Frequency tuning range	360 kHz to 440 kHz
Frequency stability	< 50 ppm of selected frequency

Table 3-2. Electrical specifications (Continued)

Description	Specification
Reflected power limit	1500 W maximum
Delivered power into mismatched loads (Automatic load mismatch protection, unlimited load impedance range, full frequency range)	Generator maximum delivered power is based on reflected power limit. • Within VSWR 1.1:1 it is 2000 W • Within VSWR 2.0:1 it is 2000 W • Within VSWR 4.79:1 it is 2000 W • Outside VSWR 4.79:1, maximum delivered power is restricted by reflected power limit, 1500 W.
Delivered power setpoint range	5 W to 2000 W
Frequency resolution	1 Hz
Regulation modes selected by tool interface	Regulation modes: • Forward power regulation mode • Load power regulation mode • Voltage regulation mode
Measured power accuracy in full frequency range and across full line voltage range	Measured power accuracy is a combination of the generator and measurement equipment accuracy. These specifications were created per an AE test measurement procedure. Using alternate test measurement devices and/or procedures will result in deviations from the provided numbers and values listed in this specification.
Measured power accuracy into 50 Ω non-reactive load	Power accuracy: • ± 0.5 W of setpoint for 5 W to 50 W • ± 1% of setpoint or ± 2 W, whichever is greater, when operating at 400 kHz, into a 50 Ω, non-reactive load for 50 W to 2000 W • ± 1.5% of setpoint or ± 2 W, whichever is greater, over entire frequency range when operated into a 50 Ω, non-reactive load, for 50 W to 2000 W
Measured power accuracy into 2:1 VSWR circle	Power accuracy: • ± 1.5 W of setpoint for 5 W to 50 W, over entire frequency range • ± 2.5% of setpoint or ± 2 W for 50 W to 2000 W, whichever is greater, over entire frequency range

Table 3-2. Electrical specifications (Continued)

Description	Specification
Measured power accuracy into 4.79:1 VSWR circle	Power accuracy: • ± 2 W of setpoint for 5 W to 50 W, over entire frequency range • ± 3.5% of setpoint or ± 2 W for 50 W to 2000 W, whichever is greater, over entire frequency range
Repeatability (same generator) over the full frequency and power range into 50 Ω non-reactive load	Same generator repeatability: • ± 1 W of setpoint for 5 W to 50 W • ± 1% of setpoint or ± 1.5 W, whichever is greater, when operating at 400 kHz, into a 50 Ω, nonreactive load for 50 W to 2000 W • ± 1.5% of setpoint or ± 2 W, whichever is greater, over entire frequency range when operated into a 50 Ω, nonreactive load, for 50 W to 2000 W
Repeatability generator-to-generator over the full frequency and power range into 50 Ω non-reactive load	< 2.0% or 4 W, whichever is greater, from 50 W to 2000 W into a 50 Ω, non-reactive load
Load mismatch stability over full frequency and power range	The generator will operate continuously into any load impedance without failure.
Short term output power drift operating into a 50 Ω load	< 1.0% during one continuous hour of operation beginning with a setpoint of 0 W at 400 kHz and giving the generator a 2000 W setpoint operating into a 50 Ω load.
RF on/off response time	Analog **User** interface: • RF rise time: < 20 ms from leading edge of *RF ENABLE* signal to 81% of setpoint (90% of the output voltage) provided a single command received by the generator. No overshoot. • RF fall time: < 6 ms from falling edge of *RF ENABLE* signal to < 5 W provided a single command received by the generator.
RF on/off response time	Serial **Host** interface: • RF rise time: < 20 ms upon receipt of AE Bus command to 81% of setpoint provided a single command received by the generator. No overshoot. • RF fall time: < 6 ms upon receipt of AE Bus command to < 5 W provided a single command received by the generator.

Table 3-2. Electrical specifications (Continued)

Description	Specification
Setpoint change response time Analog **User** interface	Analog response time is measured from step setpoint change to 90% change of the RF output voltage. • RF rise time < 30 ms over full power range into a broadband load • RF fall time < 30 ms over full power range into a broadband load
Setpoint change response time Serial **Host** interface	Serial interface response time is measured upon receipt of an AE Bus command to 90% change of the output RF voltage. • RF rise time < 25 ms over full power range into a broadband load • RF fall time < 25 ms over full power range into a broadband load
Spurious signals in full frequency and power range on 50 Ω load	- 50 dBc
Harmonics in full frequency range at maximum power on 50 Ω load	- 30 dBc
Maximum allowable forward power incident upon the RF outputs from external sources/ load	50 W minimum between 2 MHz and 300 MHz
Zero/Low setpoint	RF output is disabled if setpoint in power control mode is less than 5 W. RF output is disabled if setpoint in external voltage control mode is less than 20 V. **RF ON** LED on the front panel remains on.
RF ramp rate control	The rise and fall rate of the RF output can be programmed via the serial **Host** interface. This function is enabled for RF ON and setpoint up or down changes via the serial **Host** interface. For safety reasons, an RF OFF command will not ramp down the output. The rate can be defined in watts per second or absolute time through the serial **Host** interface. Watts per second mode can be set in 1 W increments. Absolute time mode range in 1 ms increments: • Minimum ramp time: 1 ms • Maximum ramp time: 30000 ms The ramp rate parameters are not allowed to change while a setpoint ramp is currently in progress.

Table 3-2. Electrical specifications (Continued)

Description	Specification
Diagnostics	The generator will evaluate its internal parameters for the relative health of the generator. Special diagnostic capability is provided for testing into short (0 Ω) load.
Tuning Algorithm The unit is designed and programmed to utilize a sweep frequency algorithm to optimize power delivery and minimize load mismatch as detected by the unit's output sensor. The algorithm is able to: • Minimize load mismatch • Lock the generator at a tune point • Track (re-tune) frequency to follow changes in load impedance to minimize load mismatch	
Frequency tuning range	360.1 kHz to 439.6 kHz
Frequency preset: Start minimum and maximum frequency	360.1 kHz to 439.6 kHz, 1 kHz resolution
Tune time	< 0.1 second from RF enabled at a preset frequency (within 10% or 2 W of the minimum reflected power, whichever is greater)
Typical tune time for factory set tuning parameters	60 ms tuning delay +25 ms tuning
Tracking and re-tune	< 0.1 s maximum If load mismatch increases above a user defined threshold, the generator will re-tune.
Tuned frequency repeatability	± 2 kHz
Pulsing into Broadband 50 Ω	
Frequency range	10 Hz to 2 kHz (minimum on width has to be satisfied)
Duty cycle range	10% to 90% (minimum on width has to be satisfied)
Minimum on width	225 µs
Rise/ fall time	When output voltage reaches 67% of nominal: • Rise time 10 µs maximum • Fall time 10 µs maximum
Settling time	When output voltage settles within 10% of nominal: • 300 µs at 5 W output power • 30 µs at 2000 W output power
Voltage overshoot	With a 50 Ω broadband load:

Table 3-2. Electrical specifications (Continued)

Description	Specification
	• Maximum 25%
Power accuracy	Pulse power level is the same as CW after pulse settling time.
Pulse to pulse jitter	Pulse length uncertainty (pulses can be longer than programmed): Maximum 1 RF period (2.5 µs at 400 kHz)
Synchronization	Start of pulse is synchronized to the phase of the RF clock.
Pulsing into non 50 Ω Loads Load is a fixed matching network loaded to the "plasma model", which is 30 Ω to 116 Ω resistor in series with 1.1 nF capacitor.	
Minimum on width	225 µs
Settling time	Less than 500 µs
Voltage overshoot	x 6 times (typical)
Pulse Sync In/Out	
Frequency range	10 Hz to 2 kHz Minimum on width must be satisfied.
Duty cycle	10% to 90% Minimum on width must be satisfied.
Minimum on width	225 µs
Pulse **Sync In**	RF pulse on high level Z = 50 Ω 0 VDC to 5 VDC maximum
Pulse **Sync Out**	RF pulse on high level Z = 50 Ω source impedance 0 VDC to 5 VDC unloaded 0 VDC to 2.5 VDC across a 50 Ω load
Pulsed output timing accuracy	1.0 µs edge uncertainty
RF Voltage/Power Detection Sampling	
Sample delay	150 µs
Sample rate	36 µs sampling rate of voltage in voltage control mode 16 µs sampling rate of power in power control mode
Averaging	Control loop--averaging by integrator, readback--Moving average of 8 samples

Table 3-2. Electrical specifications (Continued)

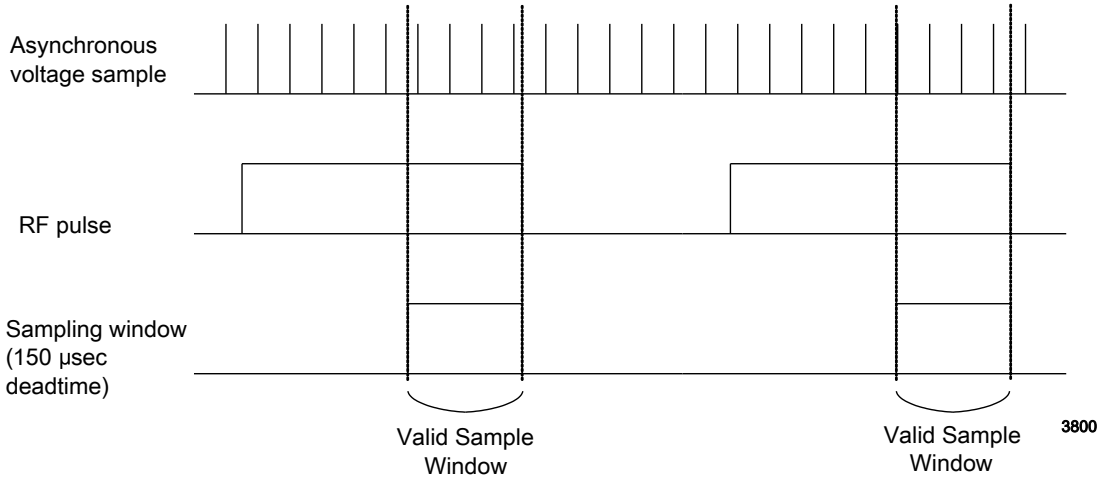
Description	Specification
 *Figure 3-1. Timing diagram*	
External Voltage Control Mode	
General specification	When operating the unit in external voltage regulation mode: • Minimum voltage setpoint in this mode = 0.1 V • Maximum forward power in the voltage control mode = 1800 W
Control loop response time	Typical settling time is 8 µs to 10 µs when operating on 50 Ω load with peak detector from the AE Low Frequency Fixed Match. Settling time is measured from the start of step disturbance to 90% change of the output voltage.
Sense Voltage In input characteristics	Input specification for this SMA connector: • Input voltage 0 V to 10 V • Accuracy of voltage measurement ± 0.6% or ± 20 mV • The input impedance for all analog signals is greater than 10 kΩ The input has protection from a disconnected cable using a 70 kΩ pull-up resistor. If the cable is not connected, input voltage is 10.7 V, which causes the generator to pull back output power down to 0 W.
Bias Voltage Out output characteristics	Output specification for this SMA connector: • Output voltage range 0 V to -5 V

Table 3-2. Electrical specifications (Continued)

Description	Specification
	• Accuracy of output voltage ± 0.7% or ± 80 mV (accuracy is the difference between the digital signal sent to DAC and the actual output voltage) • The load impedance should be greater than 1 kΩ

COOLING SPECIFICATIONS

> **CAUTION:**
> Do not use deionized water for cooling purposes. Deionized water causes both corrosion and erosion of cooling manifolds.

Table 3-3. Cooling specifications

Description	Specification
Coolant Requirements	
Inlet water temperature	+5°C to +35°C (+41°F to +95°F)
Flow rate	7.6 lpm (2 gpm), minimum
Maximum inlet water pressure	6.9 bar (100 psi)
Pressure drop	See the following pressure drop figure
Contaminates	AE recommends the following specifications for the water used to cool the Paramount MF 2 kW generator: • pH between 7.0 and 9.0 • Total chlorine < 20 ppm • Total nitrate < 10 ppm • Total sulfate < 100 ppm • Total dissolved solids < 250 ppm • Total hardness expressed as calcium carbonate equivalent less than 250 ppm • Specific resistivity of 2500 Ω/cm or higher at 25°C • Total dissolved solids (TDS) as estimated by the following: ◦ TDS ≤ 640,000 ÷ specific resistivity (Ω/cm)

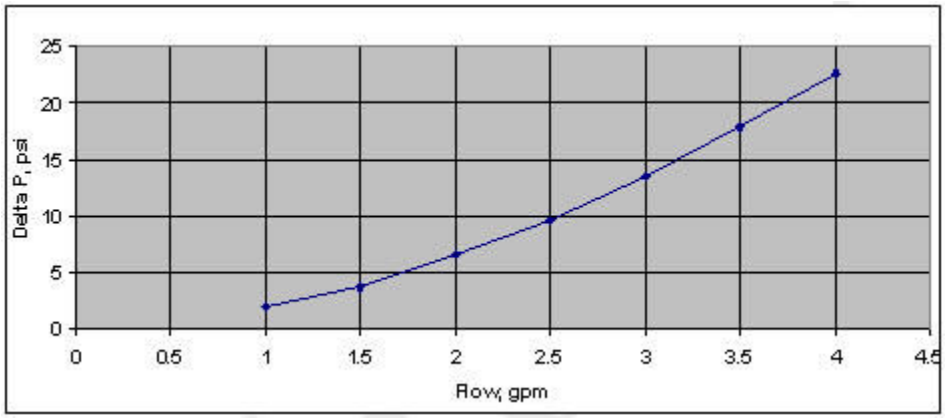


Figure 3-2. *Pressure drop*

ENVIRONMENTAL SPECIFICATIONS

Table 3-4. Environmental standard specifications

Description	Specification
Overvoltage Category	II
Pollution degree	2

Table 3-5. Climatic specifications

	Temperature	Relative Humidity	Air Pressure
Operating	+5°C to +40°C +41°F to +104°F	5% to 85% *[1]* 1 g/m^3 to 25 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: +2000 m to -500 m (+6562′ to -1640′)
Storage	-25°C to +55°C -13°F to +131°F	5% to 95% 1 g/m^3 to 29 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: +2000 m to -500 m (+6562′ to -1640′)
Transportation	-25°C to +70°C -13°F to +158°F	95% *[2]* 60 g/m^3 *[3]*	65.6 kPa to 106 kPa 656 mbar to 1060 mbar Equivalent altitude: +3500 m to -500 m (+11483′ to -1640′)

[1] Non-condensing, no formation of ice

[2] Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25°C to +30°C (-13°F to +86°F)

[3] Maximum absolute humidity when the unit temperature directly decreases from +70°C to +15°C (+158°F to +59°F)

Communication Controls

25-PIN USER PORT

25-Pin User Port Connector

The **User** port uses a 25-pin, shielded, female, subminiature-D connector. Ground/return lines are floating and need to be connected as close to the system as possible.

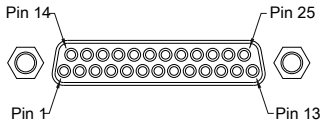


***Figure 4-1. User** port connector, 25-pin*

User Port Cabling Requirements

The cable used to connect the generator's **User** port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring may be used 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 10 meters (33′). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the generator must be tied to a local earth ground through an adequately sized copper grounding strap.

Satisfying Minimal Requirements for the 25-Pin User Port

Regardless of whether you are controlling and monitoring the generator through the **User** port or through another port, two **User** port signals must be satisfied for the unit to be operational: *RF PWR ON* (pin 4) and *INTERLOCK LOOP* (pins 10 and 23). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled on the **User** port, and the interlock satisfied.

☞ **Important**

If you are controlling your generator through a port other than the **User** port, make sure that the control mode is set appropriately (to host mode to control through the **Host** port, for example). The control mode can be set through an AE Host command.

If you are not using the **User** port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these signals, thereby ignoring the **User** port. To make a dummy plug, solder these jumpers on a mating connector.

Table 4-1. Jumpers on a dummy plug to satisfy minimal signal requirements

Jumper Between Pins	Description
4 and 13	Connects *RF PWR ON* pin to *+15 V* pin
17 and 21	Satisfies *RF PWR ON* return to ground
10 and 23	Satisfies *INTERLOCK LOOP* signal

If desired, you can add an emergency off switch in series with the *RF PWR ON* signal (pin 4) and/or tie your system interlocks in series with the generator *INTERLOCK LOOP* signal (pins 10 and 23).

If the minimum requirements are met and then AC power is applied, RF output will not automatically be activated. Choose a control mode, and then, to activate RF output:

- If you are in host control mode, send an RF on command.
- If you are in user control mode, send an RF off signal and then an RF on signal.

25-Pin User Port Signal and Pin Descriptions

The following tables describe the 25-pin **User** port signals and pin descriptions. Wiring diagrams are also provided.

Table 4-2. User port signal descriptions

Description	Specification
Digital inputs (DI)	Optocouple-insulated Logic high: 4 V to 25 V, typical input current 11 mA Logic low: Less than 1 V
Digital outputs (DO)	Optocouplers open or close state Open (high impedance): V maximum = 30 V (IC < 500 µA) Close (low impedance): I maximum = 11 mA; Voltage drop is less than: • 1.2 V at 0.1 mA • 3.2 V at 5 mA • 5.6 V at 11 mA
Analog inputs (AI)	Voltage range 0 V to 10 V

*Table 4-2. **User** port signal descriptions (Continued)*

Description	Specification
	Return wire should be connected to system ground. Accuracy of voltage measurement: ± 0.6% or ± 20 mV. The input impedance for all analog input signals is greater than 10 kΩ.
Analog outputs (AO)	Voltage range 0 V to 10 V Return wire should be connected to system ground. Accuracy of voltage measurement: ± 0.6% or ± 15 mV. The load impedance for all analog output signals should be greater than 1 kΩ.

*Table 4-3. 25-pin **User** port pin descriptions*

Signal Pin	Related Pin	Name	Signal Type	Description
1	14	*SET POINT STATUS RETURN*	Digital output	See pin 14.
2	15	*RFL PWR MONITOR*	Analog output	This signal provides a linearly scaled readback of reflected power. • 0 V = 0 W • 10 V = 1500 W See Figure 4-2 on page 4-6 for the wiring diagram.
3	16	*FWD/LOAD PWR MONITOR*	Analog output	This signal provides a linearly scaled readback of forward power when the generator is operated in forward power regulation mode or the load power when operated in load power regulation mode. In voltage control mode, this signal provides readback of forward power. • 0 V = 0 W • 10 V = Maximum rated output power See Figure 4-3 on page 4-7 for the wiring diagram.
4	17	*RF PWR ON*	Digital input	When logic high is applied to this pin, RF output is enabled (if generator is in user control mode). Logic low disables

*Table 4-3. 25-pin **User** port pin descriptions (Continued)*

Signal Pin	Related Pin	Name	Signal Type	Description
				the RF output. Logic low disables the RF output in either user control mode or host control mode. ☞ **Important** The interlocks must be satisfied and the set point must be within the output power range before unit will deliver power. See Figure 4-4 on page 4-7 for the wiring diagram.
5	18	*SET POINT*	Analog input	This pin linearly controls the RF output of the generator in either forward power mode or load power mode. • 0 V to 10 V = 0 W to maximum rated output power This input also provides set point in the voltage control mode. • 0 V to 10 V = 0 V to 2000 V peak to peak See Figure 4-5 on page 4-7 for the wiring diagram.
6	19	*DC BIAS/ POWER REGULATION*	Digital input	This pin switches the regulation mode of the generator. When logic low is applied to this pin, or if there is no connection to this pin, the generator regulates output power (either forward or load, as defined by the signal on pin 8). When logic high is applied to this pin, the generator regulates in the voltage control mode. See Figure 4-6 on page 4-8 for the wiring diagram.
7				Not connected.
8	21	*FWD/LOAD PWR REGULATION*	Digital input	Applying logic high to this pin causes the generator to regulate on load power. Logic low or no connection to this pin causes the generator to default to forward power regulation.

*Table 4-3. 25-pin **User** port pin descriptions (Continued)*

Signal Pin	Related Pin	Name	Signal Type	Description
				In voltage control mode, this pin is ignored. See Figure 4-7 on page 4-8 for the wiring diagram.
9	22	*OVERTEMP RETURN*	Digital output	See pin 22.
10	23	*INTERLOCK LOOP*		This pin should connect to pin 23 to complete the interlock chain. If the interlock chain is broken, the unit will not operate. External circuit should be capable of switching 50 mA at 24 VAC. Maximum allowed resistance of the interlock chain is 75 Ω. See Figure 4-8 on page 4-9 for the wiring diagram.
11	24	*DC BUS OK RETURN*	Digital output	See pin 24.
12				Not connected.
13	21	*+15 VDC*	Analog output	User voltage for interface purposes. Rated 400 mA maximum. Short-circuit protected. See Figure 4-9 on page 4-9 for the wiring diagram.
14	1	*SET POINT STATUS*	Digital output	When the generator is out of set point by more than 1% and 3 W, a low (opto-coupler output) impedance is created between this pin and pin 1. See Figure 4-10 on page 4-9 for the wiring diagram.
15	2	*RFL POWER MONITOR RETURN*	Analog output	Signal return for pin 2.
16	3	*FWD/LOAD PWR MONITOR RETURN*	Analog output	Signal return for pin 3.
17	4	*RF PWR ON RETURN*	Digital input	Signal return for pin 4.
18	5	*SET POINT RETURN*	Analog input	Signal return for pin 5.

*Table 4-3. 25-pin **User** port pin descriptions (Continued)*

Signal Pin	Related Pin	Name	Signal Type	Description
19		*GROUND*		Signal/chassis ground.
20				Not connected.
21		*GROUND*		Signal/chassis ground.
22	9	*OVERTEMP*	Digital output	When an internal overtemperature shutdown condition is detected, a low (opto-coupler output) impedance is created between this pin and pin 9. See Figure 4-11 on page 4-10 for the wiring diagram.
23	10	*INTERLOCK LOOP RETURN*		See pin 10.
24	11	*DC BUS OK*	Digital output	When the interlocks are satisfied and no faults are present, a low (opto-coupler output) impedance is created between this pin and pin 11. See Figure 4-12 on page 4-10 for the wiring diagram.
25				Not connected.

WIRING DIAGRAMS FOR THE 25-PIN USER PORT

The diagrams in this section provide wiring information to connect to the 25-pin **User** port.

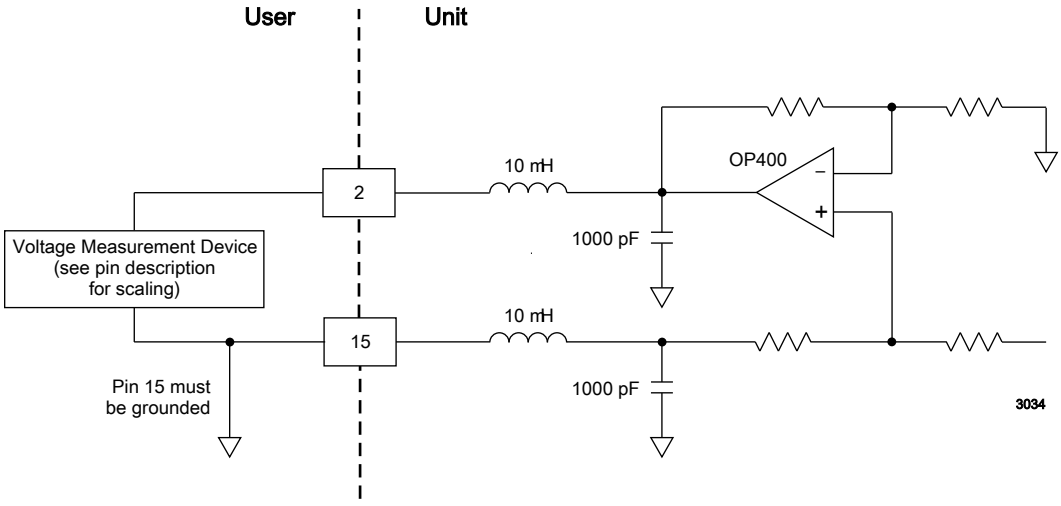


Figure 4-2. REFL PWR MONITOR (pins 2 and 15)

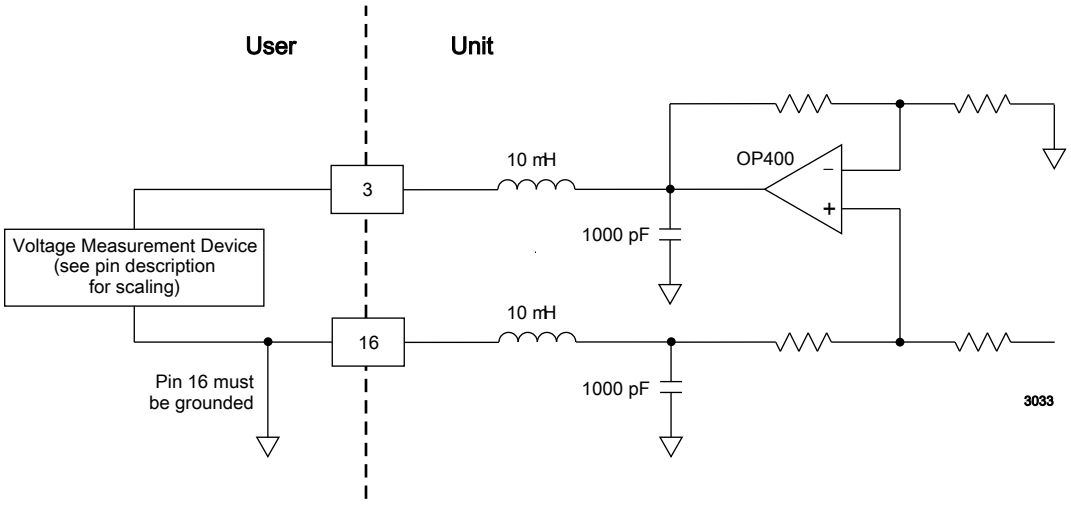


Figure 4-3. FWD/LOAD PWR MONITOR (pins 3 and 16)

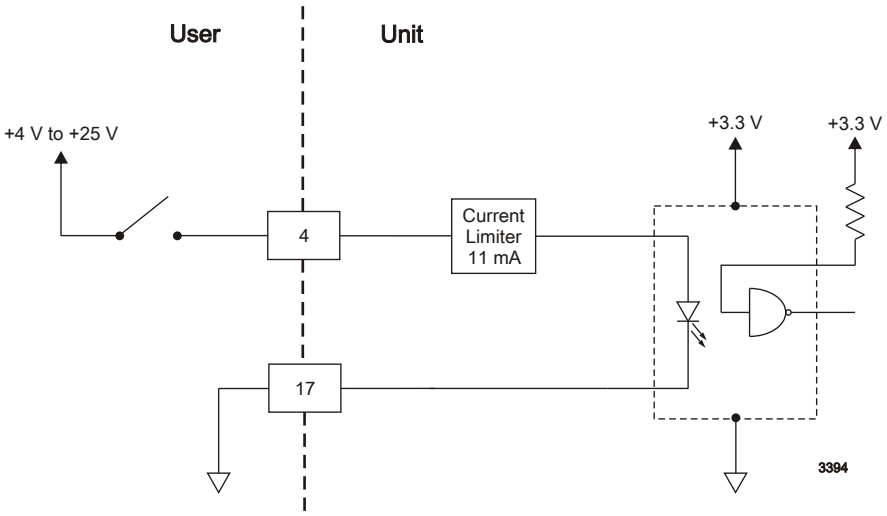


Figure 4-4. RF PWR ON (pins 4 and 17)

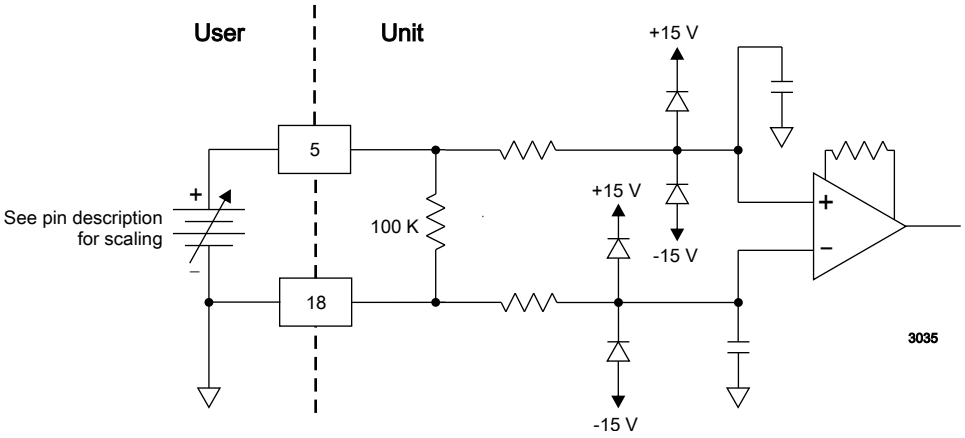


Figure 4-5. SET POINT (pins 5 and 18)

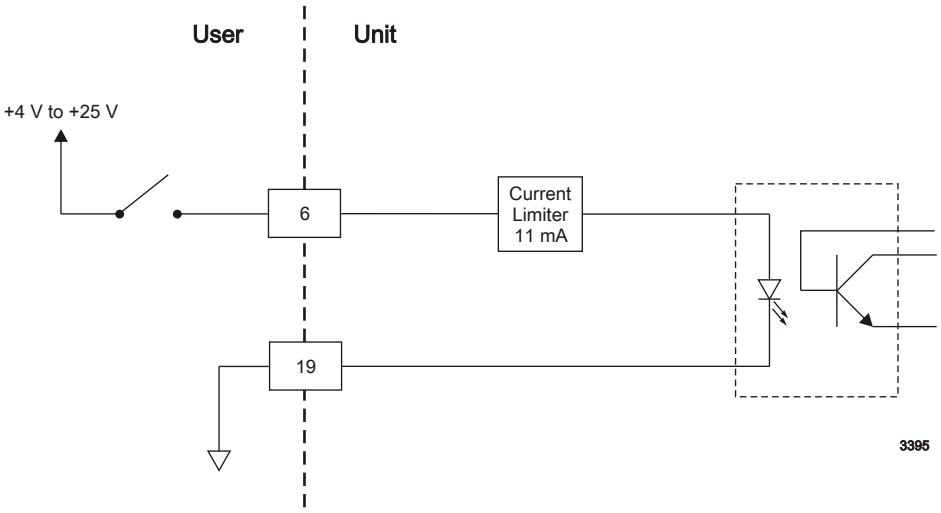


Figure 4-6. DC BIAS/POWER REGULATION (pins 6 and 19)

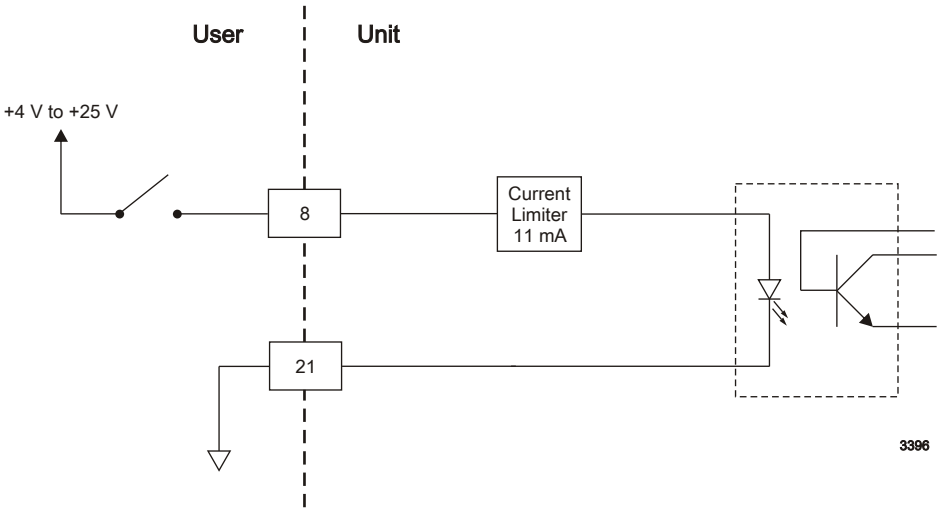


Figure 4-7. FWD/LOAD PWR REGULATION (pins 8 and 21)

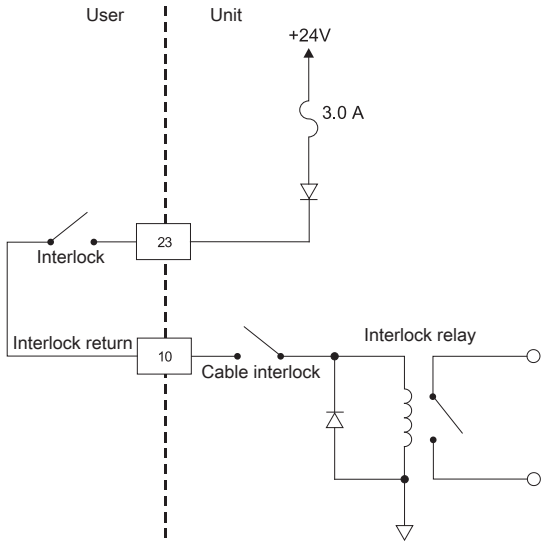


Figure 4-8. INTERLOCK LOOP (pins 23 and 10)

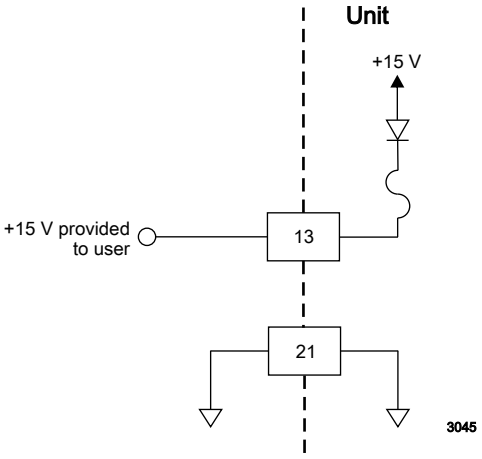


Figure 4-9. +15 VDC (pins 13 and 21)

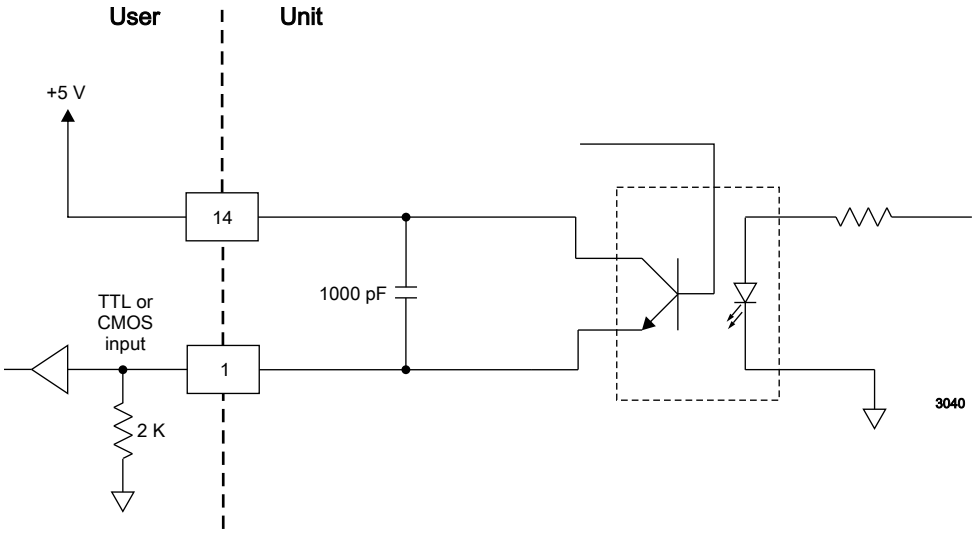


Figure 4-10. SET POINT STATUS (pins 14 and 1)

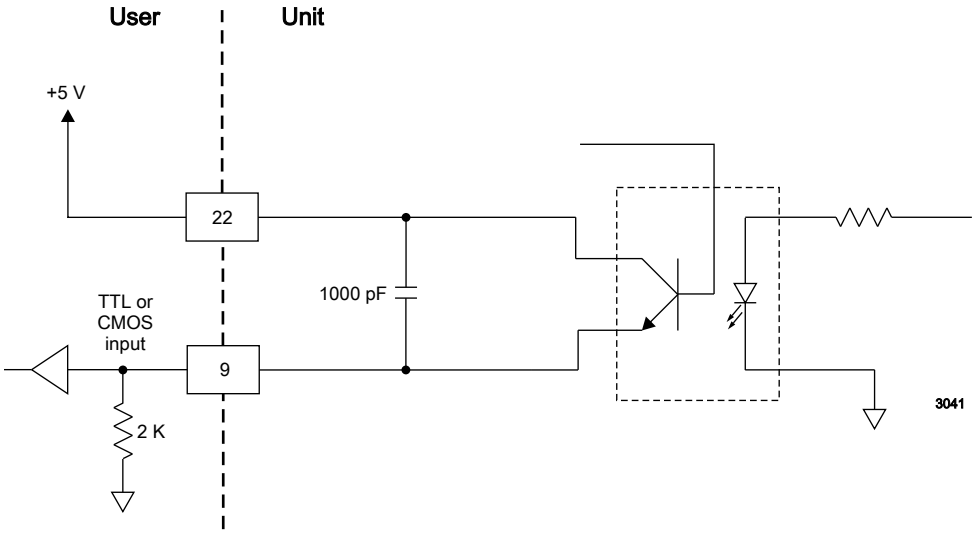


Figure 4-11. OVERTEMP (pins 22 and 9)

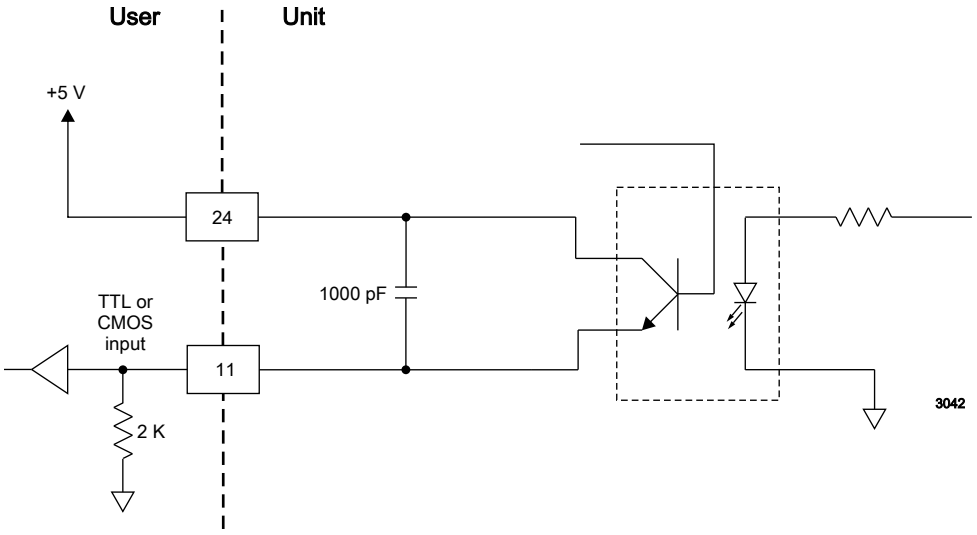


Figure 4-12. DC BUS OK (pins 24 and 11)

AE BUS INTERFACE (HOST PORT)

The Paramount MF 2 kW unit provides a serial communications interface through the **Host** port. This interface allows the Paramount MF 2 kW unit to interface with a host computer using the AE Bus protocol.

To obtain a basic sample of host software for the **Host** port, please call AE Global Services.

AE manufactures a more full-function interface software for some products, called Virtual Front Panel, which allows you to use a host computer to communicate with

the unit through the **Host** port. To find out more about this software, please call AE Global Services.

Host Connector

The serial **Host** port connector is a 9-pin, female, shielded, subminiature-D connector for interfacing with a host computer.



*Figure 4-13. **Host** port connector*

Host Port Pin Descriptions

*Table 4-4. **Host** port pin descriptions*

Signal Pin	Name	Description
1	*RESERVED*	Reserved for future use
2	*TX RS232*	RS-232 transmit data
3	*RX RS232*	RS-232 receive data
4	*RESERVED*	Reserved for future use
5	*COM*	Data common
6	*RESERVED*	Reserved for future use
7	*RESERVED*	Reserved for future use
8	*RESERVED*	Reserved for future use
9 [1]	*RESERVED (FACTORY)*	Reserved for future use

[1] Do not ground this factory reserved pin. Grounding this pin disrupts the operation of the unit.

Do not connect pins marked *RESERVED*.

AE Bus Transmission Parameters

The communications capability of the **Host** port is limited to the following parameters:

- RS-232 protocol
- Baud rates:
  - 9600

  - 19200
  - 57600
  - 115200
- Paramount MF 2 kW unit addresses 1 to 31
- Odd parity
- One start bit, eight data bits, one stop bit
- Low-order bytes transmitted before high-order bytes (little endian)

The timeout period for the Paramount MF 2 kW unit is factory set at 0.75 seconds (that is, no more than 0.75 seconds can elapse between bytes, or the unit will reset and begin searching for a new message packet). Use command **40** to change this value.

The host computer must finish one transaction with the Paramount MF 2 kW unit before it initiates another transaction, either with the same unit or any other unit.

The Paramount MF 2 kW unit sends data through pin 2 (*TX RS-232*). This pin must be connected to the receive pin (*RX RS-232*) on the host computer's serial connector. The receive pin is normally pin 2 for a standard, 9-pin serial port.

Host Port DIP Switches

DIP SWITCH AND SWITCH SETTINGS

Use the DIP switch to set the baud rate and the AE Bus address for your unit.

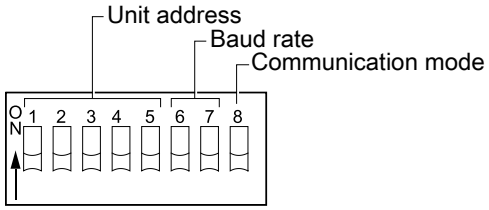


Figure 4-14. *Slide DIP switch*

The DIP switch contains eight individual switches. Setting a switch to the on position means sliding the switch toward the numbers on the DIP, and setting a switch to the off position means sliding it away from the numbers.

SWITCHES

The first five switches (1 to 5) specify the address of the unit, which a host computer must include in the message packet it sends.

The next two switches (6 and 7) specify the AE Bus port baud rate.

Switch 8 (communication mode) is unused.

SETTING THE BAUD RATE

Use the DIP switch to set the serial AE Bus port baud rate.

Table 4-5. DIP switch settings for variable baud rate, switches 6 and 7

Baud	Switch 6	Switch 7
9600	On	On
19200	On	Off
57600	Off	On
115200	Off	Off

DEFAULT DIP SWITCH SETTINGS

The default Host settings for the unit are AE Bus address 1, baud rate 19200, and RS-232 communication mode.

Table 4-6. Default dip switch settings

Switch number	1	2	3	4	5	6	7	8
Default position	on	on	on	on	off	on	off	on

SETTING THE UNIT AE BUS ADDRESS

Use the DIP switch to set the unit AE Bus address.

Table 4-7. AE Bus address settings

Address	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5
0	Do not assign this address to a unit; it is the AE Bus broadcast address. All AE Bus units receive a message sent to this address by the host, but will not reply. If you set the address to 0, the unit automatically reassigns the address to 1				
1	On	On	On	On	Off
2	On	On	On	Off	On
3	On	On	On	Off	Off
4	On	On	Off	On	On
5	On	On	Off	On	Off
6	On	On	Off	Off	On

Table 4-7. AE Bus address settings (Continued)

Address	Switch 1	Switch 2	Switch 3	Switch 4	Switch 5
7	On	On	Off	Off	Off
8	On	Off	On	On	On
9	On	Off	On	On	Off
10	On	Off	On	Off	On
11	On	Off	On	Off	Off
12	On	Off	Off	On	On
13	On	Off	Off	On	Off
14	On	Off	Off	Off	On
15	On	Off	Off	Off	Off
16	Off	On	On	On	On
17	Off	On	On	On	Off
18	Off	On	On	Off	On
19	Off	On	On	Off	Off
20	Off	On	Off	On	On
21	Off	On	Off	On	Off
22	Off	On	Off	Off	On
23	Off	On	Off	Off	Off
24	Off	Off	On	On	On
25	Off	Off	On	On	Off
26	Off	Off	On	Off	On
27	Off	Off	On	Off	Off
28	Off	Off	Off	On	On
29	Off	Off	Off	On	Off
30	Off	Off	Off	Off	On
31	Off	Off	Off	Off	Off

AE Bus Protocol

The AE Bus protocol uses pure binary data (nothing is coded in ASCII) and is designed to facilitate direct communications between a host computer and the Paramount MF 2 kW unit. The AE Bus message packet combines a set quantity of bits and bytes in such a way that groups of information can be sent over communications lines at one time. Five types of information (fields) make up a communications message packet.

- Header (address and the length of data field)

- Command number
- Optional length byte
- Data
- Checksum

Figure 4-15 shows the organization of these fields in the AE Bus message packet. The subsequent paragraphs describe each field in detail.

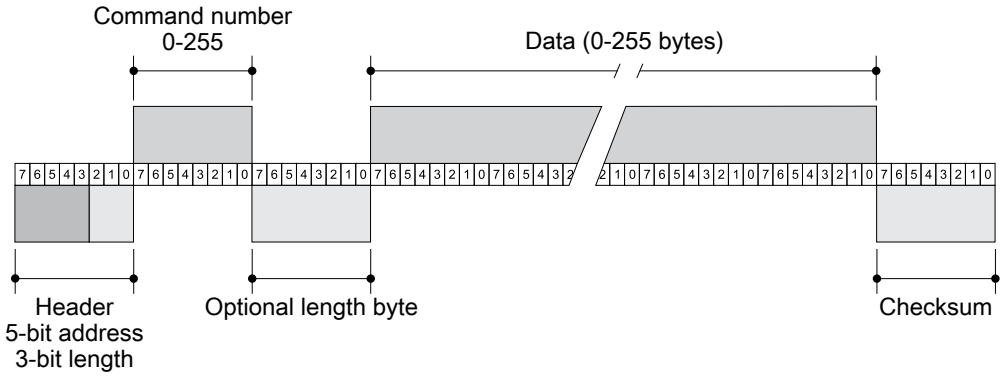


Figure 4-15. *Graphic representation of a message packet*

AE BUS HEADER BYTE

The first byte in each packet contains two pieces of information: five bits contain the packet address, and three bits contain the data byte count. If the message packet originates with the host computer, the address specifies the packet destination (to the Paramount MF 2 kW unit, for example). If the packet is going to the host, the address specifies the packet origin (from the Paramount MF 2 kW unit). The address section of the header field is five bits long (bits 3 to 7), which allows a total of 32 distinct addresses. Address 0 (zero) is reserved for the network broadcast address, which the Paramount MF 2 kW unit does not support.

The remaining three bits (bits 0, 1, and 2) are the length bits. These bits tell the receiving unit how long the data field is so that the unit can determine when it has received the entire message. If the data field contains more than six bytes, the value of these three bits will be set to 7 (07h), and the optional length byte field will contain a value indicating the number of data bytes in the data field.

☞ **Important**

The value of these bits refers only to the number of actual data bytes in the data field. Do not include the checksum byte when calculating the value for these bits.

AE BUS COMMAND NUMBER BYTE

This 1-byte field contains an 8-bit value from 0 to 255 (00h to ffh) representing the command number. If the message packet originates with the host computer, this value

specifies the purpose of the message packet. If the message originates with the Paramount MF 2 kW unit, the value specifies the command to which it is responding.

AE BUS OPTIONAL LENGTH BYTE

This field supplements the header field and exists only when the length bits (bits 0, 1, and 2) in the header field contain a value of 7 (07h). If the number of data bytes in the data field is ≤ 6, then the three length bits in the header field are sufficient to represent this amount, 0 to 6 (00h to 06h). Since the data field contains up to 255 bytes of information, the optional length byte is required when the data field is larger than six bytes.

When the data field is larger than six bytes, the length bits in the header (bits 0, 1, and 2) equals 7 (07h) and the optional length byte contains a 1-byte value, from 7 to 255 (07h to ffh), representing the number of data bytes in the data field.

AE BUS DATA BYTES

The data field contains 0 to 255 bytes of binary data. This field contains command-related data or a command status response (CSR). Since some commands do not require data, sometimes the data field is not present.

If the value specified in the length bits (bits 0, 1, and 2) of the header field is 0 to 6, the Paramount MF 2 kW unit expects 0 to 6 data bytes. However, if the value in the header field is 7 (07h), the Paramount MF 2 kW unit looks for the optional length byte after the command field and reads this value to calculate the data byte count.

Unless otherwise specified for individual commands, AE Bus protocol is little endian, which means that all values greater than 1 byte are sent in little endian order. For example, a command with 7 data bytes that included one 8-bit value, one 16-bit value, and one 32-bit value, would be sent as shown in Table 4-8.

Table 4-8. AE Bus byte structure

Value to Send	Byte Configuration
8-bit value = 15	Byte 1 = 0x0F
16-bit value = 23450	Bytes 2 and 3 = 0x9A 0x5B
32-bit value = 147679	Bytes 4 to 7 = 0xDF 0x40 0x02 0x00

AE BUS CHECKSUM BYTE

This 1-byte field is the last byte in the packet. The value of this byte depends upon the number of bytes in each of the preceding fields. The transmitting unit determines this value by accumulating the exclusive-or (XOR) of all bytes of the packet up to, but not including, the checksum value. The receiving unit accumulates the XOR of all bytes of the packet, including the checksum. If the result is zero, the unit has received the packet intact.

The unit will act on the message only if the address is valid and the checksum is validated.

Creating an Ideal Communications Transaction

Figure 4-16 illustrates the steps in an ideal communications transaction between a host computer and the Paramount MF 2 kW unit.

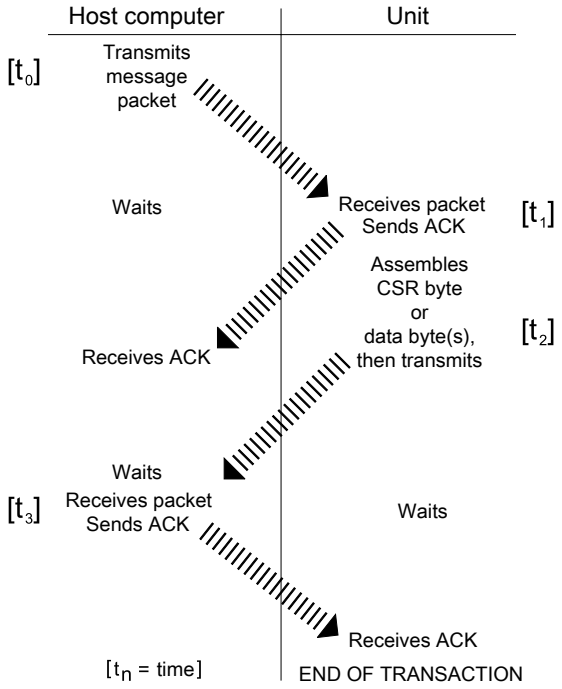


Figure 4-16. AE Bus communications transaction

T_0: HOST TRANSMITS MESSAGE PACKET

The host computer sends a message packet to the Paramount MF 2 kW unit. The packet contains one of the following:

- A command that requests data or status information
- A command and data that change a parameter setting
- An executable command

T_1: UNIT VERIFIES HOST TRANSMISSION PACKET

Once the Paramount MF 2 kW unit receives the host computer transmission message packet, the Paramount MF 2 kW unit verifies that the message is intended for it and not for another unit on the network. At this time, the Paramount MF 2 kW unit also analyzes the checksum to verify that the message was received correctly.

- If the address does not match, the Paramount MF 2 kW unit does not respond to the host computer; the Paramount MF 2 kW unit resets and resumes waiting for

a message addressed to it. If the address matches but the exclusive-or (XOR) sum of the bytes in the packet (including the checksum) is not zero, the Paramount MF 2 kW unit sends a negative acknowledgment (NAK), hexadecimal 15h, to the host computer.

- If the address matches and the message is intact, the Paramount MF 2 kW unit sends an acknowledgment (ACK), hexadecimal 06h, to the host computer.

If the Paramount MF 2 kW unit receives a request for data or status information, it gathers and sends the requested information. Otherwise, it evaluates the incoming command and sends a message packet that contains a 1-byte data value (CSR code) to the host. The power supply sends CSR code 0 when it has accepted the command.

If the host computer receives a NAK from the Paramount MF 2 kW unit, the host computer either retransmits the packet or does whatever else it has been programmed to do in this situation. If the host computer receives an ACK, it waits for the requested data or status information, or it waits for the CSR code telling it whether or not the new parameter was accepted. If the host computer receives no response within a reasonable period, it takes whatever action it has been programmed to take.

T_2: UNIT TRANSMITS RESPONSE TO HOST

The Paramount MF 2 kW unit prepares a response packet with the requested information or appropriate CSR code, which it then transmits to the host computer. The host computer then determines, by means of the checksum, if the response packet is complete. If the host computer detects an error in the transmission (the checksum is not validated), it can request the packet be sent again by transmitting a NAK.

T_3: HOST ACKNOWLEDGES UNIT RESPONSE

If the Paramount MF 2 kW unit receives an ACK from the host computer, it returns to the normal waiting state. If the Paramount MF 2 kW unit receives a NAK from the host computer, the unit retransmits the response packet. The Paramount MF 2 kW unit continues to retransmit in response to NAK transmissions until the host computer stops the cycle. If the Paramount MF 2 kW unit receives no response, it assumes an ACK and returns to the waiting state.

AE BUS COMMUNICATIONS TRANSACTION EXAMPLE

Figure 4-17 illustrates the steps in an example communications transaction between a host computer and the Paramount MF 2 kW unit.

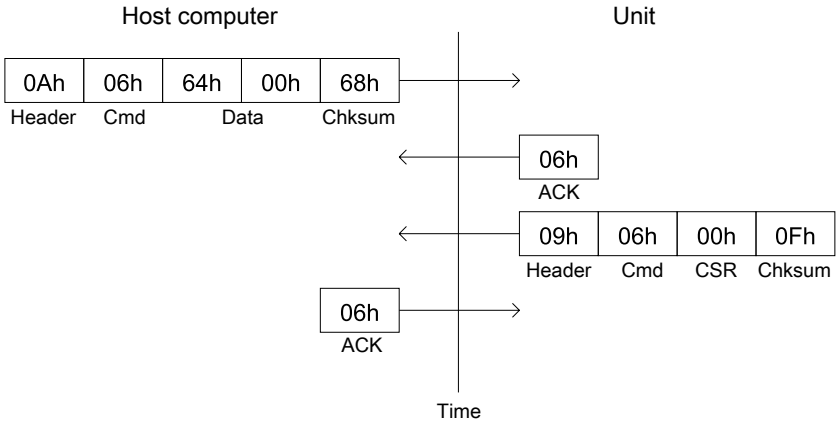


Figure 4-17. Communications transaction example

AE HOST COMMANDS

The following sections describe the command status response (CSR) codes returned by the Paramount MF 2 kW unit in response to a command, as well as the AE Host commands for the Paramount MF 2 kW unit.

AE Host Command Status Response (CSR) Codes

When the Paramount MF 2 kW unit receives a command requesting a change in unit operation (commands **1** through **127**), or when the Paramount MF 2 kW unit receives any command that it rejects (commands **1** through **255**), it responds with a command status response (CSR) code. The CSR is a single-byte number that indicates whether the unit accepted or rejected the command and, in the case of rejection, the reason the unit could not respond to the command.

Table 4-9. AE Host command status response (CSR) codes

Code	Meaning
0	Command accepted
The following CSR codes are sent in response to a command that was not accepted and provide an indication of why the command was not accepted	
1	Control mode is incorrect
2	Output is on (change not allowed)
4	Command specifies a value that exceeds the limit for that parameter
5	**User** port off signal is active.
7	One or more faults are active.
8	Set point ramping is active.

Table 4-9. AE Host command status response (CSR) codes (Continued)

Code	Meaning
9	Command's data byte count is incorrect.
12	Feature is not available on this unit.
17	Minimum off time is active.
28	Set point exceeds user limit.
30	EEPROM read/write error.
41	One or more warnings are active.
42	DHCP is active.
50	Frequency is out of range.
51	Duty cycle is out of range.
52	Minimum on or off time is violated.
61	Real time clock was busy.
63	Flash mode is active.
99	Command not accepted (there is no such command).

AE Host Command Set

- Commands **1** through **127** request a change to the Paramount MF 2 kW unit, such as changing a setting in the unit. The unit responds to these commands by sending a command status response (CSR). This single-byte response indicates whether the unit has accepted or rejected the command and, in the case of rejection, the reason the unit could not respond to the command.
- Commands **128** through **255** request information from the unit, such as unit settings. The unit responds to these commands by sending the data requested if the command was successful, and a CSR if the command was not successful.

Unless otherwise specified for individual commands, AE Bus protocol is little endian, which means that all values greater than 1 byte are sent least significant byte first.

Table 4-10. AE Host commands

Command	Description	Data Bytes Sent	Data Bytes Returned
1 RF Off	Turns RF output off. Accepted regardless of control mode. This command explicitly clears all latched faults, but it does not clear any faults that are currently active. Command **162** reports this value.	0	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
2 RF On	Turns RF output on if there are no active or latched faults or warnings. Accepted only when host control mode is active. Command **162** reports this value.	0	1
3 set regulation mode	Sets the regulation mode. Send 1 data byte (8-bit value): • 6 = Forward • 7 = Delivered or load • 8 = External (DC bias) Command **154** reports this value.	1	1
4 set user power limit	Sets the user power limit. You cannot change the power limit while the unit is on. Valid values are from the low power limit to the unit maximum power. The user power limit is directly related to the active regulation mode. For example, when in load regulation mode, the user power limit will limit delivered power. Send 2 data bytes (16-bit value) = Power limit in watts Command **169** reports this value.	2	1
5 set user reflected power limit	Sets the user reflected power limit in watts. The user reflected power limit affects all regulation modes. The unit retains the user reflected power limit as long as power is applied. If power is cycled, the reflected power limit returns to the default value, the specified reflected power maximum. You cannot change the user reflected power limit while the output is on. Valid values are from the specified reflected power minimum to the specified reflected power maximum. Send 2 data bytes (16-bit value) = Reflected power limit in watts Command **170** reports this value.	2	1
6 set user external feedback limit	Sets the user external feedback limit in volts. The user external feedback limit affects only the external DC bias regulation mode. The	2	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	unit retains the user external feedback limit as long as power is applied. If power is cycled, the external feedback limit returns to the default value, 2000 V. You cannot change the user external feedback limit while the output is on. Valid values are from 1% of the maximum external feedback value minimum up to the maximum external feedback value (set with command **9**). Send 2 data bytes (16-bit value) = External feedback limit in volts Command **171** reports this value.		
7 restore factory defaults	Restores all nonvolatile RAM values to the factory preset values. See individual product specifications for factory default parameters. For more information, contact AE Global Services. Send 2 data bytes (16-bit value): • 0 = Restore all default values	2	1
8 set power setpoint	Sets a power setpoint in watts. Sets a setpoint in volts when operating in external (DC bias) regulation mode. Setpoint cannot be greater than the unit's maximum output power or the user power limit. Setpoint cannot be greater than the maximum external feedback value when in external regulation mode. • User power limit = Set with command **4** Accepted only when host control mode is active. Send 2 data bytes (16-bit value) = Power setpoint in watts.When operating in external (DC bias) regulation mode, the setpoint is in volts. Command **164** reports this value.	2	1
9 set maximum external feedback value (NV)	Sets the maximum external feedback value in volts. This setting only affects the unit in the external (DC bias) regulation mode. The unit stores the maximum external feedback value in nonvolatile memory. You cannot change the	3	1

Table 4-10. AE Host commands (Continued)

<table>
<tr><th>Command</th><th>Description</th><th>Data Bytes Sent</th><th>Data Bytes Returned</th></tr>
<tr><td></td><td>maximum external feedback value while the output is on.
Valid values are from 10 V to 65535 V. If the new maximum external feedback value is less than the user external feedback limit, the unit reduces the user external feedback limit to equal to the new maximum external feedback value.
Send 3 data bytes:
• Bytes 0 and 1 = Maximum external feedback value in volts
• Byte 2 = Dummy byte for RFX II compatibility (can contain any value)</td><td></td><td></td></tr>
<tr><td>14
set active control mode</td><td>Sets the control mode. This mode cannot be changed while the output is on.
Send 1 data byte (8-bit value):
• 2 = Host
• 4 = User port (analog)
• 8 = Diagnostic
Command 155 reports this value.</td><td>1</td><td>1</td></tr>
<tr><td>26
set pulsing configuration</td><td>Set pulsing configuration. Set unit as master or slave, turn pulse sync input on or off, set memory mode, set explicit enable mode, and enable or disable pulsing mode.
This command allows you to send subcommands. Send a value in the first two bytes that selects the parameter to set, and then send subcommands to set parameter values.
<table>
<tr><th>Byte 0-1 =</th><th>Subcommand</th></tr>
<tr><td>1</td><td>Set pulsing mode</td></tr>
<tr><td>2</td><td>Set pulse sync output</td></tr>
<tr><td>3</td><td>Reserved</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>5</td><td>Set memory mode</td></tr>
</table></td><td>6</td><td>1</td></tr>
</table>

Table 4-10. AE Host commands (Continued)

<table>
<tr><th>Command</th><th>Description</th><th>Data Bytes Sent</th><th>Data Bytes Returned</th></tr>
<tr><td></td><td>The following table shows the factory set/ default values for pulsing parameters.<table><tr><th>Parameter</th><th>Factory Set/ Default Value</th></tr><tr><td>Pulsing mode</td><td>Master mode</td></tr><tr><td>Enable pulse sync output</td><td>Pulse sync output enabled</td></tr><tr><td>Memory mode</td><td>RAM</td></tr></table></td><td></td><td></td></tr>
<tr><td>26
set pulsing mode
(subcommand 1)</td><td>Sets the unit pulsing mode to master or slave. You can not use this command while RF output is on.
Send 6 data bytes.
Bytes 0 and 1 = 1 (set pulsing mode)
Bytes 2 and 3 = Pulsing mode
1 = Master mode
2 = Slave mode
Bytes 4 and 5 = Reserved
Command 172 B0 = 1 reports these values.</td><td>6</td><td>1</td></tr>
<tr><td>26
enable pulse sync output
(subcommand 2)</td><td>Enables or disables pulse sync output.
Send 6 data bytes.
Bytes 0 and 1 = 2 (enable/disable pulse sync output)
Bytes 2 and 3 = Pulse sync output on or off
0= Pulse sync output off
1= Pulse sync output on
Bytes 4 and 5 = Reserved
Command 172 B0 = 2 reports these values.</td><td>6</td><td>1</td></tr>
<tr><td>26
set memory mode
(subcommand 5)</td><td>Sets the unit memory mode to RAM or NVRAM. The unit saves parameters to the currently active memory as specified by this value. Future parameter changes will also be saved to the current active memory.</td><td>6</td><td>1</td></tr>
</table>

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 6 data bytes. • Bytes 0 and 1 = 5 (set memory mode) • Bytes 2 and 3 = Memory mode ◦ 0 = RAM ◦ 1 = NVRAM • Bytes 4 and 5 = Reserved Command **172** B0 = 5 reports these values.		
31 set setpoint ramping configuration	Sets the setpoint ramping mode and ramp parameters or sets ramping memory mode. The ramp up and down parameters can be set independently. Send 6 or 8 data bytes. Sending 6 data bytes allows you to set the setpoint ramping mode and ramp parameters. Sending 8 data bytes allows you to select a subcommand, and then set the setpoint ramping mode and parameters or set the ramping memory mode. **Ramping Mode and Parameters** In W/s mode, the ramp parameters represent the ramp rate in watts per second. The acceptable range for the ramp up and ramp down parameters in W/s mode is 1 W/s to 65535 W/s. In timed mode, the ramp parameters represent the time in ms. The acceptable range for the ramp up and ramp down parameters in timed mode is 1 ms to 65535 ms. The setpoint ramp parameters can be set while output is on. The ramp parameters are not allowed to change during a setpoint ramp that is currently in progress. The setpoint will not be ramped in either mode if the setpoint change is less than 1 W. **6 Data Byte Version** Send 6 data bytes (three 16-bit values): • Bytes 0 and 1 = Ramp mode	6 or 8	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 0 = Disabled ◦ 1 = Watts/second (W/s) ◦ 2 = Timed (in ms) • Bytes 2 and 3 (16-bit value) = Ramp up (in W/s or time in ms) • Bytes 4 and 5 (16-bit value) = Ramp down (in W/s or time in ms) **8 Data Byte Version** Send 8 data bytes to set either ramp data or memory mode. To set ramp data: • Bytes 0 and 1 = 1 (set ramp data) • Bytes 2 and 3 = Ramp mode (0 = Disabled, 1 = W/s, 2 = ms) • Bytes 4 and 5 = Ramp up (in W/s or time in ms) • Bytes 6 and 7 = Ramp down (in W/s or time in ms) To set the memory mode: • Bytes 0 and 1 = 2 (set memory mode) • Byte 2 and 3 = Memory mode (0 = RAM, 1 = NVRAM) • Bytes 4 through 7 = 0 Command **151** reports this value.		
38 set tuning time-out value	Sets the time in ms that the generator is allowed to tune without finding a match before it turns off RF output and activates a fault. The unit stores this setting in nonvolatile memory. You cannot change this mode while output is on. A value of 0 disables tuning time-out, causing the generator to tune indefinitely. Command **138** reports this value.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
39 set communications watchdog timer	Sets the communications watchdog timer value in ms. This timer denotes the amount of time that can pass without a successful communication. If this timer value is exceeded, the unit will turn output off if the output is on. Each AE Bus communications interface has its own unique watchdog timer. To set the watchdog timer value for a given port (for example, the **Host** port), send this command from that port. You can set up any combination of enable, disable, or time-out values among the interfaces. A value of 0 disables the watchdog timer. This parameter is volatile and defaults to 0 ms each time you turn the unit on. The maximum value is 65535 ms. The unit stores the watchdog timer value internally in 10 ms increments, and truncates any fractional remainder. The unit accepts a value from 1 to 9, but stores it as a time-out period of 10 ms. Send 3 data bytes: • Byte 0 = Enable/disable timer • Bytes 1 and 2 = Timer value in ms. Valid values are 1 to 65535 ms Command **139** reports this value	3	1
40 set host port time-out	Sets the amount of time that the generator waits between bytes from the host before resetting and waiting for a new packet. Each AE Bus communications interface has its own unique host port time-out. To set the host port time-out value for a given port (for example, the **Host** port), send this command from that port. Send 2 data bytes (16-bit value) representing units of 10 ms for the time-out value. The valid range of values is from 2 to 500 (20 ms to 5.0 s). The default value is 750 ms. Command **140** reports this value.	2	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
44 set minimum tuning frequency	Sets the minimum frequency that the generator uses for automatic tuning. The unit stores this parameter in nonvolatile memory. You cannot change this setting while output is on. Send 4 data bytes to set the value in kHz, or 5 data bytes to set the value in either kHz or Hz. Send 4 data bytes: • Frequency in kHz Send 5 data bytes: • Byte 0 = kHz or Hz ◦ 0 = Frequency is in kHz ◦ 1 = Frequency is in Hz • Bytes 1 through 4 = Frequency value Command **144** reports this value.	4 or 5	1
45 set maximum tuning frequency	Sets the maximum frequency that the generator uses for automatic tuning. The unit stores this parameter in nonvolatile memory. You cannot change this setting while output is on. Send 4 data bytes to set the value in kHz, or 5 data bytes to set the value in either kHz or Hz. Send 4 data bytes: • Frequency in kHz Send 5 data bytes: • Byte 0 = kHz or Hz ◦ 0 = Frequency is in kHz ◦ 1 = Frequency is in Hz • Bytes 1 through 4 = Frequency value Command **145** reports this value	4	1
46 set tuning start frequency	Sets the frequency at which the generator starts automatic tuning. The unit stores this parameter in nonvolatile memory. You cannot change this setting while output is on.	4 or 5	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 4 data bytes to set the value in kHz, or 5 data bytes to set the value in either kHz or Hz. Send 4 data bytes: • Frequency in kHz Send 5 data bytes: • Byte 0 = kHz or Hz ◦ 0 = Frequency is in kHz ◦ 1 = Frequency is in Hz • Bytes 1 through 4 = Frequency value Command **146** reports this value.		
48 set fixed or sweep frequency mode	Sets the frequency control mode. You can change this mode while the output is on. While the output is on, changing to fixed frequency mode causes the unit to change immediately to the previously set fixed frequency. Changing to sweep frequency mode causes the unit to output the start frequency first, and then to begin sweeping according to the tuning algorithm. The default setting is sweep frequency mode. The unit stores this value in nonvolatile memory. Send 1 data byte (8-bit value): • 0 = Fixed frequency mode • 1 = Sweep frequency mode Command **148** reports this value.	1	1
58 set retuning threshold	Sets the tuning criteria level at which the tuning algorithm determines that the generator requires retuning. The unit stores this parameter in nonvolatile memory. You cannot change this setting while output is on. Valid values are from 1 to 3000. Send 4 data bytes (32-bit value). Command **158** reports this value.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
60 set tune delay	Sets the time in ms that the tuning algorithm waits before beginning to tune the generator automatically. The unit stores this parameter in nonvolatile memory. You cannot change this setting while output is on. The maximum tune delay value is 60,000 ms. The default value is 50 ms. Send 2 or 4 data bytes. If the value doesn't fit into two bytes, it should be sent in four. • Bytes 0 and 1 = Tune delay time in ms. Command **160** reports this value.	2 or 4	1
61 set fixed frequency	Sets the generator output frequency when operating in fixed frequency mode. You can change the generator frequency while the output is on when operating in the fixed frequency mode. The fixed frequency value must be within the unit frequency range. For units that allow you to set the fixed frequency memory mode (see command **118**; B0 = 51), the fixed frequency parameter can be set to either volatile or nonvolatile. Some units allow you to retrieve minimum and maximum fixed frequency settings with command **161**. Send 4 data bytes to set the value in kHz, or 5 data bytes to set the value in either kHz or Hz. Send 4 data bytes (32-bit value): • Frequency in kHz Send 5 data bytes: • Byte 0 = kHz or Hz ◦ 0 = Frequency is in kHz ◦ 1 = Frequency is in Hz • Bytes 1 through 4 = Frequency value Command **161** reports this value	4 or 5	1
70 set real time clock	Sets the system real time clock to the time/ date specified. The data transmitted must be encoded in BCD (binary coded decimal)	7	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	format. For example, to set the seconds to 48, the data value transmitted must be 0x48. The real time clock features automatic leap year compensation for years up to 2100. Send 7 data bytes (8-bit values): • Byte 0 = Seconds (valid values are 0 to 59) • Byte 1 = Minutes (valid values are 0 to 59) • Byte 2 = Hours (valid values are 0 to 23) • Byte 3 = Day of the week (valid values are 1 to 7) ◦ 1 = Sunday ◦ 2 = Monday ◦ 3 = Tuesday ◦ 4 = Wednesday ◦ 5 = Thursday ◦ 6 = Friday ◦ 7 = Saturday • Byte 4 = Date (valid values are 1 to 31) • Byte 5 = Month (valid values are 1 to 12) • Byte 6 = Year (valid values are 00 to 99) Command **215** reports this value.		
93 set pulsing frequency	Sets the RF pulsing frequency in Hz. Valid values range from 10 Hz to 2000 Hz. Either a master or a slave unit can store this value in volatile or nonvolatile memory. You can set the memory mode (volatile or nonvolatile memory) with command **26**. **For Master Units** If the unit is a master unit, setting the pulsing frequency to 0 disables pulsing. If the master unit is operating in volatile storage mode, the unit always begins operation with pulsing disabled.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	You must enter a valid command for pulsing frequency and duty cycle to enable pulsing. Any combination of pulsing frequency and duty cycle that results in an output on time of less than 225 µs is invalid and returns a CSR error code. **For Slave Units** If the unit is a slave unit, this command sets the minimum pulse on time the unit accepts without asserting an error. The unit uses this frequency with an implied duty cycle of 50% to calculate the minimum pulse on time. The default minimum on time is 250 µs. Send 4 data bytes. • Bytes 0 through 3 = Pulsing frequency in Hz Command **193** reports this value.		
95 set diagnostic command	Controls the diagnostic self-test. The unit must be in diagnostic control mode before using this command (see command **14**). Sending a value of 0 disables the self-test and clears the self-test results from the previous run (if any). Sending a value of 1 clears the self-test results from the previous run (if any) and starts the diagnostic self-test. Send 1 byte. • Byte 0 = Enable/disable diagnostics. ◦ 0 = Disable diagnostics mode ◦ 1 = Enable diagnostic mode and start diagnostics Command **244** reports this value.	1	1
96 set pulsing duty cycle	Sets the RF pulsing duty cycle in percentage. The unit can store this value in one of two storage locations: • Volatile memory • Nonvolatile memory	2	1

Table 4-10. AE Host commands (Continued)

<table>
<tr><th>Command</th><th>Description</th><th>Data Bytes Sent</th><th>Data Bytes Returned</th></tr>
<tr><td></td><td>You can set the memory mode (volatile or nonvolatile memory) with command 26.
If the unit is a master unit, setting the pulsing duty cycle to 0 disables pulsing. If the master unit is operating in volatile storage mode, the unit always starts operation with pulsing disabled.
You must enter a valid command for pulsing frequency and duty cycle to enable pulsing The default value is 0. Any combination of pulsing frequency and duty cycle that results in an output on time less than 225 µs is invalid and returns a CSR error code.
Valid values range from 10% to 90% and represent output on time. Setting this value to 0 disables pulsing.
This command is valid only when operating in master mode. When operating in slave mode, this command returns CSR 12, Feature Not Available.
Send 2 data bytes = Duty cycle in %
Command 196 reports this value.</td><td></td><td></td></tr>
<tr><td>118
set operating parameter subcommands</td><td>This command allows you to send subcommands that set a variety of operating parameters. Send a value in the first two bytes that selects the parameter to set, and then send subcommands to set parameter values.
Your unit may not have all the features in this list. If you issue a command for a feature that your unit does not have, the unit returns CSR 12, Feature Not Available.
<table>
<tr><th>Byte 0 =</th><th>Subcommand</th></tr>
<tr><td>1</td><td>Set frequency step minimum</td></tr>
<tr><td>2</td><td>Set frequency step maximum</td></tr>
<tr><td>3</td><td>Set step up gain</td></tr>
<tr><td>4</td><td>Set step down gain</td></tr>
</table></td><td>Variable</td><td>1</td></tr>
</table>

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Byte 0 = / Subcommand 5 Set frequency step start 6 Set gamma threshold high 7 Set gamma threshold low 8 Set maximum tuning count 22 Set tuning step time 23 Set tuning gain delay 50 Set DC bias operating mode 51 Set fixed frequency memory mode		
118 set frequency step minimum (NV) (subcommand 1)	Sets the frequency tuning frequency step minimum size in Hz. Valid values must be less than the frequency step maximum and greater than 200 Hz. Send 6 data bytes. • Bytes 0 and 1 = 1 (set frequency step minimum) • Bytes 2 through 5 = Frequency step minimum Command **248** reports this value; B0 = 1.	6	1
118 set frequency step maximum (NV) (subcommand 2)	Sets the frequency tuning frequency step maximum size in Hz. Valid values must be greater than the frequency step minimum and less than 100,000 Hz. Send 6 data bytes. • Bytes 0 and 1 = 2 (set frequency step maximum) • Bytes 2 through 5 = Frequency step maximum Command **248** reports this value; B0 = 2.	6	1
118 set step up gain (NV) (subcommand 3)	Sets the magnitude of frequency step increase when the error is decreasing. A value of ^{n} sets the gain to 2^{n}. The default value is 2 (gain = $2^{n} = 2^{2} = 4$). Valid values are 1 to 7.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 4 data bytes. • Bytes 0 and 1 = 3 (set step up gain) • Bytes 2 and 3 = Step up gain Command **248** reports this value; B0 = 3.		
118 set step down gain (NV) (subcommand 4)	Sets the magnitude of frequency step decrease when the error is increasing. A value of 3 sets the gain to 2^{-3}= 0.125. Valid values are 1 to 7. Send 4 data bytes. • Bytes 0 and 1 = 4 (set step down gain) • Bytes 2 and 3 = Step down gain Command **248** reports this value; B0 = 4.	4	1
118 set gamma threshold high (NV) (subcommand 6)	Sets the frequency tuning gamma threshold high. The generator will use the high threshold after first attempting (and failing) to achieve a tuning criteria less than the low threshold. The generator also uses this value as the threshold to determine when to begin retuning. Valid values for gamma threshold high must be greater than or equal to gamma threshold low and less than 3000. Send 4 data bytes. • Bytes 0 and 1 = 6 (set gamma threshold high, LSB first) • Bytes 2 and 3 = Gamma threshold high Command **248** reports this value; B0 = 6.	4	1
118 set gamma threshold low (NV) (subcommand 7)	Sets the frequency tuning gamma threshold low. The generator first attempts to achieve a tuning criterion less than the low threshold. If the unit cannot find a tuning criterion less than the low threshold, and if the maximum tuning counter expires, the generator gives up and tries the high threshold. Valid values for gamma threshold low must be less than or equal to gamma threshold high.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 4 data bytes. • Bytes 0 and 1 = 7 (set gamma threshold low, LSB first) • Bytes 2 and 3 = Gamma threshold low Command **248** reports this value; B0 = 7.		
118 set maximum tuning count (NV) (subcommand 8)	Sets the frequency tuning maximum tuning count. This sets the number of attempts to tune to the low threshold before trying the high threshold. Valid values for maximum tuning count are from 0 to 65535. Send 4 data bytes. • Bytes 0 and 1 = 8 (set maximum tuning count, LSB first) • Bytes 2 and 3 = Maximum tuning count Command **248** reports this value; B0 = 8.	4	1
118 set tuning step time (NV) (subcommand 22)	Sets the tuning step time. This command is not available while the RF output is on. The range of valid values is from 8 µs to 4096 µs. The resolution for setting tuning step time is 16 µs. The unit rounds all values of tuning step time to the nearest multiple of 16 µs; for example, the minimum value of 8 is rounded up to 16. Send 4 data bytes. • Bytes 0 and 1 = 22 (set tuning step time) • Bytes 2 and 3 = Tuning step time Command **248** reports this value; B0 =22.	4	1
118 set tuning gain delay (NV) (subcommand 23)	Sets the tuning gain delay. This command is not available while RF output is turned on. The range of valid values is from 0 to 7. This parameter specifies the delay before increasing the step size after a change in direction. The factory default value is set by an EEPROM value. Send 4 data bytes.	4	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	• Bytes 0 and 1 = 23 (set tuning gain delay) • Bytes 2 and 3 = Tuning gain delay Command **248** reports this value; B0 =23.		
118 set DC bias operating mode (subcommand 50)	Sets the following parameters: • Power limit setting for external (DC bias) regulation mode—when operating in external (DC bias) regulation mode, the unit uses an internally set value as a maximum output power limit. In some units, this parameter is hard coded to limit forward power. Units that have the power limit setting for external regulation mode allow you to set the power limit to either forward or delivered power. • SOA mode—Enables/disables the safe operating area feature. • Memory mode—Sets whether these settings are volatile or nonvolatile. When set to volatile, the settings will default to factory default settings when power to the unit is cycled. See the product specifications for factory default settings. Send 6 data bytes. • Bytes 0 and 1 = 50 (set DC bias operating mode) • Bytes 2 and 3 = Select parameter to set: ◦ 1 = DC bias mode ◦ 2 = SOA mode ◦ 3 = Memory mode • Bytes 4 and 5 = Command data (dependent on selection in previous two bytes) If you selected DC bias mode: ◦ 1 = Forward power limit	6	1

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 2 = Delivered power limit If you selected SOA mode ◦ 0 = Disabled ◦ 1 = Enabled If you selected memory mode: ◦ 0 = Volatile ◦ 1 = Nonvolatile Command **248** reports this value; B0 = 50.		
118 set fixed frequency memory mode (subcommand 51)	Sets the fixed frequency mode to either volatile or nonvolatile. • When set to volatile, the fixed frequency defaults to the center frequency on power up. • When set to nonvolatile, the fixed frequency defaults to the factory default fixed frequency setting or last setting if changed from the factory default. See product specification for the fixed frequency factory default setting. The factory default setting for this command is configured for each product option. See the product specification for the default setting. Send 4 data bytes. • Bytes 0 and 1 = 51 (set fixed frequency memory mode) • Bytes 4 and 5 = Mode setting ◦ 0 = Volatile ◦ 1 = Nonvolatile Command **248** reports this value; B0 = 51.	4	1
128 report power supply type	Reports the power supply type. You can send 0 or 1 data bytes. Send 0 data bytes:	0 or 1	9 or 10 ASCII characters

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns a nonterminated 9-character ASCII string that represents the power supply type (`PT-MF`). Send 1 data byte: • Byte 0 = 3 Returns 10 bytes: • Bytes 0 through 3 = 4 ASCII characters • Bytes 4 through 9 = Six-digit ASCII representation of the 3 least significant bytes of the unit MAC ID.		
129 report power supply size	Reports the power supply size in kW, in four or six digits, depending on the sent data bytes. Send 0 or 1 data bytes. Send 0 data bytes: • Returns four data bytes = Power supply size formatted to four ASCII characters. Optional: Send 1 data byte (with a value of 0): • Returns six data bytes = Power supply size formatted to six ASCII characters, right justified.	0 or 1	4 or 6 ASCII characters
130 report software part number	Reports the software part number. Returns a nonterminated ASCII string that represents the AE software part number (for example, “7432006”). You can use this number in conjunction with the revision number returned by command **198** to identify the software in the unit. Sending a request data byte is optional. You can send 0 data bytes or 1 data byte. Send 0 data bytes. • Returns Coldfire application firmware part number.	0 or 1	7 ASCII characters

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 1 data byte (8-bit value) to select the software part number to be returned. • Byte 0 = Software request ◦ 0 = Coldfire application firmware part number ◦ 1 = Measurement board FPGA firmware part number ◦ 3 = Bootloader firmware part number ◦ 13 = Display board application firmware part number ◦ 14 = Display board FPGA firmware part number ◦ 15 = Display board bootloader firmware part number Returns 7 data bytes: • Bytes 0 through 6 = ASCII string representing the software part number.		
138 report tuning time-out value	Reports the time in ms that the generator is allowed to tune without finding a match before it turns off RF output and activates a fault. The maximum tuning time-out value is 60,000 ms. A value of 0 disables the tuning time-out feature, causing the generator to tune indefinitely. Returns 4 data bytes: • Bytes 0 through 4 = Time in ms Set this value with command **38**.	0	4
139 report communication watchdog timer	Reports the communications watchdog timer value in ms. A value of 0 ms indicates that the watchdog timer is disabled. This parameter is volatile and defaults to 0 each time you turn the unit on. The maximum reported value is 65530 ms. The unit stores the watchdog timer value internally in 10 ms increments and truncates any fractional remainder. The unit reports all values in multiples of 10 ms.	1	2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Since each interface has a unique watchdog timer, the value reported is the value of the watchdog timer associated with that specific interface. Send 1 data byte with a value of zero. Returns 2 data bytes. • Bytes 0 and 1 = Watchdog timer value in ms (16-bit value). Set this value with command **39**.		
140 report host time-out	Reports the current host port time-out value for the serial port. Host port time-out value is the maximum time allowed between bytes received. This value is in units of 10 ms. The allowable range of values is from 2 to 500, representing 20 ms to 5.00 seconds. Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = Host port time-out value. Set this value with command **40**.	0	2
144 report minimum tuning frequency	Reports the minimum frequency that the generator uses for automatic tuning. The minimum tuning frequency must be within the unit's factory-set frequency range. The unit stores this parameter in nonvolatile memory. Send 0 data bytes to return frequency in kHz, or send 1 data byte to return frequency in kHz or Hz. Send 0 data bytes: • Returns 4 data bytes = Frequency in kHz Send 1 data byte: • Byte 0 = Frequency in kHz or Hz ◦ 0 = Returns frequency in kHz ◦ 1 = Returns frequency in Hz Returns 4 data bytes = Frequency in kHz or Hz	0 or 1	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Set this value with command **44**.		
145 report maximum tuning frequency	Reports the maximum frequency that the generator uses for automatic tuning. The maximum tuning frequency must be within the unit's factory-set frequency range. The unit stores this parameter in nonvolatile memory. Send 0 data bytes to return frequency in kHz, or send 1 data byte to return frequency in kHz or Hz. Send 0 data bytes: • Returns 4 data bytes = Frequency in kHz Send 1 data byte: • Byte 0 = Frequency in kHz or Hz ◦ 0 = Returns frequency in kHz ◦ 1 = Returns frequency in Hz Returns 4 data bytes = Frequency in kHz or Hz Set this value with command **45**.	0 or 1	4
146 report tuning start frequency	Reports the frequency in kHz at which the generator starts automatic tuning. The tuning start frequency must be greater than or equal to the current minimum tuning frequency and less than or equal to the current maximum tuning frequency. The unit stores this parameter in nonvolatile memory. Send 0 or 1 data bytes. Send 0 data bytes to return frequency in kHz, or send 1 data byte to return frequency in kHz or Hz. Send 0 data bytes: • Returns 4 data bytes = Frequency in kHz. Send 1 data byte: • Byte 0 = Frequency in kHz or Hz	0 or 1	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 0 = Returns frequency in kHz ◦ 1 = Returns frequency in Hz Set this value with command **46**.		
147 report generator actual frequency	If output is on when you send this command, it reports the actual output frequency. If output is off when you send this command: • If the unit is in fixed frequency mode, the command reports the fixed frequency (as in command **161**). • If the unit is in sweep frequency mode, the command reports the tuning start frequency (as in command **146**). In either fixed or variable mode, if the output is off when you send this command, the unit reports the frequency that it will first output the next time you turn the unit on. Send 0 data bytes to return frequency in kHz or send 1 data byte to return frequency in kHz or Hz. Send 0 data bytes: • Returns 4 data bytes = Frequency in kHz Send 1 data byte: • Byte 0 = Frequency in kHz or Hz ◦ 0 = Returns frequency in kHz ◦ 1 = Returns frequency in Hz Returns 4 data bytes (32-bit value) = Frequency in kHz or Hz	0 or 1	4
148 report fixed or sweep frequency mode	Reports the frequency mode. Send 0 or 1 data bytes. Send 0 data bytes: Returns 1 data byte (8-bit value): • 0 = Fixed frequency mode • 1 = Sweep frequency mode	0 or 1	1 or 2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Optional: Send 1 data byte (with a value of 0). Returns 2 data bytes (16-bit value): • Byte 1: ◦ 0 = Fixed frequency mode ◦ 1 = Sweep frequency mode • Byte 2 = 0 Set this value with command **48**.		
151 report setpoint ramping configuration	Reports the setpoint ramping mode and ramp parameters or reports ramping memory mode. Send 0 or 2 data bytes. • Send 0 data bytes to return the setpoint ramping mode and ramp parameters. • Send 2 data bytes to select the parameters that will be returned, either the setpoint ramping mode and parameters or the ramping memory mode. **Ramping Mode and Parameters** The ramp up and ramp down parameters are independent. In W/s mode, the ramp parameters represent the ramp rate in watts per second. The acceptable range for the ramp up and ramp down parameters in W/s mode is 1 W/s to 65535 W/s. In timed mode, the ramp parameters represent the time in ms. The acceptable range for the ramp up and ramp down parameters in timed mode is 1 ms to 65535 ms. The setpoint will not be ramped in either mode if the setpoint change is less than 1 watt. **0 Data Byte Version** When 0 bytes are sent, returns 6 data bytes (three 16-bit values): • Bytes 0 and 1 (16-bit value) = Ramp mode ◦ 0 = Disabled	0 or 2	6 or 8

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 1 = W/s ◦ 2 = Timed (in ms) • Bytes 2 and 3 (16-bit value) = Ramp up (in W/s or time in ms) • Bytes 4 and 5 (16-bit value) = Ramp down (in W/s or time in ms) **2 Data Byte Version** Send 2 data bytes (16-bit value) indicating the parameters to return. • 1 = Ramp mode and parameter data • 2 = Ramp memory mode Returns 8 data bytes: • If you send a value of 1 = Get ramp data ◦ Bytes 0 and 1 = 1 (Ramp mode and parameter data selection) ◦ Bytes 2 and 3 = Ramp mode (0 = Disabled, 1 = W/s, 2 = ms) ◦ Bytes 4 and 5 = Ramp up (in W/s or time in ms) ◦ Bytes 6 and 7 = Ramp down (in W/s or time in ms) • If you send a value of 2 = Get memory mode ◦ Bytes 0 and 1 = 2 (ramp memory mode selection) ◦ Byte 2 and 3 = Memory mode (0 = RAM, 1 = NVRAM) ◦ Bytes 4 through 7 = Return 0 Set this value with command **31**.		
154 report regulation mode	Reports the active regulation mode. Send 0 or 1 data bytes. Send 0 data bytes:	0 or 1	1 or 2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 1 data byte (8-bit value): • 6 = Forward • 7 = Delivered or real • 8 = External (DC bias) Optional: Send 1 data byte (with a value of 0). Returns 2 data bytes (16-bit value): • Byte 1: ◦ 6 = Forward ◦ 7 = Delivered or real ◦ 8 = External (DC bias) • Byte 2 = 0 Set this value with command **3**.		
155 report active control mode	Reports the active control mode. Send 0 or 1 data bytes. Send 0 data bytes: Returns 1 data byte (8-bit value): • 2 = Host • 4 = **User** port (analog) • 8 = Diagnostic Optional: Send 1 data byte (with a value of 0). Returns 2 data bytes (16-bit value): • Byte 1: ◦ 2 = Host ◦ 4 = **User** port (analog) ◦ 8 = Diagnostic • Byte 2 = 0 Set this value with command **14**.	0 or 1	1 or 2
158 report retuning threshold	Reports the tuning criteria level at which the tuning algorithm determines that the generator requires retuning. The unit stores this parameter in nonvolatile memory.	0	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 4 data bytes: • Bytes 0 through 3 = Tuning criteria Set this value with command **58**.		
159 report tuning time	Reports the time in ms from an RF on (command **2**) to the first time that the tuning algorithm declares the generator to be tuned. Returns 4 data bytes: • Bytes 0 through 3 = Time in ms	0	4
160 report tune delay	Reports the time in ms that the tuning algorithm waits before beginning to automatically tune the generator. The maximum tune delay value is 60,000 ms. The unit stores this parameter in nonvolatile memory. Returns 4 data bytes: • Bytes 0 through 3 = Time in ms Set this value with command **60**.	0	4
161 report fixed frequency	Reports the output frequency when the generator is operating in fixed frequency mode. The fixed frequency value must be within the unit frequency range. With some units, you can also use this command to report the maximum and minimum fixed frequencies for the unit. For units that allow you to set the fixed frequency memory mode (see command **118**; B0 = 51), the fixed frequency parameter can be set to either volatile or nonvolatile. Send 0 data bytes to return frequency in kHz, or send 1 data byte to return frequency in kHz or Hz or maximum/minimum frequency settings. Send 0 data bytes: • Returns 4 data bytes = Frequency in kHz	0 or 1	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 1 data byte: • Byte 0: ◦ 0 = Returns frequency in kHz ◦ 1 = Returns frequency in Hz ◦ 2 = Maximum fixed frequency that the unit can be set to in Hz (only available in some units) ◦ 3 = Minimum fixed frequency that the unit can be set to in Hz (only available in some units) Returns 4 data bytes (32-bit value) = Frequency in kHz or Hz Set this value with command **61**.		
162 report process status	Reports the generator process status. Returns 4 data bytes (four 8-bit flags): • Byte 0: ◦ Bit 0 = Tuning status (0 = Not tuned, 1 = Tuned) ◦ Bit 1 = setpoint ramping (0 = Not ramping, 1 = Ramp in progress) ◦ Bit 2 = Reserved for recipe active ◦ Bits 3 and 4 = Reserved ◦ Bit 5 = RF output on (0 = Off, 1 = On) ◦ Bit 6 = RF On requested (0 = Off, 1 = On) ◦ Bit 7 = setpoint tolerance (0 = In tolerance, 1 = Out of tolerance) • Byte 1: ◦ Bit 0 = Reserved for end of target life ◦ Bits 1 and 2 = Reserved ◦ Bit 3 = Coldplate overtemperature fault (1 = Fault)	0	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ Bits 4 through 6 = Reserved ◦ Bit 7 = Interlock (0 = interlock closed, 1 = interlock open) • Byte 2: ◦ Bits 0 and 1 = Reserved ◦ Bit 2 = High AC line voltage warning (1 = Warning) ◦ Bit 3 = Reserved ◦ Bit 4 = Low AC line voltage warning (1 = Warning) ◦ Bit 5 = Protection Limit (1 = Limit active) ◦ Bits 6 and 7 = Reserved • Byte 3: ◦ Bit 0 = Reserved ◦ Bit 1 = Inverter not ready (1 = Not ready) ◦ Bit 2 = Reserved ◦ Bits 3 and 4 = Reserved ◦ Bit 5 = Fault present (0 = No faults, 1 = Faults exist) ◦ Bit 6 = Warning present (0 = No warnings, 1 = Warnings exist) ◦ Bit 7 = Reserved When either of the fault present or warning present bits are set, one or more active or latched faults or warnings currently exist in the unit. You can obtain a list of current faults or warnings by issuing command **223** with the appropriate parameter.		
164 report setpoint and regulation mode	Reports the output setpoint set with command **8** and the output regulation mode set with command **3**. Reports the setpoint value in watts when operating in forward or delivered power regulation modes. If the unit is in DC bias regulation mode, the setpoint is returned	0	3

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	in volts. This command also returns the active regulation mode. Returns 3 data bytes (one 16-bit value, one 8-bit value): • Bytes 0 and 1 = setpoint value in watts or volts • Byte 2 = Output regulation mode ◦ 6 = Forward ◦ 7 = Delivered or load ◦ 8 = External (DC Bias) Set the setpoint with command **8** and the regulation mode with command **3**.		
165 report forward power	Reports the forward power in watts. Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = Forward power	0	2
166 report reflected power	Reports the reflected power in watts. Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = Reflected power Set this value with command **5**.	0	2
167 report delivered power	Reports the delivered power in watts. Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = Delivered power	0	2
168 report DC bias external feedback	Reports the external feedback value in volts as measured at the DC bias input on the user card. Returns 2 data bytes. • Bytes 0 and 1 = External feedback Set this value with command **9**.	0	2
169 report user power limit	Reports the user power limit in watts. The user power limit is directly related to the active regulation mode. For example, when in load regulation mode, the user power limit will limit delivered power.	0	2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = Power limit Set this value with command **4**.		
170 report user reflected power limit	Reports the user reflected power limit in watts. The user reflected power limit affects all regulation modes. The unit retains the user reflected power limit as long as power is applied. You cannot change the user reflected power limit while the unit is on. Valid values are from the specified reflected power minimum to the specified reflected power maximum. Returns 2 data bytes (16-bit value): • Bytes 0 and 1 = User reflected power limit Set this value with command **5**.	0	2
171 report DC bias external feedback limit	Reports the DC bias value when operating in external (DC bias) regulation mode. Send 0 data bytes to return external feedback limit in volts or send 1 data byte to return User External Feedback Limit, User External Feedback Limit Max, or Max User setpoint, in volts. Send 0 data bytes: • Returns 2 data bytes: ◦ Bytes 0 and 1 = User external feedback limit in volts Send 1 data byte (8-bit value): • 0 = Returns user external feedback limit in volts • 1 = Returns user external feedback limit maximum in volts • 2 = Returns maximum user setpoint in volts Returns 2 data bytes = Selected value in volts Set this value with command **6**.	0 or 1	2

Table 4-10. AE Host commands (Continued)

<table>
<tr><th>Command</th><th>Description</th><th>Data Bytes Sent</th><th>Data Bytes Returned</th></tr>
<tr><td>172
report pulsing configuration</td><td>Reports pulsing configuration.
This command allows you to send subcommands. Send a value in the first two bytes that selects the parameter to report, and then send subcommands to report parameter values.
<table>
<tr><th>Byte 0 =</th><th>Subcommand</th></tr>
<tr><td>1</td><td>Report pulsing mode (master or slave)</td></tr>
<tr><td>2</td><td>Report pulse sync output status</td></tr>
<tr><td>3</td><td>Reserved</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>5</td><td>Report memory mode</td></tr>
</table></td><td>2</td><td>4</td></tr>
<tr><td>172
report pulsing mode
(subcommand 1)</td><td>Reports whether the unit is set to master or slave pulsing mode.
Send 2 data bytes.
• Bytes 0 and 1 = 1 (report pulsing mode)
Returns 4 data bytes.
• Bytes 1 and 2 = Pulsing mode
◦ 1 = Master mode
◦ 2 = Slave mode
• Bytes 2 and 3 = Reserved
Command 26 B0 = 1 sets these values.</td><td>2</td><td>4</td></tr>
<tr><td>172
report pulse sync output status
(subcommand 2)</td><td>Reports the status of pulse sync output.
Send 2 data bytes.
• Bytes 0 and 1 = 2 (report pulse sync output status)
Returns 4 data bytes.
• Bytes 0 and 1 = Pulse sync output on or off
◦ 0 = Pulse sync output off</td><td>2</td><td>4</td></tr>
</table>

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 1 = Pulse sync output on • Bytes 2 and 3 = Reserved Command **26** B0 = 2 sets these values.		
172 report memory mode (subcommand 5)	Reports the unit memory mode settings. Send 2 data bytes. • Bytes 0 and 1 = 5 (report memory mode) Returns 4 data bytes. • Bytes 0 and 1 = Memory mode ◦ 0 = RAM ◦ 1 = NVRAM • Bytes 2 and 3 = Reserved Command **26** B0 = 5 sets these values.	2	4
193 report pulsing frequency	Reports the pulsing frequency in Hz. Valid values range from 10 Hz to 2000 Hz.The unit may store pulsing frequency values in either volatile or nonvolatile memory, depending on the current memory mode (see command **26**). The unit reports the value from the currently active memory. This command is available in both master and slave modes. Returns 4 data bytes: • Bytes 0 to 3 = Pulsing frequency in Hz. Command **93** sets this value.	0	4
196 report pulsing duty cycle	Reports the pulsing duty cycle in increments of 1%. Valid values range from 10% to 90%. The unit may store pulsing duty cycle values in either volatile or nonvolatile memory, depending on the current memory mode (see command **26**). The unit reports the value from the currently active memory. When operating in slave mode, the unit returns CSR 12, Feature Not Available.	0	2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 2 data bytes: • Bytes 0 and 1= Pulsing duty cycle in % (on time) Command **96** sets this value.		
198 report software revision level	Reports the software revision level as a three-character ASCII string: one letter and two numbers. You can use this number in conjunction with the part number returned by command **130** to identify the software in the unit. Sending a request data byte is optional. If you issue command **198** with zero data bytes, it returns the Coldfire application firmware revision. Sending 1 data byte allows you to select the software for which the revision will be returned. Send 1 data byte (8-bit value). • Byte 0 = Software request ◦ 0 = Coldfire application firmware revision ◦ 1 = Motherboard FPGA firmware revision ◦ 2 = Measurement board FPGA firmware revision ◦ 4 = ColdFire bootloader firmware revision ◦ 13 = Display board application firmware revision ◦ 15 = Display board bootloader firmware revision Returns a 3-element ASCII character string: • Byte 0 = ASCII revision level letter • Bytes 1 and 2 = ASCII revision level numerals (0 to 99)	0 or 1	3 ASCII characters

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
201 report unit on events	Reports the number of unit on events stored in nonvolatile memory. The unit increments the number of unit on events each time you supply AC power to the generator. Returns 4 data bytes (one 32-bit value). • Bytes 0 through 3 = Number of unit on events.	0	4
202 report output on events	Reports the number of output on events. The unit increments the number of output on events each time you turn RF power on. Returns 4 data bytes (one 32-bit value). • Bytes 0 through 3 = Number of output on events.	0	4
203 report overtemperature events	Reports the number of overtemperature events stored in nonvolatile memory. The unit increments the number of overtemperature events each time the coldplate temperature exceeds the fault threshold. Returns 4 data bytes (one 32-bit value). • Bytes 0 through 3 = Number of overtemperature events.	0	4
205 report unit run time	Reports the unit run time in seconds. The unit increments the run time each second RF power is turned on. The unit stores the unit run time in nonvolatile memory. Returns 4 data bytes (one 32-bit value). • Bytes 0 through 3 = Unit run time in seconds.	0	4
206 report total energy output	Reports the total energy output. The unit increments this number each time it delivers a full kWh of energy to the load. The unit also stores partial kWh internally in nonvolatile memory.	0	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 4 data bytes (one 32-bit value). • Bytes 0 through 3 = Total energy output in kWh		
215 report real time clock	Reports the system real time clock time and date. The data received is encoded in Binary Coded Decimal (BCD) format; for example: if the value for seconds is 48, the data value received will be 0x48. The real time clock features automatic leap year compensation for years up to 2100. Returns 7 data bytes (8-bit values): • Byte 0 = Seconds (valid values are 0 to 59) • Byte 1 = Minutes (valid values are 0 to 59) • Byte 2 = Hours (valid values are 0 to 23) • Byte 3 = Day of the week (valid values are 1 to 7) ◦ 1 = Sunday ◦ 2 = Monday ◦ 3 = Tuesday ◦ 4 = Wednesday ◦ 5 = Thursday ◦ 6 = Friday ◦ 7 = Saturday • Byte 4 = Date (valid values are 1 to 31) • Byte 5 = Month (valid values are 1 to 12) • Byte 6 = Year (valid values are 00 to 99) Set this value with command **70**.	0	7
219 report condensed generator snapshot data	Reports a selected collection of data identical to the data reported by the individual commands.	0	28

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 28 data bytes: • Bytes 0 and 1 (16-bit value) = Forward power in watts (see command **165**). • Bytes 2 and 3 (16-bit value) = Reflected power in watts (see command **166**). • Bytes 4 and 5 (16-bit value) = Delivered power in watts (see command **167**). • Bytes 6 and 7 (16-bit value) = Power setpoint in watts (see command **8**). • Bytes 8 through 11 (32-bit value) = Real impedance in hundredths of ohms (see command **225**) • Bytes 12 through 15 (32-bit value) = Reactive impedance in hundredths of ohms (see command **225**) • Bytes 16 through 19 (32-bit value) = Actual frequency in kHz (see command **147**) • Bytes 20 through 23 (four 8-bit values) = Process status (see command **162**) • Byte 24 (8-bit value) = Regulation mode (see command **154**) • Byte 25 (8-bit value) = Control mode (see command **155**) • Bytes 26 and 27 (16-bit value) = Coldplate temperature in degrees Celsius (see command **228**)		
225 report impedance	Reports the real and reactive impedance in hundredths of ohms. Returns 8 data bytes (two 32-bit values): • Bytes 0 through 3 = Signed long integer value of the real impedance • Bytes 4 to 7 = Signed long integer value of the reactive impedance	0	8

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
228 report coldplate temperature	Reports the coldplate temperature in degrees Celsius. You can send either 0 or 1 data bytes. If you send 0 data bytes, the unit reports the coldplate temperature in degrees Celsius. If you send 1 data byte, the unit reports the coldplate temperature in tenths of degrees Celsius. Send 1 data byte: • 0 = Coldplate temperature • 1 = Reserved Returns 2 data bytes representing the requested data.	0 or 1	2
231 report unit serial or part number	If you send 0 data bytes, reports the unit serial number; if you send 1 data byte, you can request either the unit serial number or the unit part number. Send 0 data bytes: • Returns 4 data bytes (32-bit value) representing the unit serial number. Send 1 data byte: • Byte 0 = Value to be returned. ◦ 0 = Requests unit serial number ◦ 1 = Requests unit part number Returns as many as 12 ASCII characters representing the unit part number (315 ...) or the unit serial number.	0 or 1	4, or as many as 12
244 report diagnostic status	Reports the results of the diagnostic self test. Send 1 data byte. • Byte 0 (8-bit value) ◦ 1 = Report diagnostic status For the diagnostic status report, returns 5 data bytes. • Byte 0 = Status code	1	5

Table 4-10. AE Host commands (Continued)

<table>
<tr><th>Command</th><th>Description</th><th>Data Bytes Sent</th><th>Data Bytes Returned</th></tr>
<tr><td></td><td>◦ 0 = Diagnostics in progress
◦ 1 = Diagnostic test complete – passed
◦ 2 = Diagnostic test complete – failed
◦ 3 = Diagnostic test interrupted
◦ 4 = Diagnostic mode disabled
• Byte 1 = Failure status (bit flags)
◦ Bit 0 = Forward power
◦ Bit 1 = Rectified bus voltage
◦ Bit 2 = Test voltage
◦ Bits 3 through 7 = Unused
• Bytes 2 through 4 = Unused
• Byte 4 = Unused</td><td></td><td></td></tr>
<tr><td>248
report operating parameters</td><td>This command allows you to send subcommands that report a variety of operating parameters. Send a value in the first two bytes that selects the parameter to report. The subcommands are 16-bit commands ranging in value from 1 to 65535.
Your unit may not have all the features in this list. If you issue a command for a feature that your unit does not have, the unit returns CSR 12, Feature Not Available.
<table>
<tr><th>Byte 0 =</th><th>Subcommand</th></tr>
<tr><td>1</td><td>Report frequency step minimum</td></tr>
<tr><td>2</td><td>Report frequency step maximum</td></tr>
<tr><td>3</td><td>Report step up gain</td></tr>
<tr><td>4</td><td>Report step down gain</td></tr>
<tr><td>6</td><td>Report gamma threshold high</td></tr>
<tr><td>7</td><td>Report gamma threshold low</td></tr>
</table></td><td>variable</td><td>variable</td></tr>
</table>

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Byte 0 = / Subcommand 8 — Report maximum tuning count 22 — Report tuning step time 23 — Report tuning gain delay 50 — Report DC bias operating mode 51 — Report fixed frequency memory mode		
248 report frequency step minimum (subcommand 1)	Reports the frequency step minimum used during the tuning process. This is the smallest step size used by the tuning algorithm when making frequency step changes. Send 2 data bytes. • Bytes 0 and 1 = 1 (report frequency step minimum) Returns 4 data bytes: • Bytes 0 through 3 = Frequency step minimum in Hz (unsigned long) Set this value with command **118**; B0 = 1.	2	4
248 report frequency step maximum (subcommand 2)	Reports the frequency step maximum used during the tuning process. This is the largest step size used by the tuning algorithm when making frequency step changes. Send 2 data bytes. • Bytes 0 and 1 = 2 (report frequency step maximum) Returns 4 data bytes: • Bytes 0 through 3 = Frequency step maximum in Hz (unsigned long) Set this value with command **118**; B0 = 2.	2	4
248 report step up gain (subcommand 3)	Reports the step up gain used during the tuning process. This parameter sets the magnitude of frequency step increase when	2	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	the error is decreasing (frequency step size is increasing). A value of n sets the gain to 2^n. Send 2 data bytes. • Bytes 0 and 1 = 3 (report step up gain) Returns 4 data bytes: • Bytes 0 through 3 = Step up gain (unsigned short) Set this value with command **118**; B0 = 3.		
248 report step down gain (subcommand 4)	Reports the step down gain used during the tuning process. This parameter sets the magnitude of frequency step decrease when the error is increasing (frequency step size is decreasing). A value of n sets the gain to 2^{-n}. Send 2 data bytes. • Bytes 0 and 1 = 4 (report step down gain) Returns 4 data bytes: • Bytes 0 through 3 = Step down gain (unsigned short) Set this value with command **118**; B0 = 4.	2	4
248 report gamma threshold high (subcommand 6)	Reports the gamma threshold high used during the tuning process. The generator uses the high threshold after first attempting (and failing) to achieve a tuning criteria less than the low threshold. The generator also uses it as the threshold to determine when to begin retuning. Send 2 data bytes. • Bytes 0 and 1 = 6 (report gamma threshold high) Returns 2 data bytes: • Bytes 0 and 1 = Gamma threshold high (unsigned short) Set this value with command **118**; B0 = 6.	2	2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
248 report gamma threshold low (subcommand 7)	Reports the gamma threshold low used during the tuning process. The generator first attempts to achieve a tuning criteria less than the low threshold. If it fails, it tries the high threshold next, after the maximum tuning counter has expired. Send 2 data bytes. • Bytes 0 and 1 = 7 (report gamma threshold low) Returns 2 data bytes: • Bytes 0 and 1 = Gamma threshold low (unsigned short) Set this value with command **118**; B0 = 7.	2	2
248 report maximum tuning count (subcommand 8)	Reports the maximum tuning count used during the tuning process. This reports the number of attempts to tune to the low threshold before giving up and trying the high threshold. Send 2 data bytes. • Bytes 0 and 1 = 8 (maximum tuning count) Returns 2 data bytes: • Bytes 0 and 1 = Maximum tuning count (unsigned short) Set this value with command **118**; B0 = 8.	2	2
248 report tuning step time (subcommand 22)	Reports tuning step time. Valid values range from 8 µs to 4096 µs. Send 2 data bytes. • Bytes 0 and 1 = 22 (tuning step time) Returns 2 data bytes. • Bytes 0 and 1 = Tuning step time in µs. Set this value with command **118**; B0 = 22.	2	2

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
248 report tuning gain delay (subcommand 23)	Reports tuning gain delay, which is the delay before increasing the step size after a change in direction. Valid values range from 0 to 7. Send 2 data bytes. • Bytes 0 and 1 = 23 (tuning gain delay) Returns 2 data bytes. • Bytes 0 and 1 = Tuning gain delay Set this value with command **118**; B0 = 23.	2	2
248 report DC bias operating mode (subcommand 50)	Reports the following parameters: • Power limit setting for external (DC bias) regulation mode—When operating in external (DC bias) regulation mode, the unit uses an internally set value as a maximum output power limit. In units without this feature, this parameter is hard coded to limit forward power. This feature allows you to set the power limit to either forward or delivered power. This parameter reports whether the unit is set to use forward or delivered power. • SOA mode—Reports whether the safe operating area feature is enabled or disabled • Memory mode—Reports whether these settings are volatile or nonvolatile. When set to volatile, the settings will default to factory default settings when power to the unit is cycled. See the product specifications for factory default settings. Send 4 data bytes. • Bytes 0 and 1 = 50 (report DC bias operating mode) • Bytes 2 and 3 = Select parameter to report: ◦ 1 = DC bias mode ◦ 2 = SOA mode	4	4

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ 3 = Memory mode Returns 4 data bytes. • Bytes 0 and 1 = Parameter being reported: ◦ 1 = DC bias mode ◦ 2 = SOA mode ◦ 3 = Memory mode • Bytes 2 and 3 = Command data (dependent on selection in previous two bytes) If you selected DC bias mode: ◦ 1 = Forward power limit ◦ 2 = Delivered power limit If you selected SOA mode ◦ 0 = Disabled ◦ 1 = Enabled If you selected memory mode: ◦ 0 = Volatile ◦ 1 = Nonvolatile Set this value with command **118**; B0 = 50.		
248 report fixed frequency memory mode (subcommand 51)	Reports the setting of the fixed frequency memory mode: either volatile or nonvolatile. • When set to volatile, the fixed frequency defaults to the center frequency on power up. • When set to nonvolatile, the fixed frequency defaults to the factory default fixed frequency setting or last setting if changed from the factory default. See product specification for the fixed frequency factory default setting. The factory default setting for this command is configured for each product option. See the product specification for the default setting.		

Table 4-10. AE Host commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Send 2 data bytes. • Bytes 0 and 1 = 51 (report fixed frequency memory mode) Returns 2 data bytes. • Bytes 0 and 1 = Mode setting ◦ 0 = Volatile ◦ 1 = Nonvolatile Set this value with command **118**; B0 = 51.		

Installation, Setup, and Operation

PREPARING TO INSTALL THE UNIT

Spacing and Mounting Requirements

For proper cooling, mount the unit so that there is 13 mm (0.51″) minimum clearance on the right side of the unit and 102 mm (4″) minimum clearance at the rear. Any blockages could cause overheating to occur.

For rack installation, ensure that there are supports at the front and the rear of the unit. Do not use the rack ears to support the weight of the unit.

The lifting brackets can be removed before installation if you do not need them. Use care when removing them as the edges can be sharp.

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

Unit Drawings

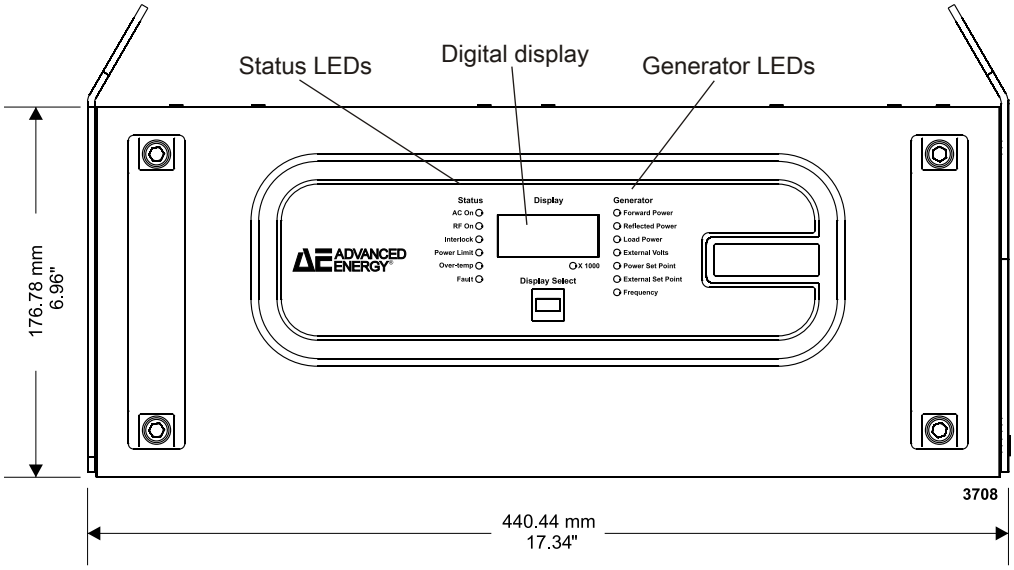


Figure 5-1. *Front panel*

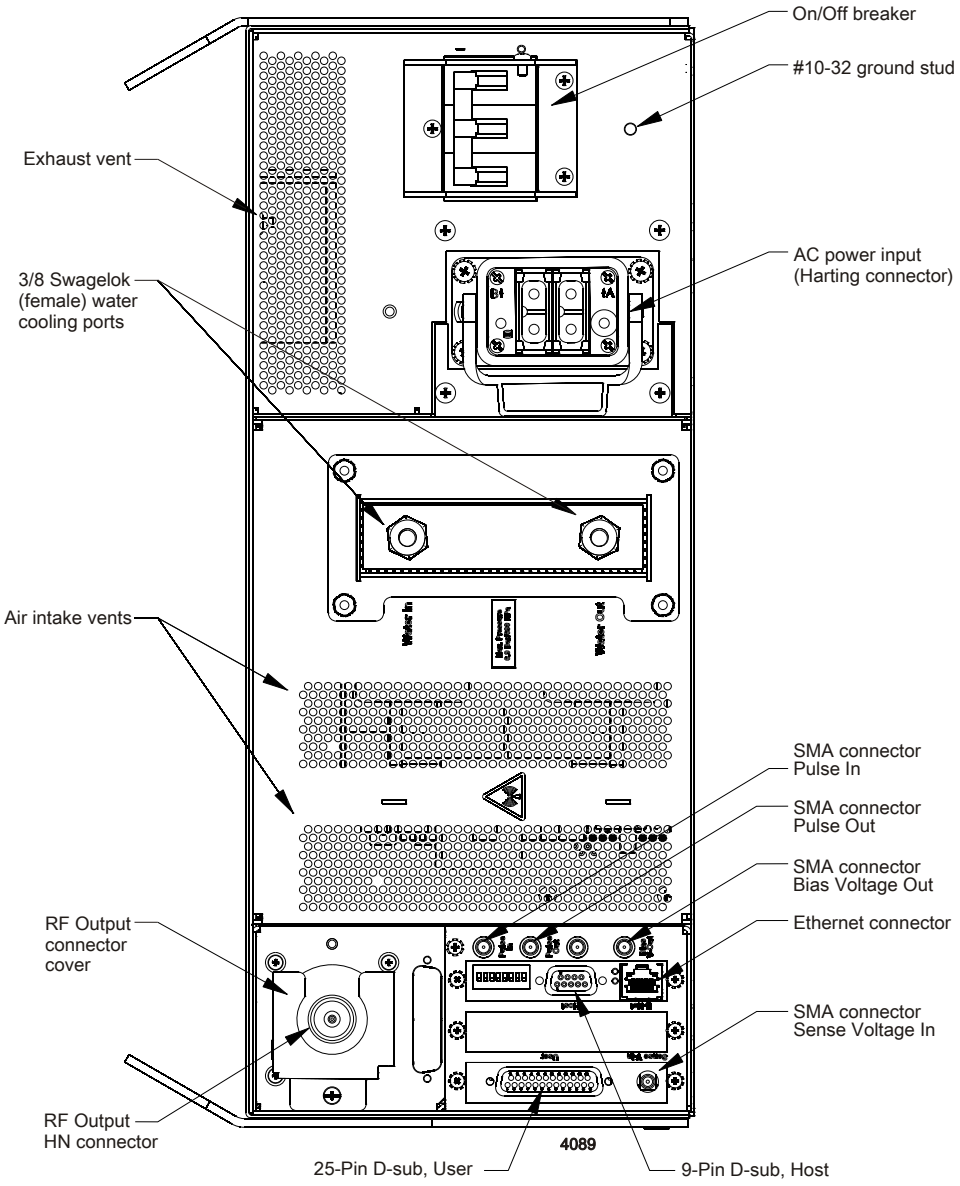


Figure 5-2. Rear panel

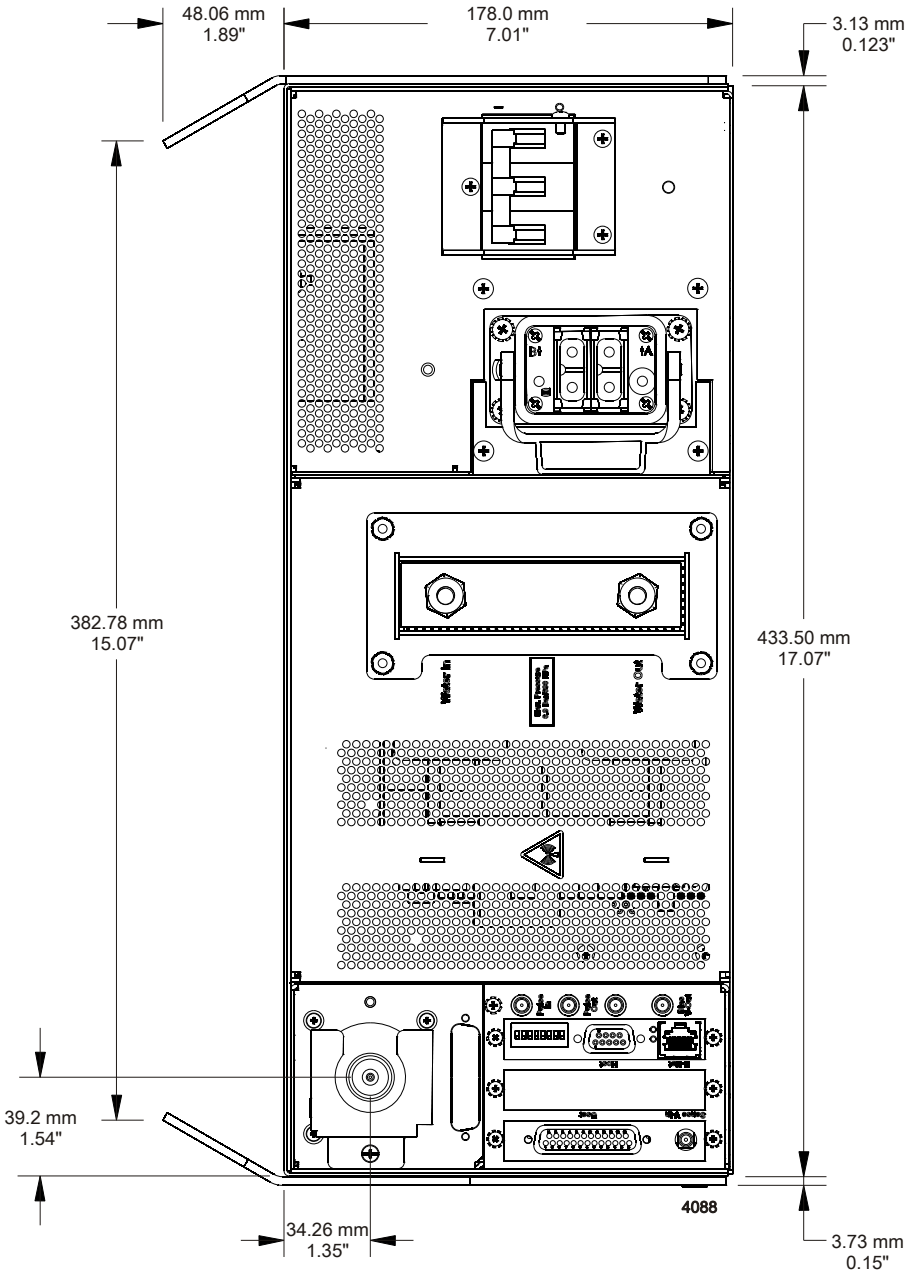


Figure 5-3. Rear panel with dimensions

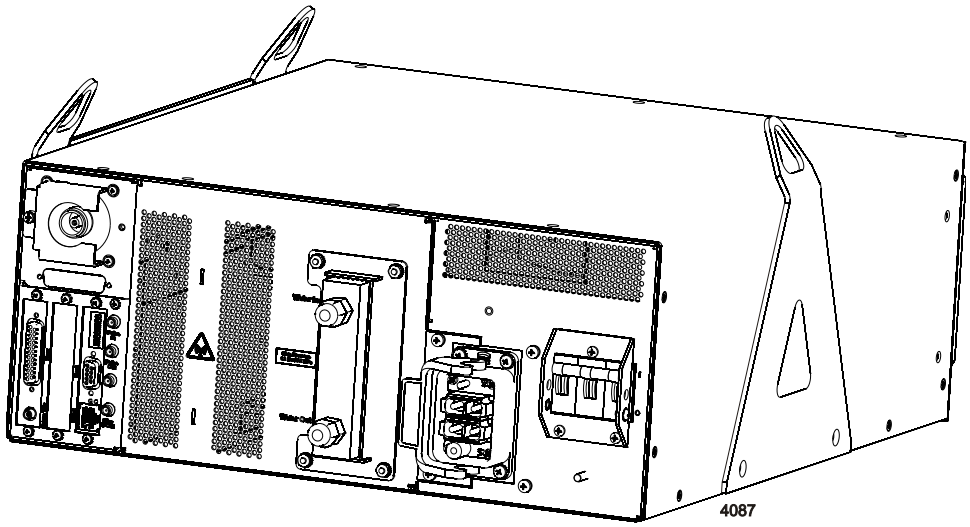


Figure 5-4. Rear panel three dimensional

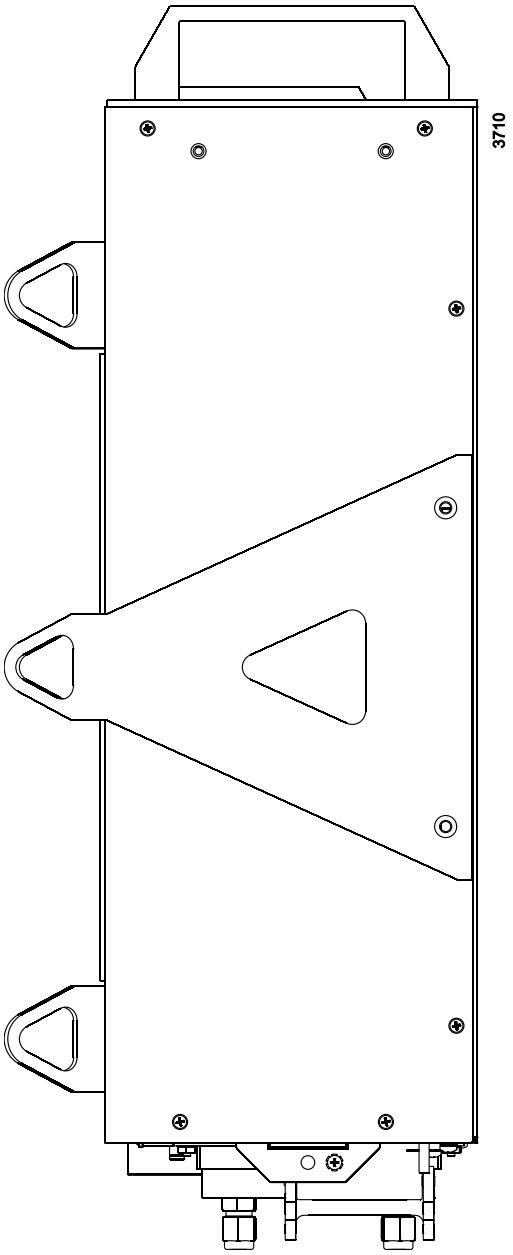


Figure 5-5. Left side

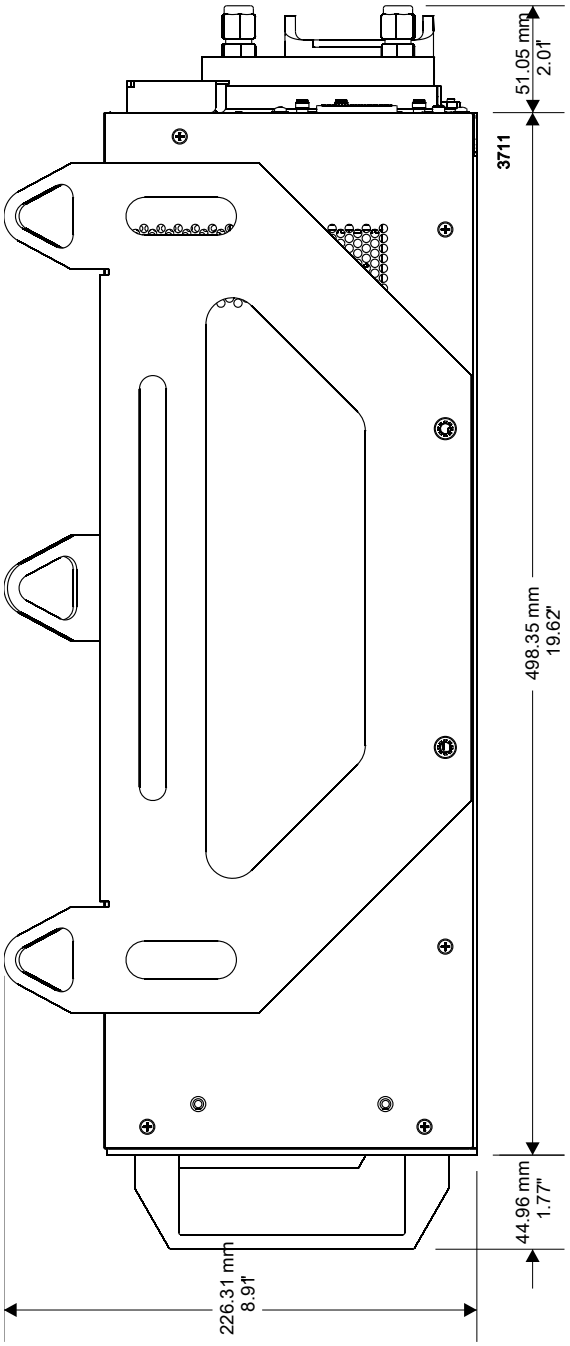


Figure 5-6. *Right side*

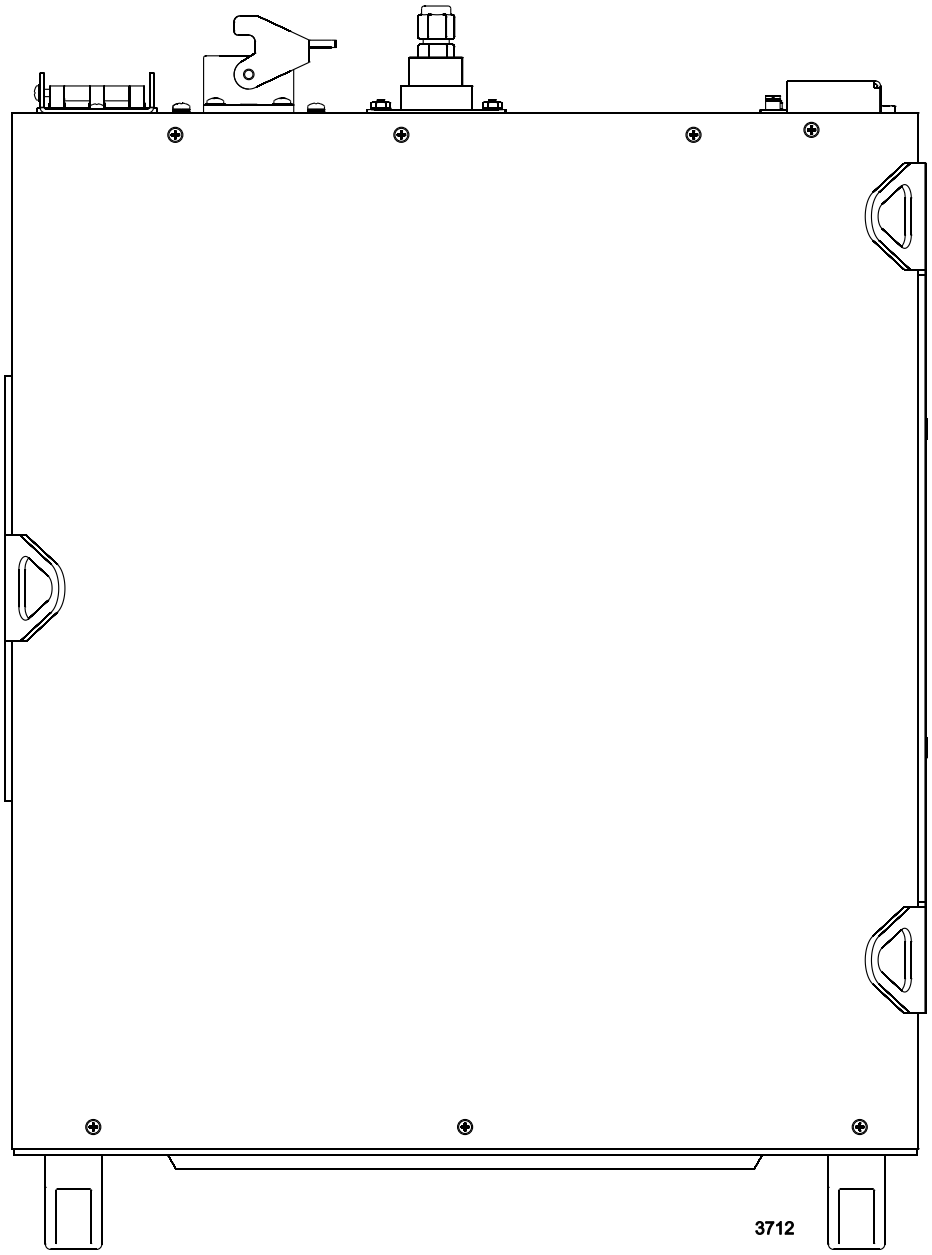


Figure 5-7. Top side

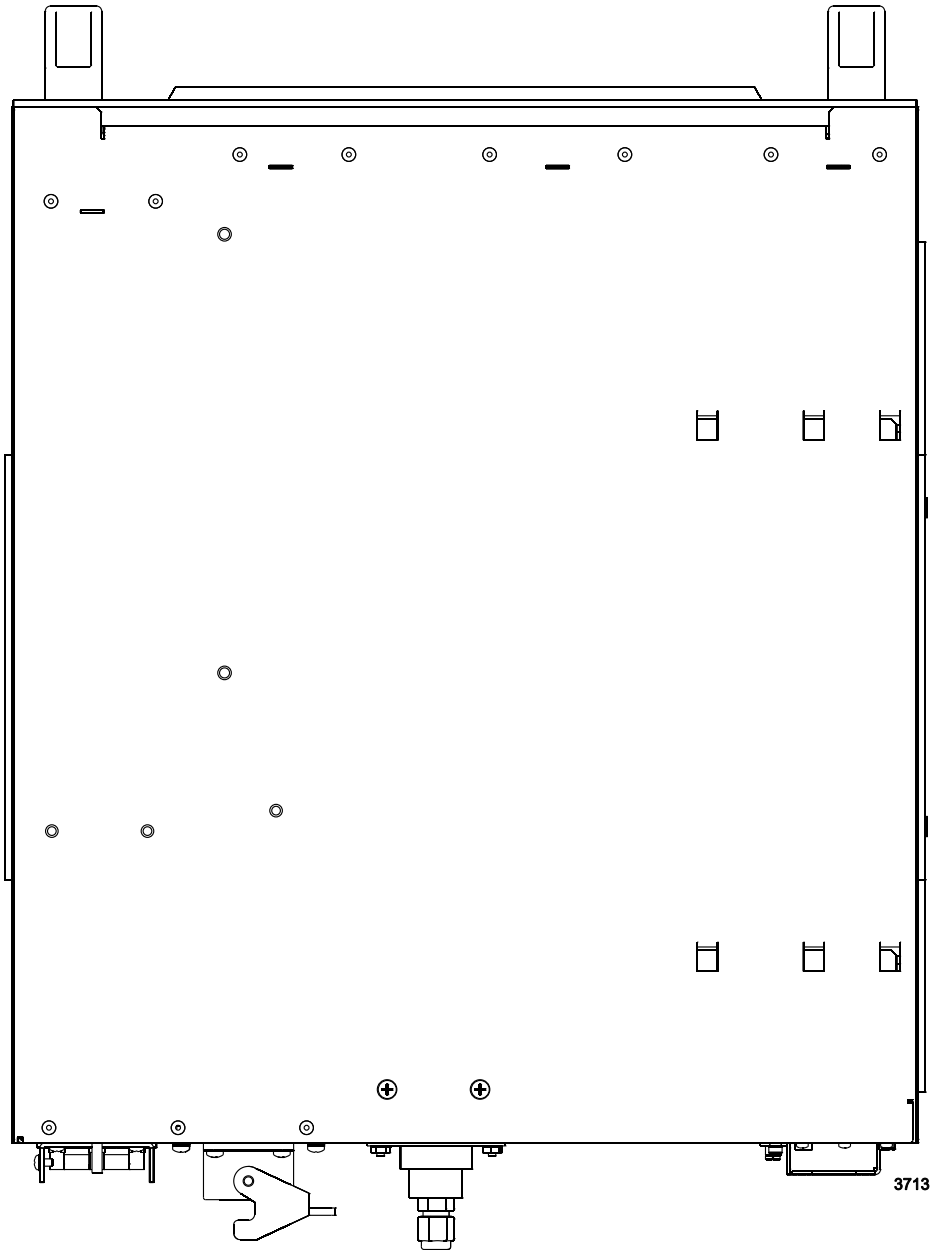


Figure 5-8. *Bottom side*

Installation Requirements

Install this unit according to the following requirements.

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

DANGER:

Personnel must receive proper training before installing or troubleshooting 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.

Unpacking the Unit

Important

Some Paramount MF 2 kW units are double-bagged to prevent contamination. The labels on the packaging provide important handling information. In many cases, the inner bag should not be removed until the unit is in the cleanroom.

1. Unpack and inspect the unit carefully, looking for obvious physical damage.
2. If no damage is apparent, proceed with the unit installation and setup.
3. If you do see signs of shipping damage, contact Advanced Energy and the carrier immediately.

   Save the shipping container for submitting necessary claims to the carrier.

INSTALLING THE UNIT

Grounding

WARNING:

Do not attempt to turn on power until the Paramount MF 2 kW unit is grounded.

WARNING:

For a corner-grounded delta configuration, connect the secondary Protective Earth (ground) stud to the system ground terminal before making any other connection. This connection is mandatory.

- Connect the secondary protective earth ground stud to the system ground terminal. Corner-grounded delta power connections require secondary protective earth grounding.

TO GROUND THE UNIT

- You must make all ground connections before operating the Paramount MF 2 kW generator. The unit provides one 10-32 stud with nut and star washer. A

suitable chassis ground connection made to this stud prevents or minimizes radio frequency interference.

Connecting Cooling Water

This generator is water cooled. Do not operate the unit until you have connected cooling water and met the cooling requirements.

CAUTION:

If you connect the cooling water on multiple units in series, be sure that input water temperature to all units is less than the maximum input water temperature.

CAUTION:

If you connect the cooling water on multiple units in a series, be sure that the water flow rate to all units meets the unit specifications.

CAUTION:

Do not use deionized water for cooling purposes. Deionized water causes both corrosion and erosion of cooling manifolds.

CAUTION:

Do not apply more than 54.2 Nm (40 ft-lb) to water fittings. Water leakage and damage to the unit could result.

The water fittings used on the Paramount MF 2 kW generator are SS female 3/8″ Swagelok.

TO CONNECT COOLING WATER

1. Make input and output water connections and tighten securely.
2. Turn on the water and ensure that there are no leaks.
3. Be sure that the flow rate, pressure, and temperature are within the minimum specifications required to operate the generator.

Connecting Output Power

CONNECTING OUTPUT POWER AND SATISFYING RF CONNECTOR INTERLOCK

WARNING:

This device must be installed so that the output power connection is inaccessible to the user.

The Paramount MF 2 kW generator output connector is a female HN coaxial. The center pin provides the RF output connection, while the outer cable provides a ground connection.

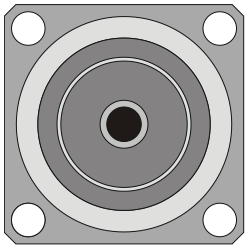


Figure 5-9. RF output connector, HN coaxial, female (TRU-8371-SNT)

To Connect Output Power and Satisfy Interlock

1. Remove the output power connector cover from the rear of the generator.
2. Slide the output power cable through the output power connector cover, and connect the output power cable connector to the output power connector on the unit.

   Make sure to thread the connection carefully and that the connector is fully mated.
3. Install the output power connector cover over the unit connectors.
4. Connect the output power cable to the load.

   The output power cable should be an RG-393 cable terminated with an HN connector. Be sure to use as short a cable length as possible.

When the output power connector is secure, interlock is engaged and RF output can be enabled. If the cable connector interlock is not satisfied, the unit cannot turn on RF output.

Connecting AC Input Power

HARTING AC POWER CONNECTOR

The Paramount MF 2 kW generator provides a HARTING Han 70 A input power connector that should be used with a four-conductor input cable.

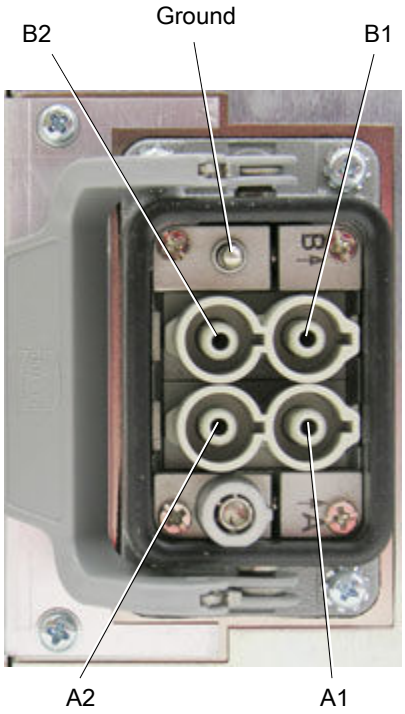


Figure 5-10. *HARTING AC 70 A power input connector on back of unit*

Table 5-1. *HARTING 70 A connector pin descriptions*

Pin	Description
A1	Phase
A2	Phase
B1	Phase
B2	Not connected
Gnd	Ground

The parts listed in the following table are those used on the Paramount MF 2 kW generator HARTING AC connector. Do not order these parts. Contact HARTING to find mating connector parts for the customer side of the AC connection.

Table 5-2. HARTING 70 A connector part numbers

HARTING Part Number	Quantity	Description
09 14 006 0303	1	HARTING frame
09 30 006 0301	1	HARTING housing mounting
09 14 002 2642	2	HARTING 70 A insert

TO CONNECT AC INPUT POWER WITH THE HARTING CONNECTOR

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

WARNING:

This device must be installed so that the input power connection is inaccessible to the user.

CAUTION:

To provide the required overcurrent protection, install and operate this device with a 50 A (maximum) circuit breaker switch on the AC input. The circuit breaker switch must be easily accessible and near the device.

CAUTION:

This equipment is intended for use with a single source of 3-phase power with all phases vectored at 120º angles ± 5º. If the equipment is used with an uninterruptable power supply (UPS), or other type of power conditioner, the user is responsible to guarantee the safety and EMC performance of the entire system.

1. Ensure that the AC line to which you are connecting the unit is a balanced, three-phase AC line that complies with the input specifications.

   All phases must be vectored at 120° angles ± 5°.

   ☞ **Important**

   Connection to an unbalanced line could negatively impact the dynamic performance of this device and its viable range of operation.

2. Ensure that the AC power circuit breaker to the connector is switched off.

Lockout/tagout procedures are strongly advised.

3. Connect a properly wired Harting female connector and lock it in place by closing the latch or by using the two pressure-loaded side tabs.

Connecting I/O and Auxiliary Connectors

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

CAUTION:

Do not connect any power to this unit without first connecting cooling water and ensuring there are no leaks.

Depending on your process and the Paramount MF 2 kW generator configuration, connect one or more of the I/O or auxiliary ports to communicate with the unit.

Table 5-3. I/O and auxiliary ports

Port	Description	For More Information, See ...
User	Allows analog/digital communication through voltage signals	25-Pin **User** Port
Host	Allows serial communications with a computer using AE Bus communications protocol	AE Bus **Host** Interface

Connecting For External Voltage Regulation Mode

In external voltage regulation mode (also referred to as DC bias regulation), the generator regulates on an external voltage rather than output power. The external voltage feeds into the generator through an SMA connector, **Sense V-In**, located on the back panel. The generator adjusts RF output voltage to make voltage coming to the **Sense V-In** connector to be equal to the voltage on pin 5, *SET POINT*, of the **User** port.

The Paramount MF 2 kW generator is designed to be used with the AE Low Frequency Fixed Match. This fixed match has an output where the RF output voltage is scaled to 10 VDC = 2000 V pk-pk.

If no connection on **Sense V-In** is present, the generator will read the peak to peak voltage as 2000 V. If you are in voltage control mode, this voltage will show on the

front panel if you scroll to the **External Volts** generator LED. You can also read peak to peak voltage on the **Sense V-In** connector with host port command **168**.

- Minimum voltage set point in this mode = 0.1 V
- Maximum forward power in the external voltage regulation mode = 1800 W

The external voltage scaling may be changed using host command **9**, set maximum external feedback value, when using a fixed match other than the AE Low Frequency Fixed Match. The user can also limit the usable range of the bias voltage by using host command **6**, set user external feedback limit.

The output voltage at the **Bias V-Out** SMA connector is proportional to the input voltage of the **Sense V-In** connector. 0 V input voltage at the **Sense V-In** connector gives 0 V output at the **Bias V-Out** connector. 10 V input voltage gives -5 V output. If input voltage is pulsing (with pulsing RF), output voltage is constant (DC).

FRONT PANEL FUNCTIONS

Using the Front Panel to Monitor Unit Status and Unit Operating Data

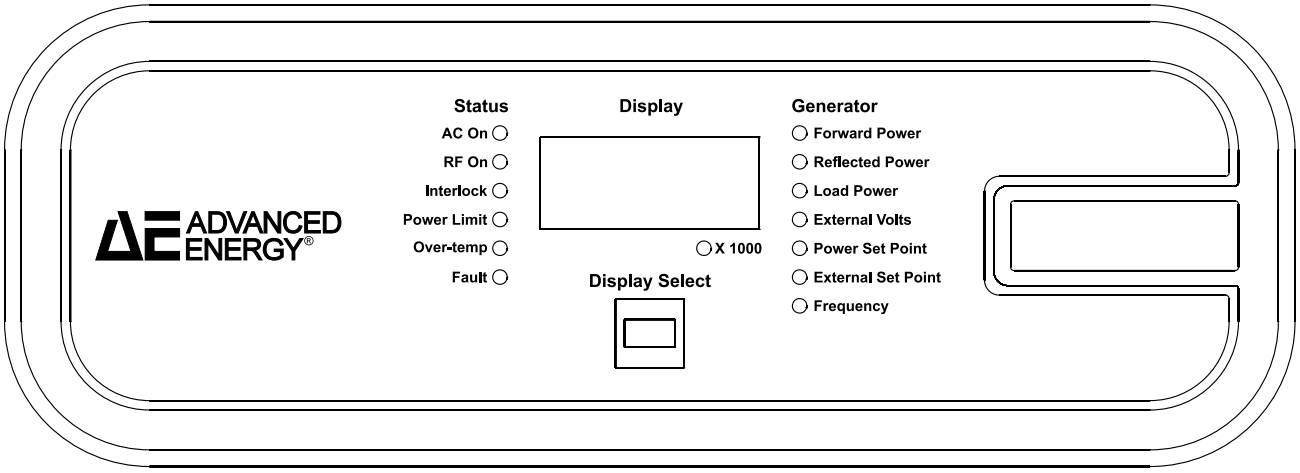


Figure 5-11. Front panel display with Status and Generator LEDs

The Paramount MF 2 kW generator does not provide an operator control panel. All power, control, and water connections are made at the rear of the unit. Six **Status** LEDs are visible from the front of the unit for monitoring the status of the generator.

You can also monitor basic operating data on the front panel of your unit using the seven segment, 4-digit numeric display and the **Generator** LEDs. To change the display, push the **Display Select** button below the numeric display. Push the **Display Select** button multiple times to scroll through the **Generator** LED list. When a particular **Generator** LED is lit, the display screen will show the current operating data for that parameter.

LED and Numeric Display Behavior When a Fault is Present

When a fault is present the **Fault** LED lights. All LEDs in the **Generator** column are unlit. The **Display Select** (**Generator** LED scroll) button is disabled. Active error codes are displayed on the numeric display. The display scrolls through the active error codes, showing each for about one second. If there is only one active error code, it is displayed continuously.

LED and Numeric Display Behavior When Interlock is Not Satisfied

When interlock is closed, the **Interlock** LED lights. When interlock is open, the **Interlock** LED is unlit, and the **Fault** LED is lit. Depending on what is open in the interlock chain, you may see these error codes scroll on the numeric display:

- Error code **30**: Interlock is open (always displays when any interlock is open)
- Error code **36**: RF cable interlock is open (may display)
- Error code **37**: **User** port interlock is open (may display)

Status LED Indicators

Table 5-4. Status LED indicators

Status LED	Description
AC On	When lit, this green LED indicates that AC power is on.
RF On	When lit, this green LED indicates that RF power is enabled. Depending on the selected set point value, actual RF power may or may not be present at the output connector when this LED is lit.
Interlock	When lit, this green LED indicates that all interlock criteria are satisfied: • The interlock pins on the **User** port are connected. • The cable is firmly connected to the RF output connector. When this LED is lit, the unit is ready to supply output power.
Power Limit	When unlit, this yellow LED indicates that the unit is able to satisfy the requested set point power within ± 1% and 3 W. When lit, this yellow LED indicates that the unit is unable to satisfy the requested set point due to a limit or alarm condition detected by the generator. Some of the conditions that can cause an out-of-set-point condition are high VSWR and output voltage or current limits.

Table 5-4. Status LED indicators (Continued)

Status LED	Description
Over-temp	When lit, this yellow LED indicates that the unit's internal temperature has exceeded its allowable level. The unit's output power will be disabled until the temperature falls below the internal temperature limit and the RF on command is toggled.
Fault	When lit, this yellow LED indicates that the unit has a fault condition. The display will scroll through all error codes which caused the fault. While fault conditions are active, the unit's output power will be disabled. Once the fault condition is cleared, send an RF off command and then an RF on command, and output will be enabled.

Generator LEDs

Table 5-5. Generator LEDs

Generator LED	Display Value Description
Forward Power	Displays forward power in watts.
Reflected Power	Displays reflected power in watts.
Load Power	Displays load power in watts.
External Volts	Displays voltage on the SMA connector **Sense Voltage In** in volts, multiplied by 200 (10 V is displayed as 2000 V).If nothing is connected to the **Sense Voltage In** connector, the display shows 2000 V.
Power Set Point	When the unit is in power control mode, displays power set point in watts. When the unit is in voltage control mode, the display will be dark when you scroll to this LED.
External Set Point	When the unit is in power control mode, the display will be dark when you scroll to this LED. When the unit is in voltage control mode, displays the voltage set point in volts, multiplied by 200 (10 V is displayed as 2000 V).
Frequency	Displays output frequency in kHz.

FIRST TIME OPERATION

Minimum Operating Requirements

The Paramount MF 2 kW generator provides serial and user communications interfaces. The **User** port provides only essential control capabilities. The RS-232 interface provides full control and read back capabilities. When the unit is operated through the **User** port, the RS-232 interface can be used to read back unit parameters.

Whether you control and monitor the unit through the **User** port or the RS-232 **Host** interface, you must satisfy the **User** port *INTERLOCK* (pins 10 and 23) signal to operate the Paramount MF 2 kW generator. The RF output cable interlock must also be satisfied by firmly connecting the RF cable.

If the unit is operated through the RS-232 **Host** interface, positive voltage between 4 V and 24 V should be supplied to pins 4 (positive) and 17 (return) of the **User** port (the *RF POWER ON* signal).

For RF delivery, set point in power control mode should be set between the minimum and maximum specifications. For RF delivery in voltage control mode, set point should be set at 20 V or more.

To Operate the Unit for the First Time

1. Install the generator according to the installation procedures in this user manual.
2. Turn on the circuit breaker supplying AC input power to the generator.
3. Turn on the circuit breaker at the rear of the generator. The front panel numeric display should light.
4. Connect the RF cable to the output connector and make sure cable is connected all the way.

   If the RF cable is not fully connected, the RF output cable interlock may not engage.
5. Establish interlock connection through the generator **User** port.

   The **INTERLOCK** LED should light. This LED will only light if both the RF cable and **User** interlocks are satisfied.
6. Set the generator to operate in any of the available serial or user communications interfaces.

   The generator returns to user control mode every time that AC power is cycled. To change the control mode, use host command **14** .
7. If in the host control mode, make sure that a positive voltage between 4 V and 24 V is supplied to pins 4 (positive) and 17 (return) (*RF POWER ON*) of the **User** port.

   See the **User** port *RF POWER ON* signal for more information.

8. Select the regulation mode:
   - forward power
   - load power
   - voltage regulation
9. Make sure that set point in power control mode is set between the minimum and maximum specifications. In voltage control mode, ensure that set point is set at 20 V or more.

   The requested set point should be accurately displayed on the front panel display.
10. Send the *RF POWER ON* signal.

    The **RF ON** LED on the front panel should light.

    In user control mode, the *RF POWER ON* signal transitions from low to high on pins 4 and 17 of the **User** port. If positive voltage was already applied to pins 4 and 17 when AC power to generator was enabled, there would be no output RF power. The user has to cycle voltage on pins 4 and 17 to low and then back to high to enable RF.

    In host control mode, the *RF POWER ON* signal is **Host** port command **2**. To enable RF with command **2**, a high level signal should be present on pins 4 and 17 of the **User** port.

The unit is now ready for normal operation.

Related Links

- "Frequency Tuning" on page 5-23
- "Pulsing Output" on page 5-27

COMMAND SEQUENCE AND TIMING RECOMMENDATIONS

The recommended command sequence and timing provides guidelines to ensure that:

- Commands are issued in the correct order
- The delay between sending commands is long enough to allow the generator to respond to the previous command

If commands are issued in an incorrect order or the required time between issuing commands has not been met, the generator may not respond in the expected manner. This could appear to be a generator malfunction when it is not, and that can be avoided by using the recommended command sequence and timing.

Table 5-6. Recommended command sequence and timing

Sequence description	Command sequence
1 To set the unit to voltage control (DC bias) mode with a set point and turn RF on when: • RF is off • Unit is set to power regulation mode • Set point is zero	Issue commands in this order from the indicated interface: 1. Set to voltage control (DC bias) mode at the **User** port. 2. Wait 20 ms. 3. Turn RF ON at the **User** port. 4. Wait 10 ms. 5. Set voltage set point at the **User** port.
2 To set the unit to voltage control mode with a set point and turn RF on when: • RF is off • Unit is set to power regulation mode • Set point is zero	Issue commands in this order from the indicated interface: 1. Set to voltage control (DC bias) mode at the **User** port. 2. Wait 10 ms. 3. Set voltage set point at the **User** port. 4. Wait 20 ms. 5. Turn RF ON at the **User** port.
3 To set the unit to load power regulation with a set point and turn RF on when: • RF is off • Unit is set to voltage control (DC bias) mode • Set point is zero • Forward power regulation setting is active	Issue commands in this order from the indicated interface: 1. Set to power regulation mode at the **User** port. 2. Wait 10 ms. 3. Set to load power regulation at the **User** port. 4. Wait 10 ms. 5. Turn RF ON at the **User** port. 6. Wait 20 ms. 7. Set power set point at the **User** port.
4 To set the unit to load power regulation mode and with a set point and turn RF on when: • RF is off • Unit is set to voltage control (DC bias) mode • Set point is zero	Issue commands in this order from the indicated interface: 1. Set to power regulation mode at the **User** port. 2. Wait 10 ms. 3. Set to load power regulation at the **User** port. 4. Wait 10 ms. 5. Set power set point at the **User** port. 6. Wait 20 ms.

Table 5-6. Recommended command sequence and timing (Continued)

Sequence description	Command sequence
• Forward power regulation setting is active	7. Turn RF ON at the **User** port.
5 To set the unit to load power regulation mode with a set point and leave RF off when: • RF is on • Unit is set to voltage control (DC bias) mode • Forward power regulation setting is active	Issue commands in this order from the indicated interface: 1. Send an RF OFF command at the **User** port. 2. Wait 10 ms. 3. Set to power regulation mode at the **User** port. 4. Wait 10 ms. 5. Set to load power regulation at the **User** port. 6. Wait 10 ms. 7. Set power set point at the **User** port.
6 To set the unit to voltage control (DC bias) mode with a set point and leave RF off when: • RF is on	Issue commands in this order from the indicated interface: 1. Send an RF OFF command at the **User** port. 2. Wait 10 ms. 3. Set to voltage control (DC bias) mode at the **User** port. 4. Wait 10 ms. 5. Set voltage set point at the **User** port.
7 To set the unit to voltage control (DC bias) mode with a set point, pulsing frequency, pulsing duty cycle, and turn RF on when: • RF is off • Unit is in power regulation mode	Issue commands in this order from the indicated interface: 1. Set to voltage control (DC bias) mode at the **User** port. 2. Wait 5 ms. 3. Set pulse frequency at the **Host** port. 4. Wait 10 ms. 5. Set pulse duty cycle at the **Host** port. 6. Wait 5 ms. 7. Set voltage set point at the **User** port. 8. Wait 20 ms. 9. Turn RF ON at the **User** port.
8 To set the unit to load power regulation mode with pulse frequency, pulse duty cycle, a set point, and turn RF on when:	Issue commands in this order from the indicated interface: 1. Set to power regulation mode at the **User** port. 2. Wait 10 ms. 3. Set to load power regulation at the **User** port.

Table 5-6. Recommended command sequence and timing (Continued)

Sequence description	Command sequence
• RF is off • Unit is in voltage control (DC bias) mode • Forward power regulation setting is active	4. Wait 10 ms. 5. Set pulse frequency at the **Host** port. 6. Wait 10 ms or wait for CSR code before sending next command. 7. Set pulse duty cycle at the **Host** port. 8. Wait 5 ms. 9. Set power set point at the **User** port. 10. Wait 20 ms. 11. Turn RF ON at the **User** port.

FREQUENCY TUNING

Understanding Automatic Tuning and Sweep Frequency

The Paramount MF 2 kW generator has an automatic tuning feature, which allows a generator to sweep through its frequencies until it optimizes power delivery and minimizes load mismatch.

Different processes and chambers run with varying operating parameters. The Paramount MF 2 kW generator delivers up to 2000 W from 360 kHz to 440 kHz (400 kHz ± 10%). To optimize the power being delivered, the Paramount MF 2 kW generator uses an automatic tuning algorithm.

During tuning, the Paramount MF 2 kW generator minimizes parameter D, which is calculated based on load impedance and quantifies the amount of load mismatch.

D can vary from 0 to 3000. If the generator is loaded to 50 Ω, D = 0. If the generator is loaded to an open or short circuit, D = 3000.

RF ON TUNING

☞ **Important**
This description gives only basic information about automatic tuning. For detailed information about automatic tuning, contact AE Global Services.

If automatic frequency tuning is enabled, the generator automatically tries to find the best operating frequency. The best operating frequency is the frequency at which the parameter D is at its lowest possible value (a small value of D corresponds to small load mismatch when load impedance is close to 50 Ω).

At RF on, the generator starts at predefined frequency (start frequency) and waits a predefined amount of time (tuning delay) to let the process to stabilize. Actual initial delay is:

t = Tuning delay + 10 ms

After the initial delay, the generator starts to adjust the frequency to minimize the parameter D. The target for D is the low tuning threshold (which can be numbers between 0 and the high tuning threshold).

The tuning process may result in one of four outcomes:

- The generator continues adjusting the frequency until the D magnitude falls below the low tuning threshold. When the low tuning threshold is reached, tuning stops.
- If the generator cannot reach the low tuning threshold before the tune time exceeds the tuning timeout, and maximum tuning count isn't reached, the generator delivers error code **200**, Unable to Tune, and turns RF off.
- If the generator cannot reach the low tuning threshold and it exceeds maximum tuning count before exceeding the tuning timeout, the target for the D changes to the high tuning threshold. Now the generator continues to adjust the frequency until the D magnitude falls below the high tuning threshold. When the high tuning threshold is reached, tuning stops.
- If the generator can't reach the high tuning threshold and the tune time exceeds the tuning time-out, the generator delivers error code **200**, Unable to Tune.

We recommend a very low value for the low tuning threshold and a very high value for the high tuning threshold. In most cases, tuning trajectory never reaches the low tuning threshold and always crosses the high tuning threshold. As a result, the unit cannot reach the low tuning threshold and keeps tuning near the optimal point until it reaches the maximum tuning count. When the maximum tuning count is reached, tuning stops at this point because it is already below the high tuning threshold.

RETUNING

As a process continues with RF on, conditions can change, and the changing conditions can affect the load impedance and the value of D.

If tuning was just stopped, D = D_tuned and frequency is constant. Now, if because of a process change parameter D increases above the value:

D_retune = D_tuned + Retuning threshold

then, the generator starts the retuning process. The retuning process also starts if D increases above the high tuning threshold.

The retuning algorithm works exactly the same way as for RF ON tuning, except there is no initial tuning delay. Also, if the generator is already tuned, and command for sweep frequency tuning mode is sent, the generator goes to the start frequency and starts the automatic tuning process from the beginning.

Automatic Tuning Parameters

You can allow the tuning algorithm to sweep the entire range of generator frequencies, or you can optimize the automatic tuning by setting tuning parameters. For additional information on these parameters and how to use them, contact AE Global Services..

Table 5-7 describes frequency tuning parameters and shows the AE Host command used to set or report each parameter value. See the AE Host for additional description of the commands and parameter ranges.

Table 5-7. Frequency tuning parameters

Parameter	Description	Command
Frequency tuning mode	Toggles between automatic tuning and manual frequency adjustment. • Fixed: Turns automatic tuning off, allowing to set or change generator frequency manually. • Sweep: Turns automatic tuning on. The generator will accept but not act on manual frequency commands until placed back into fixed mode.	Set: **48** Report: **148**
Start frequency (kHz)	Sets the start frequency for automatic tuning. Must be within the minimum and maximum specified frequency.	Set: **46** Report: **146**
Minimum frequency (kHz)	Sets the low frequency limit for automatic tuning. Does not affect the range of manual frequency setting.	Set: **44** Report: **144**
Maximum frequency (kHz)	Sets the high frequency limit for automatic tuning. Does not affect the range of manual frequency setting.	Set: **45** Report: **145**
Frequency step maximum (Hz)	Sets the maximum single frequency step the generator uses during automatic tuning. Large values are faster but may cause overshoot. Smaller values are more stable but may not keep up with a dynamic load.	Set: **118**, subcommand **2** Report: **248**, subcommand **2**
Frequency step minimum (Hz)	Sets the minimum single frequency step the generator uses during automatic tuning. Large values are faster but may cause overshoot. Smaller values are more stable but may not keep up with a dynamic load. Smaller values should be large enough to make the resulting change in load reflection coefficient significant when compared to system and measurement fluctuations and noise.	Set: **118**, subcommand **1** Report: **248**, subcommand **1**
Retuning threshold	If parameter D increases beyond its tuned value plus the retuning threshold value (D_tuned + retuning threshold), the generator starts the retuning process.	Set: **58** Report: **158**

Table 5-7. Frequency tuning parameters (Continued)

Parameter	Description	Command
High tuning threshold	Sets the high tuning threshold. If the generator cannot reach the low tuning threshold and it exceeds the maximum tuning count, the target for the D changes to the high tuning threshold.	Set: **118**, subcommand **6** Report: **248**, subcommand **6**
Low tuning threshold	Sets the low tuning threshold. After an initial delay, the generator starts to adjust the frequency to minimize parameter D for normal operation. The target for D is the low tuning threshold.	Set: **118**, subcommand **7** Report: **248**, subcommand **7**
Fixed frequency	Sets the unit frequency in Hz when the unit is in fixed frequency mode. If this command is sent during automatic tuning mode, then the generator will return to this value only when fixed mode is initiated again.	Set: **61** Report: **161**
Tuning time-out	The time that the generator will attempt to reach either the high or the low tuning threshold during automatic tuning. Once this time expires, the generator will deliver error code **200** and turn RF off. If this value is set to zero, the generator will continuously tune.	Set: **38** Report: **138**
Tune delay (µs)	Sets the time in ms the generator waits after RF is turned on before automatic tuning begins. RF output remains fixed at start frequency until this time expires. Actual tune delay is 10 ms longer than the parameter value.	Set: **60** Report: **160**
Tuning gain delay	Prevents the algorithm from increasing the frequency step size immediately after changing the sign of the frequency step. Increasing this number increases the delay. Helps to prevent unstable tuning at high VSWR or unstable plasma conditions.	Set: **118**, subcommand **23** Report: **248**, subcommand **23**
Maximum tuning count	Sets the number of intervals that the generator uses when attempting to reach the low tuning threshold.	Set: **118**, subcommand **8** Report: **248**, subcommand **8**
Step up gain	Sets the magnitude of frequency step increase when the error is decreasing. A value of ^{n} sets the gain to 2^{n}. The default value is 2 (gain = $2^{n} = 2^{2} = 4$).	Set: **118**, subcommand **3** Report: **248**, subcommand **3**
Step down gain	Sets the magnitude of frequency step decrease when the error is increasing. A value of 3 sets the gain to $2^{-3} = 0.125$.	Set: **118**, subcommand **4** Report: **248**, subcommand **4**
Scan step size (Hz)	This command is not active.	n/a

Table 5-7. Frequency tuning parameters (Continued)

Parameter	Description	Command
Tuning step time	Sets the amount of measurement averaging time before the automatic tuning algorithm makes a frequency change. You cannot change this parameter while the RF output is on.	Set: **118**, subcommand **22** Report: **248**, subcommand **22**
Gamma threshold mode	This command is not active	n/a

PULSING OUTPUT

Understanding Pulsing

When pulsing is enabled, the Paramount MF 2 kW generator pulses RF output on and off based on frequency and duty-cycle settings:

- The frequency defines the length of pulsing cycles, that is, the time from the beginning of one RF on event to the beginning of the next RF on event.
- The duty cycle sets the percentage of each pulsing cycle for which output is on.

If either frequency or duty cycle is set to zero, pulsing is disabled.

An RF on event during pulsing is different than an RF on event when RF is enabled:

- When RF is enabled, the generator starts with the lowest power level and then ramps up the power until it meets the set point. The ramp up process lasts about 8 ms and is too slow for pulsing.
- During pulsing, when RF turns off, the generator remembers inverter settings. When the next RF on event happens, RF comes on with the same power setting as the end of the previous pulse. Power control loop becomes active 150 µs after the start of the pulse, when the pulse transient process is over, and regulates power until RF is off again. Then all settings get frozen until the start of the next pulse.

This way of turning RF on and off allows for the much faster pulsing, but at the same time it results in more transients and overshoots. To minimize transients, RF always turns on and off in the correct phase of the RF clock. When an internal circuitry command comes to start the next pulse, the generator waits up to one RF cycle for the correct phase of the internal RF clock, and then starts in this phase. The same event happens when the generator receives another internal circuitry command to end pulse. As a result, RF on length could be more than programmed by up to 2.5 µs. RF off length also could be longer than programmed by up to 2.5 µs.

For master/slave pulsing, the rear SMA **Sync Out** connector on the master unit should be connected to the rear SMA **Sync In** connector on a slave unit, using a coax cable. The slave unit receives a signal (*PSYNC*) from the master, and then matches its

pulsing to the signal from the master. Configure the unit for master or slave operation with host command **26** (subcommand 1).

Pulsing Parameters

Pulsing and its master/slave mode operate on a series of parameters.

Table 5-8. Pulsing parameters

Parameter	Description	Command
Pulsing master/slave	Sets a Paramount MF 2 kW generator to be a master unit or a slave unit.	Set: **26** Report: **172**
Pulse sync out	Enables a signal (*PSYNC*) from a master unit that synchronizes pulsing in slave units.	Set: **26** Report: **172**
Pulsing frequency (Hz)	Sets the length of pulsing cycles; that is, the time from the beginning of one RF on event to the beginning of the next RF on event.	Set: **93** Report: **193**
Pulsing duty cycle (%)	Sets the percentage of each pulsing cycle for which output is on.	Set: **96** Report: **196**
Slave delay	Command not active	n/a

To Set Up Master/Slave Pulsing

To prepare for master/slave operation, you need a coaxial cable.

1. Make sure that RF output is off.
2. Connect one end of the coaxial cable to the **Pulse Out** connector (SMA) on the unit that will be the master unit.
3. Connect the other end of the coaxial cable to the **Pulse In** connector (SMA) on the unit that will be the slave unit. You can daisy-chain multiple units.
4. Using **AE Host** port command **26** , set the pulsing mode, master or slave mode, and pulse sync output for each unit.

   You can use **AE Host** port command **172** to report these values.

To Enable/Disable Pulsing and Set Pulsing Parameters

If your Paramount MF 2 kW generator has the pulsing option, you can enable or disable pulsing output. You can make pulsing settings through any of the generator's serial communication ports or Virtual Front Panel (VFP). If you are using VFP, see the VFP help system for an explanation of how to enable or disable pulsing.

1. Configure the unit as a master using the serial communications port command **26**, subcommand 1.
2. To enable pulsing, send a valid set of frequency and duty cycle settings to the Paramount MF 2 kW generator:
   - Command **93** – pulsing frequency
   - Command **96** – duty cycle.
3. To disable pulsing, send a value of zero to either the pulsing frequency command or the duty cycle command.

Serial communications port commands **193** and **196** report the frequency and duty cycle settings. Serial communications port command **172** reports the slave input delay setting.

The unit does not save pulsing settings when you turn it off. To return pulsing settings to default, cycle power to the unit.

If using master/ slave, you do not need to make identical pulsing settings for all units.

SAFE OPERATING AREA (SOA) FEATURE

When enabled, the safe operating area (SOA) feature limits delivered power in different operating areas based on frequency and Γ. A hardware-controlled loop uses a lookup table to limit (that is, to foldback) power output to prevent exceeding programmed limits. This lookup table is stored in flash memory independent of firmware. The programmed limits in the lookup table are created to specific customer requirements.

When the SOA feature limits power, the unit sets the protection limit bit and the warning present bit in the process status. AE Bus commands **162** or **219** read the process status. The SOA protection warning code **74** is also set. The SOA protection warning and the process status bits self clear when no longer operating in limiting conditions.

The SOA feature is enabled/disabled using AE Bus command 118 (subcommand 50). This feature is not available in all options. See product specification for details.

MAINTENANCE

Consumable Parts

Some parts in the Paramount MF 2 kW are consumable and may wear out over time. For a current list of consumable and wear components in the Paramount MF 2 kW as well as for estimated lifetimes and recommended refurbishment schedules, please contact AE Global Services.

Troubleshooting and Global Services

Before calling AE Global Services, perform recommended checks and troubleshooting procedures. If you are still unable to resolve the issue and resume normal operation after following these checks and procedures, contact AE Global Services.

TROUBLESHOOTING THE UNIT

This troubleshooting procedure assumes that the unit was properly installed and operated. To install and operate the unit, follow installation procedures and the first time operation process.

If unit doesn't deliver output power or output power doesn't match set point, follow the procedure outlined below before calling AE Global Services.

1. Is the front panel numeric display or the **AC ON** LED lit?
   - If yes, go to the next step.
   - If no, the unit may have experienced an overtemperature condition (meaning that the internal temperature of the unit exceeds 65°C (149°F). Turn AC power off and let the unit cool down.
   - Also, there could be an external AC line fault. Verify that there is AC voltage on the pins of the connector that plugs into the Paramount MF 2 kW generator.
2. Is the **INTERLOCK** LED lit?
   - If yes, go to the next step.
   - If no, the interlock is not satisfied.
     1) Ensure that there is a connection between the interlock pins 10 and 23 on the **User** port. You may try to remove the user connector and connect these interlock pins with separate piece of wire to see if it satisfies the interlock. If the user interlock is not satisfied, the front panel numeric display will show error code **37** (other interlock error codes may also be present).
     2) Make sure that the RF output cable is firmly attached. RF cannot be enabled if this cable is not securely attached. If the numeric display shows error code **36**, the RF output cable interlock is not satisfied.

3) Make sure that the RF output interlock is properly calibrated as described in the installation procedures.

3. Is the **FAULT** LED lit?
   - If no, go to the next step.
   - If yes, the unit has detected a fault. This fault will generate an error code which can be read on the front panel numeric display and is also provided through the serial port.
4. Is the **RF ON** LED lit ?
   - If yes, go to the next step.
   - If no, the unit may not have received an RF on command.
     1) Make sure you are in the correct communications mode (user or host).
     2) If unit is controlled through the RS-232 **Host** interface, make sure there is positive voltage between 4 V and 24 V supplied to pins 4 (positive) and 17 (return) of the **User** port. If this voltage is interrupted even for a short time, the unit will turn output off. To reset the unit, restore the voltage and through the serial port send an RF off command and then send an RF on command.
     3) Verify that set point in power control mode is set between the minimum and maximum specifications. In voltage control mode, verify that set point is set at 20 V or more.
5. Is the **POWER LIMIT** LED lit?
   - If no, go to next step.
   - If yes, see "To Troubleshoot Set Point Problems" on page 6-3.
6. Turn the unit off. Verify that the unit has been installed correctly and then follow the procedure for first time operation. If the problem persists, contact AE Global Services.

To Troubleshoot an Overtemperature Condition

If your unit has an overtemperature condition with the **OVERTEMP** LED lit, it means that either the cold plate temperature or the internal air temperature has exceeded the limit, disabling output. Usually, disabling RF output stops temperature rise and the unit starts to cool down.

However, if external air temperature or the temperature of the cooling water is extremely high (above overtemperature limits), the internal temperature will continue to rise, and when it reaches 65°C (149°F), it will disable the auxiliary power supply. In this case, the display and the internal fan will stop working and the unit will not communicate through the interface ports.

The overtemperature fault clears when the internal temperature falls below fault levels.

1. Make sure that the inlet cooling water is flowing at the specified rate.
2. Make sure that inlet water temperature does not exceed specifications.
3. Make sure that the ambient air temperature around the Paramount MF 2 kW generator during operation does not exceed the specified limit, 40ºC (104ºF).
4. Make sure air inlet and outlet vents have proper clearance, 1.27 cm (0.5″) at the right side and 10.16 cm (4″) at the rear panel.
5. Check air inlet and outlet for debris.

To Troubleshoot Set Point Problems

When the **POWER LIMIT** LED is lit, the unit is unable to supply enough power to match the set point due to limiting conditions. When an internal protection limit is exceeded, the RF output is limited, but does not shut off. If this LED is lit along with a high reflected power reading, it is most likely that the generator is protecting itself in response to an external load condition.

1. Disable the output.
2. In the voltage control mode, make sure the cable from the connector **Sense V-In** is connected to the output of the peak detector. Check the value of **External Volts** on the **Generator** LEDs, front panel numeric display. If it is 2000 V, this indicates a problem with the cable (open). If it is 0 V, the cable may have an internal short.
3. Inspect and evaluate the unit's RF output connector, output cable, tuner, and chamber. Look for signs of arcing and heat stress.
4. Make sure that RF cables are not shorted.
5. Verify cable continuity. Swap suspected cables or units with known good cables or units.

Also, if unit is in pulsing mode with the shortest RF ON time and load has very high Q, transients may last longer than the pulse length. In this case the power (or voltage) control loop may not have enough time to adjust the power level and may not be able to meet set point.

INTERNAL DIAGNOSTICS

Paramount MF 2 kW generator units have self-diagnostics that indicate unit operational status. You can use these diagnostics to test a unit without removing it from a production system. For example, the system stops and you need to check all components to determine which of its components has a problem. You can quickly determine your Paramount MF 2 kW generator unit's operational status.

You must change the unit's control mode to diagnostic before starting the diagnostic test. After you start the self-diagnostic test, the unit performs these tasks:

1. Turns RF on and operates into a shorted load condition.
2. Determines if the values of three parameters are within ranges set in a diagnostic tab file:
   - Rectified bus voltage
   - Test voltage
   - Forward power
3. Turns RF off.

Once the self-diagnostic test is complete, you can send a command that will return test status codes.

To Run Internal Diagnostics

You can run this test by issuing AE Host commands.

1. Turn RF off.
2. Remove AC power from the unit by taking one or both of the following actions:
   - Turn off the circuit breaker.
   - Disconnect AC power.
3. Prepare the output connector for the test.
   a. Remove the RF output connector cover on the RF output.
   b. Disconnect the output cable.
   c. Attach an RF shorting cap.

      An RF shorting cap is a cap that provides an "short" RF connection. To obtain an RF shorting cap, contact AE Global Services.

   d. Install the RF output connector cover.
4. Restore AC power to the unit by taking one or both of the following actions:
   - Reconnect AC power.
   - Turn on the circuit breaker.
5. Using command **14**, Byte 0 = 8, change the control mode to diagnostic.
6. Issue command **95** with byte 0 = 1 (enable diagnostics mode and start diagnostics).

   The unit turns RF on for a second, and then turns RF off. When it turns RF off, the unit disables the diagnostics mode.
7. Issue command **244**.

   The unit returns a diagnostic status code that reports whether the diagnostic test passed or failed, and if it failed, which parameters failed. See host port command **244** for more details.

8. Remove AC power from the unit by taking one or both of the following actions:
   - Turn off the circuit breaker.
   - Disconnect AC power.
9. Prepare the output connector for normal operation.
   a. Remove the RF output connector cover on the RF output.
   b. Connect the RF output cable.
   c. Install the RF output connector cover.
10. Restore AC power to the unit by taking one or both of the following actions:
    - Reconnect AC power.
    - Turn on circuit breaker.
11. Issue command **14** to reset the control mode.

    The unit is ready for normal operation.

TROUBLESHOOTING USING ERROR CODES

Accessing Error Codes

You can access Paramount MF 2 kW generator error codes in two ways:

- You can view active error codes on the front panel display. The display will scroll through the active error codes, showing each for about one second. If there is only one error code, it is displayed continuously.
- You can use serial communication to request a report of active warning or fault error codes (command **223**). Once you have received a list of active errors, see the error code table to look up these error codes and troubleshoot the associated faults or warnings.

☞ **Important**
Only active fault error codes will show on the front panel display. Warning error codes do not display on the front panel. Therefore, if you see an error code displayed on the front panel, it is a fault code, not a warning.

Fault and Warning Types and Clearing Faults

The unit can report one or more types of faults or warnings:

- Unrecoverable Fault: This type of fault can occur at initialization or after running. You can try to clear it by AC power cycling the unit. If the fault persists, contact AE Global Services.

- Latching Faults: When these faults occur, regardless of whether RF is off or on at the time that the fault occurs, they remain latched until the unit receives an RF off command. If the cause of the fault has not cleared, the fault will not clear.
- Non-Latching Faults: Faults that are self clearing when RF is off.
  - Fault occurs when RF is off: A fault is non-latching only if the fault occurs while RF is off. If the fault condition clears, the fault self clears. If the cause of the fault has not cleared, the fault does not clear. The unit does not require an RF off command before turning output on. As soon as the fault condition clears, you can turn output on.
  - Fault occurs when RF is on: If output was on when the fault occurred, output turns off and the fault latches. The unit requires an RF off command before turning output on.
- Non-Latching Warnings: Warnings self clear when the condition that caused the warning clears. If a warning occurs while output is on, output remains on.

Warning and Fault Code Tables

The Paramount MF 2 kW generator provides both warning and fault codes for unit troubleshooting.

- See Table 6-1 on page 6-6 for warning code descriptions and suggested actions.
- See Table 6-2 on page 6-9 for fault code descriptions and suggested actions.

WARNING CODES

Warning codes can only be accessed through serial communication. Warning **39** also causes the **Power Limit** LED on the front panel to light.

Table 6-1. Warning codes

Warning Code	Problem Description	Suggested Action
32 Ambient Air Overtemperature Warning	Non-latching warning • Air temperature is higher than 60°C (140°F)	1. Verify ambient temperature at air inlet on the side panel. 2. Verify that there is no obstruction within 13 mm (0.5″) of the air inlet panel. If the warning persists, contact AE Global Services.

Table 6-1. Warning codes (Continued)

Warning Code	Problem Description	Suggested Action
39 Out Of Setpoint Warning	Non-latching warning • **Power Limit** LED on the front panel will light when this warning is active. • This warning can occur anytime a nonfavorable (high VSWR) load is presented to the generator output such that the unit cannot produce the requested delivered power. The threshold for this warning is ± 1% or 3 W, whichever is greater.	1. Ensure that you have set the correct regulation mode. 2. Check the RF output cable connections and integrity. 3. Ensure that your setpoint is neither above nor below power limits for the generator. If the warning persists, contact AE Global Services.
50 DC Bus Low Warning	Non-latching warning • AC line voltage is low	Verify that AC line voltage meets specifications. If the warning persists, contact AE Global Services.
70 Auxiliary Temperature Warning	Non-latching warning • Auxiliary temperature is higher than 60°C (140°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air inlet panel on the back of the unit. If the warning persists, contact AE Global Services.
71 Auxiliary Cap Bank Temperature Warning	Non-latching warning • Cap bank temperature is higher than 60°C (140°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air inlet panel on the back of the unit.

Table 6-1. Warning codes (Continued)

Warning Code	Problem Description	Suggested Action
		If the warning persists, contact AE Global Services.
72 Auxiliary Coldplate Temperature Warning	Non-latching warning • Auxiliary coldplate temperature is higher than 60°C (140°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air inlet panel on the back of the unit. If the warning persists, contact AE Global Services.
73 Coldplate Temperature Warning	Non-latching warning Temperature is detected by a thermistor. • Coldplate temperature is higher than 60°C (140°F) • Coolant might be out of specification	Verify that coolant specifications for flow rate and maximum temperature are met. If the warning persists, contact AE Global Services.
74 SOA Protection Warning	Output power is being folded back to prevent the unit from exceeding the safe operating area (SOA).	Check the process operation parameters to ensure that they are correct. If the warning persists, contact AE Global Services.
300 UART 0 Buffer Overflow Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
301 UART 1 Buffer Overflow Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
302 UART 2 Buffer Overflow Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.

Table 6-1. Warning codes (Continued)

Warning Code	Problem Description	Suggested Action
303 UART 3 Buffer Overflow Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
320 UART 0 Receive Error Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
321 UART 1 Receive Error Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
322 UART 2 Receive Error Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.
323 UART 3 Receive Error Warning	Non-latching warning • Serial communication hardware problem	Cycle AC power to the unit. If the warning persists, contact AE Global Services.

FAULT CODES

Fault codes are displayed on the front panel and can also be accessed through serial communication.

Table 6-2. Fault codes

Fault Code	Problem Description	Suggested Action
19 EEPROM CRC Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
20 Hardware Initialization Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
21 RTOS Initialization Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
22 EEPROM Initialization Fault	Internal, unrecoverable fault	Cycle AC power to the unit.

Table 6-2. Fault codes (Continued)

Fault Code	Problem Description	Suggested Action
		If the fault persists, contact AE Global Services.
23 A-D Converter Initialization Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
24 Invalid Pin Number Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
25 Unexpected Error Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
26 RTOS Runtime Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
27 User Card Configuration Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
28 NOVRAM Fixed Store Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
29 NOVRAM Free Store Fault	Internal, unrecoverable fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
30 Interlock Open Fault	Non-latching fault • An interlock is open	If the interlock was open when the unit was in an RF on state, send an RF off command to clear this fault. If the fault persists, contact AE Global Services.
31 Coldplate Overtemperature Fault	Latching fault Temperature is detected by a thermal switch. • Coldplate temperature is higher than 65°C (149°F) • Coolant is out of specification	Verify that coolant specifications for flow rate and maximum temperature are met. If the fault persists, contact AE Global Services.

Table 6-2. Fault codes (Continued)

Fault Code	Problem Description	Suggested Action
32 Ambient Air Overtemperature Fault	Latching fault • Air temperature is higher than 70°C (158°F)	1. Verify ambient temperature at air inlet on the side panel. 2. Verify that there is no obstruction within 13 mm (0.5″) of the air inlet panel. If the fault persists, contact AE Global Services.
36 RF Output Cable Interlock Open Fault	Non-latching fault • The RF output cable interlock is open.	Verify that the RF output cable is firmly attached. If the fault persists, contact AE Global Services.
37 User Port Interlock Open Fault	Non-latching fault • Interlock at the **User** port is not satisfied	Verify interlock. If the fault persists, contact AE Global Services.
40 Coldplate Temperature Rate Fault	Latching fault • Coolant flow rate and temperature might be out of specification • Water might be flowing in the wrong direction • Water temperature is rising too fast	• Verify that coolant specifications for flow rate and maximum temperature are met. • Verify that water is flowing in the correct direction. If the fault persists, contact AE Global Services.
47 AC Line Sag Fault	Latching fault • AC line voltage is not meeting specifications	Verify that AC line voltage meets specifications. If the fault persists, contact AE Global Services.
48 DC Bus Low Fault	Latching fault • AC line voltage is low	Verify that AC line voltage meets specifications. If the fault persists, contact AE Global Services.
49 DC Bus High Fault	Non-latching fault • AC line voltage is high	Verify that AC line voltage meets specifications. If the fault persists, contact AE Global Services.
51 Bad Temperature Sensor Fault	Latching fault	Cycle AC power to the unit.

Table 6-2. Fault codes (Continued)

Fault Code	Problem Description	Suggested Action
	• A temperature sensor has failed	If the fault persists, contact AE Global Services.
54 Onboard Power Fault	Latching fault • A voltage regulator has failed	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
55 Measurement FPGA Version Fault	Internal, unrecoverable fault • Hardware configuration fault	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
70 Auxiliary Temperature Fault	Latching fault • Auxiliary temperature is higher than 70°C (158°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air inlet panel on the back of the unit. If the fault persists, contact AE Global Services.
71 Auxiliary Cap bank Temperature Fault	Latching fault • Cap bank temperature is higher than 75°C (167°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air inlet panel on the back of the unit. If the fault persists, contact AE Global Services.
72 Auxiliary Coldplate Temperature Fault	Latching fault • Auxiliary coldplate temperature is higher than 63°C (145°F)	1. Verify ambient temperature at air inlet on the rear panel. 2. Verify that there is no obstruction within 100 mm (4″) of the air

Table 6-2. Fault codes (Continued)

Fault Code	Problem Description	Suggested Action
		inlet panel on the back of the unit. If the fault persists, contact AE Global Services.
73 Coldplate Temperature Fault	Latching fault Temperature is detected by a thermistor. • Coldplate temperature is higher than 65°C (149°F) • Coolant is out of specification	Verify that coolant specifications for flow rate and maximum temperature are met. If the fault persists, contact AE Global Services.
101 Inverter Not Ready Fault	Non-latching fault Generator is in soft start mode. Soft start mode is engaged on initial power up or following a deep AC line sag. • AC line voltage is less than 90% nominal • AC cable might be faulty	• Verify that loaded AC line voltage meets specifications. • Verify that AC cable is intact and functioning. If the fault persists, contact AE Global Services.
200 Unable To Tune Fault	Latching fault • The auto-tuning algorithm might be unsuccessful (see the tuning sections for more information) • A problem external to the generator exists: ◦ The plasma did not ignite ◦ The match position is not correct	• Check the RF output cable connections and integrity. • Ensure that process parameters are within limits. If the fault persists, contact AE Global Services.
201 Communication Watchdog Timer Fault	Latching fault • No communications. Timer timed out.	Ensure that host communications meet minimum timeout value. If the fault persists, contact AE Global Services.

Table 6-2. Fault codes (Continued)

Fault Code	Problem Description	Suggested Action
998 Flash Mode Failure	Latching fault • Unit failed to go into flash mode	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
999 Flash Mode Active	Latching fault • Unit is in flash mode	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1001 Message Queue Overflow	Internal, unrecoverable fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1002 Network Configuration Fault	Latching fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1003 UART Queue Fault	Internal, unrecoverable fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1004 AEBus Master Message Queue Overflow Fault	Internal, unrecoverable fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1005 AEBus Master Communication Fault	Internal, unrecoverable fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.
1006 AEBus Master Command Fault	Internal, unrecoverable fault • Serial communication hardware problem	Cycle AC power to the unit. If the fault persists, contact AE Global Services.

AE GLOBAL SERVICES

Please contact AE Global Services if you have questions or problems that cannot be resolved by working through the provided troubleshooting. When you call Global Services, make sure to have the unit serial number and part number. These numbers are available on unit labels.

☞ **Important**
For returns and repairs, please call AE Global Services to get the correct shipping address.

Table 6-3. AE Global Services 24 X 7 contact information

Office	Contact
AE World Headquarters	Address: 1625 Sharp Point Drive Fort Collins, CO 80525 USA Phone (24 hrs/day, 7 days/week): 800.446.9167 or +1.970.221.0108 Email: (We will respond to email by the next business day.) mailto:technical.support@aei.com
Thermal product support	Contact by phone or email: +1.360.694.7871 mailto:thermalapplications@aei.com
Power Control Module product support	Contact by phone or email: +49 (0) 2902 910370 10 (technical support during German business hours) mailto:powercontroller@aei.com
High Voltage product support: HiTek Power, Ltd.	Contact by phone or email: +44 (0) 1903 712400 mailto:support.centre@aei.com
High Voltage product support: UltraVolt, Inc.	Contact by phone or email: +1.631.471.4444 mailto:sales.support-uv@aei.com

Table 6-3. AE Global Services 24 X 7 contact information (Continued)

Office	Contact
Local or regional sales or service office	Visit the Advanced Energy website for current contact information: http://www.advanced-energy.com

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, first follow all troubleshooting procedures. After following troubleshooting procedures, if your unit is unable to resume normal operation, contact AE Global Services and discuss the problem with a representative. 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 Global Services to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

Purging Water for Transport or Storage

Before transporting or storing water-cooled units, you must first purge water from the unit. Failure to do so can result in damage to the unit and will void the unit warranty.

DANGER:

RISK OF DEATH OR BODILY INJURY. Disconnect and lockout/tagout all sources of input power before working on this unit or anything connected to it.

CAUTION:

Purge all water from the unit before shipping. Failure to do so can result in damage to the unit during shipping and will void the unit warranty.

To purge water from the unit:

1. Uninstall the unit and, if applicable, remove the unit from the rack.
2. Apply compressed air to the water intake connector. Water will exit through the water outflow connector.
3. Apply compressed air until water no longer exits the water outflow connector.

If you need additional information on how to purge water from the unit, contact AE Global Services.

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