HFV 8000 Generator

2 MHz, 208 V Input with DeviceNet

March 2004 5705211-C

User Manual

User Manual

HFV 8000 Generator
2 MHz, 208 V Input with DeviceNet

5705211-C

ADVANCED ENERGY®

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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 may 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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Advanced Energy's technical writing staff has carefully developed this manual using research-based document design principles. However, improvement is ongoing, and the writing staff welcomes and appreciates customer feedback. Please send any comments on the content, organization, or format of this user manual to:

- tech.writing@aei.com

To order a manual, please contact Technical Support:

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Safety and Product Compliance Guidelines

IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy® HFV generator, read and understand this manual before attempting to install and operate this unit. At a minimum, read and follow the safety instructions and practices documented under "Safety Guidelines" on page 1-2.

INTERPRETING THE MANUAL

The following sections explain the document type conventions and the danger, warning, and caution boxes that provide information about the specific levels of hazard seriousness.

Type Conventions

Please note the following type conventions:

- Pin (*2*) and signal names (*REFLECTED POWER OUTPUT*) appear in capitalized italics.
- Technical terms appear in italicized text when first introduced, and many terms are defined in the Glossary.
- Unit labels (switches, indicators, and so forth) generally appear in boldface letters as they are labeled on the unit (**Standby**).
- Commands (**5**) and command names (**starting frequency**) appear in boldface lowercase letters.

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 damage to property. 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 for safe installation and operation of the product.

- 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 line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper electrostatic discharge (ESD) precautions.
- Always be careful around this equipment.

Interpreting Product Labels

The following labels could appear on your unit.

Hazardous voltage



1332

Short circuit protected



1024

High voltage



1028

Protective Earth ground



1029

Earth ground



1069

CE label



1020

Nonionizing radiation



1030

Hot surface



1309

Warning (refer to manual)



1027

NRTL



1154

SEMI F47 compliant



2105

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 are certified by:

- Canadian Standards Association (CSA) (NRTL/C)
- CE marking, self addressed by AE Compliance Engineering
- EMC measurements, verified by TÜV

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

Safety and Compliance Directives and Standards

Certain options of this unit have been tested for and comply with the following electromagnetic compatibility (EMC) and safety directives and standards and industry guidelines.

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

ELECTROMAGNETIC COMPATIBILITY (EMC) DIRECTIVES AND STANDARDS

Table 1-1. *Electromagnetic compatibility (EMC) directives and standards*

Directive	Description
89/336/EEC	EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive)
47 CFR Part 18	Code of Federal Regulations—Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical equipment
EN 55011	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, medical (ISM) radio frequency equipment (Class A, Group 2) (CISPR 11)
EN 61000-6-2	Electromagnetic Compatibility (generic immunity standard—industrial)

SAFETY DIRECTIVES AND STANDARDS

Table 1-2. *Safety directives and standards*

Directive	Description
73/23/EEC	EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive)
ANSI/ISA 82.02.01	Safety standard for electrical and electronic test, measuring, controlling and related equipment—general requirements (harmonized standard to IEC publication 61010-1)
CSA C22.2 No. 1010.1	Safety requirements for electrical equipment for measurement, control, and laboratory use
EN 50178	Electronic equipment for use in electrical power installations

INDUSTRY GUIDELINES

Table 1-3. *Industry guidelines*

Guideline	Description
SEMI F47-0200	Specification for Semiconductor Processing Equipment Voltage Sag Immunity*
SEMI S2-0200	Environmental, health, and safety guidelines for semiconductor manufacturing equipment
*The power regulation folds back during a voltage sag event, then self-recovers.	

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

Conditions of Use

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

- This device must be used in an overvoltage category II installation only.
- Before making any other connection, connect the auxiliary Protective Earth ground conductor on the rear panel.
- Use only a shielded power cable on the output power connector.
- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only nonconductive pollution occurs during operation. Occasionally, a temporary conductivity caused by condensation occurs when the device is not operating.
- Nonstandard connectors for input/output power must be inaccessible to the user.
- Use only shielded cables on control, interface, and communication connectors.

INTERLOCKS

⚠ WARNING:
Advanced Energy Industries, Inc. products may include interlocks. When interlocks exist, they are not intended for the protection of the operator, but are intended to prevent damage to equipment or property. Hazardous areas of Advanced Energy products are not operator accessible; the use of a tool is required.

Table 1-4 lists the hardware interlocks associated with the HFV generator. To recover from an interlock fault, see “Interlock OK Indicator Off” on page 6-5.

Table 1-4. *Hardware interlocks*

Interlock Mechanism	Detection Method	Equipment Condition While Interlock is Not Satisfied
RF output cover	Switch opens	The main contactor is open; RF output is disabled
Front panel **Standby** switch	Switch opens	The main contactor is open; RF output is disabled

Figure 1-1 illustrates the interlock circuit.

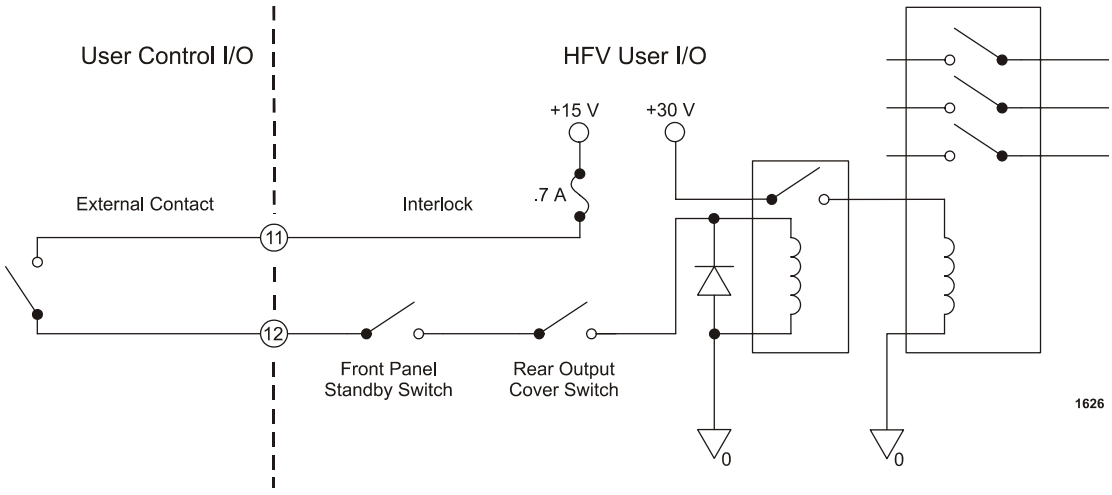


Figure 1-1. *Interlock circuit*

Chapter 2

Product Overview and Theory

GENERAL DESCRIPTION

This HFV generator is an 8-kilowatt, high-efficiency, 1.765-megahertz to 2.165-megahertz generator intended for continuous, heavy use in a vacuum chamber environment. The generator employs Advanced Energy's patented RF circuit topology in a compact, rack-mountable enclosure.

Designed to regulate on forward power or load (delivered) power into a broad range of output impedances, the HFV generator can operate in *center frequency* mode or in *automatic tuning* mode. *Direct digital synthesis* (DDS) continually adjusts the operating frequency in order to minimize the reflected power for a given load impedance. Both center frequency and automatic tuning modes support operation into a fixed impedance matching network, which simplifies system complexity, increases reliability, and improves process-to-process repeatability. Automatic tuning mode continuously minimizes the mismatch to the generator. This mode is available while in forward power regulation mode. In load power regulation, an initial frequency sweep is performed to determine the frequency that yields the minimum reflected power. For operation instructions, see "First-Time Operation" on page 5-8 and "Normal Operation" on page 5-12.

You can control the HFV generator through a 15-pin, custom analog **Generator User** port (see "Generator User Port (15-Pin)" on page 4-1) or through a **DeviceNet™** interface (see "DeviceNet™ Port" on page 4-37). DeviceNet is an electrically isolated interface installed with either a 5-pin, 12-millimeter "Micro" Lumberg RSF 5/0.5 or Turck FS 4.5 series connector. This interface supports the DeviceNet Group 2 I/O Poll Command message and Group 1 I/O Poll Response message for data transfer. You may configure MAC ID and baud rate settings through rotary switches, or you may program a DeviceNet master. Module Status and Network Status indicators are provided in accordance with the DeviceNet specification, in addition to isolated Module Status and Network Status drive signals on the 15-pin **Generator User** port for remote indicators. See "DeviceNet™ Operation" on page 4-53 for more information. You can also control the frequency and frequency tuning algorithm through the generator's serial **Host** port, which is RS-232, RS-422, and RS-485 compatible (see "Serial I/O Host Port (RS-232 With AE Bus)" on page 4-9).

In addition, Advanced Energy has Virtual Front Panel (VFP) software available for purchase. With VFP software, you can control most generator functions and monitor the HFV generator using a personal computer. To order VFP software, contact your AE sales representative (for contact information, see Table 6-1 on page 6-10).

The front panel features a liquid crystal display (LCD) mode selector and five status indicators. The HFV generator also has an internal diagnostics program to help determine generator integrity. The front panel is primarily for monitoring the operation of the generator or initiating the internal diagnostics program (see "Front view" on page 5-3).

The HFV generator is designed to fit into a 48-centimeter (19″) rack with a panel height of 13 centimeters (5.25″) (3U). The generator operates from a 208 VAC, 3 ϕ, 50/60 Hz power source and can tolerate arbitrary phase rotation of the input power connections. The HFV generator is water-cooled with all power, interface-port, and water connections at the rear of the generator (see Figure 5-2 on page 5-4).

THEORY OF OPERATION

Figure 2-1 represents high-level modules of HFV generator operation; Table 2-1 explains each module.

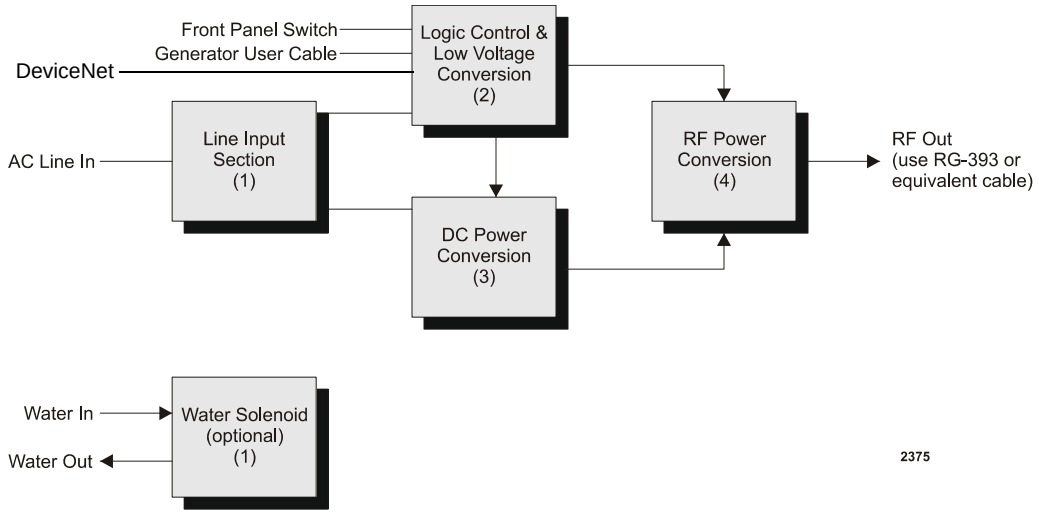


Figure 2-1. *HFV generator block diagram*

Table 2-1. *HFV generator theory of operation*

Module	Explanation
(1) Line input section	The line input section provides input line filtering and circuit protection.
(2) Logic control and low voltage conversion	This module controls the operation of HFV generator power conversions.

Table 2-1. *HFV generator theory of operation (Continued)*

Module	Explanation
(3) DC power conversion	The DC power conversion module converts AC line power to regulated DC power.
(4) RF power conversion	The RF power conversion module converts DC power to regulated RF power.
(5) Water solenoid (optional)	The optional water solenoid provides water flow control. If your generator has this option, the valve controlling water flow opens during RF power delivery and closes 30 minutes after the last RF off command.

Product Specifications

FUNCTIONAL SPECIFICATIONS

Table 3-1 describes the functional specifications of the HFV generator.

Table 3-1. *Functional specifications*

Description	Specification
Output regulation modes	The HFV generator provides forward power and load (delivered) power regulation modes, as measured at the RF output. To set, see: • Command **12** in Table 4-7 on page 4-20
Interface configurations	The HFV generator has a 15-pin analog **Generator User** port for generator control. In addition, it has is a 5-pin **DeviceNet** interface. A 9-pin serial **Host** port (RS-232, RS-422, and RS-485 compatible) is available for pre-selecting the frequency or frequency tuning algorithm. You can access the 9-pin **Host** port through a rear panel access cover (see "Host Connector and Pin Descriptions" on page 4-10 and Figure 5-2 on page 5-4).
Host port control features	The **Host** port controls the frequency and frequency tuning algorithm, along with other control features (see "AE Bus Command Set" on page 4-18).
DeviceNet control features	The **DeviceNet** interface allows you to set a power set point and enable/disable the output. Read back values are provided for forward regulation, reflected power, and various status bits (see "DeviceNet™ Port" on page 4-37).

Table 3-1. *Functional specifications (Continued)*

Description	Specification
RF output operating conditions	To achieve RF output, ensure the following conditions are met: • External interlock loop closed (less than 15 Ω in series path) • RF output cover firmly attached • Front panel **Standby** switch in the **Standby** (up) position • No faults present (Front Panel **Fault** indicator should be off) • No chamber arcing present • Set point signal > 220 mV (**Generator User** port) Set point signal > 180 W (**DeviceNet**) • RF Enable command present
Cooling	The HFV generator is water-cooled to allow operation in a clean room environment. The HFV generator will not reduce performance when the inlet water temperature is +15°C to +30°C (59°F to 86°F) and the flow rate is 11.4 lpm (3 gpm) or greater. All supplied water connections should be 9.53 mm (3/8″) ID or larger water lines. Keep the incoming and outgoing water lines as short as possible and the outlet back-pressure minimized. In addition, you may purchase an optional *water solenoid* to control water flow. A valve automatically opens during RF power delivery and closes 30 minutes after the last RF off command. An electrical connector is located on the rear panel for this option. To order the optional solenoid, contact AE Global Customer Support (see “AE Global Customer Support” on page 6-10).

PHYSICAL SPECIFICATIONS

Figure 3-1 illustrates the HFV generator's physical dimensions, and Table 3-2 describes the physical specifications.

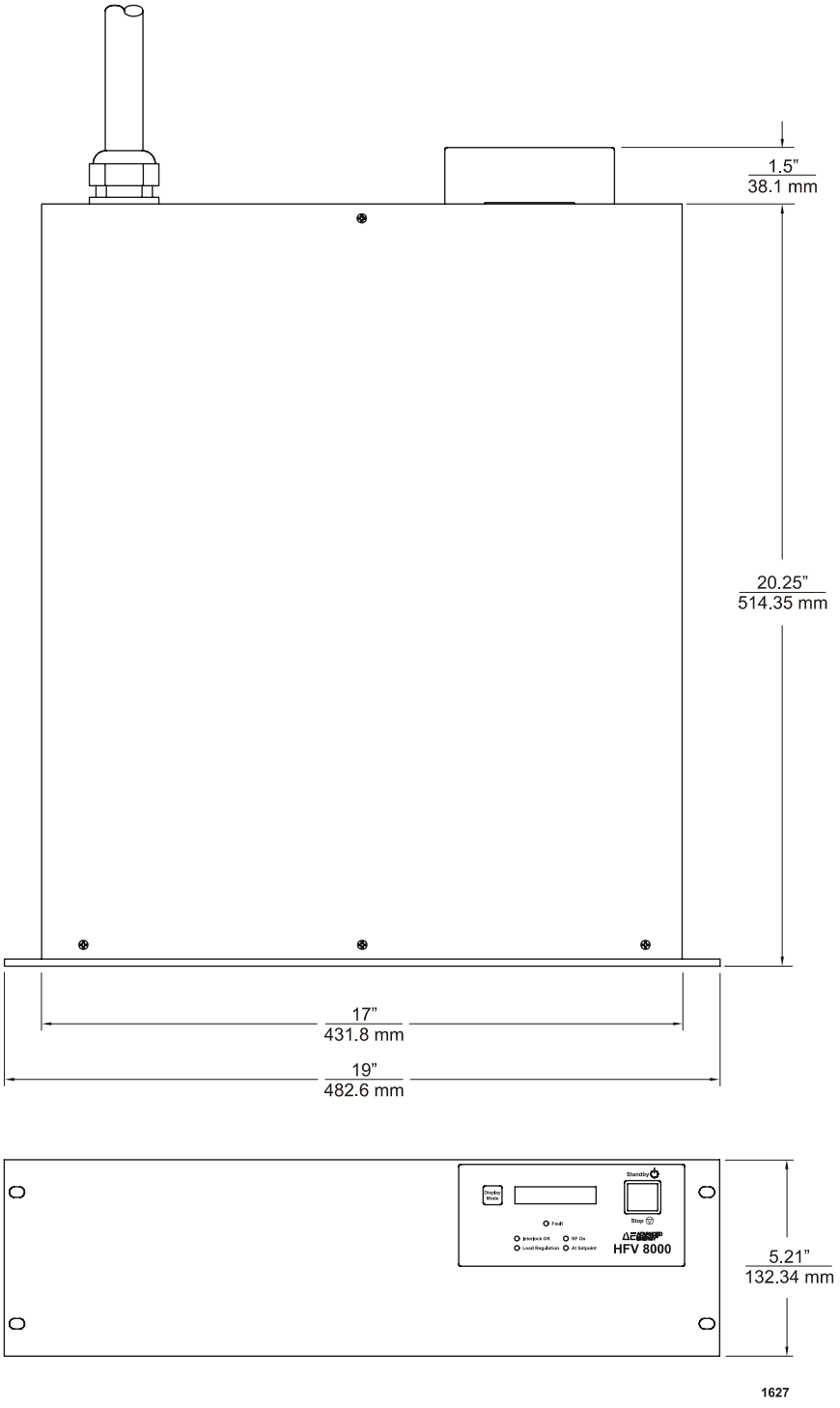


Figure 3-1. *Mounting dimensions (shown without optional water solenoid)*

Table 3-2. *Physical specifications*

Description	Specification
Size	13.3 cm (H) x 43.2 cm (W) x 51.4 cm (D) 5.25″ (H) x 17.0″ (W) x 20.25″ (D). Allow 10.16 cm (4.0″) additional depth for line cord service loop (right-hand side of rear panel). Allow 3.81 cm (1.50″) additional depth for the RF output cover (left-hand side of rear panel). Allow 11.94 cm (4.7″) additional depth for the optional water solenoid. See also Figure 3-1 on page 3-4.
Weight	34 kg (75 lb) maximum
Connector/cable specifications	
RF output	SQS™ female connector *Note:* RF output cable not provided; RG-393 or equivalent recommended
AC input power	4-wire cord, 10 mm (8 AWG), 60 cm (2´) long with Hubbell connector (CS8365C).
Generator User port	15-pin, shielded, female, subminiature-D
Host port	9-pin, shielded, female, subminiature-D
DeviceNet port	Either a 5-pin, 12 mm “Micro” Lumberg RSF 5/0.5 or Turck FS 4.5 series connector
Coolant	3/8″ stainless steel, female NPT

ELECTRICAL SPECIFICATIONS

Table 3-3 describes the electrical specifications for the HFV generator.

Table 3-3. *Electrical specifications*

Description	Specification
Input power specifications	
Line voltage	208 V, 3 ϕ with ground; no neutral connection required
Line frequency	50/60 Hz

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

Description	Specification
Line current	34.5 A at 176 VAC 29.5 A at 208 VAC During F47 line sag events, the line currents can exceed the circuit breaker rating but will not trip the breaker.
Power	11 kW maximum (at full rated RF output power)
Overcurrent protection	40 A circuit breaker
RF output specifications	
Output power	Scaled for 8000 W maximum with operator-selectable set point. RF is off when set point falls below 180 mV; RF is on when set point rises above 220 mV (see Table 4-1 on page 4-2).
Reflected power	Reflected power is limited internally to 1000 W.
Regulation	Across full frequency range into 50 Ω load: • Forward power regulation mode is ± 3.0% of set point or ± 24 W (whichever is greater) • Load power regulation mode is ± 4.0% of set point or ± 32 W (whichever is greater) • Display accuracy is ± 2% of set point (regulated) or ± 16 W (whichever is greater)
Transient regulation	≤ 0.1% change for a 10% disturbance in the AC line voltage
Frequency	1.765 to 2.165 MHz, center or automatic, selectable through the 9-pin **Host** port or front panel LCD and display mode switch (see "AE Bus Command Set" on page 4-18 or "Display Mode and the LCD Display Indicator" on page 5-16)
Response Time	≤ 100 ms rise (at full scale set point) and fall time from RF On or RF Off
Load Impedance	50 Ω, ± 2 Ω center impedance

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

Description	Specification
Harmonics	At full rated output, all harmonics are 21 dB below the RF output signal when operated into a 50 Ω, nonreactive load impedance. All spurious (nonharmonic) outputs are 30 dB below the RF output signal.
AC Line Sag Response	The HFV generator is compliant with the SEMI F47-0200 guidelines for voltage sag immunity; the power regulation folds back during a voltage event, then self-recovers.

ENVIRONMENTAL SPECIFICATIONS

Table 3-4 and Table 3-5 describe the environmental specifications.

Table 3-4. *Climatic specifications*

	Temperature	Relative Humidity	Air Pressure
Operating	Class 3K3 5°C to +40°C +41°F to +104°F	Class 3K2 10% to 85% Note 1 +2 g/m^3 to +25 g/m^3	Class 3K3 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Storage	Class 1K4 -25°C to +55°C -13°F to +131°F	Class 1K3 5% to 95% +1 g/m^3 to +29 g/m^3	Class 1K4 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Transportation	Class 2K3 -25°C to +70°C -13°F to +158°F	Class 2K3 95%Note 2 +60 g/m^3 Note 3	Class 2K3 70 kPa to 106 kPa 700 mbar to 1060 mbar (approximately 3265 m above sea level)

Note 1 Noncondensing

Note 2 Maximum relative humidity when the unit temperature slowly increases, or when the unit temperature directly increases from -25°C to +30°C

Note 3 Maximum absolute humidity when the unit temperature directly decreases from +70°C to +15°C

Table 3-5. *Environmental specifications*

Description	Specification
Overvoltage	Category II
Pollution degree	2
Coolant requirements	
Temperature	+15°C to +30°C (+59°F to +86°F) inlet temperature
Flow rate	11.4 lpm (3 gpm) minimum

Table 3-5. *Environmental specifications (Continued)*

Description	Specification
Pressure	620.5 kPa (90 psi) maximum inlet pressure *Note:* If your generator has a water solenoid, the maximum water pressure is 275 kPa (40 psi)
Contaminates	AE recommends the following specifications for the water that cools the HFV generator: • pH between 7 and 9 • 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 per cm or higher at 25°C • Total dissolved solids (TDS) as estimated by the following: $TDS \leq \frac{640{,}000}{\text{specific resistivity } (\Omega \text{ per cm})}$

Communication Interfaces

GENERATOR USER PORT (15-PIN)

The 15-pin **Generator User** port on the HFV generator provides analog and digital signals for controlling and monitoring the unit. This section describes the **User** port connector, the minimal **User** port connections required to operate the unit, **User** port cabling requirements, and detailed information about the **User** port signals.

The **Generator User** port is a 15-pin, shielded, female, subminiature-D connector (see Figure 4-1).

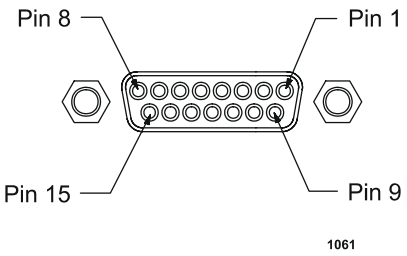


Figure 4-1. *Generator User port connector*

Satisfying DeviceNet™ Minimum Requirements

Regardless of whether you are controlling and monitoring the generator through the **Generator User** port or through another port, the *INTERLOCK LOOP* signal (pins *11* and *12*) of the **Generator User** port *must* be satisfied for the HFV generator to operate. In other words, even if you are controlling the HFV generator through the **DeviceNet** interface, the interlock signal must be satisfied. (For a wiring diagram, see Figure 4-7 on page 4-9.)

If you are not controlling or monitoring the unit through the **Generator User** port, you can use a *dummy* or *cheater* plug to satisfy these two signals and thereby ignore the **Generator User** port. To make such a plug, solder a jumper on a mating conductor between pins *11* and *12* to satisfy the *INTERLOCK LOOP* signal. To determine the physical location of these pin numbers on the **Generator User** port, see Figure 4-1.

If desired, you can add an emergency off switch in series with the *RF PWR ENABLE* signal (pin *4*) or tie your system interlocks in series with the generator *INTERLOCK LOOP* signal (pins *11* and *12*) by following the connections for those pins described in “Generator User Port Pin Descriptions” on page 4-2 and “Interconnect Schematics” on page 4-7.

User Port Interface Cabling Requirements

Connect the HFV generator's **User** port to the system controller with a shielded, 15-wire I/O cable. Shielded twisted-pair wiring may be used but is not mandatory. Minimize signal losses by keeping the cable as short as possible. The maximum recommended cable length between the HFV generator and the controller is 10 meters (33 feet). Minimize interference from adjacent electrical equipment by terminating the EMI shield in the cable to the metal shells of the cable's connectors. Additionally, you must tie the chassis of the HFV generator to a local earth ground through an adequately sized copper grounding strap.

Note: Grounding the **User** port at the HFV generator reduces noise interference. To avoid ground loop problems, you should typically ground only one end of the **User** port cable.

Generator User Port Pin Descriptions

Table 4-1 describes the connector pins for the **Generator User** port interface.

Table 4-1. *Generator User port pin descriptions*

Signal Pin	Return Pin	Signal Name	Signal Type	Description
1		*+24 V* (user provided)		Used for DeviceNet isolation
2	*6*	*REFLECTED POWER OUTPUT*	Analog output	0 V to 10 V = 0 W to 1000 W (See Figure 4-2 on page 4-7 for an electrical diagram.)
3	*6*	*FORWARD/LOAD POWER OUTPUT*	Analog output	0 V to 10 V = 0 W to 8000 W Forward power is represented when forward power regulation is selected. Load power is represented when load power regulation is selected. To select regulation mode, see: • Command **12** in Table 4-7 on page 4-20 (See Figure 4-3 on page 4-7 for an electrical diagram.)

Table 4-1. *Generator User port pin descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Description
4	*9*	*RF POWER ENABLE*	Input	Enables RF output power with an external contact closure between pins *4* and *9*. This pin is tied to +15 V through a 1 kΩ resistor. In order for the generator to deliver RF output power, the conditions below must be met in the following order: 1. Interlocks satisfied 2. RF Power enabled and Set point > 220 mV 3. Generator not in fault mode (See Table 5-2 on page 5-17) (See Figure 4-4 on page 4-8 for an electrical diagram.)
5	*6*	*FORWARD/LOAD POWER SET POINT*	Analog input	0 V to 10 V = 0 W to 8000 W The set point circuitry uses hysteresis. If RF on command (pins *4* & *9*) is enabled, the set point signal must be greater than 220 mV for RF to be turned on, or less than 180 mV for it to be turned off. (See Figure 4-5 on page 4-8 for an electrical diagram.)
6		*RETURN*		Common for pins *2*, *3*, and *5*; tied to chassis ground.

Table 4-1. *Generator User port pin descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Description
7	*8*	*RF POWER ON STATUS*	Output	Pin *7* is supplied with +15 V through a 10 kΩ resistor. While RF power is present at the output, an internal relay opens the contacts between pin *7* and pin *8*. (See Figure 4-6 on page 4-9 for an electrical diagram.) With pin *8* grounded externally, pin *7* will be at +15 V when RF power is present and at 0 V when there is *no* RF power. *Note:* For RF to be present at the output, the output must be enabled and the set point level must be above the minimum specification (see "Electrical specifications" on page 3-5).
8		*RF POWER ON STATUS REFERENCE*	Output	Floating pin that can be used as a reference for pin *7;* while RF power is present at the output, an internal relay opens the contacts between pin *7* and pin *8*.
9		*RF POWER ENABLE RETURN*	Output	Enables output RF power with an external contact closure between pins *4* and *9;* this pin is tied to the LED anode of an opto-coupler through a 1 kΩ resistor. (See Figure 4-4 on page 4-8 for an electrical diagram.)

Table 4-1. *Generator User port pin descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Description
10		*MODULE STATUS OK*	LED output	Provides the output for remote DeviceNet indicators and is connected to the emitter of an opto-coupler. You must limit current draw through this pin to 45 mA or less. *Note:* Defined by *DeviceNet Specification, Release 2.0* (see the Open DeviceNet Vendor Association web site at www.ODVA.org)
11	*12*	*INTERLOCK LOOP*		Enables the internal AC power contactor with an external closure between pins *11* and *12* (provided front panel **Standby** switch is closed and RF output cover is on). External series resistance must be 15 Ω or less. This pin is tied to +15 V by a resettable fuse. *Note:* When this loop is interrupted, the unit disables the output by opening the main contactor inside the supply. Once the interlock is reestablished, the main contactor will close, but the output will not come on until the RF POWER ENABLE line (pin *4*) is cycled. (See Figure 4-7 on page 4-9 for an electrical diagram.)

Table 4-1. *Generator User port pin descriptions (Continued)*

Signal Pin	Return Pin	Signal Name	Signal Type	Description
13		*NETWORK STATUS OK*	LED output	Provides the output for remote DeviceNet indicators and is connected to the emitter of an opto-coupler. You must limit current draw through this pin to 45 mA or less. *Note:* Defined by *DeviceNet Specification, Release 2.0* (see the Open DeviceNet Vendor Association web site at www.ODVA.org)
14		*MODULE STATUS ERROR*	LED output	Provides the output for remote DeviceNet indicators and is connected to the emitter of an opto-coupler. You must limit current draw through this pin to 45 mA or less. *Note:* Defined by *DeviceNet Specification, Release 2.0* (see the Open DeviceNet Vendor Association web site at www.ODVA.org)
15		*NETWORK STATUS ERROR*	LED output	This pin provides the output for remote DeviceNet indicators and is connected to the emitter of an opto-coupler.You must limit current draw through this pin to 45 mA or less. *Note:* Defined by *DeviceNet Specification, Release 2.0* (see the Open DeviceNet Vendor Association web site at www.ODVA.org)

INTERCONNECT SCHEMATICS

The following electrical diagrams detail the interface circuitry in the HFV unit.

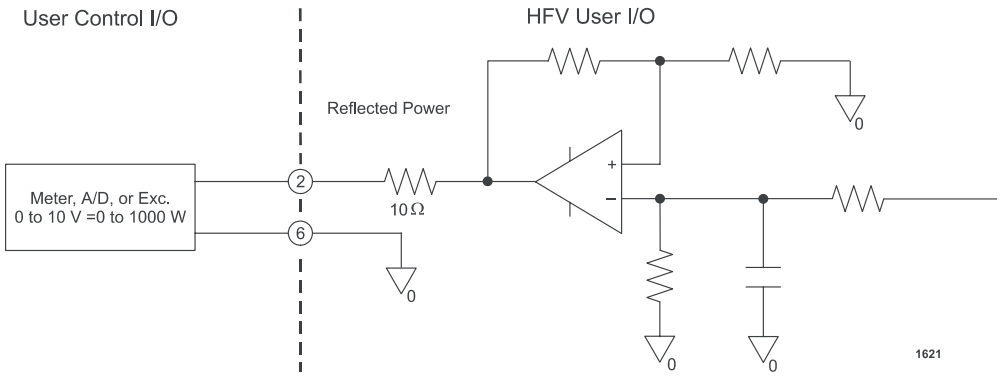


Figure 4-2. *Reflected power*

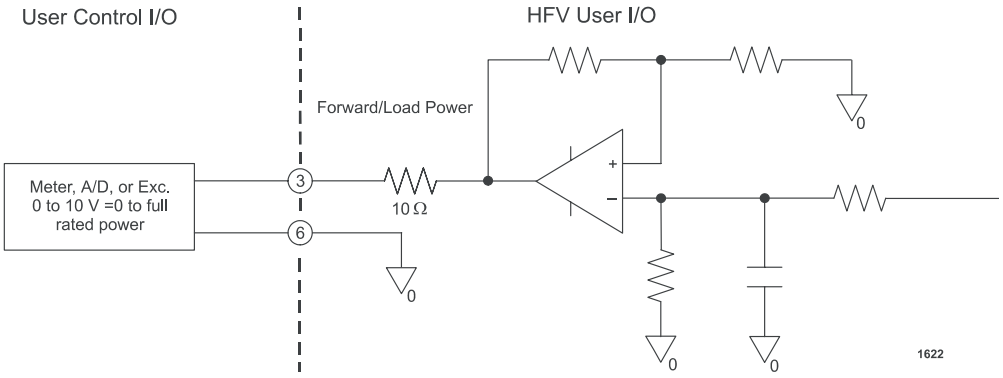


Figure 4-3. *Forward/load power output*

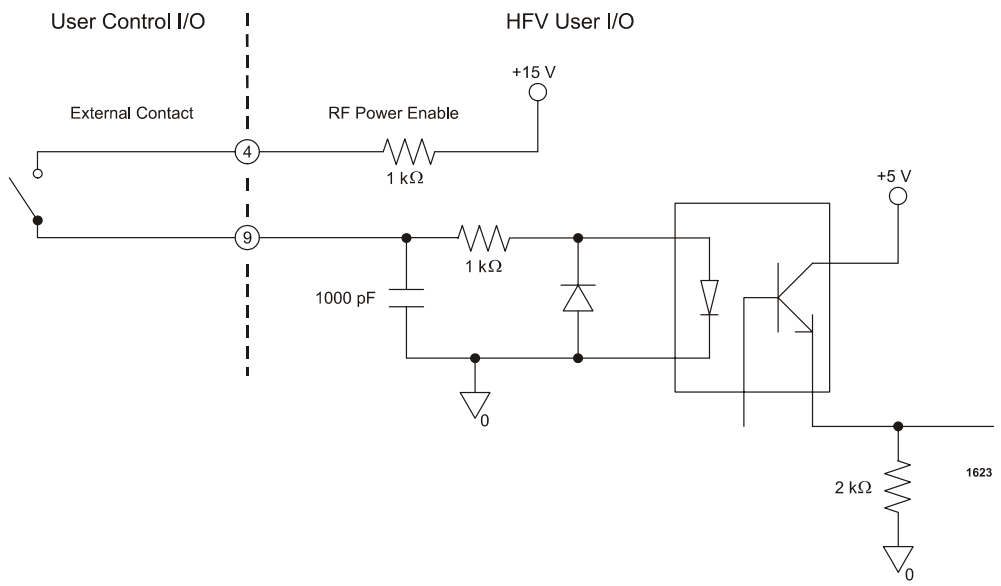


Figure 4-4. *RF power enable*

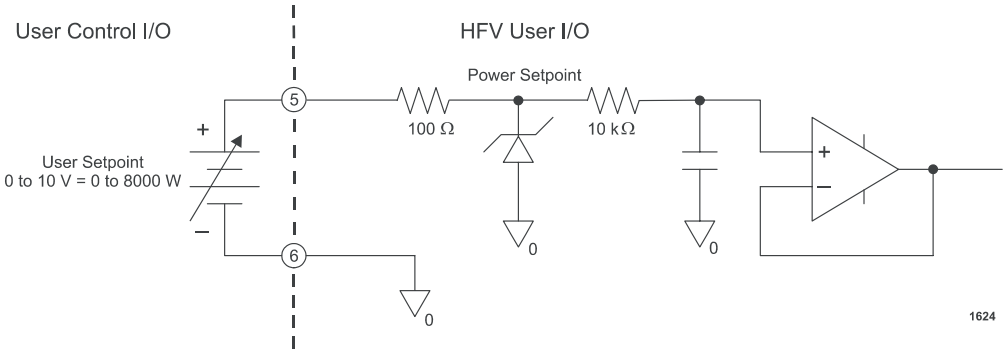


Figure 4-5. *Forward/load power set point*

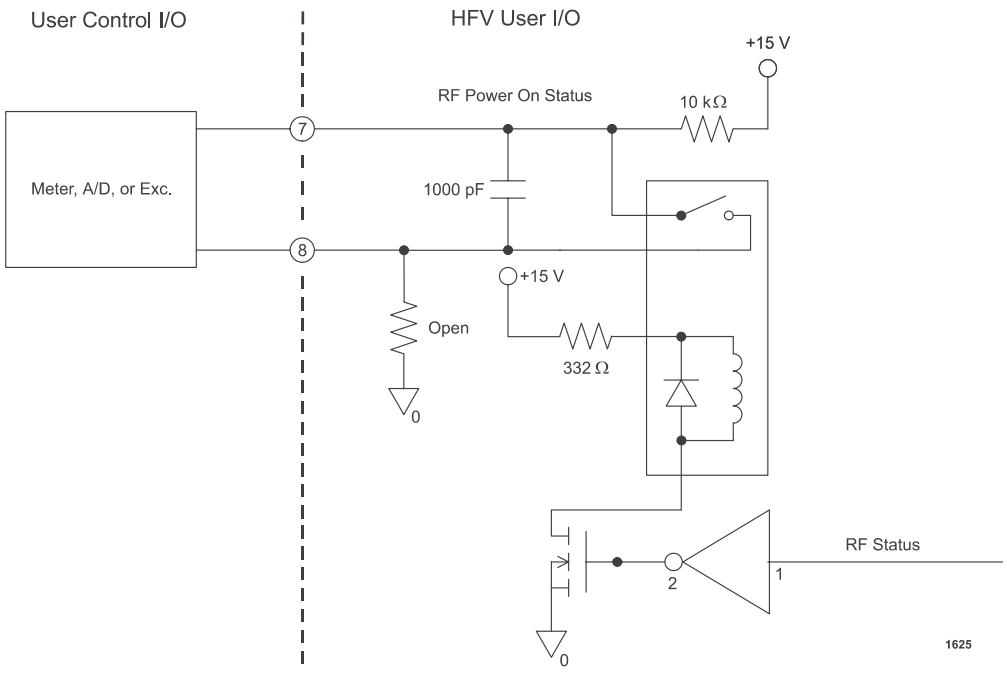


Figure 4-6. *RF power on status*

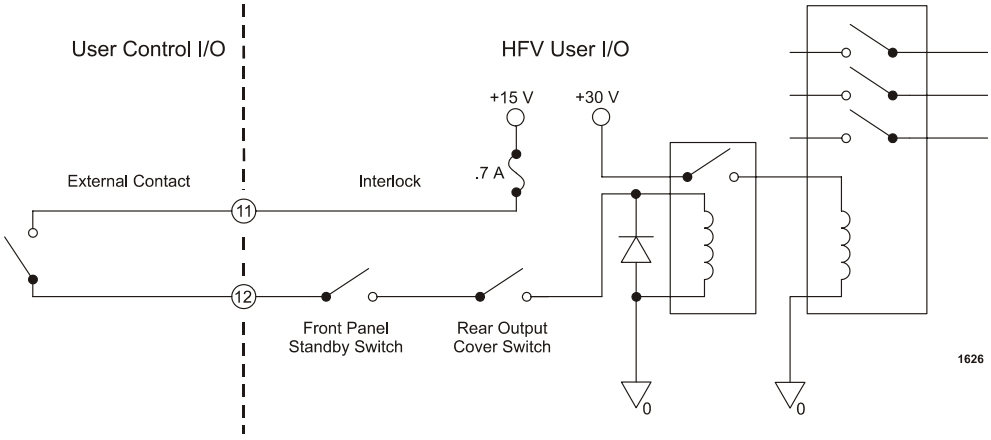


Figure 4-7. *Interlock loop*

SERIAL I/O HOST PORT (RS-232 WITH AE BUS)

The HFV generator provides a serial communications interface through the AE Bus **Host** port. The **Host** port enables you to modify the default settings of the complex tuning algorithm for detailed process control and enhancement. For a complete list of

available functions, see “AE Bus Command Set” on page 4-18. To obtain sample AE Bus host software, please contact AE Global Customer Support (see “AE Global Customer Support” on page 6-10).

Note: The unit is configured at the factory to use RS-232 but may be changed to RS-422 or RS-485 by contacting AE Technical Support (see “AE Global Customer Support” on page 6-10).

Host Connector and Pin Descriptions

The serial AE Bus **Host** port is a 9-pin, female, shielded, subminiature-D connector.

To access the **Host** port:

1. Use a screwdriver to remove the two screws from the rear panel access cover (see Figure 5-2 on page 5-4).
2. Remove the rear panel access cover. The **Host** port connector and an 8-position DIP switch are directly behind the cover.

Figure 4-8 shows the serial **Host** port, and Table 4-2 describes each pin.

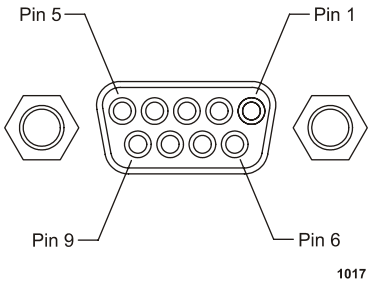


Figure 4-8. *Serial AE Bus Host port connector*

Table 4-2. *Host port connector*

Pin	Name	Description
1	*RESERVED*	Reserved for future use
2	*TXD*	RS-232 transmit data
3	*RXD*	RS-232 receive data
4	*RESERVED*	Reserved for future use
5	*COM*	Data common
6	*TR–*	RS-485 (–) xmit/rx data/RS-422 (–) rx data
7	*TR+*	RS-485 (+) xmit/rx data/RS-422 (+) rx data

Table 4-2. *Host port connector (Continued)*

Pin	Name	Description
8	*RESERVED*	Reserved for future use
9	*RESERVED*	Reserved for future use

Host Port Settings

An 8-position DIP switch determines the device ID (network address) and communications baud rate.

To access the DIP switch:

1. Use a screwdriver to remove the two screws from the rear panel access cover (see Figure 5-2 on page 5-4).
2. Remove the rear panel access cover. The **Host** port connector and an 8-position DIP switch are directly behind the cover.

Up to 31 device addresses are available (address 0 is reserved for broadcast commands). A switch in the **OPEN** or **OFF** position represents a binary 1 for address selection purposes. Table 4-3 lists the switch designations, and Table 4-4 lists the baud rate selections.

Table 4-3. *Host port settings*

Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8
A4	**A3**	**A2**	**A1**	**A0**	**BR1**	**BR0**	
Host Port Address MSB	- - - - - -	- - - - - -	- - - - - -	**Host** Port Address LSB	Baud Rate Selection MSB	Baud Rate Selection LSB	Open for RS-232 Closed for RS-485/422[Note 1]

[Note 1] Requires internal modification to the unit. Contact Global Customer Support before removing the safety cover (see "AE Global Customer Support" on page 6-10).

Use A4 to A0 (straight binary representation) to select **Host** port addresses 1 to 31. Use BR1 and BR0 to define baud rate selection (see also Table 4-4).

Table 4-4. *Baud rate for Host port*

BR1	BR0	RS-232 (switch 8 open) Baud Rate	RS-485/422 (switch 8 closed) Baud Rate[Note 1]
Closed	Closed	1200	9600
Closed	Open	4800	19.2 K
Open	Closed	9600	38.4 K
Open	Open	19.2 K	57.6 K

Note 1 Requires internal modification to the unit. Contact Global Customer Support before removing the safety cover (see "AE Global Customer Support" on page 6-10).

AE Bus (Host) Port Transmission Parameters

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

- Start bits: One
- Number of Data Bits: 8
- Parity: Odd
- Stop bits: One
- Low-order bytes transmitted before high-order bytes.

Table 4-5 lists the **Host** port transmission parameters.

Table 4-5. *Transmission parameters*

	RS-232	RS-485	RS-422
Baud rate (user selectable)	1200, 4800, 9600, 19.2 K	9600, 19.2 K, 38.4 K, 57.6 K	9600, 19.2 K, 38.4 K, 57.6 K
Connector pins	*2, 3, 5*	*5, 6, 7*	Internal jumper

The host computer must finish one transaction with the HFV generator before it initiates another, either with the same unit or any other unit.

Note: The HFV generator sends data through pin *2* (*TXD.D*). This pin must be connected to the receive pin (*RXD.D*) on the host computer's PC serial connector. The receive pin is normally pin *2* for a standard, 9-pin PC serial port and normally pin *3* for a standard, 25-pin PC serial port.

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 HFV generator.

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 communications message packets (see Figure 4-9):

- Header (address and the length of Data field)
- Command Number (the commands are listed in Table 4-7 on page 4-20)
- Optional Length byte
- Data
- Checksum

Figure 4-9 shows the organization of these fields in the AE Bus message packet. The subsequent paragraphs describe each field in detail.

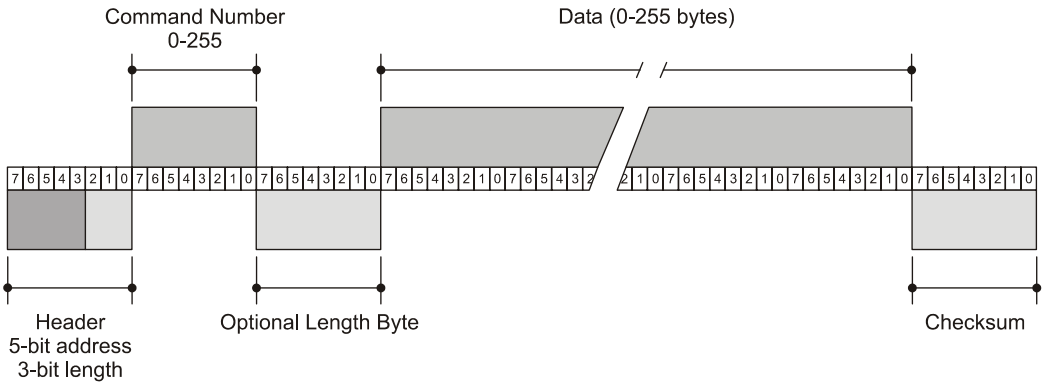


Figure 4-9. *Graphic representation of a message packet*

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 (master), the address specifies the packet destination (to an HFV generator, for example). If the packet is going to the host, the address specifies the packet origin (from the HFV generator). The address section of the Header field is five bits long (bits 3-7), which allows a total of 32 distinct addresses. Address 0 (zero) is reserved for the network broadcast address; when this address is used in a host-originated packet, all units execute the packet (but do not respond to the host).

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 6 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.

Note: 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 (see "AE Bus Checksum Byte" on page 4-15).

AE BUS COMMAND NUMBER BYTE

This one-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 HFV generator, the value specifies the command to which it is responding. See "AE Bus Commands" on page 4-17 for a complete list of commands.

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 or less, 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 may contain up to 255 bytes of information, the Optional Length byte is required when the Data field is larger than 6 bytes.

When the Data field is larger than 6 bytes, the length bits in the header (bits 0, 1, and 2) will equal 7 (07h) and the Optional Length byte will contain a one-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 may contain from 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 HFV generator expects 0 to 6 data bytes. However, if the value in the Header field is 7 (07h), the HFV generator looks for the Optional Length byte after the Command field and reads this value to calculate the data byte count.

AE BUS CHECKSUM BYTE

This one-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 as having no parity errors.

Creating an Ideal Communications Transaction

Figure 4-10 illustrates the steps in an ideal communications transaction between a host computer and the HFV generator.

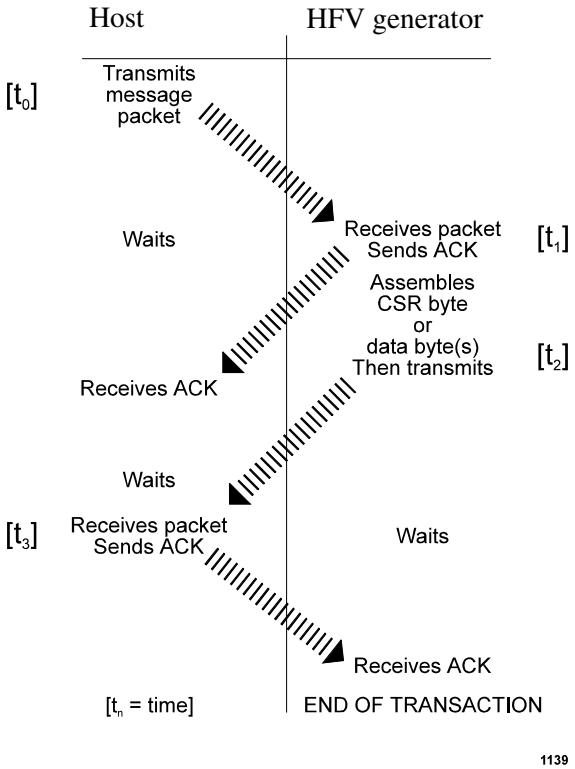


Figure 4-10. *AE Bus communications transaction*

T_0: HOST TRANSMITS MESSAGE PACKET

The host computer sends a message packet to the HFV generator. 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 HFV generator receives the host computer transmission message packet, the HFV generator verifies that the message is intended for it and not for another unit on the network. At this time, the HFV generator also analyzes the checksum to verify that the message was received correctly.

- If the address does not match, the HFV generator does not respond to the host computer; the HFV generator 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 HFV generator sends a negative acknowledgment (NAK), hexadecimal 15h, to the host computer.
- If the address matches and the message is intact, the HFV generator sends an acknowledgment (ACK), hexadecimal 06h, to the host computer.

If the HFV generator 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 one-byte data value (CSR code) to the host (see "AE Bus Command Status Response (CSR) Codes" on page 4-18). CSR code 0 is sent when the command has been accepted.

If the host receives a NAK (15h) from the HFV generator, the host either retransmits the packet or does whatever else it has been programmed to do in this situation. If the host receives an ACK (06h), 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 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 HFV generator 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 (15h).

T_3: HOST ACKNOWLEDGES UNIT RESPONSE

If the HFV generator receives an ACK (15h) from the host computer, it returns to the normal waiting state. If the HFV generator receives a NAK (06h) from the host computer, the HFV generator retransmits the response packet. The HFV generator continues to retransmit in response to NAK transmissions until the host computer stops the cycle. If the HFV generator receives no response, it assumes an ACK and returns to the waiting state.

AE BUS COMMUNICATIONS TRANSACTION EXAMPLE

Figure 4-11 is a simplified graphic showing the steps in an example communications transaction between a host computer and an HFV generator.

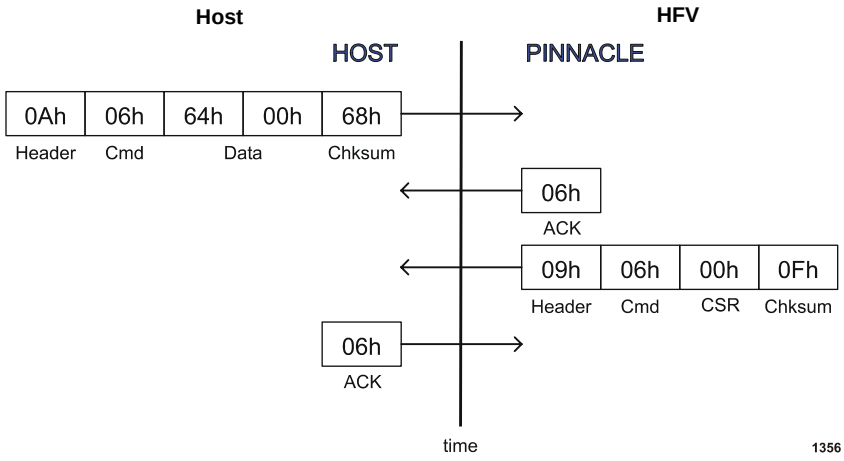


Figure 4-11. *Communications transaction example*

AE Bus Commands

The following sections describe the command status response (CSR) codes returned by the HFV generator in response to a command as well as the AE Bus commands for the HFV generator.

AE BUS COMMAND STATUS RESPONSE (CSR) CODES

When the HFV generator receives a command requesting a change in unit operation or status (command numbers **1** through **127**), 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. Use Table 4-6 to interpret the CSR codes.

Table 4-6. *Command Status Response (CSR) codes*

Value	Meaning
0	Command accepted
The following CSR codes are sent in response to a command that was not accepted and indicate why the command was not accepted.	
1	Control mode is incorrect
2	Output is on; change not allowed
3	Output is off; change not allowed
4	Data is out of range
5	Invalid parameter
7	Active fault(s) exist
8	Ramping is active; change not allowed
9	Data byte count is incorrect
16	Target life has been consumed
17	Output OFF timer active (minimum off time is 50 ms)
19	Recipe is active; change not allowed
21	Joule set point has not been reached
24	Bus fault active (high or low)
28	Set point exceeds user limit
30	TCC is active; change not allowed
36	Data sent is greater than user limit for P, V, or I
99	Command not accepted (there is no such command)

AE BUS COMMAND SET

The HFV generator AE Bus serial communication interface has two types of commands:

- Commands **1** through **127** request a change to the HFV generator, such as turning output on or off or 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. For more information on CSR codes, see "AE Bus Command Status Response (CSR) Codes" on page 4-18.
- Command numbers **128** through **255** request information from the unit, such as output on/off status and unit settings. The unit responds to these commands by sending the data requested.

Table 4-7 lists the **Host** commands.

Table 4-7. *Host port commands*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
3 minimum frequency	Sets the minimum frequency. *Note:* This command is invalid when the unit is in center frequency mode. Send four bytes, least significant byte first, representing the minimum frequency value in Hertz. • Range is 1765000 to 2165000, but the value cannot be greater than the value set by command **4** (**maximum frequency**). • For example, enter 2000000 (2,000,000 Hz). Set maximum frequency with command **4**. Set starting frequency value with command **5**. Read back with command **133**. See also "Frequency Limits" on page 5-14.	4	1 CSR only
4 maximum frequency	Sets the maximum frequency. Send four bytes, least significant byte first, representing the maximum frequency value in Hertz. *Note:* This command is invalid when the unit is in center frequency mode. • Range is 1765000 to 2165000, but the value cannot be less than the value set by command **3** (**minimum frequency**). • For example, enter 2000000 (2,000,000 Hz). Set minimum frequency with command **3**. Set starting frequency value with command **5**. Read back with command **134**. See also "Frequency Limits" on page 5-14.	4	1 CSR only

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
5 **starting frequency**	Sets the starting frequency. Send four bytes, least significant byte first, representing the starting frequency value in Hertz. *Note:* This command is invalid when the unit is in center frequency mode. • The value must be greater than or equal to the value set by command **3** (**minimum frequency**) and less than or equal to the value set by command **4** (**maximum frequency**). • For example, enter 2000000 (2,000,000 Hz). Read back with command **135**. See also "Frequency Limits" on page 5-14.	4	1 CSR only
7 **reset tuning parameters**	Resets tuning parameters to factory defaults. Send 1 byte to select the setting: • 0 = Keep current settings • 1 = Factory defaults	1	1 CSR only
11 **frequency rate of change**	Specifies the frequency rate of change. Send two bytes, least significant byte first, representing the frequency rate of change in seconds. • Accepts a value of 5 to 1000 (0.005 s to 1.000 s, decimal is implied) Read back with command **141**. See also "Frequency rate of change (ms)" on page 5-15.	2	1 CSR only
12 **set regulation mode**	Sets regulation mode. Send one data byte, indicating the desired mode: • 2 = Forward power regulation • 3 = Load (delivered) power regulation Read back with command **132**.	1	1 CSR only

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
14 **tuning goal**	Specifies the desired goal that the tuning algorithm will attempt to achieve. Send two bytes, least significant byte first, representing the desired goal. • Range is 1 to 8000 Read back with command **153**. See also "Tuning goal" on page 5-15.	2	1 CSR only
15 **tuning gain**	Specifies the gain used in the tuning algorithm. Send two bytes, least significant byte first, representing the tuning gain. • Accepts a value of 1 to 1000 Read back with command **154**. See also "Tuning gain" on page 5-15.	2	1 CSR only
16 **tuning delta limits**	Specifies the maximum frequency delta for the tuning algorithm. Send four bytes, least significant byte first, representing the tuning delta limit. • Accepts a value of 1 to 100000 Read back with command **155**. See also "Tuning delta limit (Hz)" on page 5-15.	4	1 CSR only
19 **scan delta**	Specifies the frequency step size for the scan algorithm. Send four bytes, least significant byte first, representing the scan delta in Hertz. • Accepts a value of 1 to 10000 (1 to 10000 Hz). Read back with command **156**. See also "Scan delta frequency (Hz)" on page 5-15.	4	1 CSR only
20 **scan threshold**	Specifies the threshold at which the scan algorithm completes. Send two bytes, least significant byte first, representing the scan threshold. • Accepts a value of 1 to 8000 Read back with command **157**. See also "Scan threshold" on page 5-16.	2	1 CSR only

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
40 **set Host port time-out**	Sets the host port time-out value through the host. Send two bytes, least significant byte first, representing the time-out value in seconds. • Range is 2 to 500 (20 ms to 5.00 s, decimal implied) Read back with command **140**.	2	1 CSR only
127 **data logging on/off**	Enables or disables data logging. Send one byte to toggle data logging off or on: • 0 = Off • 1 = On Command **255** reads the log records.	1	1 CSR only
128 **report device type**	Reads the device type. The controller board returns a three- or four-byte ASCII string: • HFV or HFV-L	0	3- or 4-byte ASCII string
129 **report device size**	Reads the output power value in watts. The controller board returns a four-byte ASCII string: • 8000 (8000 W)	0	4-byte ASCII string
130 **report software part number**	Reads the software part number. The controller board returns a seven-byte ASCII string representing the initial seven digits of the AE part number. Command **198** retrieves the revision letter.	0	7-byte ASCII string
132 **report regulation mode**	Reads regulation mode. The controller board returns one data byte: • 2 = Forward power regulation • 3 = Load (delivered) power regulation Set with command **12**.	0	1

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
133 report minimum frequency	Reads the minimum frequency value. The controller board returns four data bytes representing the minimum frequency in Hertz. • Range is 1765000 to 2165000. • For example, 2000000 (2,000,000 Hz) Set with command **3**.	0	4
134 report maximum frequency	Reads the maximum frequency value. The controller board returns four data bytes representing the maximum frequency value in Hertz. • Range is 1765000 to 2165000 • For example, 2000000 (2,000,000 Hz). Set with command **4**.	0	4
135 report starting frequency	Reads the starting frequency value. The controller board returns four data bytes representing the starting frequency in Hertz. • Range is 1765000 to 2165000 • For example, 2000000 (2,000,000 Hz). Set with command **5**.	0	4
136 report forward power	Reads the generator forward power. The controller board returns two data bytes representing the value in watts. • For example, 2500 (2500 W)	0	2
137 report reflected power	Reads the generator reflected power. The controller board returns two data bytes representing the reflected power value in watts. • For example, 2500 (2500 W)	0	2
140 Host port time-out value	Reads the host port time-out value. The controller board returns two data bytes representing the time-out value in seconds. • For example, 500 (5.00 s, decimal is implied) Set with command **40**.	0	2

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
141 report frequency rate of change	Reads the frequency rate of change. The controller board returns two data bytes representing the frequency rate of change in seconds. • For example, 1000 (1.000 s, decimal is implied) Set with command **11**.	0	2
142 report real gamma	Reads the generator real gamma. The controller board returns two data bytes. • For example, 250 (0.250, decimal is implied)	0	2
144 report VSWR	Reads the generator actual VSWR. The controller board returns two data bytes. • For example, 1330 (1.330, decimal is implied)	0	2
147 report actual frequency out	Reads the actual frequency value. The controller board returns four data bytes representing the actual frequency value in Hertz. • For example, 2000000 (2,000,000 Hz)	0	4
153 report tuning goal	Reads the goal that the tuning algorithm is attempting to achieve. The controller board returns two data bytes. • For example, 8000 Set with command **14**. See also "Tuning goal" on page 5-15.	0	2
154 report tuning gain	Reads the gain used in the tuning algorithm. The controller board returns two bytes. • For example, 8000 Set with command **15**. See also "Tuning gain" on page 5-15.	0	2

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
155 report tuning delta limit	Reads the maximum frequency delta for the tuning algorithm. The controller board returns two data bytes. • For example, 100000 Set with command **16**. See also "Tuning delta limit (Hz)" on page 5-15.	0	4
156 report delta	Reads the frequency step size for the scan algorithm. The controller board returns four data bytes representing the scan delta in Hertz. • For example, 10000 (10000 Hz) Set with command **19**. See also "Scan delta frequency (Hz)" on page 5-15.	0	4
157 report scan threshold	Requests the threshold at which the scan algorithm completes. The controller board returns two data bytes. • For example, 8000 Set with command **20**. See also "Scan threshold" on page 5-16.	0	2
160 report configuration file flags	Reports configuration file flags (read with VFP). The controller board returns four data bytes.	0	4

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
162 report status	Reads the process status. The controller board returns four data bytes. 1st status byte • 0 = Power failure • 1 = Unassigned interrupt has occurred • 2 = A/D conversion failure • 3 = Output on • 4 = Load power regulation • 5 = Overtemperature • 6 = Interlock • 7 = Line fault 2nd status byte • 0 = Divide error • 1 = Software single step • 2 = Breakpoint • 3 = Overflow • 4 = Array bounds exception • 5 = Undefined opcode • 6 = Escape opcode exception • 7 = Numeric coprocessor exception 3rd status byte • 0 = Center frequency • 1 = Set point unscaled • 2 = Wide bus voltage test • 3 = Water valve is off • 4 = In diagnostic mode • 5 = RF request • 6 = Digital frequency display • 7 = Continuous load power tuning 4th status byte • 0 = At set point • 1 = Datalogging enabled • 2 = RF enabled without interlock • 3 = Heartbeat time-out off	0	4

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
164 report set point	Reads the set point value. The controller board returns three data bytes: • Bytes 1 and 2 represent the set point value in watts ▸ Maximum power is 8000 W. • Byte 3 indicates the regulation mode: ▸ 2 = Forward power regulation ▸ 3= Load power regulation Set with command **12**.	0	3
195 report AC On total time	Reads the AC On total time. The controller board returns four data bytes, each count equal to 0.25 h. • For example, 11358 = 2839.5 h	0	4
196 report RF On total time	Reads the RF On total time. The controller board returns 4 data bytes, each count equal to 0.25 h. • For example, 10235 = 2558.75 h	0	4
197 report kilowatt-hours delivered	Reads the total kilowatt-hours delivered. The controller board returns four data bytes, each count equal to 0.25 kWh. • For example, 37581 = 9395.25 kWh	0	4
198 report software level	Reads the generator software revision level. The controller board returns three ASCII characters: • One letter, followed by a two-digit number	0	3 ASCII characters

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
199 report diagnosis status	Requests analog voltages from diagnostic analog to digital converter. Send one data byte as follows: • 0 = Forward power • 1 = Reflected power • 2 = Inverter power • 3 = Fast I • 4 = PAED • 5 = Bus sample • 6 = 10 V ref • 7 = Ground • 10 = I inverter • 11 = V inverter • 12 = Dissipation • 13 = +15 V supply • 14 = 10 V reference • 15 = +30 V supply • 16 = -15 V supply • 17 = User set point analog The controller board returns two bytes representing the requested voltage value.	1	2
200 report software checksum	Reads the logic software checksum.	0	2
201 report software configuration ID	Reads the software configuration ID string. The controller board returns a 32-byte ASCII string representing the initial seven digits of the AE part number, revision, and device description.	0	32-byte ASCII string
202 report DeviceNet MAC ID	Reads MAC ID of **DeviceNet** interface. The controller board returns one data byte representing the ID. *Note:* If the DeviceNet is not installed or powered, the response data byte will be 255.	0	1

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
203 report DeviceNet baud rate	Reads baud rate of **DeviceNet** interface. The controller board returns one data byte: • 0 = 125 kbd • 1 = 250 kbd • 2 = 500 kbd *Note:* If the DeviceNet is not installed or powered, the response data byte will be 255.	0	1
204 report DeviceNet software version	Reads software version of **DeviceNet** interface. The controller board returns three data bytes of ASCII data (X.X).	0	3

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
219 report condensed snapshot of generator data	Reports a snapshot of generator data. The controller board returns 21 data bytes: • Bytes 0 and 1 represent forward power • Bytes 2 and 3 represent reflected power • Bytes 4 and 5 represent delivered power • Bytes 6 and 7 represent the set point • Byte 8 represents the regulation mode: ▸ 2 = Forward power regulation ▸ 3 = Load power regulation • Byte 9 represents process status information: ▸ 0 = Power failure ▸ 1 = Unassigned interrupt has occurred ▸ 2 = A/D conversion failure ▸ 3 = Output on ▸ 4 = Load power regulation ▸ 5 = Overtemperature ▸ 6 = Interlock ▸ 7 = Line fault • Byte 10 represents process status information: ▸ 0 = Divide error ▸ 1 = Software single step ▸ 2 = Breakpoint ▸ 3 = Overflow ▸ 4 = Array bounds exception ▸ 5 = Undefined opcode ▸ 6 = Escape opcode exception ▸ 7 = Numeric coprocessor exception	0	21

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
219 (cont'd)	• Byte 11 represents process status information: ▸ 0 = Center frequency ▸ 1 = Set point unscaled ▸ 2 = Wide bus voltage test ▸ 3 = Water valve is off ▸ 4 = In diagnostic mode ▸ 5 = RF request ▸ 6 = Digital frequency display ▸ 7 = Continuous load power tuning • Byte 12 represents process status information: ▸ 0 = At set point ▸ 1 = Datalogging enabled ▸ 2 = RF enabled without interlock ▸ 3 = Heartbeat time-out off • Bytes 13-16 represent the frequency value in Hertz. ▸ For example, 2000000 (2,000,000 Hz) • Bytes 17 and 18 represent the generator real gamma. ▸ For example, 250 (0.250, decimal is implied) • Bytes 19 and 20 represent the generator actual VSWR. ▸ For example, 1330 (1.330, decimal is implied)	(cont'd)	(cont'd)

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
220 report customer service statistics	Reads statistics on events in the unit. The command from the Host should contain a one-byte number indicating which statistic value is wanted. The controller returns 4 bytes (4-9 represent a 32-bit number count of the event): • 0 = AC On total time • 1 = RF On total time • 2 = Total kilowatt-hours delivered • 3 = Joules • 4 = The number of times the unit has been powered on • 5 = The number of times RF output has been enabled • 6 = The number of **DeviceNet** communication faults that has occurred • 7 = The number of times RF enable has been set without the interlock set • 8 = The number of line faults that have occurred • 9 = The number of overtemperature faults that have occurred • 10 = The number of host port heartbeat time-outs	1	4
221 report last ten faults	Returns fault codes for the last ten faults. The controller returns 10 bytes. Each byte contains a fault code. The low order byte is the most recent fault. The fault codes are: • 0 = No fault • 1 = Overtemperature fault • 2 = Line fault • 3 = RF enable without interlock fault • 4 = **DeviceNet** communications fault • 5 to 254 = Undefined	0	10

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
240 report last diagnostic test data	Reads data recorded during the last diagnostic test. The controller board returns 48 data bytes, three bytes for each of the 16 A/D channels: • Byte 1 = Forward power test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 2 and 3 = The forward power value at the time of the test • Byte 4 = Reflected power test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 5 and 6 = The reflected power value at the time of the test • Byte 7 = Inverter power test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 8 and 9 = The inverter power value at the time of the test • Byte 10 = Fast I test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 11 and 12 = The Fast I value at the time of the test • Byte 13 = PAED test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 14 and 15 = The PAED value at the time of the test	0	48

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
240 (continued) report last diagnostic test data	• Byte 16 = Bus sample test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 17 and 18 = The Bus sample value at the time of the test • Byte 19 = +10 V reference test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 20 and 21 = The +10 V reference value at the time of the test • Byte 22 = Ground test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 23 and 24 = The ground value at the time of the test • Byte 25 = I inverter test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 26 and 27 = The I inverter value at the time of the test • Byte 28 = V inverter test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 29 and 30 = The V inverter value at the time of the test • Byte 31 = Dissipation test ▸ 0 = The value is in range ▸ 1 = The value is out of nominal operating parameters • Bytes 32 and 33 = The dissipation value at the time of the test	0	48

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes

240 (continued) report last diagnostic test data	• Byte 34 = +15 V supply test
	  ◗ 0 = The value is in range
	  ◗ 1 = The value is out of nominal operating parameters
	• Bytes 35 and 36 = The +15 V supply value at the time of the test
	• Byte 37 = +10 V reference test
	  ◗ 0 = The value is in range
	  ◗ 1 = The value is out of nominal operating parameters
	• Bytes 38 and 39 = The +10 V reference value at the time of the test
	• Byte 40 = +30 V supply test
	  ◗ 0 = The value is in range
	  ◗ 1 = The value is out of nominal operating parameters
	• Bytes 41 and 42 = The +30 V supply value at the time of the test
	• Byte 43 =-15 V supply test
	  ◗ 0 = The value is in range
	  ◗ 1 = The value is out of nominal operating parameters
	• Bytes 44 and 45 = The -15 V supply value at the time of the test
	• Byte 46 = User set point analog test
	  ◗ 0 = The value is in range
	  ◗ 1 = The value is out of nominal operating parameters
	• Bytes 47 and 48 = The User set point analog value at the time of the test
		0	48

Table 4-7. *Host port commands (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
250 report serial number	Reports the unit serial number. The controller returns 4 bytes representing the serial number.	0	4
255 report logged data	Reads a data packet from the log buffer. Send two bytes, least significant byte first, representing the data packet number. • Accepts a value of 0 to 3999. The controller board returns four data bytes for the data packet requested. • Bytes 1 and 2 report forward power • Bytes 3 and 4 report reflected power Command **127** toggles data logging on and off.	2	4

DEVICENET™ PORT

The DeviceNet™ system enables basic control of the HFV generator through a 5-pin serial **DeviceNet** port. The HFV generator operates as a GROUP 2 slave device on an established DeviceNet network in accordance with the Open DeviceNet Vender Association (ODVA) DeviceNet specification (revision 2.0 or later). For questions specific to the DeviceNet system or for a copy of the DeviceNet specification, consult either a DeviceNet network administrator or visit the ODVA web site at: http://www.odva.org.

WARNING:
Powering up the unit when the unit interlock is satisfied and a Power On signal is present on the DeviceNet bus will cause the unit output power to turn on.

The **DeviceNet** connector is either a 5-pin, 12-millimeter "Micro" Lumberg RSF 5/0.5 or Turck FS 4.5 series connector. Figure 4-12 shows the **DeviceNet** connector, and Table 4-8 describes each pin.

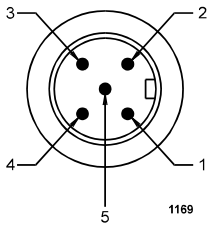


Figure 4-12. *DeviceNet™ connector*

Table 4-8. *DeviceNet™ pin descriptions*

Signal Pin	Name	Description
1	*DRAIN*	Shield
2	*V+*	DeviceNet supply
3	*V-*	DeviceNet supply
4	*CAN_H*	DeviceNet data transmit/ receive
5	*CAN_L*	DeviceNet data transmit/ receive

DeviceNet™ Control Panel

Figure 4-13 shows the DeviceNet control panel.

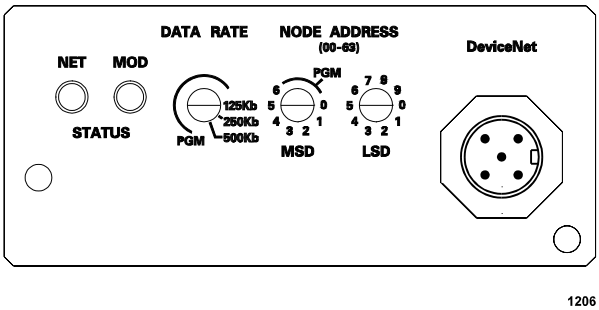


Figure 4-13. *DeviceNet™ control panel*

CONTROL PANEL LEDS

The DeviceNet control panel features two bicolor LEDs (light-emitting diodes). One LED is labeled **MOD** and indicates module status. The other LED is labeled **NET** and indicates network status.

Module Status (MOD) LED

The **MOD** bicolor (amber/green) LED provides device status, for instance, whether the device has power and is operating properly. Table 4-9 describes the LED states and associated unit status.

Table 4-9. *Module status (**MOD**) LED*

LED	Indication	Unit Status
Off	No power	Unit is not receiving power.
Green (steady)	Operational	Unit is operating normally.
Green (flashing)	Standby	Unit requires maintenance because the configuration is missing, incomplete, or incorrect.
Amber (steady)	Unrecoverable fault	Unit has experienced a fault from which it cannot recover; you may need to cycle power.
Amber/Green (flashing)	Device self-testing	Unit is running self diagnostics.

Note: For further information on indicator flash rates, refer to the current DeviceNet specification (available from the ODVA web site at: http://www.odva.org).

For further information about module status indications during power-up, refer to the current DeviceNet specification (see the ODVA web site at: http://www.odva.org).

Network Status (NET) LED

The **NET** bicolor (amber/green) LED is the network status LED and indicates the status of the communication link. Table 4-10 describes the LED states and associated unit status.

Table 4-10. *Network status (**NET**) LED*

LED Status	Indication	Unit Status
Off	No power	Unit is not on-line because: • Unit has not completed the Dup_MAC_ID test • Unit is not receiving power (check the **MOD** LED)
Green (steady)	Link okay	Unit is on-line and allocated to the master.
Green (flashing)	On-line, not connected	Unit is on-line but has no connections in its existing state because: • Unit has not established connections to other nodes • Unit is not allocated to the master
Amber (flashing)	Connection time-out, critical link failure	One or more I/O connections are in the timed-out state.
Amber (steady)	Critical link failure	Communication has failed (that is, the unit has detected an error that has made it incapable of communicating on the network). If you have a unit configured with two DeviceNet cards, the cause of this failure may be: • The two DeviceNet cards are not set to the same data rate as the network • The two DeviceNet cards have the same node address

Note: For further information on indicator flash rates, refer to the current DeviceNet specification (available from the ODVA web site at: http://www.odva.org).

CONTROL PANEL ROTARY SWITCHES

The DeviceNet control panel features three rotary switches to set the network address and communication data rate. Each time the DeviceNet interface is energized the switch settings are read by the DeviceNet master. Figure 4-13 provides an illustration of these switches.

Data Rate Rotary Switch

Use the **DATA RATE** switch to select a communication baud rate:

- 0 = 125 kbits per second
- 1 = 250 kbits per second
- 2 = 500 kbits per second

The default is 500 kbits/s. A switch setting in the **PGM** region allows the DeviceNet master to set the baud rate for the unit.

Note: If your power supply is configured with two DeviceNet cards, it is important that you set the **DATA RATE** for *both* cards to the same setting as the DeviceNet network setting. Any card not set to the network setting will fault when the network is brought up.

Node Address Rotary Switches

Use the **NODE ADDRESS** rotary switches, **MSD** (most significant digit) and **LSD** (least significant digit), to select the DeviceNet network address (MAC ID). MAC IDs 0 through 63 are valid. Use the **MSD** switch to select the MAC ID's most significant digit; use the **LSD** switch to select the MAC ID's least significant digit. Switch settings greater than 63 (or in the **PGM** region of the **MSD** switch) allow you to set the MAC ID through the DeviceNet master.

If your power supply is configured with two DeviceNet cards, it is important that you set the combined NODE ADDRESS of the first card to a different setting than the combined NODE ADDRESS of the second card. If you fail to do this, one side will fault when the network is brought up.

DeviceNet™ Interface Information and Supported Features

The Advanced Energy HFV generator operates as a GROUP 2 slave device on a DeviceNet network. The unit supports explicit messages and polled I/O messages of the predefined master/slave connection set. The Advanced Energy DeviceNet interface does *not* support the explicit unconnected message manager (UCMM).

The DeviceNet interface responds to poll requests in less than one millisecond (<1 ms poll response time). Explicit requests are serviced in under two millisecond (<2 ms explicit response time).

The following sections list the DeviceNet features supported by the Advanced Energy interface and provide information necessary to add an Advanced Energy power supply to a DeviceNet network. Additional information specific to DeviceNet networks may be found in the latest revision of the ODVA DeviceNet specification available online at: http://www.odva.org.

DEVICENET™ MESSAGE TYPES

As a GROUP 2 slave device, the Advanced Energy DeviceNet interface supports the message types listed in Table 4-11.

Note: In Table 4-11, xxxxxx = Node address

Table 4-11. *DeviceNet™ supported message types*

CAN Identifier	GROUP 2 Message Type
10xxxxxx111	Duplicate MACID Check Message
10xxxxxx110	Unconnected Explicit Request Message
10xxxxxx101	Master I/O Poll Command Message
10xxxxxx100	Master Explicit Request Message

DEVICENET™ CLASS SERVICES

As a GROUP 2 slave device, the Advanced Energy DeviceNet interface supports the class services and instance services listed in Table 4-12.

Table 4-12. *DeviceNet™ supported class services*

CAN Identifier	GROUP 2 Message Type
05 (0x05)	Reset
14 (0x0E)	Get Attribute Single
16 (0x10)	Set Attribute Single
75 (0x4B)	Allocate GROUP 2 Identifier Set
76 (0x4C)	Release GROUP 2 Identifier Set

DEVICENET™ OBJECT CLASSES

The Advanced Energy DeviceNet interface supports the DeviceNet object classes listed in Table 4-13. These object classes are discussed in detail in the sections that follow.

Table 4-13. *DeviceNet™ supported object classes*

CAN Identifier	GROUP 2 Message Type
01 (0x05)	Identity (see page 4-43 for more information)
02 (0x0E)	Router (see page 4-45 for more information)
03 (0x10)	DeviceNet (see page 4-46 for more information)
04 (0x4B)	Assembly (see page 4-47 for more information)
05 (0x05)	Connection (see page 4-49 for more information)
76 (0x4C)	Application (see page 4-51 for more information)

DEVICENET™ DATA TYPES

The Advanced Energy DeviceNet interface supports the DeviceNet data types listed in Table 4-14.

Table 4-14. *DeviceNet data types*

Key Word	Description
BOOL	Boolean (0 = False; 1 = True)
INT	Integer (-32768 to 32767)
UINT	Unsigned integer (0 to 65536)
BYTE	Bit string (8 bits)
USINT	Unsigned short integer (0 to 255)
SHORT STRING	Character string (1 byte per character, 1 byte length indicator)
ULINT	Unsigned long integer (0 to 2^{64} - 1)

IDENTITY OBJECT—CLASS CODE: 01 (0X01)

The identity object is required on all devices and provides identification and general information about the device.

- Table 4-15 lists the class attributes.
- Table 4-16 lists the instance attributes.
- Table 4-17 lists the common services.

Table 4-15. *Identity object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	7

Table 4-16. *Identity object instance attributes*

Attribute	Access	Name	Type	Value
1	Get	Vendor	UINT	198
2	Get	Product Type	UINT	7
3	Get	Product Code	UINT	1
4	Get	Revision	STRUCT OF	
		Major Revision	USINT	1
		Minor Revision	USINT	1
5	Get	Device Status	UINT	Note 1 below
6	Get	Serial Number	UINT	Note 2 below
7	Get	Product Name	STRUCT OF	
		Length	USINT	6
		Name	STRING []	

Note 1: The device status bit flags (attribute 5 of the identity object instance) are defined as follows:

- Bit 0 = Owned status
  - 0 = Not owned
  - 1 = Owned (allocated)
- Bit 1 = Reserved (set to 0)
- Bit 2 = Configured (set to 0)
- Bit 3 = Reserved (set to 0)
- Bit 4 through 7 = Vendor specific (set to 0)
- Bit 8 = Minor configuration fault status
  - 0 = No fault

- 1 = Minor fault

- Bit 9 = Minor device fault status
  - 0 = No fault
  - 1 = Minor device fault
- Bit 10 = Major configuration fault status
  - 0 = No fault
  - 1 = Major fault
- Bit 11 = Major device fault status
  - 0 = No fault
  - 1 = Major device fault
- Bits 12 through 15 = Reserved (set to 0)

Note 2: This number is an unique serial number.

Table 4-17. *Identity object common services*

Service Code	Class	Instance	Service Name
05 (0x05)	No	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single

ROUTER OBJECT—CLASS CODE: 02 (0X02)

The message router object provides a messaging connection point through which a client may address a service to any object class or instance residing in the physical device.

- Table 4-18 lists the class attributes.
- Table 4-19 lists the instance 1 attributes.
- Table 4-20 lists the common services.

Table 4-18. *Router object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	2

Table 4-19. *Router object instance 1 attributes*

Attribute	Access	Name	Type	Value
2	Get	Number of Connections	UINT	2

Table 4-20. *Router object common services*

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single

DEVICENET™ OBJECT—CLASS CODE: 03 (0X03)

The DeviceNet object provides a messaging connection point through which a client may assign DeviceNet communication attributes to the Advanced Energy power supply.

- Table 4-21 lists the class attributes.
- Table 4-22 lists the instance 1 attributes.
- Table 4-23 lists the common services.

Table 4-21. *DeviceNet™ object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 4-22. *DeviceNet™ object instance 1 attributes*

Attribute	Access	Name	Type	Value
1	Get	MACID	USINT	Note 1 below
2	Get	Baud Rate	USINT	Note 2 below
3	Get/Set	Bus Off Interrupt	BOOL	Note 3 below
5	Get	Allocation Information	STRUCT of	Note 4 below
		Choice Byte	BYTE	
		Master Node Addr.	USINT	

Note 1: This parameter may be set only if the **MSD** node address switch is set to the **PGM** (programmable) range. The value returned will be the value indicated on the DeviceNet control panel rotary switch unless the switch is in the **PGM** range. In the **PGM** range the value is the last value set.

Note 2: This parameter may be set only if the **DATA RATE** switch is set in the **PGM** (programmable) range. The value returned will be the value indicated on the DeviceNet control panel rotary switch unless the switch is in the **PGM** range. In the **PGM** range the value is the last value set. The following are the supported baud rates:

- 125 kbits/s
- 250 kbits/s
- 500 kbits/s

Note 3: Bus off interrupt (BOI) determines the action if a bus off state is encountered. The following are the values supported:

- 0 = Hold chip in off state (default)
- 1 = Reset CAN chip (if possible)

Note 4: The allocation byte (attribute 5) is defined as:

- Bit 0 = Explicit (set to 1 to allocate)
- Bit 1 = Polled (set to 1 to allocate)
- Bit 2 = Strobed (not supported)
- Bits 3 through 7 = Reserved (set to 0)

Table 4-23. *DeviceNet™ object common services*

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single
75 (0x4B)	No	Yes	Allocate Master/Slave
76 (0x4C)	No	Yes	Release Master/Slave

ASSEMBLY OBJECT—CLASS CODE: 04 (0X04)

The assembly objects bind attributes of multiple objects to allow data to or from each object to be sent or received over a single connection.

- Table 4-24 lists the class attributes.
- Table 4-25 lists the instance 100 attributes.
- Table 4-26 lists the instance 101 attributes.
- Table 4-27 lists the common services.

Table 4-24. *Assembly object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	2
2	Get	Max Class ID	UINT	2

Table 4-25. *Assembly object instance 100 attributes*

Attribute	Access	Name	Type	Value
3	Get	Data	STRUCT of	
		Forward Power	UINT	Note 1 below
		Reflected Power	UINT	Note 2 below
		Not used	UINT	
		Not used	UINT	
		Status	USINT	Note 3 below

Table 4-26. *Assembly object instance 101 attributes*

Attribute	Access	Name	Type	Value
3	Get/Set	Data	STRUCT of	
		Power Output Setpt.	UINT	Note 4 below
		Not Used	UINT	
		Power On Off	USINT	Note 5 below

Note 1: Forward power sense expressed in 12 bit A/D units with upper 4 bits = 0.

Note 2: Reflected power sense expressed in 12 bit A/D units with the upper 4 bits = 0.

Note 3: Status byte bit flags are defined as:

- Bit 0 = POS (power on/off status)
  - 0 = Power off
  - 1 = Power On
- Bit 1 = SPS (set point status)
  - 0 = Not at setpoint
  - 1 = At setpoint
- Bit 2 = TS (temperature status)
  - 0 = Not at overtemperature
  - 1 = Overtemperature
- Bit 3 = Unused
- Bit 4 = INTS (interlock status)
  - 0 = Interlock not satisfied
  - 1 = Interlock satisfied
- Bits 5 through 7 = Unused

Note 4: Power output expressed in 12 bit A/D units with the upper 4 bits = 0.

Note 5: Bit 0 = Power on/off

- 0 = Power off
- 1 = Power on

Table 4-27. *Assembly object common services*

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

CONNECTION OBJECT—CLASS CODE: 05 (0X05)

The connection objects manage the characteristics of each communication connection. As a GROUP 2 slave device, the Advanced Energy DeviceNet interface supports one explicit message connection and one poll message condition.

- Table 4-28 lists the class attributes.
- Table 4-29 lists the instance 1 attributes (explicit message).
- Table 4-30 lists the instance 2 attributes (poll message).
- Table 4-31 lists the common services.

Table 4-28. *Connection object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 4-29. *Connection object instance 1 attributes (explicit message)*

Attribute	Access	Name	Type	Value
1	Get	State	USINT	Note 1 below
2	Get	Instance Type	USINT	0 = Explicit Message
3	Get	Transport Class Trigger	USINT	0x83
4	Get	Production Connection	UINT	Note 2 below
5	Get	Consumed Connection	UINT	Note 2 below
6	Get	Initial Communication Characteristic	USINT	0x21
7	Get	Production Size	UINT	54
8	Get	Consumed Size	UINT	54
9	Get/Set	Expected Packet Rate	UINT	2500 ms default

Table 4-29. *Connection object instance 1 attributes (explicit message)*

Attribute	Access	Name	Type	Value
12	Get	Time out Action	USINT	Note 3 below
13	Get	Production Path Length	USINT	0
14	Get	Production Path		(Null)
15	Get	Consumed Path Length	USINT	0
16	Get	Consumed Path		(Null)

Table 4-30. *Connection object instance 2 attributes (poll message)*

Attribute	Access	Name	Type	Value
1	Get	State	USINT	Note 1 below
2	Get	Instance Type	USINT	1 = I/O Message
3	Get	Transport Class Trigger	USINT	0x82
4	Get	Production Connection	UINT	Note 2 below
5	Get	Consumed Connection	UINT	Note 2 below
6	Get	Initial Communication Characteristic	USINT	0x1
7	Get	Production Size	UINT	9
8	Get	Consumed Size	UINT	5
9	Get/Set	Expected Packet Rate	UINT	2500 ms default
12	Get/Set	Time out Action	USINT	Note 3 below
13	Get	Production Path Length	USINT	6
14	Get	Production Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log. Seg., Instance	USINT	0x24
		Instance Number	USINT	0x01
		Log. Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03
15	Get	Consumed Path Length	USINT	0

Table 4-30. *Connection object instance 2 attributes (poll message)*

Attribute	Access	Name	Type	Value
16	Get	Consumed Path	STRUCT of	
		Log. Seg., Class	USINT	0x20
		Class Number	USINT	0x04
		Log. Seg., Instance	USINT	0x24
		Instance Number	USINT	0x02
		Log. Seg., Attribute	USINT	0x30
		Attribute Number	USINT	0x03

Note 1: The connection states is defined as:

- 0 = Non-existent
- 1 = Configuring
- 3 = Established
- 4 = Timed out

Note 2: The connection IDs are defined as:

- Connection 1 produced connection ID: 10xxxxxx011
- Connection 1 consumed connection ID: 10xxxxxx100
- Connection 2 produced connection ID: 01111xxxxxx
- Connection 2 produced connection ID: 10xxxxxx101
  Note: xxxxxx = Node address

Note 3: Watch dog time out activity is defined as:

- 0 = Time out (default for I/O)
- 1 = Auto delete (default for explicit message)
- 2 = Auto reset
- 3 = Deferred delete

Table 4-31. *Connection object common services*

Service Code	Class	Instance	Service Name
05 (0x05)	Yes	Yes	Reset
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

APPLICATION OBJECT—CLASS CODE: 64 (0X40)

****(THE FOLLOWING SECTION IS FOR RF SUPPLIES ONLY)****

The application object is a user defined object that allows control of Advanced Energy generator through a DeviceNet network.

- Table 4-32 lists the class attributes.
- Table 4-33 lists the instance 1 attributes.
- Table 4-34 lists the common services.

Table 4-32. *Application object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1
2	Get	Max Object Instance	UINT	1
6	Get	Max Class Identifier	UINT	7
7	Get	Max Instance Attribute	UINT	7

Table 4-33. *Application object instance 1 attributes*

Attribute	Access	Name	Type	Value
1	Get	Forward Power	UINT	Note 1 below
2	Get	Reflected Power	UINT	Note 2 below
3	Get	Not Used	UINT	Note 3 below
4	Get/Set	Not Used	UINT	Note 4 below
5	Get	Status	USINT	Note 5 below
6	Get	Maximum Power	UINT	Note 6 below
7	Get	Not Used	UINT	Note 7 below
8	Get	Internal Status	USINT	Note 8 below

Table 4-34. *Application object common services*

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Set_Attribute_Single

Note 1: Forward power expressed in 12 bit A/D units with upper 4 bits = 0.

Note 2: Reflected power expressed in 12 bit A/D units with upper 4 bits = 0.

Note 3: Not used—dummy value.

Note 4: Not used—dummy value.

Note 5: The status byte is defined as follows:

- Bit 0 = POS (power on/off status)

- 0 = Power off
- 1 = Power on

- Bit 1 = SPS (set point status)
  - 0 = Not at set point
  - 1 = At set point
- Bit 2 = TS (temperature status)
  - 0 = Overtemperature
  - 1 = Not at overtemperature
- Bit 3 = Not used
- Bit 4 = INTS (interlock status)
  - 0 = Interlock not satisfied
  - 1 = Interlock satisfied
- Bits 5 through 7 = Not used

Note 6: Maximum power expressed in 12 bit A/D units with upper 4 bits = 0.

Note 7: Not used—dummy value.

Note 8: Not used—dummy value.

DeviceNet™ Operation

When the HFV generator is energized (powers on), it defaults to user control mode; however, engaging the **DeviceNet** port from the DeviceNet master places the HFV generator under DeviceNet control until the next time the HFV generator input power is cycled (turned off and then on).

ADDING THE HFV GENERATOR TO A DEVICENET™ NETWORK

Before operating the HFV generator through the **DeviceNet** port:

- Satisfy all interlocks on the HFV generator **User** port (see "Satisfying DeviceNet™ Minimum Requirements" on page 4-1 for more information).
- Ensure the existing DeviceNet network conforms to the Open DeviceNet Vender Association (ODVA) DeviceNet specification (version 2.0 or later) available from the ODVA web site at: http://www.odva.org.
- Connect the **DeviceNet** port to the network (see "DeviceNet™ connector" on page 4-38 for connector pin information).
- Select the appropriate MAC ID and transmission baud rate (see "Control Panel Rotary Switches" on page 4-41 for more information).
- Read the section titled, "DeviceNet™ Interface Information and Supported Features" on page 4-41.

DEVICENET™ MESSAGING (POLL AND EXPLICIT COMMANDS)

The Advanced Energy DeviceNet interface supports both poll command messaging and explicit command messaging.

POLL COMMAND AND POLL RESPONSE MESSAGES

The HFV generator DeviceNet interface uses DeviceNet's GROUP 2 I/O Poll Command message (and the associated GROUP 1 I/O Poll Response message) to transfer low-level I/O data between the device (slave) and the DeviceNet master. For detailed information concerning the features of the poll command message supported by the Advanced Energy DeviceNet interface, see "Connection Object—Class Code: 05 (0x05)" on page 4-49.

Note: For additional information about this message type, refer to the ODVA DeviceNet specification (revision 2.0 or later).

Poll Command Message

The following table represents the structure of the poll command message.

Table 4-35. *Structure of the poll command message*

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Power Output Set Point (LSB) Note 1							
1	0	0	0	0	Power Output Set Point (MSB)			

Table 4-35. *Structure of the poll command message (Continued)*

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4								PO[Note2]

Note 1: The power output set point is a 16-bit value, but only 12-bits are used. The 16-bit value should be shifted right four bits, and the remaining four bits filled with 0 (zero). All poll commands and response messages are scaled so that 0FFFh = full-rated output.

Note 2: PO = Power on off:

- 0 = Power off (turns output off)
- 1 = Power on (turns output on)

Poll Response Message

The following table represents the structure of the poll response message.

Table 4-36. *Poll response message*

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Forward Power Sense (LSB)[Note 1]							
1	0	0	0	0	Forward Power Sense (MSB)			
2	Reflected Power Sense (LSB)[Note 2]							
3	0	0	0	0	Reflected Power Sense (MSB)			
4	Not Used (LSB)							
5	0	0	0	0	Not Used (MSB)			
6	Not Used (LSB)							
7	0	0	0	0	Not Used (MSB)			
8				INTS[Note 6]		TS[Note 5]	SPS[Note 4]	POS[Note 3]

Note 1: Forward power sense is a 16-bit value, but only 12-bits are used. The 16-bit value should be shifted right four bits, and the remaining four bits filled with 0 (zero). All poll commands and response messages are scaled so that 0FFFh = full-rated forward power.

Note 2: Reflected power sense is a 16-bit value, but only 12-bits are used. The 16-bit value should be shifted right four bits, and the remaining four bits filled with 0 (zero). All poll commands and response messages are scaled so that 0FFFh = full-rated reflected power.

Note 3: POS = Power on/off status

- 0 = Power off
- 1 = Power on

Note 4: SPS = Set point status

- 0 = Not at set point
- 1 = At set point

Note 5: TS = Temperature status

- 0 = Overtemperature
- 1 = Not at overtemperature

Note 6: INTS = Interlock status

- 0 = Interlock not satisfied
- 1 = Interlock satisfied

Scaling

Parts of the message structure are based on binary representations of analog voltages and have analog scaling associated with them.

DeviceNet uses unsigned binary to represent zero to the full-rated output power of the HFV generator (scaled 0 V to +10 V). Use Table 4-37 to define the voltage ranges and the corresponding digital values (assuming N is the number of bits of resolution available at the DeviceNet interface).

Table 4-37. *DeviceNet voltage ranges*

0 to +10 V Range	
AI/AO Digital Value (at the DeviceNet interface)	**Analog Input/Output to device**
0	0.000 V
$2^N - 1$	$10V \times \frac{2^N - 1}{2^N}$

The conversion is assumed to be linear across the range (a one-bit change always corresponds to the same change in output power within the hardware capabilities of the power supply.

Values exceeding 0FFFh are limited to 0FFFh. Thus, the maximum calculation of a 10 kW unit (at 12-bit resolution) is 0FFFh (or 4095 decimal).

EXPLICIT MESSAGING

The HFV generator DeviceNet interface supports explicit messaging formats useful for reporting system parameters—for instance, maximum power. For more information about this type of messaging, refer to "Connection Object—Class Code: 05 (0x05)" on page 4-49 in this manual. You may find additional information in the latest DeviceNet specification (version 2.0 or later).

Use the following application object class code 64 (0x40), instance 1 attributes to retrieve maximum power readings:

Attribute	Access	Name	Type	Value
6	Get	Max Power	UINT	Note 1

Note 1: The maximum power attribute returns a value in watts if the unit is operating as a stand alone device. For example, a value of 20,000 equates to 20,000 W. The maximum power attribute scaling is watts x 10 if the unit is operating in a master/slave system. For example, a value of 2,000 equates to 20,000 W.

For more information about this type of messaging, refer to the DeviceNet specification (version 2.0 or later).

The following common services apply:

Service Code	Class	Instance	Service Name
14 (0x0E)	Yes	Yes	Get_Attribute_Single
16 (0x10)	No	Yes	Get_Attribute_Single

Installation, Setup, and Operation

PREPARING TO INSTALL THE HFV GENERATOR

The following sections provide information that you need to understand before installing the HFV generator.

Spacing Requirements

See Figure 3-1 on page 3-4 for unit dimensions.

Installation Requirements

Install this unit according to the following requirements.

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

WARNING:
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.

Unpacking

Unpack the unit carefully. Inspect the unit, looking for obvious physical damage. If no damage is apparent, proceed with the next section. If you do see signs of shipping damage, contact Advanced Energy Industries, Inc., and the carrier immediately (see "AE Global Customer Support" on page 6-10). Save the shipping container for submitting necessary claims to the carrier.

DANGER:

Capacitor discharge time of the 300 V bus is two minutes. Do not remove top cover; there are no user-serviceable parts within.

INSTALLING THE HFV GENERATOR

The following sections explain how to install the unit.

Front Panel Drawing

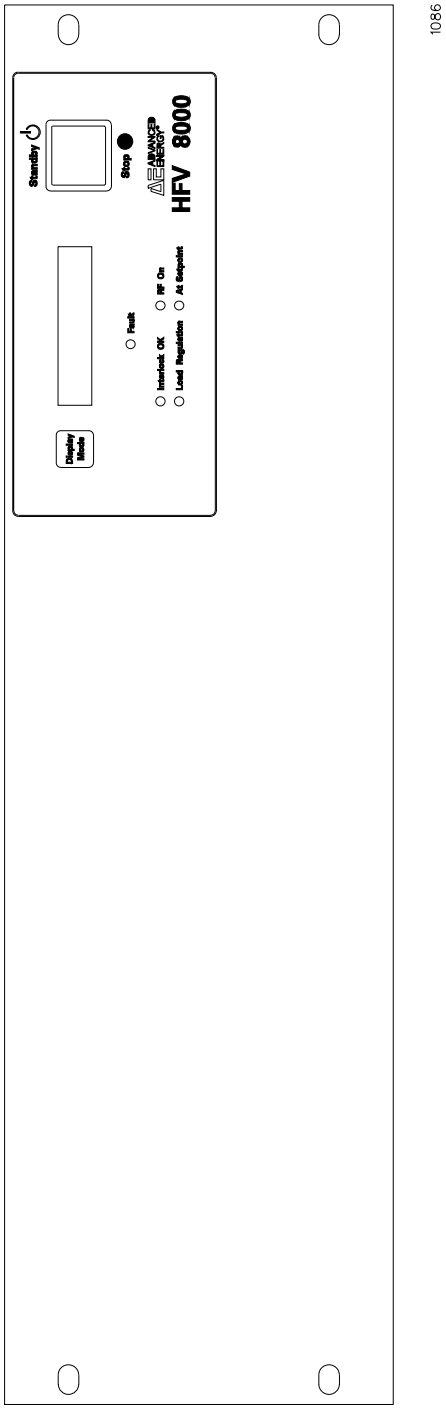


Figure 5-1. *Front view*

Rear Panel Drawing

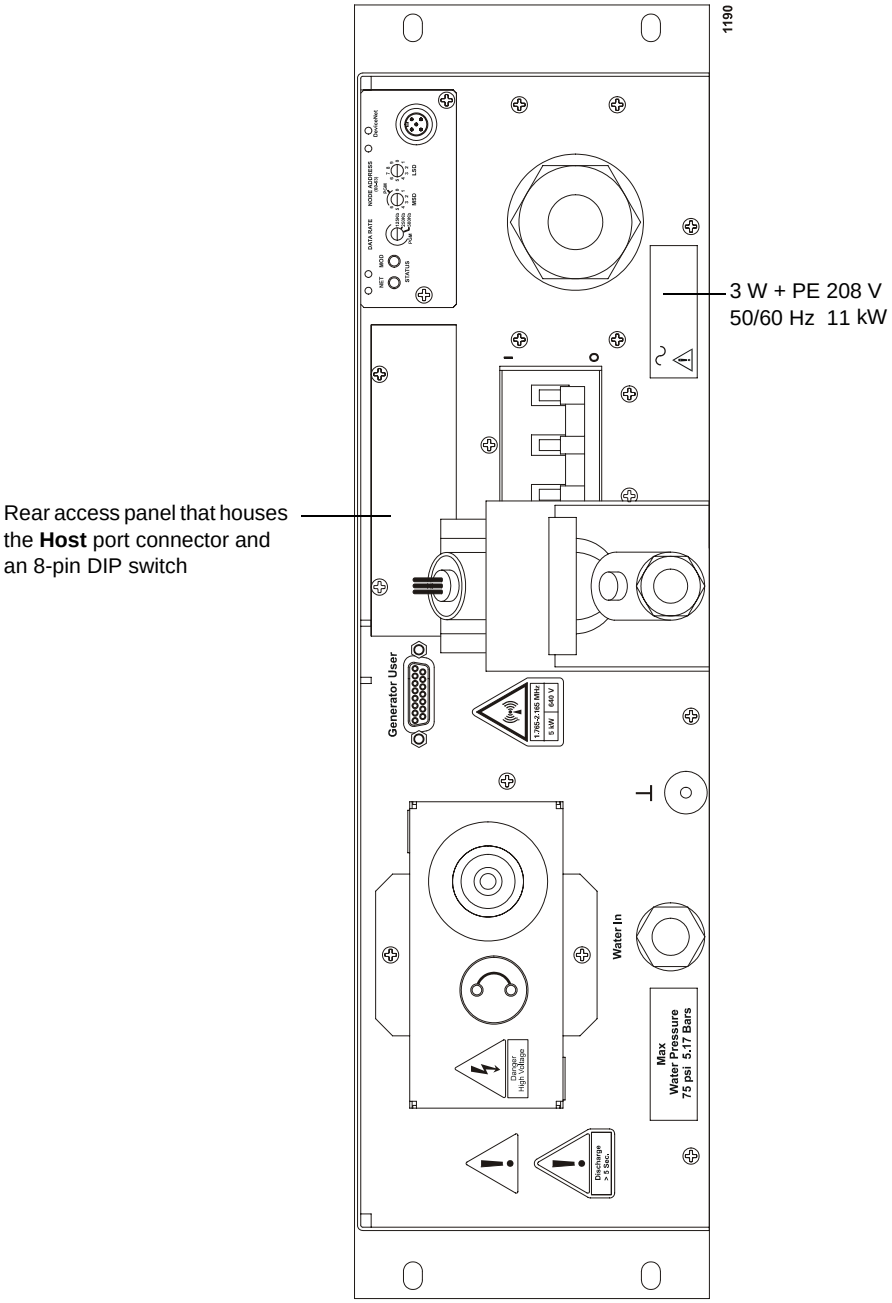


Figure 5-2. *Rear view (shown with optional water solenoid)*

Electromagnetic Field (EMF) Shielding Requirements

In order to meet current EMF compliance regulations, you must install the provided EMI suppression ferrite on the 15-pin, shielded **Generator User** port cable (see also "Generator User Port (15-Pin)" on page 4-1).

1. Install the ferrite on the cable.
2. Attached it to the HFV generator.

Grounding

WARNING:
Do not attempt to turn on power until the generator is grounded.

The HFV generator provides an RFI ground mounting hole for a 10-32 screw. A suitable chassis ground connection made to this mounting hole prevents or minimizes radio frequency interference.

Connecting Cooling Water

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

CAUTION:
Water connections must be made in accordance with applicable requirements.

CAUTION:
If you connect the cooling water on multiple generators in series, ensure the input water temperature to all generators is less than the maximum input water temperature.

CAUTION:
The overtemperature fault protects only in the event of a complete loss of coolant.

To connect the cooling water, complete the following steps:

1. Connect the input and output water connections and tighten securely.
2. If you do not have an optional water solenoid, install the water shield.
3. Turn on the water and ensure that there are no leaks.
4. Ensure the flow rate and temperature are within the minimum specifications required to operate the HFV generator (see "Functional Specifications" on page 3-1 and "Environmental Specifications" on page 3-8).

Note: Keep the water-cooling system running as long as the rear circuit breaker is on to help maximize the cooling of the auxilliary supply, which is also water-cooled.

WARNING:
If your generator does not include the water solenoid, be sure the water shield is installed.

Connecting I/O and Auxiliary Connectors

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

Connect and secure all interface connectors as well as any auxiliary connectors. See "Interconnect Schematics" on page 4-7 for interface circuitry electrical diagrams.

Connecting Output Power

DANGER:

Remove and lockout/tagout the input power before working on or around the output terminals. Failure to do so could result in death or bodily injury.

Complete the following steps to connect the output power connector:

1. Remove the two screws holding the output safety connector cover, and remove the cover.
2. Slide the connector cover on the power cable.
3. Install the output cable on the output connector of the HFV generator.
4. Replace the output safety connector cover on the generator and fasten with screws and star washers.

   Note: The screws and star washers must be securely installed to prevent excessive RF emissions and electrical shock.

Connecting Input Power

DANGER:

Before making any input line power connection, turn off and lockout/tagout building circuit breakers supplying input power to the HFV generator. Also, ensure that the circuit breakers on the rear panel are in the OFF position.

WARNING:
This generator must be used in a pollution degree 2 or better environment.

WARNING:
This device must be used in an overvoltage category II installation only.

CAUTION:
Make input power connections and wire terminations in accordance with local safety requirements.

Check for proper power requirements at the source and then connect input power, ensuring the following:

- The 8 AWG yellow/green wire must be connected to ground.

FIRST-TIME OPERATION

Before proceeding, be sure the setup of the HFV generator is complete (see "Installing the HFV generator" on page 5-2).

DANGER:
The HFV generator can operate without being connected to either a chamber or a dummy load. You are exposed to high voltage output from the generator if you do not hook the output to either a chamber or a dummy load.

Note: If using a dummy load (50 Ω), connect the HFV generator to the load with an RG-393 cable and an appropriate load. If you connect the generator to your chamber, be sure to satisfy all chamber conditions for operation.

Before Engaging the Rear Circuit Breaker

Become familiar with the Unpacking, Spacing Requirements, and Grounding sections in this chapter. Also, review the following sections:

- Cooling water: "Connecting Cooling Water" on page 5-5.
- Output power: "Connecting I/O and Auxiliary Connectors" on page 5-6.
- Input Power: "Connecting Input Power" on page 5-7.

Control Port (**Generator User** port or **DeviceNet** port):

- **Generator User** port: Table 4-1 on page 4-2.
- **DeviceNet** port: Table 4-8 on page 4-38.

  Note: If you use the **DeviceNet** interface, the interlocks still require external contact closure between pin *11* and pin *12* of the **Generator User** port. See Table 4-7 on page 4-20.

Before Enabling the Output

1. Be sure to complete the steps in "Before Engaging the Rear Circuit Breaker" on page 5-9.
2. Make sure the **Standby/Stop** switch on the front panel is in the **Stop** (down) position.
3. Engage the rear circuit breaker.

   Note: The front panel display should now activate.

4. Verify the desired regulation mode is selected by looking at the front panel **Load Regulation** indicator.
   ON = load power regulation mode is selected (this is the default).
   OFF = Forward power regulation is selected.
   FLASHING = The generator has been set to center frequency mode.

   To change the regulation mode, see:

   ▸ Command **12** in Table 4-7 on page 4-20

5. Select the proper frequency band. See "Setting the Frequency Band" on page 5-11 for more information.

Enabling the Output

1. Be sure to have completed the steps listed in "Before Engaging the Rear Circuit Breaker" on page 5-9 and "Before Enabling the Output" on page 5-9.

2. Turn the **Standby/Stop** switch on the front panel to the **Standby** (up) position. The generator should now be under control of the **Generator User** port or the **DeviceNet** interface.

   Note: If any problems arise during the preceding process, refer to the "Troubleshooting Guide" on page 6-1.

3. Make sure there are no faults present by verifying that the front panel **Fault** indicator is off.

   Note: If this indicator is lit, see "Fault Indicator On" on page 6-3.

⚠ CAUTION:
The overtemperature fault protects only in the event of a complete loss of coolant.

4. Make sure the interlock circuit is satisfied by verifying the front panel **Interlock OK** indicator is lit.

   Note: If this indicator is off, see "Interlock OK Indicator Off" on page 6-5.

5. In order for the HFV generator to deliver power, it must receive an RF On command, *and* the set point (or requested output power level) must be above a specified minimum (see pin *4* and pin *5* in Table 4-1 on page 4-2). When these two conditions are met, the **RF On** indicator is on, and the generator will deliver power.

⚠ CAUTION:
Do not exceed the specified full rated output power.

Note: How to send the RF On command depends on how the unit is being controlled:

- For **Generator User** port control, verify:

  There is an external contact closure between pins *4* and *9* to enable the RF output power. See Table 4-1 on page 4-2 and Figure 4-4 on page 4-8.

- For **DeviceNet** control, verify:

  An RF on command is given by having Bit 0 of Byte 4 of the poll command message set to 1. See Table 4-36 on page 4-55.

Meeting Minimum Power Threshold

The output power set point minimum is a threshold that allows the generator to deliver power. The set point circuitry uses hysteresis so that the generator has two thresholds. If an RF On command is given, the power requested through the set point level must be above the minimum power On threshold for the HFV generator to deliver power. The HFV generator will continue to deliver power until the power requested through the set point level falls below the minimum power Off off threshold, or until the RF On command is disabled.

That is, the generator delivers power when the RF On command is enabled AND the power set point is above 176 W. The generator ceases to deliver power when the RF On command is disabled OR the Power Set Point is below 144 W.

Setting the Frequency Band

Table 5-1 lists the frequency values for the four possible frequency band options: top, side, full, and custom.

Table 5-1. *Frequency values in center frequency mode*

Frequency Band	Description	Frequency in Center Frequency Mode
Top	The frequency band that is used to operate the top coil of the process chamber (1.765 - 1.915 MHz)	1.840 MHz
Side	The frequency band that is used to operate the side coil of the process chamber (2.015 - 2.165 MHz)	2.090 MHz
Full	The entire frequency band of the HFV generator (1.765 - 2.165)	1.965 MHz
Custom	The frequency band defined by **Host** port command **3** (**minimum frequency**) and command **4** (**maximum frequency**). See “Host port commands” on page 4-20.	Automatically calculated as the midpoint between the maximum and minimum frequencies. For example, if the minimum frequency is set to 1.900 MHz and the maximum frequency is set to 2.100 MHz, the center frequency will automatically be set to 2.000 MHz.

To set the frequency band:

1. Press the **Display Mode** button repeatedly until the top line of the screen displays:

   Press and hold [Top line]

Top, Side, Full, or Custom [Bottom line]

2. If the bottom line of the display screen does not show the desired frequency band (that is, Top, Side, Full or Custom), then hold down the **Display Mode** button for approximately 5 seconds. The bottom line will change to the next frequency setting. Repeat this step until you cycle to the desired frequency setting. By simply displaying the desired frequency in the bottom line, you have set the frequency for that band.
3. After setting the frequency band, return to MODE 1 to monitor the operation of the HFV generator. Press the **Display Mode** button repeatedly until the top line of the screen displays the current forward and reflected power and the bottom line displays the set point power and output frequency. Your display screen should look something like:

FWD_ _ _ _RFL_ _ _ _
STP_ _ _ _ _ _ _ _KHZ

NORMAL OPERATION

You can operate the HFV generator either as a center frequency generator or as a variable frequency generator where the operating frequency is automatically tuned, or continually adjusted, by direct digital synthesis (DDS) to minimize reflected power and enable higher output powers.

Automatic tuning mode continuously minimizes the mismatch to the generator. This mode is only available while in forward power regulation mode. In load power regulation, an initial frequency sweep is performed to determine the frequency that yields the minimum reflected power.

Center Frequency Mode

Center frequency mode sets the output frequency to the center of the frequency band that is selected. This mode is used only to optimize settings on some systems during initial setup.

Note: Center frequency mode disables **Host** port commands **3**, **4**, and **5** (see Table 4-7 on page 4-20).

Note: If you cycle AC input power, the generator will default to automatic tuning mode.

SELECTING CENTER FREQUENCY MODE

To select center frequency mode:

1. Verify that the generator is set to the desired frequency band for your application (see "Setting the Frequency Band" on page 5-11).
2. Press the **Display Mode** button on the front panel repeatedly until the display reads:

   Top line—Press and Hold

   Bottom line—Center/Auto Tune
3. Press and hold the **Display Mode** button for at least five seconds until the Load Regulation indicator flashes.

   Note: The load regulation indicator will begin to flash, indicating center frequency mode. (See also "Display Mode and the LCD Display Indicator" on page 5-16.)

To verify the operating frequency while in center frequency mode, select **MODE 1** on the front panel LCD display (see also "Display Mode and the LCD Display Indicator" on page 5-16).

Note: Cycling AC power (circuit breaker) to the generator will cause the generator to automatically return to automatic tuning mode. You will need to repeat the steps in "Selecting Center Frequency Mode" on page 5-12 to return to center frequency mode after cycling the power.

Automatic Tuning Mode

Automatic tuning, mode continually adjusts the frequency to minimize the mismatch to the generator. This mode is particularly useful when you expect large variations in operating impedance.

SELECTING AUTOMATIC TUNING MODE

To select automatic tuning mode:

1. Press the **Display Mode** button on the front panel repeatedly until the display reads:

   Top line—Press and Hold

   Bottom line—Center/Auto Tune
2. Press and hold the **Display Mode** button for at least five seconds until the Load Regulation indicator does not flash.

   Note: When the Load Regulation indicator is not flashing, the generator is in automatic tuning mode. (See also "Display Mode and the LCD Display Indicator" on page 5-16.)

To set the generator to a single frequency while in automatic tuning mode, set **Host** port commands **3**, **4**, and **5** to the same desired frequency (see Table 4-7 on page 4-20).

ADJUSTING TUNING PARAMETERS

To control automatic tuning, the HFV generator uses a tuning algorithm, which you can adjust by setting several parameters (see "Host port commands" on page 4-20). In *automatic tuning mode*, the HFV unit begins by scanning through frequencies (using the user-set *frequency limits*) until a user-set *scan threshold* is passed. When the threshold is passed, the generator begins to tune automatically. Automatic tuning mode has, therefore, two distinct periods, the *scanning phase* and the *tuning phase*.

Note: If the scan threshold is set too high, the generator will begin to tune too early and the tuning will not be optimal. If the scan threshold is set too low, the threshold may never be reached and automatic tuning will not take over.

By characterizing a chamber, you can identify the scan threshold appropriate to a specific process and chamber. Advanced Energy offers HFV Virtual Front Panel (VFP) software that can help you characterize a chamber and identify appropriate tuning settings for it, then set those parameters (refer to the HFV VFP software manual for instructions). To order VFP software, contact your AE sales representative (for contact information, see Table 6-1 on page 6-10).

To optimize the HFV generator's automatic tuning mode, you may adjust the following tuning parameters using the "Host port commands" on page 4-20 or the optional VFP software.

To reset to factory defaults, see Table 4-7 on page 4-20, command **7**, *reset tuning parameters*.

Frequency Limits

The *frequency limits* parameter sets the range of frequencies over which the HFV unit will operate. You can set a start frequency, an upper frequency limit, and a lower frequency limit. (See Table 4-7, commands **3**, **4**, and **5**, *minimum frequency*, *maximum frequency*, and *starting frequency*.)

In center frequency mode, all three frequencies are set to the center frequency. In automatic tuning mode, the HFV unit starts searching for a tune at the start frequency and sweeps up until a satisfactory tuning is found or until the upper frequency limit is reached. If a tune is not found, this pattern is repeated. (See also "Center Frequency Mode" on page 5-12 and "Automatic Tuning Mode" on page 5-13.)

Frequency rate of change (ms)

This value defines how quickly the generator moves through the steps during both the scanning and the tuning phases, in milliseconds. For example, if you set this value to 5, the generator will make tuning adjustments no more than every 5 ms. (See Table 4-7, command **11**, *frequency rate of change*.)

Tuning goal

When the tuning parameter measurement is below the tuning goal value, the generator does not adjust the output frequency.

Note: This option of generator does not have the continuous tuning in load power regulation enabled. For power regulation mode, the generator will tune until a minimum tuning parameter is found. It then operates at that output frequency until the RF enable command is turned off, then back on (through the **Generator User** port on the HFV unit).

(See Table 4-7, command **14**, *tuning goal*.)

Tuning gain

This parameter affects the size of the tuning steps; the larger the number, the greater the size of the tuning steps.

Note: When setting the tuning gain, be aware that if the gain is set too low, the tuning function may react to noise in the signal and fail to correct the real direction of change.

(See Table 4-7, command **15**, *tuning gain*.)

Tuning delta limit (Hz)

The *tuning delta limit* sets the maximum amount of frequency change for each step during tuning.

Note: When setting the tuning delta limit, be aware that if the limit is set too low, the tuning function may react to noise in the signal and fail to correct the real direction of change. The lowest recommended tuning delta limit value is 5000.

(See Table 4-7, command **16**, *tuning delta limits*.)

Scan delta frequency (Hz)

This parameter sets the maximum amount of frequency change for each step during scanning. The typical value is 10,000. (See Table 4-7, command **19**, *scan delta frequency*.)

Scan threshold

The scan threshold sets a threshold below which the tuning phase begins.

If the *scan threshold* is set too high, the generator will begin to tune too early and the tuning will not be optimal. If the scan threshold is set too low, the threshold may never be reached and automatic tuning will not take over. (See Table 4-7, command **20**, *scan threshold*.)

Display Mode and the LCD Display Indicator

The **Display Mode** front panel push button allows you to cycle through modes 1, 2, 3, 4, and 5.

To select a mode:

1. Scroll through the menu to the desired mode.
2. Press and hold the **Display Mode** button for five seconds. The mode will change, and the indicator will display the state.

Note: **FAULT** automatically displays when a fault condition occurs. If the display mode switch is not pressed for five minutes, the display returns to MODE 1 unless a fault has occurred. In that case, **FAULT** displays until you press the **Display Mode** button.

The modes represent the following:

- **MODE 1 (default)**

  Top line—displays current forward and reflected power

  Bottom line—displays set point power and output frequency

- **MODE 2**

  Top line—displays Total Hours AC On, Total hours RF On

  Bottom line—displays Total kWh delivered

- **MODE 3**

  Top line—displays: Press and Hold

  Bottom line—displays: Center/Auto Tune

  Note: A flashing LOAD REG indicator means the generator is in center frequency mode; if the LOAD REG is not flashing, the generator is automatic tune mode.

- **MODE 4**

  Top line—displays: Press and Hold

  Bottom line—displays output frequency selection; top, side, full, or custom band

- **MODE 5**

  Top line—displays: Press and Hold

  Bottom line—displays: Mode for Diag

MONITORING THE GENERATOR

Table 5-2 describes the indicators on the HFV generator.

Note: For information on DeviceNet indicators, see "DeviceNet™ Control Panel" on page 4-38.

Table 5-2. *Indicators*

Indicator	Explanation
Interlock OK	This green indicator illuminates if interlock criteria are met (see "Interlock OK Indicator Off" on page 6-5 for troubleshooting interlock problems).
Load Regulation	This green indicator illuminates whenever load (delivered) power regulation mode is selected. An unlit indicator means that forward power regulation mode is selected. A flashing indicator indicates that the generator has been set to center frequency mode (see MODE 3 in "Display Mode and the LCD Display Indicator" on page 5-16).
RF On	This green indicator illuminates whenever RF output power is enabled. Depending on the set point level, RF power may or may not be present at the output connector. This indicator will not illuminate if: • RF power is shut off • Interlock is open • A fault condition is present

Table 5-2. *Indicators (Continued)*

Indicator	Explanation
At Set Point	This green indicator illuminates whenever output power matches the requested power (within specified accuracy spec). If RF power is on, an unlit indicator indicates that an internal power limit has been reached.
Fault	This yellow indicator illuminates whenever: • An overtemperature condition exists • The input line voltage is out of range • Loss of DeviceNet communications occurs • An RF On sequence error occurs *Note:* RF power will not turn on if the RF enable signal is enabled before setting the interlock. The sequence is to enable the interlock first, then set RF enable. When a fault conditions occurs, the LCD displays the following: Top line—displays: *****FAULT***** Bottom line—[displays a type of fault] If this indicator is on, see "Fault Indicator On" on page 6-3.

RUNNING INTERNAL DIAGNOSTICS

The Internal Diagnostics test is a 5-second open load test. During the test, the HFV generator takes a number of internal measurements to determine if the power conversion and output sections are operating properly and to ensure that the housekeeping (or logic) voltages are within tolerance. The internal diagnostics test does not check the integrity of the rear panel control ports or related logic functions.

WARNING:
Use suitable precautions; this area contains high voltages that could cause serious injury or death.

You can run the test only after configuring the generator in a special setup.

Note: Regular generator control is disabled when diagnostics are in progress. An integrity report is visually indicated by the front panel LCD.

To run the diagnostics:

1. Remove the power to the generator by disengaging the circuit breaker.
2. Remove the RF output cable and cover (see Figure 5-2 on page 5-4).
3. Replace the RF output cover in the required 180° orientation. Two microswitches on the rear panel will sense the proper position. This provides safety from high voltages while the test is being performed.
4. Engage the circuit breaker.
5. Ensure the RF Enable signal is disabled.

   Note: You must not have RF enable set. If the RF Enable is set prior to running diagnostics, you will receive a *CANNOT RUN DIAGNOSTICS* notification on the front panel display.

6. Make sure the interlock is satisfied (that is, the front panel INTLK OK indicator must be lit). If the indicator is off, see "Interlock OK Indicator Off" on page 6-5.
7. To initiate the test, use the front panel **Display Mode** button to cycle through the display modes until the display reads:

   Top line—Press and Hold

   Bottom line—Mode for Diag

8. Press and hold the **Display Mode** button for a minimum of five seconds.
9. You will receive one of two messages:

   a. *CANNOT RUN DIAGNOSTICS*

   This means the test is not set up correctly. Recheck the setup detailed above.

   b. DIAGNOSTICS IN PROGRESS

10. If, after the test, the LCD displays:

    a. PASS, the diagnostics routine did not find any internal problems.

    b. FAIL, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

Troubleshooting and Global Customer Support

This chapter contains basic troubleshooting information, as well as procedures for returning a unit for repair.

BEFORE CALLING AE GLOBAL CUSTOMER SUPPORT

The following troubleshooting guide allows you to verify the integrity of your HFV generator.

WARNING:
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.

Troubleshooting Guide

The following questions may help solve troubleshooting problems.

Note: If you have a question regarding **DeviceNet** or the **Host** port, contact AE Technical Support (see "AE Global Customer Support" on page 6-10).

1. Is the front panel display (LCD) lit?
   a. If *yes*, go to step 2.
   b. If *no*, see "Front Panel Display (LCD) Not Lit" on page 6-2.
2. Is "Advanced Energy Industries" displayed on the front panel LCD?
   a. If *yes*, see "Advanced Energy Displayed on LCD" on page 6-2.
   b. In *no*, go to step 3.
3. Is the **Fault** indicator off?
   a. If *yes*, go to step 4.
   b. If *no*, see "Fault Indicator On" on page 6-3.

4. Is the **Interlock OK** indicator on?
   a. If *yes*, go to step 5.
   b. If *no*, see "Interlock OK Indicator Off" on page 6-5.
5. Is the **Load Regulation** indicator on solid or flashing?
   a. If *solid*, go to step 6.
   b. If *flashing*, see "Load Regulation Indicator Flashing" on page 6-5.
6. Is the **RF On** indicator lit?
   a. If *yes*, go to step 7.
   b. If *no*, see "RF On Indicator Off" on page 6-6.
7. Is the **At Set Point** indicator on?
   a. If *yes*, it indicates that the HFV generator is operating properly and delivering the requested power level.
   b. If *no*, see "At Set Point Indicator Off" on page 6-7.

If these questions do not help solve your problem, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

ERROR INDICATIONS

Front Panel Display (LCD) Not Lit

The front panel display should operate as soon as the rear circuit breaker is turned on. Verify that the:

1. Rear circuit breaker is on.
2. Input line voltage is between 178 to 229 VAC between all three phases.

Advanced Energy Displayed on LCD

It is normal for ADVANCED ENERGY to display for a few seconds immediately after the rear circuit breaker has been enabled (this is not an internal fault mode indicator). However, if the message continually displays, try cycling the unit's circuit breaker. If the problem persists, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

Fault Indicator On

This indicator latches on whenever the unit detects an overtemperature, RF On sequence error, or input line out of voltage range condition. If this fault occurs, the unit automatically shuts off the front panel LCD and displays the detected fault:

Top line—*****FAULT*****

Bottom line—[Type of fault]

OVERTEMPERATURE FAULT

An overtemperature fault will display in the event of a complete loss of coolant. Verify the **Water In** and **Water Out** connections are connected with the water flowing in the correct direction. Make sure the inlet water temperature is +15ºC to +30ºC (+59ºF to +86ºF) and that the flow rate is greater than 11.4 lpm (3 gpm). Also, make sure you meet the specifications described in "Environmental Specifications" on page 3-8 and in Table 3-5 on page 3-8. After the generator cools, restore operation by cycling the RF output enable command.

If these procedures do not help solve your problem, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

RF ENABLE WITHOUT INTERLOCK FAULT

RF power will not turn on if the RF enable signal is enabled before setting the interlock. For proper operation you must set the interlock first, then the RF enable.

If this procedure does not help solve your problem, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

INPUT LINE FAULT

An input line fault occurs when the input voltage is out of range. Measure the line voltage with a true RMS voltmeter and make sure it is between 178 to 229 VAC between all three phases.

If the line voltage is within tolerance, cycle the RF output enable command to clear the fault and try operating the supply again.

If the fault reoccurs, there is either an internal failure or an external voltage spike.

- Internal failure

  In this case, run the Internal Diagnostics program. See "Running Internal Diagnostics" on page 5-18.

- External voltage spike

  In this case, try monitoring the line voltage for spikes.

If these procedures do not help solve your problem, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

BAD CAL EEPROM FAULT

A fault of this type occurs when the calibration data stored on the measurement card's EEPROM has been lost or corrupted. A snapshot of the calibration data is taken in the form of a checksum and is stored on the EEPROM during initial testing. A new checksum is calculated every time the generator is turned on. If these two checksum values differ, a fault will occur. If this failure occurs please contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

DEVICENET FAULTS

Two failure modes can occur relating to the **DeviceNet** card:

Loss of communication

A loss of communication can occur between the **DeviceNet** card and the network. The **DeviceNet** card handles communication failures, and such failures will not display on the HFV front panel. Please see the DeviceNet section for further troubleshooting details.

To return the unit to **Generator User** port control:

- Disconnect the **DeviceNet** cable.
- Cycle the power on the HFV generator. With the cable disconnected, the HFV generator will default to **Generator User** port control.

Loss of power

Loss of power to the **DeviceNet** card (which the network supplies) will result in a fault condition that displays on the HFV front panel. This is a self-recovering fault; if the power is restored to the **DeviceNet** card and the network is still active, the fault will clear within 10 seconds and communications will resume.

If the fault persists:

- Check the **DeviceNet** cable connections at both ends. Restore any loose connections and wait for the fault condition to clear.
- Disconnect the DeviceNet cable at the HFV. Verify that the voltage between pins 2 and 3 on the cable side is between 11 and 25 volts.
- If the cables are in place, the voltage is present, and there is still a fault condition, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

To clear the fault and return to **Generator User** port control:

- Disconnect the **DeviceNet** cable.

- Cycle the power on the HFV generator. With the cable disconnected, the HFV generator will default to **Generator User** port control.

Interlock OK Indicator Off

The front panel **Interlock OK** indicator illuminates when the interlock is satisfied. If this indicator is not lit, the output will be disabled. Three settings on the HFV generator will satisfy the interlock circuit.

1. The front panel **Standby/Stop** rocker switch must be in the **Standby** (up) position.

   Standby is the closed position for this switch.

2. The RF output cover must be firmly attached.

   A microswitch on the rear panel senses the presence of the output cover.

3. There must be an external closure between pins *11* and *12* on the rear panel **Generator User** port. This closure must have a series resistance of 15 Ω or less and should have no other external loading. (See Figure 4-7 on page 4-9 for an electrical diagram.)

WHAT IS THE INTERLOCK?

The HFV generator uses an interlock circuit to shut off the output in emergency situations. The interlock circuit is basically several switches wired in series. The interlock loop of the HFV generator must be closed (or satisfied) before the output power can be enabled.

Note: When this loop is interrupted, the unit disables the output by opening the main contactor inside the supply. Once the interlock is reestablished, the main contactor will close, but the output will not come on until the RF power is cycled. (See Figure 4-7 on page 4-9 for an electrical diagram.)

Load Regulation Indicator Flashing

During normal operation, the Load Regulation indicator will either be on (load power regulation) or off (forward power regulation).

When this indicator is flashing, the unit is in center frequency mode. **Center Frequency** mode is used only to optimize settings on some systems during initial setup.

To select Center Frequency mode:

1. Press the **Display Mode** button on the front panel repeatedly until the display reads:

   Top line—Press and Hold

Bottom line—Center/Auto Tune

2. Press and hold the **Display Mode** button for at least five seconds until the **Load Regulation** indicator flashes.

To return to the automatic tuning mode:

1. Press the **Display Mode** button on the front panel repeatedly until the display reads:

   Top line—Press and Hold

   Bottom line—Center/Auto Tune

2. Press and hold the **Display Mode** button for at least five seconds until the **Load Regulation** indicator does not flash.

RF On Indicator Off

When the front panel **RF On** indicator illuminates, the output is enabled and the set point (or requested power level) is above the minimum required setting. In order for the RF On indicator to be on, the following conditions must be met:

1. The front panel **Fault** indicator must be off.

   If this indicator is on, see "Fault Indicator On" on page 6-3.

2. The front panel **Interlock OK** indicator must be on.

   If this indicator is off, see "Interlock OK Indicator Off" on page 6-5.

3. In order for the HFV generator to deliver power, the unit must receive an RF on command, *and* the set point (or requested output power level) must be above a specified minimum (see Table 3-3 on page 3-5). When these two conditions are met, the RF On indicator should illuminate, and the generator will deliver power.

   Note: How to send the RF on command depends how the unit is controlled:

- For **Generator User** port control, verify:

  There is an external contact closure between pins *4* and *9* to enable the RF output power. See Table 4-1 on page 4-2 and Figure 4-4 on page 4-8.

- For **DeviceNet** control, verify:

  An RF on command is given by having Bit 0 of Byte 4 of the poll command message set to 1. See "Poll Command and Poll Response Messages" on page 4-54 for more details.

  The output power set point minimum is a threshold that allows the generator to deliver power (see "Meeting Minimum Power Threshold" on page 5-11). The set point circuitry uses hysteresis, so the generator has two thresholds. If an RF on command is given, the set point level must be above the output on threshold

for the HFV generator to deliver power. The HFV generator will continue to deliver power until the set point level falls below the output off threshold, or until the **RF on** command is disabled (see command Table 4-7 on page 4-20).

At Set Point Indicator Off

When the output is enabled (**RF On** indicator lit) and the **At Set Point** indicator is off, the power output is not meeting the set point (or requested power level). This can be caused by an internal or external (load) fault condition.

Note: The output must be enabled (**RF On** indicator must be lit) before the **At Set Point** indicator will illuminate. If the **RF On** indicator is off, see "RF On Indicator Off" on page 6-6.

INTERNAL FAULT CHECK

To check for internal faults, see "Running Internal Diagnostics" on page 5-18. If the HFV generator passes this test, then proceed to the following section; otherwise, contact AE Global Customer Support (see "AE Global Customer Support" on page 6-10).

EXTERNAL LOAD CHECKS - OPEN/SHORT RF OUTPUT PATH

Use extreme caution, as this section involves troubleshooting the output of the HFV generator.

WARNING:
Use suitable precautions; this area contains high voltages that could cause serious injury or death.

There are four basic components that could impede the RF path: the HFV generator output connector, the output cable, the tuner, or the chamber. Complete the following steps.

1. Turn the rear circuit breaker off to ensure that there is no RF power at the output of the HFV generator.

For the HFV generator output connector:

a. Remove the output cable and visually inspect the output connector for signs of arcing or heat stress.

b. Verify an open is measured between the center conductor and outer shield.

c. Make sure the output connector is mounted firmly to the chassis.

For the output cable:

a. Visually make sure there is a good connection between the output cable and end connectors on both sides of the output cable.

b. Verify the continuity of the center conductor.

c. Verify the continuity of the outer shield.

d. Verify that there is no continuity between the center conductors and outer shields.

e. Swap cables if possible and retry operating the HFV generator.

For the tuner and the chamber:

The only way to isolate the tuner or the chamber is to exchange the tuner or the HFV generator with another known, functioning unit. You can also run the HFV generator into a 50-Ω dummy load.

Also consider these questions:

1. Are you currently setting up a new chamber system?
2. Has any work been done recently on the chamber?
3. Have there been any changes in your process recently?
4. Is your reflected power reading close to 1000 W (the HFV generator's reflected power limit)?

If you answered *yes* to any one of the previous questions, and the HFV generator passed the Internal Diagnostics test, the HFV generator is probably working properly, and it may be reacting to an external load condition. You may want to consult a process engineer or system manufacturer to troubleshoot chamber-related issues.

No Output / No Plasma

If there is no output or plasma, check the front panel **RF On** indicator.

1. If the **RF On** indicator is off, see the "RF On Indicator Off" on page 6-6.
2. If the **RF On** indicator is on, then follow the troubleshooting steps in "At Set Point Indicator Off" on page 6-7.

High Reflected Power

High reflected power is usually caused by a load mismatch.

Note: The concept of reflected power is often misunderstood. Most users believe the presence of reflected power is bad and that it should be minimized. Check the regulation mode of the HFV generator. The reflected power may seem higher than expected in Load Regulation because Load power is actually the difference between Forward and Reflected (Load power = Forward power – Reflected

power). For more information, see the literature section on our web site at www.advanced-energy.com. Look for the document titled, “Forward and Reflected Powers. What do they really mean?”

To verify that your reflected power is high, use the **Display Mode** button on the front panel to cycle through the display modes and monitor the reflected power reading. If you have high reflected power:

1. Use the **Display Mode** button on the front panel to cycle through the display modes until the frequency range is displayed. Determine if the frequency band that the generator is set to is appropriate for your use. (To set the frequency band, see “Setting the Frequency Band” on page 5-11.)
2. If the reflected power reading is close to 1000 W, the troubleshooting steps are the same as those outlined in “At Set Point Indicator Off” on page 6-7.

   Note: The reflected power is limited by the HFV generator to 1000 W internally. It is most likely that your HFV generator is functioning properly and is reacting to an external condition.

3. If the reflected power reading is much less than 1000 W, see “Running Internal Diagnostics” on page 5-18.

   There could be an internal failure in the power or measurement section of the HFV generator. The Internal Diagnostics is a self-test that will verify the integrity of these sections of the supply.

AE WORLD WIDE WEB SITE

For additional product information and troubleshooting procedures, consult Advanced Energy’s World Wide Web site:

- http://www.advanced-energy.com

AE GLOBAL CUSTOMER SUPPORT

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

Table 6-1. *Global Customer Support locations*

Office	Contact
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA *Note:* For returns and repairs, please call Global Customer Support to get the correct shipping address.	Phone (24 hrs/day, 7 days/week): 800.446.9167 or 970.221.0108 Fax (M–F, 7:00 am – 5:30 pm MST): 970.407.5981 Email: technical.support@aei.com (We will respond to email by the next business day.) *Note:* For customers outside the US, please contact your local AE office.
AE, Voorhees, NJ 1007 Laurel Oak Road Voorhees, NJ 08043 USA	Phone: 800.275.6971 or 856.627.6100 Fax: 856.627.6159
AE, GmbH Raiffeisenstrasse 32 70794 Filderstadt (Bonlanden) Germany	Phone: 49.711.77927.0 Fax: 49.711.7778700
AE, Japan KK TOWA Edogawabashi Bldg. 347 Yamabuki-cho Shinjuku-ku, Tokyo Japan	Phone: 81.3.32351511 Fax: 81.3.32353580
AE, Korea Ltd. Gongduk Building, 4th floor 272-6 Seohyun-Dong, Bundang-Gu, Sungam Si Kyunggi, 463-050 Korea	Phone: 82.342.705.2100 Fax: 82.342.705.2766
AE, United Kingdom Unit 5, Minton Place, Market Court, Victoria Road Bicester, Oxon OX26 6QB UK	Phone: 44.1869.320022 Fax: 44.1869.325004

Table 6-1. *Global Customer Support locations (Continued)*

Office	Contact
AE, Taiwan, Ltd. 10F-6, No. 110, Chung Shan Rd. Sec. 3, Chungho City, Taipei Hsien Taiwan 235	Phone: 886-2-82215599 Fax: 886-2-82215050
AE, China Rm. 910 Anhui Building, No. 6007 Shennan Road, Shenzhen, China 518040	Phone: 86-755-83867986 Fax: 86-755-83867984
AE China 469 Huaxia Dong Road Zhang Jiang Town Shanghai, China 201203	Phone: 86-21-58579011 Fax: 86-21-58579003

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, ***first follow all troubleshooting procedures***. If, after following these procedures, you still have a problem, or if the procedure instructs you to, contact AE Global Customer Support and discuss the problem with a representative. Be prepared to give the model number and serial number of the unit, as well as the reason for the proposed return. This consultation call allows Global Customer Support to determine whether the problem can be corrected in the field or if the unit needs to be returned. Such technical consultation is always free of charge.

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

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

WARRANTY

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

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

For a warranty claim to be valid, it must:

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

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

Authorized Returns

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

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

Warranty Statement

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

Glossary

A

Automatic Tune mode

This mode is the common mode of use that allows the operator to determine the output frequency range. See also “Automatic Tuning Mode” on page 5-13. To set the output frequency range using the **Host** port, see commands **3**, **4**, and **5** in Table 4-7 on page 4-20.

C

Center Frequency mode

Center frequency mode limits the generator output frequency to the center of the frequency band and is typically used during chamber load match tuning and calibration of system power. A flashing load regulation indicator means that the generator has been set to Center Frequency mode (see MODE 3 in “Display Mode and the LCD Display Indicator” on page 5-16). For additional information, see “Monitoring the Generator” on page 5-17 and “Center Frequency Mode” on page 5-12.

D

DDS

Direct digital synthesis.

F

Forward power regulation

The HFV generator provides forward power and load (delivered) power regulation modes, as measured at the RF output. The load regulation indicator on the front panel illuminates whenever load power regulation mode is selected. An unlit indicator indicates that forward power regulation mode is selected. A flashing load regulation indicator indicates that the generator has been set to Center Frequency mode (see “Center Frequency Mode” on page 5-12 and MODE 3 in “Display Mode and the LCD Display Indicator” on page 5-16).

To set, see:

- Command **12** in Table 4-7 on page 4-20

Frequency limits

The *frequency limits* parameter sets the range of frequencies over which the HFV unit will operate. You can set a start frequency, an upper frequency limit, and a lower frequency limit. (See Table 4-7, commands **3**, **4**, and **5**, *minimum frequency*, *maximum frequency*, and *starting frequency*.)

In center frequency mode, all three frequencies are set to the center frequency. In automatic tuning mode, the HFV unit starts searching for a tune at the start frequency and sweeps up until a satisfactory tuning is found or until the upper frequency limit is reached. If a tune is not found, this pattern is repeated.

Frequency rate of change

The frequency rate of change parameter defines how quickly the generator moves through the steps during both the scanning and the tuning phase, in milliseconds. For example, if you set this value to 5, the generator will make tuning adjustments no more than every 5 ms. (See Table 4-7, command **11**, *frequency rate of change*.)

L

LCD

Liquid crystal display. The actual display on the front panel.

S

Scan delta frequency

This parameter sets the maximum amount of frequency change for each step during scanning. The typical value is 10,000. (See Table 4-7, command **19**, *scan delta frequency*.)

Scan Threshold

The scan threshold parameter sets a threshold below which the tuning phase begins. If the scan threshold is set too high, the generator will begin to tune too early and the tuning will not be optimal. If the scan threshold is set too low, the threshold may never be reached and automatic tuning will not take over. (See Table 4-7, command **20**, *scan threshold*.)

T

TDS

Total dissolved solids.

Tuning delta limit

This parameter sets the maximum amount of frequency change for each step during tuning. (See Table 4-7, command **16**, *tuning delta limits*.)

Note: When setting the tuning delta limit, be aware that if the limit is set too low, the tuning function may react to noise in the signal and fail to correct the real direction of change. The lowest recommended tuning delta limit value is 5000.

Tuning gain

This parameter affects the size of the tuning steps; the larger the number, the greater the size of the tuning steps. (See Table 4-7, command **15**, *tuning gain*.)

Note: When setting the tuning gain, be aware that if the gain is set too low, the tuning function may react to noise in the signal and fail to correct the real direction of change.

Tuning goal

When the tuning parameter measurement is below the tuning goal value, the generator does not adjust the output frequency. (See Table 4-7, command **14**, *tuning goal*.)

Note: This option of generator does not have the continuous tuning in load power regulation enabled. For power regulation mode, the generator will tune until a minimum tuning parameter is found. It then operates at that output frequency until the RF enable command is turned off, then back on (through the **Generator User** port on the HFV unit).

V

Virtual Front Panel (VFP) software

To order VFP, contact AE Worldwide Customer Service (see "AE Global Customer Support" on page 6-10).

W

Water solenoid

The optional water solenoid provides water flow control. If your generator has this option, the valve controlling water flow opens during RF power delivery and closes 30 minutes after the last RF off command. To order the optional solenoid, contact AE Worldwide Customer Service (see "AE Global Customer Support" on page 6-10).

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