Apex® Half-Rack Generator 500 W to 5.5 kW

August 2008 *5708009-K*

User Manual

User Manual

Apex® Half-Rack Generator
500 W to 5.5 kW

5708009-K

ADVANCED ENERGY®

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PRODUCT USAGE STATEMENT

⚠ WARNING:

Read this entire manual and all other publications pertaining to the work to be performed before you install, operate, or maintain this equipment. Practice all plant and product safety instructions and precautions. Failure to follow instructions can cause personal injury and/or property damage. If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment 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.

Advanced Energy Industries, Inc., (AE) provides information on its products and associated hazards, but it assumes no responsibility for the after-sale operation of the equipment or the safety practices of the owner or user. This equipment produces or uses potentially lethal high-voltage, high-current, radio frequency (RF) energy. NEVER DEFEAT INTERLOCKS OR GROUNDS.

TRADEMARKS

CUSTOMER FEEDBACK

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:

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Configurator Descriptions and Safety and Product Guidelines

This chapter contains several kinds of introductory information.

- "Using this Manual to Find Information About Your Generator" on page 1-1 provides important instructions on locating the information in this manual that is applicable to your Apex generator.
- "Danger, Warning, and Caution Boxes in the Manual" on page 1-14, "Safety Guidelines" on page 1-14, and "Interpreting Product Labels" on page 1-15 provide information on interpreting the type conventions, safety warnings, and labels found in this manual and on the Apex generator.
- "Product Compliance" on page 1-17, and "Installation Requirements" on page 1-19 provide important safety and compliance information about the Apex generator.

IMPORTANT SAFETY INFORMATION

To ensure safe installation and operation of the Advanced Energy® Apex 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 1-14.

USING THIS MANUAL TO FIND INFORMATION ABOUT YOUR GENERATOR

The Apex generator can be ordered with many configurable options such as different output levels, input and output connectors, and so on. This manual covers many of these options, some of which will apply to your generator and some of which will not. This section of the manual is designed to help you quickly find the information that applies to your unit.

Note: This manual does not cover all the Apex generators; some units are covered in other manuals. To make sure that you will be able to find the correct information, use the manual that came with your unit.

Understanding PIN Numbers and Apex Configuration

Each Apex generator has a serial number tag that contains the unit's specific serial number, and the part number and option of the unit. Figure 1-1 and Figure 1-2 are examples of Apex generator serial number tags.

In addition to the serial number, your tag will have either an AE 315XXXX part number or a 17-position alpha-numeric PIN that stands as a part number.

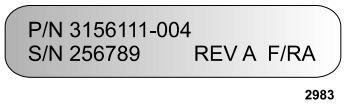


Figure 1-1. *315 part number identification tag*

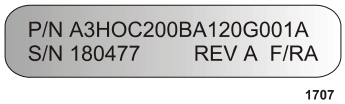
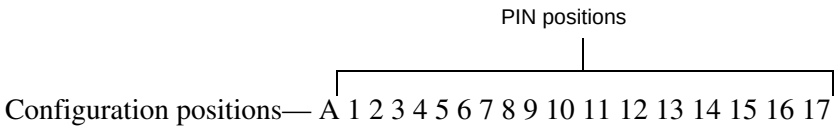


Figure 1-2. *Serial number identification tag, 17-position*

Obtaining Your PIN Number For Use with This Manual

To begin using the manual, you will first need to find and record your unit PIN number as you may want to refer to it frequently as you work with the manual. Once you determine your PIN, write it down and keep it for use with this user manual.

If you have the PIN serial tag, it is a 17-position alpha-numeric that represents the configuration of your generator and identifies the options installed on it.



The "A" that precedes the PIN defines the product as an Apex generator, and it is not counted as one of the PIN positions. The 17 PIN positions that follow the "A" are used to identify the options installed on the generator.

If you have an Apex generator with a 315XXXX number on your serial tag, you will need to obtain your PIN number to use this manual. You can:

- Call AE Global Services with your 315XXXX number to obtain your pin number
- Issue command **221** at the RS-232 host port to obtain your pin number

Using the PIN to Locate Information in the Manual

Once you have obtained your PIN number, this manual provides two basic tools to help you use the PIN in locating correct information for your unit.

- "Using the PIN to Identify Apex Options" on page 1-3 provides a complete list of Apex features and their associated options, which are identified by each position in the PIN number. When appropriate, it also provides cross-references to the manual sections containing information for particular options. This table is the easiest place to find the appropriate section of the manual when you have a question about your unit.
- Throughout the manual, you may also see Configuration Notes. These configuration notes are placed at the beginning of manual sections that provide option-specific information, and the notes provide information about the PIN position and option described in that section. Use these notes to confirm that the section of the manual you are reading applies to your unit.

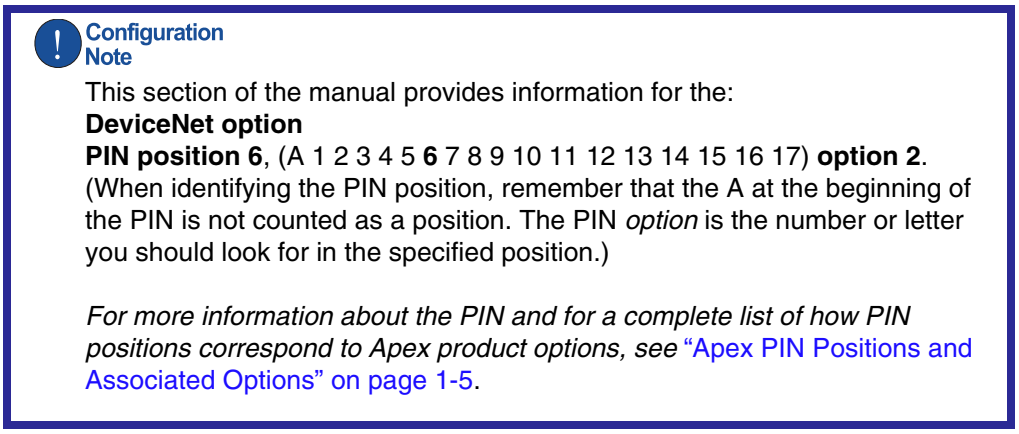


Figure 1-3. *Example configuration note*

Using the PIN to Identify Apex Options

"Apex PIN Positions and Associated Options" on page 1-5 shows all the options associated with each PIN position. When appropriate, there are cross references to help you locate the sections of the manual associated with your unit.

For example, to find information about the output connector on your unit:

- Look through the table to find the PIN position associated with output connectors, which is 11 (see row 11 of the table).
- Find that position in the PIN for your Apex generator (remember, the A at the beginning of the PIN does not count as a position) and note the number or letter in that position.

- Using the right-most cell in the correct row, identify the option installed in your unit and use the cross-reference to locate the information on that option.

Note: Not all of the options listed in the table are covered in this manual. To make sure that you will be able to find the correct information for your unit, see the manual that came with that specific unit. Contact AE for any questions about availability of specific configurations (see "AE Global Services" on page 6-9).

Table 1-1. *Apex PIN Positions and Associated Options*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
1	Output frequency	**1—4 MHz, ±0.005%** **2—13.56 MHz, ±0.005% with set point ramping** **3—13.56 MHz, ±0.005%** **4—27 MHz, ±0.005%** **5—exclusive option #1** **6—exclusive option #2** **7—exclusive option #3** **8—exclusive option #4** **9—exclusive option #5**
2	Power output	**A—2500 W (3 kW limited to 2.5 kW)** **B—1500 W** **C—1500 W w/Harmonic Suppression** **D—3000 W** **E—5500 W HALO** **F—5500 W** **G—N/A, full rack only** **H—N/A, full rack only** **J—5000 W (5.5 kW limited to 5 kW)** **K—1500 W HALO w/ Harmonic Suppression** **L—1500 W HALO** **M—3500 W (5.5 kW limited to 3.5 kW)** **N—N/A, full rack only** **P—3000 W (5.5K limited to 3 kW)** **Q—500 W HALO (1.5 kW limited to 500 W)** **R—2000 W (3 kW scaled to 2 kW)** For more information on power output and other specifications, see “Electrical Specifications” on page 3-11.

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
3	Input voltage	**0—208 V nominal, 187 to 229 VAC, 3ϕ, 47 to 63 Hz, with breaker** **1—400 V nominal, 360 to 440 VAC, 3ϕ, 47 to 63 Hz, with breaker (5.5K only)** **2—208 V nominal 187 to 229 VAC, 3ϕ, 47 to 63 Hz, with breaker (F47)** **3—208 V nominal, 187 to 229 VAC, 3ϕ, 47 to 63 Hz, without breaker** **4—400 V nominal, 360 to 440 VAC, 3ϕ, 47 to 63 Hz, with breaker (F47, 5.5 K only)** **5—208 V nominal, 187 to 229 VAC, 3ϕ, 47 to 63 Hz w/o breaker (F47)** **6—400 V nominal, 360 to 440 VAC, 3ϕ, 47 to 63 Hz w/o breaker (F47, 5.5k only)** For more information on input voltage and other specifications, see "Electrical Specifications for Apex Features" on page 3-15.

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
4	Packaging	**A—frame mount (≤ 5500 W)** **B—integrated rack mount with rack ears (1/2 rack, utilities)** **C—integrated rack mount (N/A, full rack only)** **D—integrated 1/2 rack mount (left)** **E—integrated 1/2 rack mount (right)** **F—exclusive option #1** **G—exclusive option #2** **H—exclusive option #3** **J—frame mount with 2 handles (opposite)** **K—on board frame mount, opposite end LEDs (utilities end RF output only, with rack ears, opposite end)** **L—on board integrated rack mount, opposite end LEDs with 4 handles (utilities end RF output only, with rack ears, opposite end)** **M—on board integrated rack mount, opposite end LEDs with 2 handles (utilities end RF output only, with rack ears, opposite end)** **N—integrated rack mount with rack ears (1/2 rack, opposite)** **P—frame mount with 2 handles (utilities end)** **Q—on board integrated rack-mount, opposite end LEDs with 4 handles (utilities end RF output only, without rack ears)** **R—on board integrated rack-mount, opposite end LEDs with 2 handles (utilities end RF output only, without rack ears, front surround panel)**

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
5	Panel	**0—none (on-board, frame mount)** **1—integrated rack mount with blank panel (full rack only)** **2—integrated rack mount with passive digital display (full rack only)** **4—exclusive option #1** For panel illustrations, see "Apex Panel Illustrations" on page 3-8.
6	Serial I/O	**0—RS-232 with AE Bus (default)** **1—Multidrop RS-485 with AE Bus Protocol** **2—DeviceNet (vertical mount) (Discontinued)** **3—PROFIBUS** **4—exclusive option #1** **5—DeviceNet (serial)** **6—PROFIBUS with DC heating (400 V units only)** **7—exclusive option #2** **8—RS 232 with AE Bus (default Host control mode)** For host port information, see "Apex Host Port Options" on page 4-69.
7	Serial Port 2	**0—default (no secondary serial port, default)** **1—RS-232 with AE Bus** **2—RS-485 with AE Bus** **3—TBD**

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
8	User port options	**A—25-pin Apex standard with dummy plug** **B—25-pin Apex standard (default)** **C—exclusive option #1** **D—exclusive option #2** **E—exclusive option #3** **G—exclusive option #4** **H—exclusive option #5** **J—exclusive option #6** **K—exclusive option #7** **L—option B with internal power limited to 1050 W** **N—exclusive option #8** **P—exclusive option #9** **Q—exclusive option #10** **R—exclusive option #11 (inhibits the use of PROFIBUS and DeviceNet options)** **S—exclusive option #12** For user port information, see “Apex User Port Options” on page 4-4.

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
9	Output impedance	**A—Zo=(50-j0) Ω (default)** **B—exclusive option #1** **C—exclusive option #2** **D—exclusive option #5** **E—exclusive option #6** **F—exclusive option #3** **G—exclusive option #4** **H— exclusive option #7** **J—exclusive option #8** **K—exclusive option #9** **L—exclusive option #10**
10	On-board RF output connector location	**0—opposite end from utilities** **1—utilities end (1/2 rack, 50 ohm only)**
11	Output connector	**0—exclusive option #1** **1—7/16 connector** **2—SQS™ connector** **3—LC connector** **4—HN connector (1.5 kW, 3 kW only)** **5—N connector (1.5 kW only)** **6—exclusive option #2** **7—exclusive option #3** For output connector information, see "Connecting Output Power" on page 5-8.
12	RF measurement	**0—directional coupler** **1—V/I probe** **2—V/I coupler** **3—directional coupler with Arc Detection** **4—directional coupler/ Overshoot Optimization**

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
13	AC power input	**A—ODU connector** **B—Non-terminated 9.8´ (3 m), 4-conductor, shielded pigtail (non-50 Ω only)** **C—Non-terminated 12′ , 4-conductor, pigtail (non-50 Ω only)** **D—Harting Type Han Q (1.5 kW and 3 kW only)** **E—N/A, full rack only** **F—15´ 4-conductor, with a Hubbell CS8365C connector end of line cord (non-50 Ω only)** **G—N/A, full rack only** **H—9.8´ (3m), 4 cond, shielded pigtail Marinco 3015P-AM19 (non-50 Ω only)** **J—5' terminated, 4 conductor, SH with contact LS1 BF.F6 5+PE connector at end of line cord (30 A, non-50 Ω only)** **K—ODU connector with 20 degree rotation** **L—Harting Type Han Q 5/0 (16A) rotated 180 degrees (1.5 kW only)** **M—N/A, full rack only** **N—N/A, full rack only** **P—45" (3.75´), 4 conductor shielded pigtail Marinco 3015P 90 degree connector at end of line cord (non-50 Ω only)** **Q—Amphenol connector (not available)** **R—Harting Han modular connector (40 A)** **(continued on next page)**

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
13 (continued from previous page)	AC Input Power	**S—3.3´, 4 conductor shielded pigtail Marinco 3015P connector at end of line cord (non-50 Ω only)** **T—4 terminal, stud mount with 12´ line cord attached, flying leads at end** **U—4 conductor shielded pigtail Marinco 3015P-AM24 (non 50 ohm only)** **V—N/A, full rack only** **W—Han Q 4/2 (25 A)** For AC input power connector information, see "Connecting Input Power" on page 5-12.
14	Pulsing	**0—no pulsing (default)** **1—pulsing** (not available on 400 V) **2—pulsing with filtered power** **3—pulsing with firmware enhancements below 1 KHz** For pulsing information, see "Pulsing Output" on page 5-20.
15	CEX	**0—default** (no CEX) **1—CEX** **2—CEX with 1 m Cable** **3—CEX with 1.5 m cable** **4—CEX wideband** **5—CEX with SMA connectors** For CEX information, see "The Common Exciter (CEX) Mode of Operation (optional)" on page 5-19.

Table 1-1. *Apex PIN Positions and Associated Options (Continued)*

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
16	Water fitting threads	**0—default to 3/8 BSP female (metric threads)** **1—3/8 NPT female (adapters - increases unit length)** **2—3/8 BSP to 1/2" NPT** **3—3/8 BSP female (metric threads with flowmeter)** **4—3/8 BSP ISO parallel threads** For information on connecting the water, see "Connecting Cooling Water" on page 5-6.
17	Custom configuration	**A—standard configurations** **B—exclusive option #1** **D—exclusive option #3** **E—exclusive option #4** **F—exclusive option #5** **G—exclusive option #6** **S—Sag Recovery (nonlatching)** **X—Engineering Prototype Unit**

DANGER, WARNING, AND CAUTION BOXES IN THE MANUAL

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:

- Do not attempt to install or operate this equipment if you have not first acquired proper training.
- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.

- Verify that input line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper ESD precautions.
- BE CAREFUL AROUND THIS EQUIPMENT

INTERPRETING PRODUCT LABELS

The following labels may appear on your unit:

Capacitor charge

1745

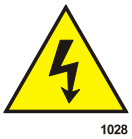
Hazardous voltage

1332

Short circuit protected

1024

High voltage



1028

Protective earth ground

1029

Earth ground

1069

CE label

1020

Non-ionizing radiation

1030

Hot surface

1309

Warning (refer to manual)

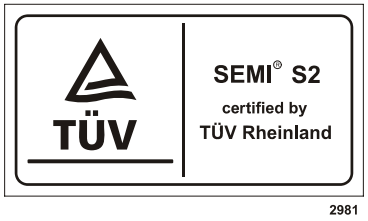
1027

NRTL
CSA is a Nationally Recognized Testing Laboratory

1154

SEMI F47 compliant

SEMI S2 compliant



PRODUCT COMPLIANCE

Certain options of the Apex generator have been tested for and comply with the following Directives and Standards.

Product Certification

Certain options of this product are certified by:

- Canadian Standards Association (CSA) (NRTL/C)
- CE marking is self addressed by AE Compliance Engineering
- EMC measurements verified by an independent, certified EMC testing laboratory.

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 safety and Electromagnetic Compatibility (EMC) standards and directives:

Table 1-2. *Electromagnetic Compatibility (EMC) Directives*

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

Table 1-3. *Electromagnetic Compatibility (EMC) Standards*

Standard	Description
47 CFR Part 18	Code of Federal Regulations—Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical equipment
EN 61000-6-2	Electromagnetic Compatibility (generic immunity standard—industrial)
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)

Table 1-4. *Safety Directives*

Directive	Description
2006/95/EC	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)

Table 1-5. *Safety Standards*

Standard	Description
CSA C22.2 No. 107.1	General use power supplies—industrial products
EN 50178	Electronic equipment for use in electrical power installations
UL 1012	Power units other than class 2

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.

Table 1-6. *SEMI Guidelines*

Guideline	Description
SEMI F47-0200	Specification for Semiconductor Processing Equipment Voltage Sag Immunity
SEMI S2-0703	Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

INSTALLATION REQUIREMENTS

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

DANGER:
RISK OF DEATH OR BODILY INJURY. Disconnect and lock-out/ tag-out all sources of input power before working on this unit or anything connected to it.

Conditions of Use

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

- Install and operate this device in an overvoltage category II installation only.
- Before making any other connection to this device, connect the auxiliary Protective Earth ground terminal to a local earth ground with a copper wire that is sized according to the applicable requirements.
- Use only a shielded cable on the input power connector.
- Use only a shielded power cable on the output power connector.

- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only non-conductive pollution occurs during operation. Occasionally, a temporary conductivity caused by condensation occurs when the device is not operating.
- Non-standard connectors for input and/or output power must be inaccessible to the user.
- If your unit does not have a circuit breaker, install and operate it with a circuit breaker on the AC input to provide over current protection. The circuit breaker must have a trip value as specified in the line current section of "Input Power Specifications" on page 3-11. The circuit breaker switch must be easily accessible and near the device. Circuit breaker or disconnect device must lock-out/ tag-out all sources of input power.
- Install this device so that the input power connection is inaccessible to the user.
- Use only shielded cables on the **Host** (RS-232) and **User** Port (analog control) connectors.

Theory

GENERAL DESCRIPTION

The Apex generator product line consists of generators and power delivery system products defined by a matrix of features and capabilities that can easily be custom configured to specific customer requirements and applications.

The Apex products may be configured with integrated SwitchMatch™ matching networks and sophisticated VI sensor instrumentation in place of standard power measurement. The Apex products feature a powerful microprocessor for flexible and accurate operation. The microprocessor also facilitates the addition of one of several optional serial communications protocols in addition to the standard AE Bus host port. Several parallel digital/analog I/O choices are also available. Apex products are designed to be used in clean room environments and are water cooled.

Other optional features include high repetition rate, variable duty cycle pulsing, common exciter (CEX) phase lock operation, and arc detection.

FUNCTIONAL DESCRIPTION

Regulation

The Apex generator regulates on forward power, delivered power, or bias voltage measured at the output of the generator. Mode selection is made through a designated pin in the interface connector or by receiving a command through a digital interface option.

Cooling

Apex generators are water-cooled only.

Interlock

The Apex generator provides a system interlock connection through the User port. The RF output connector is also interlocked by a series switch that is part of the system interlock.

Optional Water Solenoid

The Apex generator provides water solenoid control circuitry that can be accessed through a connector on the rear of the generator. When an optional water control solenoid is connected to the water solenoid control circuitry, the Apex generator controls operation of the solenoid and water flow. This feature minimizes condensation in the generator when the RF output is off and cooling water is still circulating through the generator. See “Installing the Optional Water Control” on page 5-7.

Grounding

You may connect the system RF ground to one of two holes on the rear panel of the Apex generator. One hole is a tapped M-6 hole and the other is a 5/16" x 18 tapped hole. Either hole may be used to provide an appropriate ground.

Optional Unit Features

CEX MODE

In the common exciter (CEX) mode of operation, more than one Apex generator is coupled into the same plasma. When operating in CEX mode, one Apex unit is the “master” and the other is the “slave.” The CEX output of the master is connected to the CEX input of the slave. If the slave unit receives a signal of the proper frequency and amplitude at its CEX input, it automatically phase locks to that signal and tracks the master units oscillator. See “The Common Exciter (CEX) Mode of Operation (optional)” on page 5-19 for more information.

PULSING OUTPUT

When pulsing is enabled, the Apex generates pulses of RF output based on frequency and duty-cycle settings. For units that have the pulsing option, pulsing output can be enabled or disabled. See “Pulsing Output” on page 5-20 for more information.

ARC HANDLING

The arc handling system is responsible for detecting and handling arcs. Detection is based on reflected power. Handling is done by turning RF off for a period of time. See “The Arc Handling and Detection System” on page 5-21 for more information.

THEORY OF OPERATION

Figure 2-1 and Table 2-1 describe the basic operation of the Apex generator.

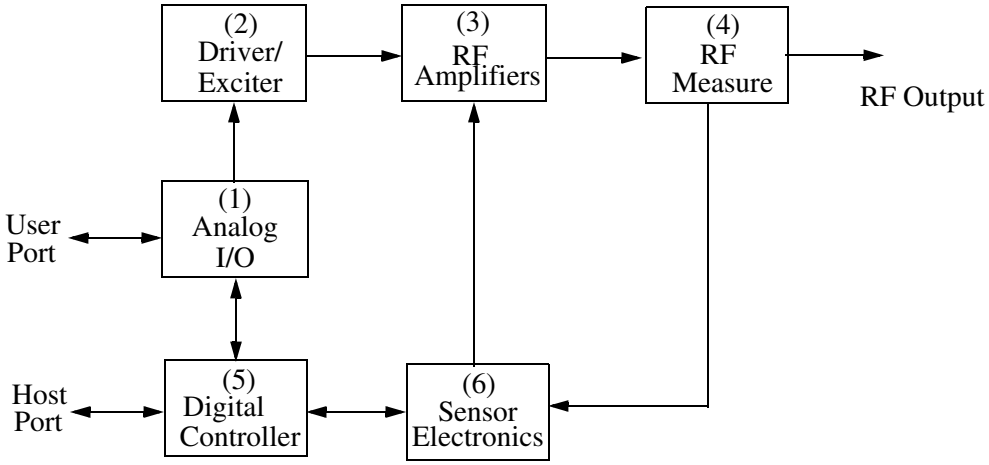


Figure 2-1. *Theory of operation block diagram*

Table 2-1. *Block Diagram Explanation*

(1) User port (Analog I/O)	This section provides user interface and CEX functions.
(2) Driver/Exciter	This section generates power at the designated output frequency to drive the main RF sections.
(3) RF Amplifier	This section generates RF power.
(4) RF Measurement	This section samples the output signal and sends it to the sensor electronics.
(5) Digital Controller	This section is the main processor and data acquisition section. It also provides host communications through an RS-232 port.
(6) Sensor Electronics	This section detects RF samples and sends them to the microprocessor.

Specifications

This chapter lists the specifications of the Apex generator in the following sections:

In some cases, specifications for all generators are the same, but in other cases, the unit specifications vary depending on the options installed on the unit. In such cases, the manual refers to the PIN position that defines those specifications, lists the PIN and configuration options that are available, and when appropriate, provides cross references to more information on those specific options. For more information on using the PIN to identify information applicable to your unit, see "Using this Manual to Find Information About Your Generator" on page 1-1.

PHYSICAL SPECIFICATIONS

"Physical Specifications" on page 3-1 describes the physical specifications of the Apex generator. In some cases, the specifications for all 500 W to 5.5 kW units are the same, but in other cases, the unit specifications vary depending on the options installed. In such cases, the specification table refers to the PIN position that defines those specifications, lists the PIN and configuration options that are available and, when appropriate, provides cross references to more information on those options. For more information on using the PIN to identify information applicable to your unit, see "Using this Manual to Find Information About Your Generator" on page 1-1.

Table 3-1. *Physical specifications*

Description	PIN Option and Specification
Packaging *Note:* Varies according to the option defined by PIN position 4.	**A**—frame mount (≤ 5500 W) **B**—integrated rack mount with rack ears (1/2 rack, utilities) **C**—integrated rack mount (full rack only) **D**—1/2 integrated rack mount (left) **E**—1/2 integrated rack mount (right) **F**—exclusive option #1 **G**—exclusive option #2 **H**—exclusive option #3 **J**—frame mount with 2 handles (opposite) **K**—on board frame mount, opposite end LEDs (utilities end RF output only, with rack ears, opposite end) **L**—on board integrated rack mount, opposite end LEDs with 4 handles (utilities end RF output only, with rack ears, opposite end) **M**—on board integrated rack mount, opposite end LEDs with 2 handles (utilities end RF output only, with rack ears, opposite end) **N**—integrated rack mount with rack ears (1/2 rack) (opposite) **P**—frame mount with 2 handles (utilities end) **Q**—on board integrated rack-mount, opposite end LEDs with 4 handles (utilities end RF output only, without rack ears) **R**—on board integrated rack-mount, opposite end LEDs with 2 handles (utilities end RF output only, without rack ears, front surround panel)
Mounting	Rack mounting ears provided. Interlocking side rail extrusions available

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

Description	PIN Option and Specification
Size	The size of the unit depends on configuration of your Apex unit. The following dimensions are for the drawing, "Apex dimensions" on page 5-5: 13.34 cm (H) x 21.6 cm (W) x 48.47 cm (D) 5.25" (H) x 8.5" (W) x 19.19" (D)
Weight	~20.4 kg (45 lb) maximum
Clearance	No special requirements

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

Description	PIN Option and Specification
AC power input connector *Note:* Varies according to the option defined by PIN position 13.	**A**—ODU connector (see "ODU Connector" on page 5-13) **B**—Non-terminated 3 m, 4-conductor, shielded pigtail (see "Non-Terminated, Four-Conductor Pigtail" on page 5-16) **C**—Non-terminated 12´, 4-conductor, pigtail (see "Non-Terminated, Four-Conductor Pigtail" on page 5-16) **D**—Harting Type Han Q (see "Harting Han Q 5/0 Connector" on page 5-14) **E**—N/A, full rack only **F**—15´, 4-conductor, with a Hubbell CS8365C plug **G**—N/A, full rack only **H**—Term 3 m, 4-conductor, shielded pigtail Marinco 3015P AM19 (non-50 Ω only) **J**—5´ terminated, 4-conductor, SH with contact LS1 BF.F6 5+PE (30 A) **K**—ODU connector with 20 degree rotation (see "ODU Connector" on page 5-13) **L**—Harting Type Han Q (16 A) rotated 180 degrees (see "Harting Han Q 5/0 Connector" on page 5-14) **M**—N/A, full rack only **N—**3´ Harting **P—**1 m, 4-conductor shielded pigtail Marinco 3015P **Q—**Amphenol connector (not available) **R—**Harting Han modular connector (40 A) (see "Harting Han Modular (40 A) Connector" on page 5-16) **S**—3.3´ 4-conductor shielded pigtail Marinco 3015P connector at end of line cord (non-50 Ω only) (continued on following page)

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

Description	PIN Option and Specification
AC power input connector (continued from previous page)	**T**—4 terminal, stud mount with 12´ line cord attached, flying leads at end **U**—4-conductor shielded pigtail Marinco 3015P-AM24 (non-50 Ω only) **V**—N/A, full rack only **W**—Han Q 4/2 (see "Harting Han Q 4/2 Connector" on page 5-14) For AC input power connector information, see "Connecting Input Power" on page 5-12
RF output connector *Note:* Varies according to the option defined by PIN position 11.	**0**—exclusive option #1 **1**—7/16 connector **2**—SQS™ connector **3**—LC connector **4**—Type HN, female **5**—N **6**—exclusive option #2 **7**—exclusive option #3 For RF output connector information, see "Connecting Output Power" on page 5-8.
RF connector location *Note:* Varies according to the option defined by PIN position 10.	**0**—opposite end from water connections **1**—utilities end (near water connections)
Water control connectors	Switchcraft™ #L712A

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

Description	PIN Option and Specification
User port (analog I/O) connector *Note:* Varies according to the option defined by PIN position 8.	**A**—25-pin Apex standard with dummy plug **B**—25-pin Apex standard (see "25-Pin Apex Standard User Port" on page 4-4) **C**—25-pin custom RFG compatible **D**—exclusive option #2 (see "15-Pin User Port (Exclusive—Option D)" on page 4-19) **E**—15-pin, exclusive option #3 (see "15-Pin User Port (Exclusive—Option E)" on page 4-30) **G**—exclusive option #4 **H**—exclusive option #5 **J**—exclusive option #6 **K—**exclusive option #7 **L**—option B with internal power limited to 1050 W **N**—exclusive option #8 **P**—exclusive option #9
Host port (serial I/O) connector *Note:* Varies according to the option defined by PIN position 6.	**0**—9-pin, shielded, female, subminiature-D (see "Host Port—RS-232 With AE Bus" on page 4-69) **1—**9-pin, shielded, female, subminiature-D (currently not available) **2**—5-pin, male, Lumberg RSF 5/0.5 or Turck FS 4.5 (discontinued) **3—**9-pin, shielded, female, subminiature-D (see "Host Port—Profibus" on page 4-96) **4**—exclusive option #1 **5**—5-pin, male, Lumberg RSF 5/0.5 or Turck FS 4.5 (see "Host Port—DeviceNet" on page 4-123) **6—**9-pin, shielded, female, subminiature-D (see "Host Port—Profibus" on page 4-96) **7**—exclusive option #2 **8**—9-pin, shielded, female, subminiature-D (see "Host Port—RS-232 With AE Bus" on page 4-69)
CEX connector	Female LIMO#EPL.00.250.NTN

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

Description	PIN Option and Specification
Coolant connectors (water fitting threads) *Note:* Varies according to the option defined by PIN position 16.	**0—**3/8 BSP female (metric threads) **1—**3/8 NPT adapters (from 3/8 BSP female threads in the manifold--increases unit length) **2—**3/8 BSP to 1/2" NPT **3—**3/8 BSP female (metric threads with flowmeter) **4**—3/8 BSP ISO parallel threads For information on connecting the water, see "Connecting Cooling Water" on page 5-6.
Panel	**0**—on-board frame mount
RF measurement option *Note:* Varies according to the option defined by PIN position 12.	**0**—directional coupler **1**—V/I probe **2—**V/I coupler **3**—Directional coupler with Arc Detection

APEX PANEL ILLUSTRATIONS

The appearance of the front and real panels of the Apex generator is highly variable due to the number of customer-selectable options available in the product line. Figure 3-1 and Figure 3-2 show a basic Apex option.

To find information about the options available on your specific Apex generator, see “Using this Manual to Find Information About Your Generator” on page 1-1.

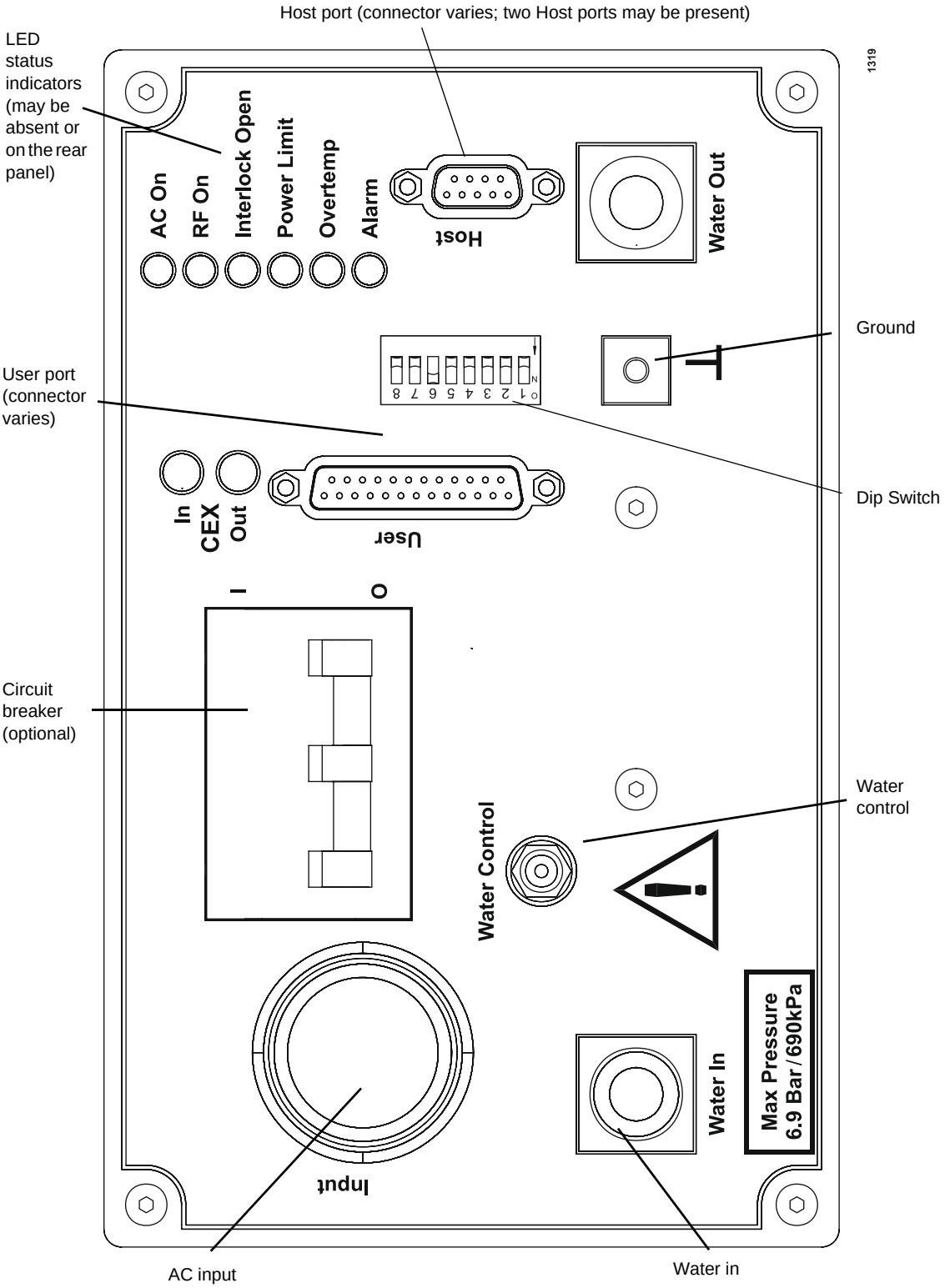


Figure 3-1. *Front Panel*

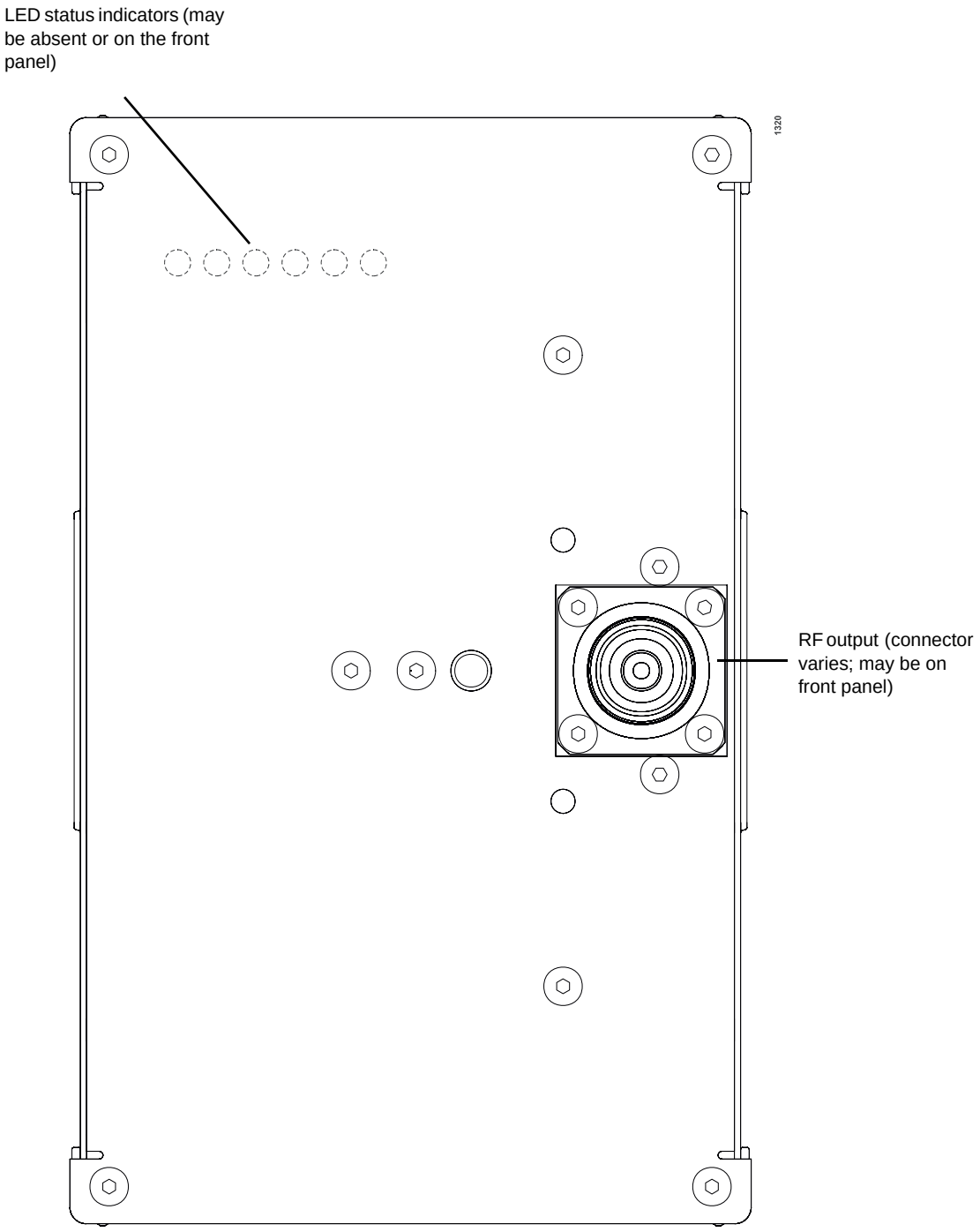


Figure 3-2. *Rear panel*

ELECTRICAL SPECIFICATIONS

Table 3-2 on page 3-11, Table 3-3 on page 3-12, and Table 3-4 on page 3-15 describe the input power, output power, and other electrical specifications for the Apex generator. In some cases, the specifications for all 500 W to 5.5 kW units are the same, but in other cases, unit specifications vary depending on the options installed. In such cases, the specification table refers to the PIN position that defines those specifications, lists the PIN and configuration options that are available and, when appropriate, provides cross references to more information on those options. For more information on using the PIN to identify information applicable to your Apex generator, see "Using this Manual to Find Information About Your Generator" on page 1-1.

Input Power Specifications

Table 3-2. *Input power specifications*

Description	PIN Option and Specification
Line voltage *Note:* Varies according to the option defined by PIN position 3.	**0**—208 V nominal, 187 to 229 VAC, 3ϕ, with breaker **1**—400 V nominal, 360 to 440 VAC, 3ϕ, with breaker (5.5 K only) **2**—208 V nominal, 187 to 229 VAC, 3 ϕ, with breaker (F47) **3**—208 V nominal, 187 to 229 VAC, 3ϕ, without breaker **4**—400 V nominal, 360 to 440 VAC, 3ϕ, with breaker (5.5 K only, F47) **5—**208 V nominal 187 to 229 VAC, 3ϕ, without breaker (F47) **6—**400 V nominal, 360 to 440 VAC, 3ϕ, without breaker (5.5 K only, F47)
Line frequency	47 Hz to 63 Hz

Table 3-2. *Input power specifications (Continued)*

Description	PIN Option and Specification
Line current	Typical amps per phase for units with 208 VAC nominal input (PIN position 3, options 0 and 3): • 500 W: 5 A • 1500 W: 9.2 A • 2000 W: 13.5 A • 3000 W: 14 A • 5000 W: 25 A • 5500 W: 26 A Typical amps per phase for units with 400 VAC nominal input (PIN position 3, option 1): • 3000 W: 8 A • 5500 W: 15 A
Circuit breaker rating	Circuit breaker rating for units with 208 VAC nominal input (PIN position 3, options 0 and 3): • Up to 2000 W: 15 A breaker • Up to 3000 W: 25 A breaker • Up to 5500 W: 40 A breaker Circuit breaker rating for units with 400 VAC nominal input (PIN position 3, option 1): • 3000 W: 15 A breaker • 5500 W: 25 A breaker

Output Electrical Specifications

Table 3-3. *Output specifications*

Description	PIN Option and Specification
Regulation modes	• Forward power • Load power • External feedback (DC bias, for example)
Output frequency *Note:* Varies according to the option defined by PIN position 1.	**0**—N/A **3**—13.56 MHz, ±0.005%

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

Description	PIN Option and Specification
Full-rated output power (Minimum into a 50 Ω, non-reactive load) *Note:* Varies according to the option defined by PIN position 2.	**A**—2500 W (3 kW limited to 2.5 kW) **B**—1500 W **C**—1500 W with harmonic suppression **D**—3000 W **E**—5500 W HALO (high accuracy low output) **F**—5500 W **G**—8000 W (10 kW limited to 8 kW, full rack only) **H**—10000 W (full rack only) **J**—5000 W (5.5 kW limited to 5 kW) **K**—1500 W HALO with harmonic suppression **L**—1500 W HALO **M**—3500 W (5.5 kW limited to 3.5 kW) **N**—7000 W (10 kW limited to 7 kW, full rack only) **P**—3000 W (5.5 kW limited to 3 kW) **Q—**500 W HALO (1.5 kW limited to 500 W) **R**—2000 W
Output impedance *Note:* Varies according to the option defined by PIN position 9.	**A**—50 Ω **B**—exclusive option #1 **C**—exclusive option #2 **D**—exclusive option #5 **E**—exclusive option #6 **F**—exclusive option #3 **G**—exclusive option #4 **H**—exclusive option #7 **J**—exclusive option #8 **K—**exclusive option #9 **L—**exclusive option #10

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

Description	PIN Option and Specification
Delivered power into 2:1 VSWR loads *Note:* Varies according to the option defined by PIN position 2.	1125 W for 1.5 kW output units 2000 W for 3 kW output units 3350 W for 5.5 kW output units
Delivered power into 3:1 VSWR loads *Note:* Varies according to the option defined by PIN position 2.	650 W for 1.5 kW output units 1200 W for 3 kW output units 1900 W for 5.5 kW output units
Output protection—Apex generators sense and employ several parameters for protection	
Reflected power limit	20% of full-rated output power
Dissipation limit	Maximum PA dissipation—non-latching alarm LED
Low/high line bus	Bus voltage outside spec window—latching alarm LED
Over-temperature	Over-temp condition—latching alarm LED preceded by non-fault warning (user setting).
Output power range	All generators with the exception of the HALO option will allow set points between 1% and 100% of full scale. HALO units have a high accuracy, low output with an output power range that starts at 5 W.
Output power regulation accuracy *Note:* All power accuracy specifications are derived from digital set point to actual generator output as measured against AE calorimetric standard.	
Into 50 Ω non-reactive load (standard or HALO option per pin position 2)	• **Standard Option:** ± 1% of set point or ± 0.1% of full-rated output, whichever is greater • **HALO Option:** ≤ ± 1% of set point or 0.25 W, whichever is greater
Into 3:1 VSWR non-reactive load	± 3% of set point (load power regulation), over all load phase angles, or ± 0.25% of full-rated output, whichever is greater
Load regulation as a function of line regulation	Less than ± 0.25% change in output power for a ±10% change in AC line voltage
Load regulation as a function of temperature—(performance in accordance with the output power regulation accuracy)	
Ambient air temperature range	+5° C to +40° C i

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

Description	PIN Option and Specification
Cooling water temperature range	+5° C to +35° C
Spurious outputs— Referenced to the fundamental signal at full rated output when operated into a broadband 50Ω non-reactive load	
Harmonic related	- 40 dBc (up to the 3rd harmonic only)
Non-harmonic related	- 40 dBc
Warm up	Two minutes from AC on to RF ready/standby
RF on response time	< 10 ms (6.4 ms typical)
Turn-off/decay time	10 µs until output decays to 1% of maximum rated value.
Power repeatability	≤ 0.5% over time for same generator for set points > 500 W. 1% generator to generator as measured against AE calorimetric standard
Power cycles, standard options *Note:* Applies to units with options 0 through 5 in PIN position 6.	6 million cycles, 0 to full power into a matched load 360 kilocycles, 0 to full power into high dissipation load
Power cycles with DC heating option *Note:* DC heating option applies only to units with option 6 or 7 in PIN position 6.	30 million cycles, 0 to full power into a matched load 5 million cycles, 0 to full power into high dissipation load
Efficiency (line to load)	60%, typical at full-rated power, nominal line 50 Ω non-reactive load.
Power factor	> 0.96 typical at full rated power, nominal line 50 Ω non-reactive load.
Maximum leakage current	3.5 mA

Electrical Specifications for Apex Features

Table 3-4. *Electrical specifications for features*

Description	Specification
Master - Slave / CEX (The Apex generator automatically locks the RF output signal phase to the common exciter—CEX—input signal phase when the following conditions are met.)	
Phase relationship (RF output inphase with the CEX input signal)	0° ± 5°

Table 3-4. *Electrical specifications for features*

Description	Specification
CEX In	• Required signal amplitude range of +2 dBm to +10 dBm • Generator operating frequency 13.56 MHz ± 0.005% • Input impedance of 50 Ω, less than 1.5:1 VSWR
CEX Out	• Output signal amplitude range of +3 dBm to +7 dBm • Generator operating frequency 13.56 MHz ± 0.005% • Output impedance of 50 Ω, less than 1.5:1 VSWR
Pulsing	
Pulsed output amplitude	Peak "on" pulse amplitude controllable over a full output power range through set point setting. Output goes to 0 during off period.
Pulsed output amplitude Accuracy	The pulsed output amplitude accuracy specification is typical at 1Khz 50% duty cycle at full power output.
Overshoot	≤ 10% of average value at t_0 +2.5 µs
Average peak value	± 2.5% of set point measured at t_0 +2.5 µs
Ripple	≤ 1.0% of set point measured at t_0 +2.5 µs
Pulsed Output Timing	
Repetition rate	150 Hz to 50 KHz
Duty cycle	1% to 90%, 1% increments
Minimum pulse width (On Time)	10 µs
Rise/Fall time (10% to 90% of average peak)	≤ 200/2 µs
Pulsed output timing accuracy	0.1 microsecond edge uncertainty
Arc Handling	
Arc response time: Measured from the first viable indication of an arc using an external coupler to measure forward and reflected power until RF is turned off	5 µs

Table 3-4. *Electrical specifications for features*

Description	Specification
Arc shutdown time	2 µs to 511 µs, ± 2 µs *Note:* 0 = disabled
Arc initial RF-on delay: Time from RF ON to arc handling enabled	20 ms to 10 s, ± 10 µs
Arc set point delay: Time from > 10 W set point change to arc handling enabled	20 ms to 245 ms, ± 10 ms
Arc suppression attempts	0 to 250 attempts *Note:* 0 = infinite attempts
Ramping *Note:* Set point ramping is only available on Arc Detect options.	
Ramp rate maximum	60,000 W per second, ± 10%
Ramp rate minimum	1 W per second, ± 10%
Ramp time maximum	60,000 ms, ± 10%
Ramp time minimum	100 ms, ± 10%

COOLING SPECIFICATIONS

Table 3-5 describes the cooling specifications for the Apex generator.

WARNING:
Do not use de-ionized water for cooling purposes. De-ionized water causes both corrosion and erosion of cooling manifolds.

Table 3-5. *Cooling Specifications*

Description	Specification
Temperature	+35° C (+95° F) *Note:* Maximum water temperature at minimum flow rate and maximum ambient air temperature (+40° C).
Flow rate *Note:* Varies according to the option defined by PIN position 2.	For less than or equal to 3 kW: 7.6 1pm (2 gpm) For greater than 3 kW: 11.4 1pm (3 gpm)
Pressure	
Minimum pressure differential (supply to drain required to achieve specified minimum flow rates)	1.5 kW = 9 psi at 2 gpm (0.62 Bar at 7.5 lpm) 5 kW, 208 VAC = 18 psi at 4 gpm (1.24 Bar at 15.14 lpm) 5 kW, 400 VAC = 18 psi at 3 gpm (1.24 Bar at 11.35 lpm)
Maximum pressure rating	6.9 Bar (100 psi)
Heat removal	• For 1.5 kW, 3410 BTU/hour, 1000 W at full rated output power • For 3 kW, 6825 BTU/hour, 2000 W at full rated output power • For 5.5 kW, 12,500 BTU/hour, 3660 W at full rated RF output power
Contaminates	The following specifications are recommended for the water used to cool the Apex 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/cm or higher at 25° C • Total dissolved solids (TDS) as estimated by the following: $TDS \leq \frac{640{,}000}{\text{specific resistivity } (\Omega/\text{cm})}$

Graphical Representations of Flow Rate

The following graph shows how flow (gpm) lessens as the pressure (psi) drops.

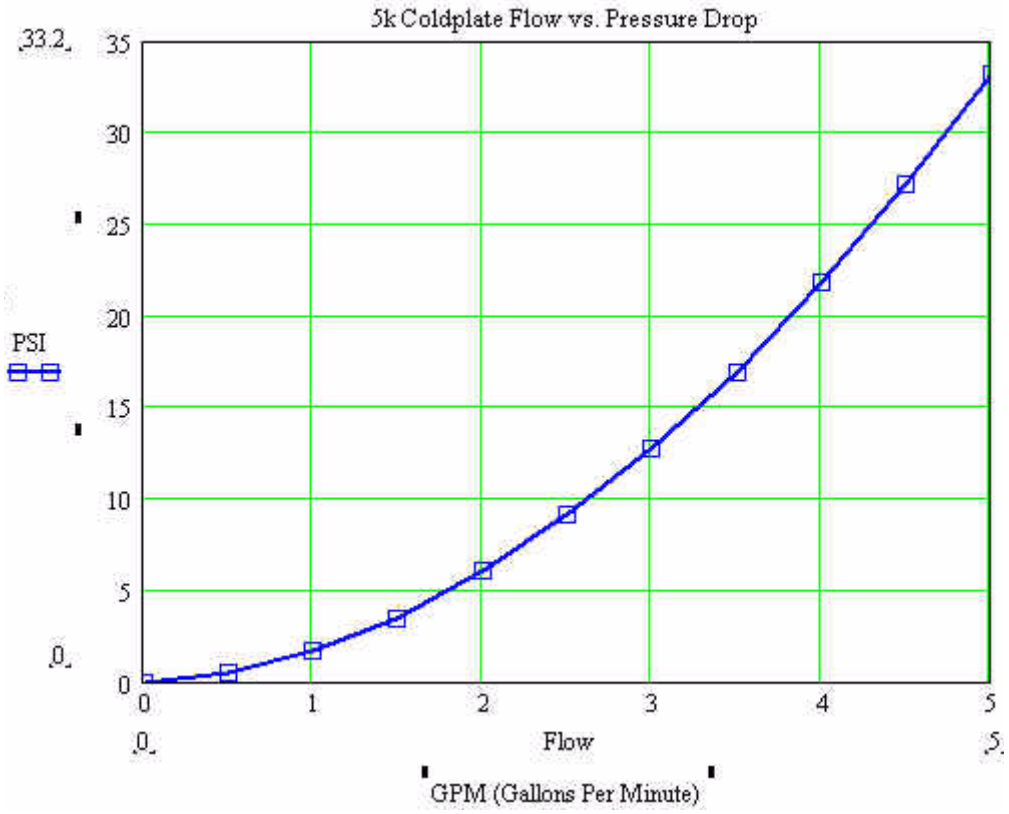


Figure 3-3. *Flow Rate vs. Pressure Drop*

ENVIRONMENTAL SPECIFICATIONS

Table 3-6 and Table 3-7 provide climatic and other environmental specifications for the Apex generator.

Table 3-6. *Climatic Specifications (per EN50178)*

	Temperature	Relative Humidity	Air Pressure
Operating	5°C to +40°C +41°F to +104°F	5% to 85%[1] +1 g/m^3 to +25 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562 ft to -1640 ft)
Storage	-25°C to +55°C -13°F to +131°F	5% to 95% +1 g/m^3 to +29 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562 ft to -1640 ft)
Transportation	-25°C to +70°C -13°F to +158°F	95%[2] +60 g/m^3	65.6 kPa to 106 kPa 656 mbar to 1060 mbar Equivalent altitude: 3500 m to -500 m (11480 ft to -1640 ft)

[1] Non-condensing, no formation of ice

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

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

Table 3-7 shows other environmental specifications for the Apex generator.

Table 3-7. *Environmental Specifications*

Description	Specification
Overvoltage	Category II
Pollution Degree	2

Communication Interfaces and Indicators

This chapter contains information on the Apex™ communication interfaces and status indicators (LEDs). It also contains representative drawings of the front and rear panels of the unit. The chapter is divided up into sections as follows.

- The first section of the chapter, "Apex Status Indicators (LEDs)" on page 4-2, contains information on interpreting the LED indicators that appear on some Apex units.
- The second section of the chapter, "Apex User Port Options" on page 4-4, contains a subsection for each of the User port options available with the Apex 500 W to 5.5 kW generator. These subsections are:
  - "25-Pin Apex Standard User Port" on page 4-4
  - "15-Pin User Port (Exclusive—Option D)" on page 4-19
  - "15-Pin User Port (Exclusive—Option E)" on page 4-30
  - "25-Pin User Port (Exclusive—Option K)" on page 4-42
  - "25-Pin/15-Pin User Ports (Exclusive—Option R)" on page 4-52
- The third section of the chapter, "Apex Host Port Options" on page 4-69, contains a subsection for each of the serial Host port options available with the Apex 500 W to 5.5 kW generator. These subsections are:
  - "Host Port—RS-232 With AE Bus" on page 4-69
  - "Host Port—Profibus" on page 4-96
  - "Host Port—DeviceNet" on page 4-123
- The final section of the chapter, "Apex Panel Illustrations" on page 3-8, provides illustrations of Apex front and rear panels.

Not all of these sections apply to any one Apex unit. To identify the sections that apply to your unit, see "Using this Manual to Find Information About Your Generator" on page 1-1. Each of the option-specific sections of this chapter also contain PIN configuration notes, which help you confirm whether or not a particular section applies to your unit.

APEX STATUS INDICATORS (LEDS)

Some Apex generators provide the following status indicators on the front or rear panel. For panel illustrations, see "Apex Panel Illustrations" on page 3-8.

Configuration Note

This section of the manual provides information for the:
Passive digital display option
PIN position 5, (A 1 2 3 4 **5** 6 7 8 9 10 11 12 13 14 15 16 17) **option 2**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

Table 4-1. *LED Status Indicators*

Indicator	Description
AC ON	When lit, this green LED indicates that AC power is available within the generator and all three phases are present.
RF ON	When lit, this green LED indicates that RF power is on (enabled). Depending on the selected set point value, RF power may or may not be present at the output connector. A flashing LED indicates an error. See "Troubleshooting Checklist" on page 6-1
INTERLOCK	When lit, this green LED indicates that the required interlock criteria have been satisfied. The interlock must be satisfied before the output can be enabled. The LED remains on as long as the interlock loop is satisfied. If you suspect an error and this LED is off, see "Troubleshooting Checklist" on page 6-1.
POWER LIMIT	When lit, this yellow LED indicates that the generator is unable to supply the requested power level due to a limiting condition in the generator. Power limits do not disable the RF output of the generator. If you suspect an error and this LED is lit, see "Troubleshooting Checklist" on page 6-1.

Table 4-1. *LED Status Indicators (Continued)*

Indicator	Description
OVERTEMP	A flashing yellow LED warns that the internal cold plate temperature is approaching the shutdown limit. A continuously lit LED indicates that the internal cold plate temperature has exceeded the allowable limit. When this condition occurs, the RF turns off and can be turned back on only after the temperature drops below the warning temperature limit and a RF Off command is given to clear the fault. See "Troubleshooting Checklist" on page 6-1 for more information.
ALARM	When lit, this yellow LED indicates that the generator has turned off RF output due to some limit or alarm condition in the generator. Some of the conditions that can cause an alarm are: • Over-temperature • Exceeded internal protection limits • AC PWR outside the limits In the event of an alarm condition, after correcting the fault condition, an RF OFF signal has to be given to reset the generator since the generator has turned off RF output. See "Troubleshooting Checklist" on page 6-1 for more information.

APEX USER PORT OPTIONS

The following sections provide information for each of the User port options available with the 500 W to 5.5 kW Apex generator. These options are:

Not all of these sections apply to any one Apex unit. To identify the section that applies to your unit, see "Using this Manual to Find Information About Your Generator" on page 1-1. Each of these sections also contains a PIN configuration note, which will help you confirm whether or not a particular section applies to your unit.

25-Pin Apex Standard User Port

The following section describes the Apex standard 25-pin User port. To determine if your Apex unit has this interface, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Apex standard 25-pin User port option
PIN position 8, (A 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 16 17) **option B**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

This User port is the standard option.

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

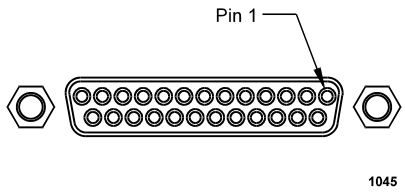


Figure 4-1. *User port connector, 25-pin, APEX standard*

Unless otherwise specified, all analog signals are 0 V to 10 V while all digital signals are 5 V to 24 V, opto-coupled (open-collector signals with return lines non-referenced to ground).

Ground/Return lines are floating and need to be connected as close to the system as possible.

SATISFYING MINIMAL REQUIREMENTS FOR THE STANDARD 25-PIN USER PORT

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

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the Host port, for example) before powering up the unit. The control mode can be set through a Host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder three jumpers on a mating connector: one between pins 4 and 13 to satisfy the *RF PWR ON* signal, one between pins 10 and 23 to satisfy the *INTERLOCK LOOP* signal, and one between pins 17 and 21 to connect *RF ON RETURN* and *GROUND*. To determine the physical location of these pin numbers on the User port, see "User port 25-pin APEX standard pin descriptions" on page 4-6.

If desired, you can add an emergency off switch in series with the *RF PWR ON* signal (pin 4) and/or tie your system interlocks in series with the generator *INTERLOCK LOOP* signal (pins 10 and 23) by following the connections for those pins described in "Pin Descriptions for the 25-Pin User Port" on page 4-6 and "Wiring Diagrams for the Standard 25-Pin User Port" on page 4-13.

INTERFACE CABLING REQUIREMENTS FOR 25-PIN USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

PIN DESCRIPTIONS FOR THE 25-PIN USER PORT

Table 4-1 provides the connector pin descriptions for this User port interface. The pin numbers are arranged in signal pairs.

Table 4-2. *User port 25-pin APEX standard pin descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1		*SET POINT STATUS RETURN*	Digital Output	See signal pin 14
2	15	*RFL PWR MONITOR*	Analog output	This signal provides a linearly scaled read back of reflected power. 0 to 10 V = 0 to maximum rated power output as defined by the configuration PIN in position 2 in Table 1-1 on page 1-5. See "RFL PWR monitor (pins 2 and 15)" on page 4-13. Pin 15 must be grounded.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
3	16	*FWD/LOAD PWR MONITOR*	Analog output	This signal provides a linearly scaled read back of forward power when the generator is operated in forward power regulation mode or the load power when operated in the load power regulation mode. 0 to 10 V = 0 to maximum rated power output as defined by the configuration PIN position 2 in Table 1-1 on page 1-5. See "Forward/Load power monitor (pins 3 and 16)" on page 4-13 for wiring diagram. Pin 16 must be grounded
4	17	*RF PWR ON*	Digital input	When a positive voltage between 4 and 30 V is applied to this pin RF output is enabled. Once the output is ON, a voltage of 1.5 VDC or less disables the RF output. See "RF Power On (pins 4 and 17)" on page 4-15 for the wiring diagram. *Note:* The interlocks must be satisfied and the set point must be within the output power range before unit will deliver power. See "Output Electrical Specifications" on page 3-12 for the output power range specification.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
5	18	*SET POINT*	Analog input	This pin linearly controls the RF output of the generator. 0 to 10 V = 0 to maximum rated power output as defined by the configuration PIN in position 2 in "Apex PIN Positions and Associated Options" on page 1-5. See "Set point (pins 5 and 18)" on page 4-14 for the wiring diagram. *Note:* set point must be greater than 1% of full rated output before unit will deliver power.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
6	19	*DC BIAS/POWER REGULATION*	Digital input	This pin is used in conjunction with signal pin 7 to allow the generator to regulate its power based on an external feedback signal. When a positive voltage between 4 and 30 V is connected to this pin (reference to ground pin 19), the generator regulates on the input voltage signal on pin 7 (DC BIAS INPUT). When using this regulation feature, the set point must be given at pin 5 (SET POINT). Set points cannot be established through the serial interface in this regulation mode. 0 to 10 V = 0 to maximum rated power output as defined by the configuration PIN in position 2 in “Apex PIN Positions and Associated Options” on page 1-5. See “DC Bias/Power Regulation (pins 6 and 19)” on page 4-15 for the wiring diagram.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
7	20	*DC BIAS INPUT*	Analog input	This pin is used in conjunction with signal pin 6 to allow the generator to regulate its power based on an external feedback signal. This User defined 0 to 10 V signal provides an input which you can use for closing the power control loop around external components in the RF path. Usually used for bias regulation with this input signal being a scaled representation of the dc bias measured at match network. See "DC Bias Input (pins 7 and 20)" on page 4-14 for the wiring diagram. *Note:* When using this regulation feature, the set point must be given at pin 5 (SET POINT). set points cannot be established through the serial interface at this time.
8	21	*FWD/LOAD PWR REGULATION*	Digital input	Applying a positive DC voltage between 4 and 30 V to this pin causes the generator to regulate on load power. No connection to this pin causes the generator to default to forward power regulation. See "FWD/Load Power Regulation (pins 8 and 21)" on page 4-16 for the wiring diagram.
9		*OVERTEMP RETURN*	Digital Output	See pin 22.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
10	23	*INTERLOCK LOOP*		This pin when connected externally to pin 23 closes the interlock and allows the RF output to be enabled. See "Interlock Loop (pins 10 and 23)" on page 4-18 for the wiring diagram.
11		*DC BUS OK RETURN*	Digital Output	See pin 24.
12	25	*CEX LOCK*	Digital output	When the generator is successfully phase-locked to an external oscillator, a low (opto-coupler output) impedance is created between this pin and return pin 25 (6 mA maximum). See "CEX Lock (pins 12 and 25)" on page 4-18 for the wiring diagram.
13	21	*+15 VDC*	Analog output	This pin, referenced to ground, provides a +15 VDC ± 1V auxiliary supply for external use. 100 mA maximum. See "+15 VDC (pins 13 and 21)" on page 4-19 for the wiring diagram.
14	1	*SET POINT STATUS*	Digital output	When the generator is out of set point, a low (opto-coupler output) impedance is created between this pin and pin 1 (6 mA maximum). See "Set point Status (pins 14 and 1)" on page 4-16 for the wiring diagram.
15		*RFL POWER MONITOR RETURN*	Analog output	See pin 2.
16		*FWD/LOAD PWR MONITOR RETURN*	Analog output	See pin 3.
17		*RF PWR ON RETURN*	Digital input	See pin 4.

Table 4-2. *User port 25-pin APEX standard pin descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
18		*SET POINT RETURN*	Analog input	See pin 5.
19		*DC GROUND*	Chassis ground	This pin represents DC ground connection common to chassis ground.
20		*DC BIAS INPUT RETURN*	Analog input	See pin 7.
21		*CHASSIS GROUND*	Chassis ground	Chassis ground connection common to DC ground.
22	9	*OVERTEMP*	Digital output	When an internal overtemperature shutdown condition is detected, a low (opto-coupler output) impedance is created between this pin and pin 9 (6 mA maximum). See "Overtemp (pins 22 and 9)" on page 4-17 for the wiring diagram. *Note:* This pin only detects a overtemp shutdown condition. The warning indication described in the Overtemp LED section is not reported on this pin.
23	10	*INTERLOCK LOOP RETURN*		See pin 10.
24	11	*DC BUS OK*	Digital output	When the interlocks are satisfied and the AC input voltage is within its specification, a low (opto-coupler output) impedance is created between this pin and pin 11 (6 mA maximum). See "DC Bus OK (pins 24 and 11)" on page 4-17 for the wiring diagram.
25		*CEX LOCK RETURN*	Digital Output	See pin 12.

WIRING DIAGRAMS FOR THE STANDARD 25-PIN USER PORT

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

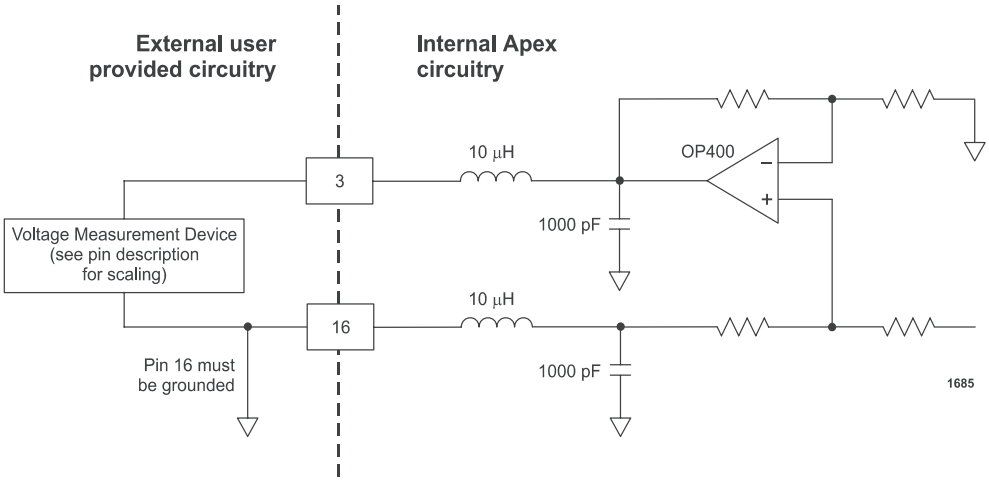


Figure 4-2. *Forward/Load power monitor (pins 3 and 16)*

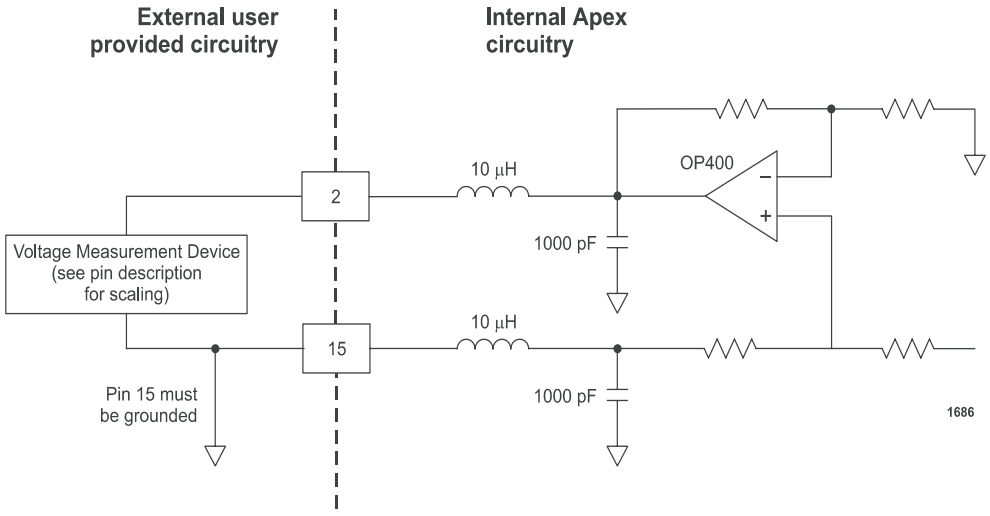


Figure 4-3. *RFL PWR monitor (pins 2 and 15)*

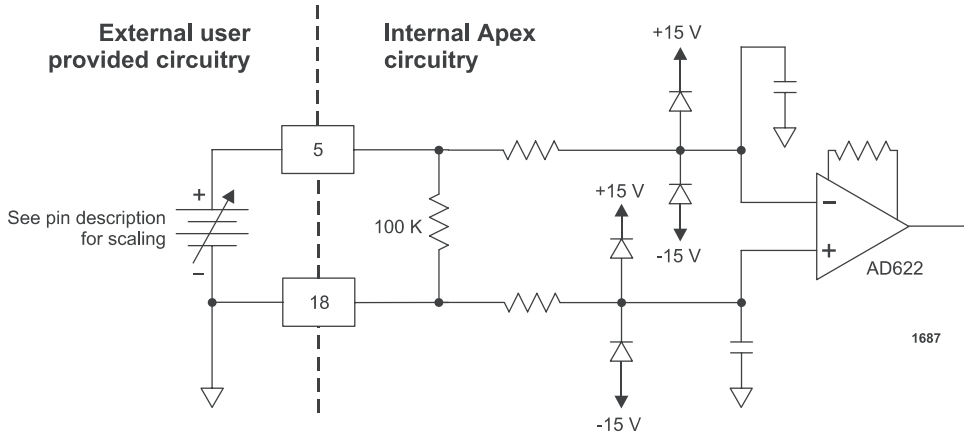


Figure 4-4. *Set point (pins 5 and 18)*

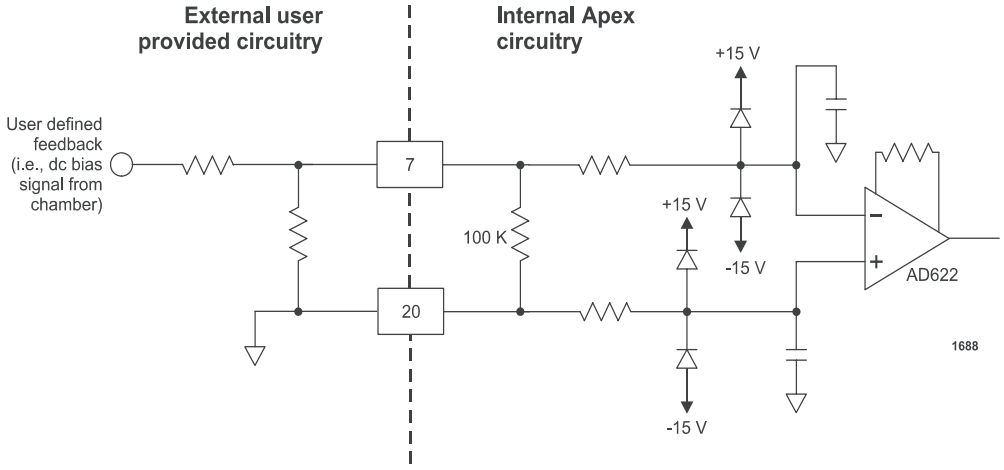


Figure 4-5. *DC Bias Input (pins 7 and 20)*

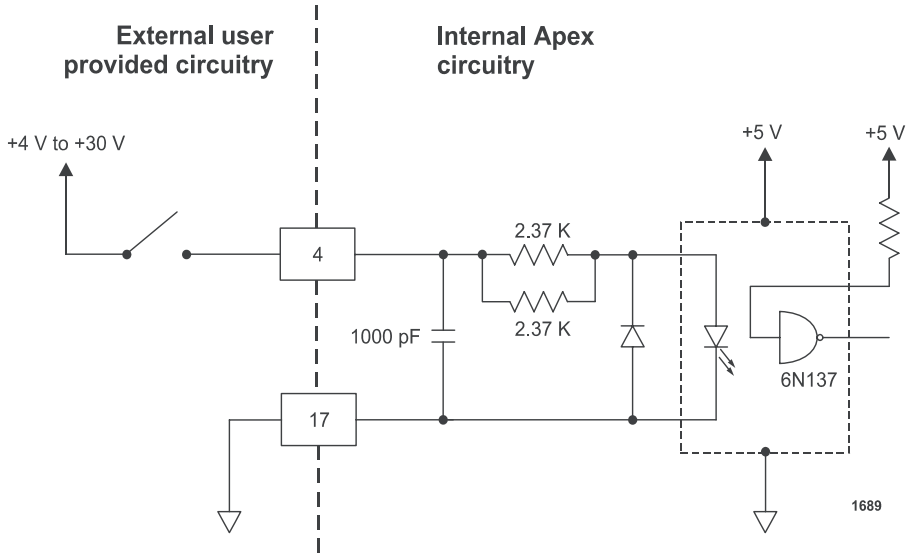


Figure 4-6. *RF Power On (pins 4 and 17)*

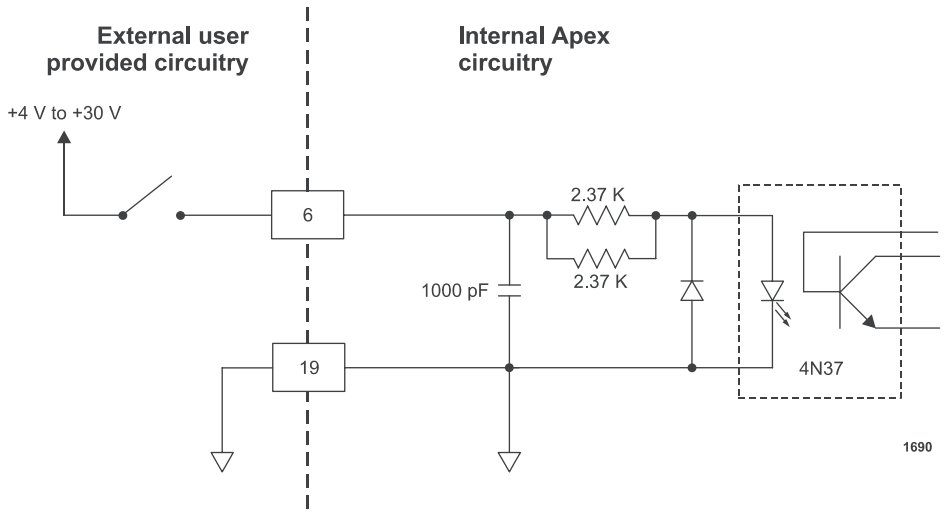


Figure 4-7. *DC Bias/Power Regulation (pins 6 and 19)*

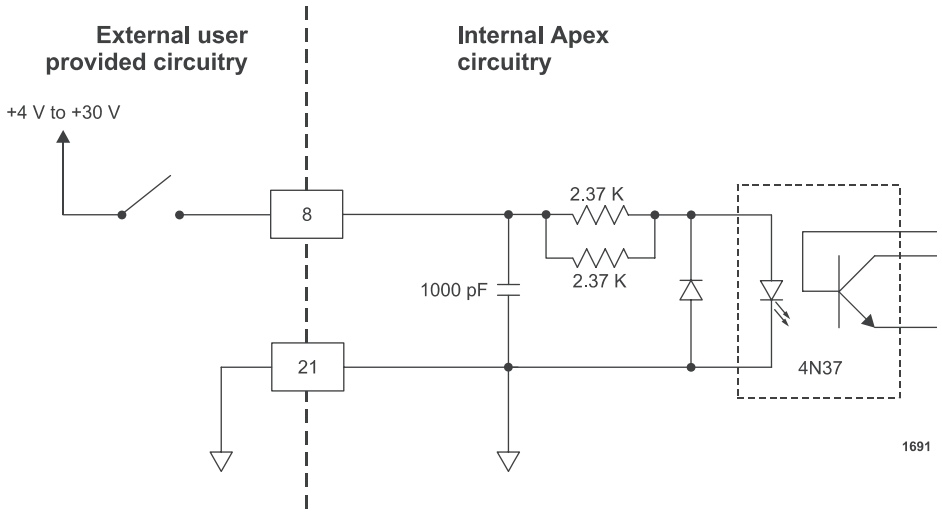


Figure 4-8. *FWD/Load Power Regulation (pins 8 and 21)*

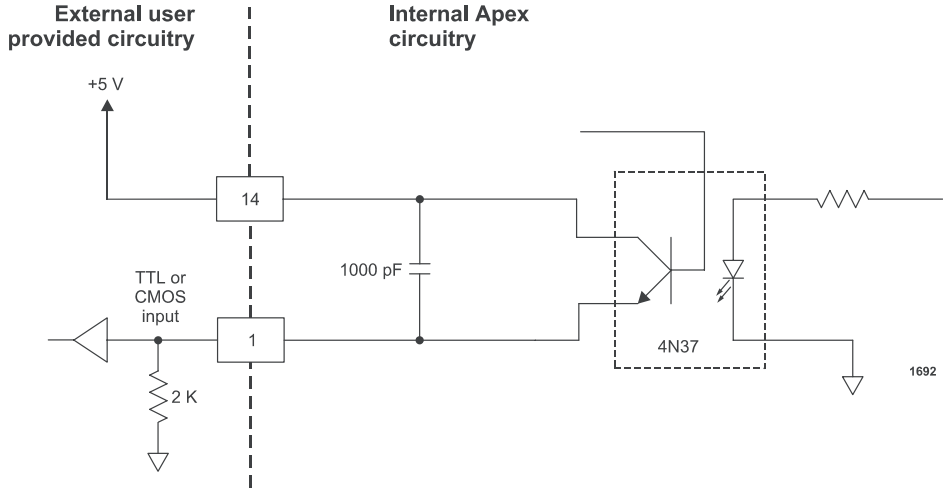


Figure 4-9. *Set point Status (pins 14 and 1)*

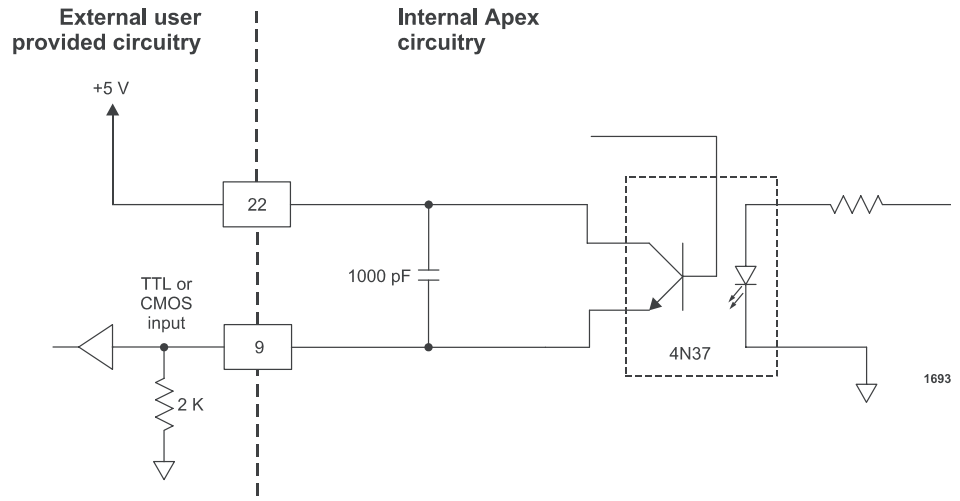


Figure 4-10. *Overtemp (pins 22 and 9)*

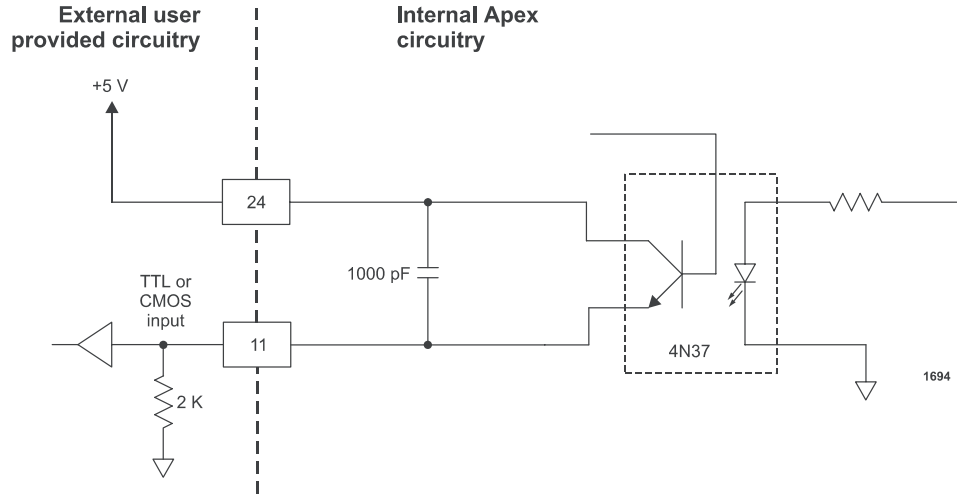


Figure 4-11. *DC Bus OK (pins 24 and 11)*

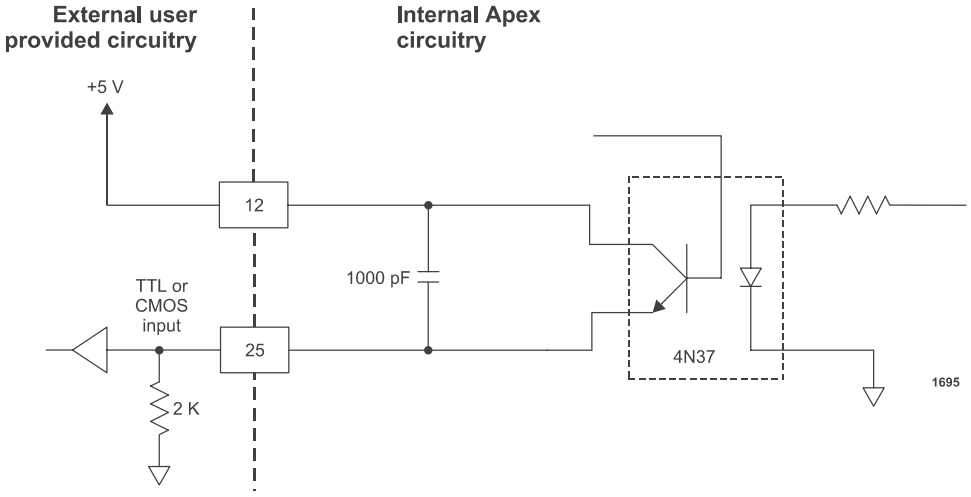


Figure 4-12. *CEX Lock (pins 12 and 25)*

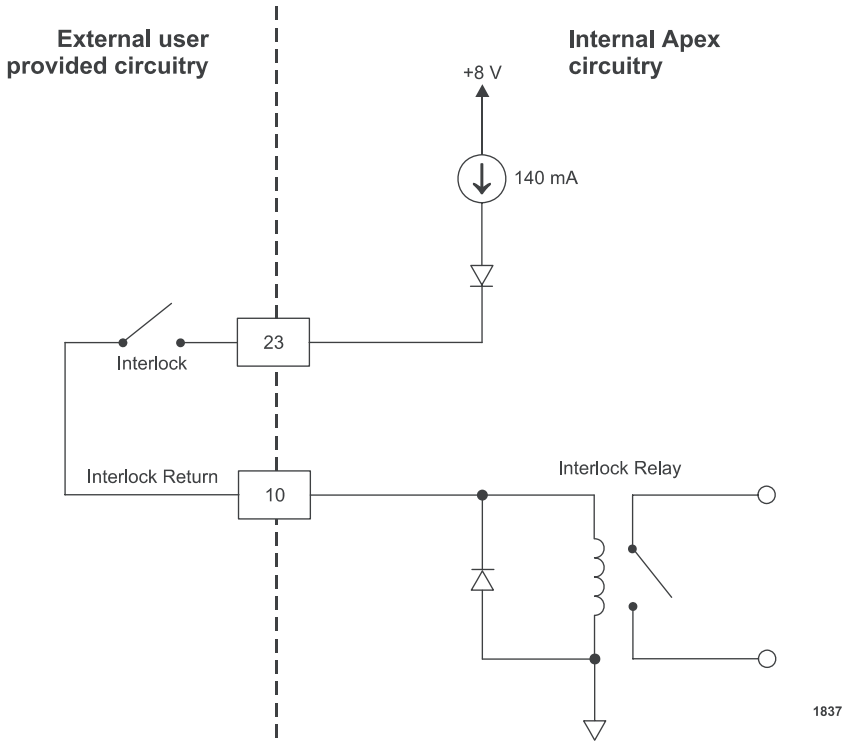


Figure 4-13. *Interlock Loop (pins 10 and 23)*

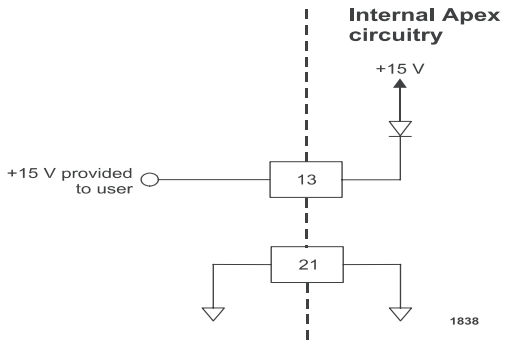


Figure 4-14. *+15 VDC (pins 13 and 21)*

15-Pin User Port (Exclusive—Option D)

To determine if your Apex unit has this interface, use the configuration PIN from your Apex unit and the following Configuration Note. The diagrams in this section provide wiring information to properly connect to the Apex option D 15-pin User port.

Configuration Note

This section of the manual provides information for the:
Apex 15-pin User port, option D
PIN position 8, (A 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 16 17) **option D**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

This 15-pin User port option offers only basic control and monitoring capability.

The User port uses a 15-pin, shielded, female, subminiature-D connector.

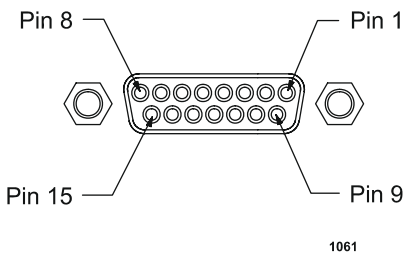


Figure 4-15. *15-Pin User port connector, option D*

SATISFYING MINIMAL REQUIREMENTS FOR OPTION D 15-PIN USER PORT

Regardless of whether you are controlling and monitoring the generator through the User port or through another port, two User port signals *must* be satisfied for the Apex unit to be operational: *RF POWER ENABLE* (pins 4 and 9) and *INTERLOCK* (pins 11 and 6). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled and the interlock satisfied.

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the Host port, for example) before powering up the unit. The control mode can be set through a Host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder two jumpers on a mating connector: one between pins 4 and 9 to satisfy the *RF POWER ENABLE* signal and one between pins 11 and 6 to satisfy the *INTERLOCK* signal. To determine the physical location of these pin numbers on the User port, see "15-Pin User port connector, option D" on page 4-20.

If desired, you can add an emergency off switch in series with the *RF POWER ENABLE* signal (pins 4 and 9) or tie your system interlocks in series with the generator *INTERLOCK* signal (pins 11 and 6) by following the connections for those pins described in "User Port (15-pin) Connector Pins for Option D" on page 4-21 and "Wiring Diagrams for Option D 15-Pin User Port" on page 4-24.

INTERFACE CABLING REQUIREMENTS FOR OPTION D USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded, 15-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical

equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

Unless otherwise specified, all analog signals are 0 to 10 V while all digital signals are 0 to 5 V.

PIN DESCRIPTIONS FOR OPTION D USER PORT

Table 4-2 provides the connector pin descriptions for the User port interface.

Table 4-3. *User Port (15-pin) Connector Pins for Option D*

Signal Pin	Return Pin	Name	Signal Type	Description
1	6	*POWER LIMIT STATUS*	Digital output	When a + 5 V signal is present at this pin, a power limit is encountered; signal low represents normal operation. See "Power limit status (pins 1 and 6)" on page 4-27 for the wiring diagram.
2	6	*REFLECTED POWER MONITOR*	Analog output	This analog signal provides a linearly scaled readback of the reflected power (1 V per 1 kW reflected power). See "Reflected power monitor (pins 2 and 6)" on page 4-25 for the wiring diagram.
3	6	*FORWARD/LOAD POWER MONITOR*	Analog output	This analog signal provides a linearly scaled readback of the forward power (when the generator is operated in forward power regulation mode) or the load power (when operated in load power regulation mode). (1 V per 1 kW forward/load power). See "Forward/load power monitor (pins 3 and 6)" on page 4-24 for the wiring diagram.

Table 4-3. *User Port (15-pin) Connector Pins for Option D (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
4	6	*RF POWER ENABLE*	Digital input	RF output is enabled when a 4 V to 30 V input (pin 9, RF ON BIAS, can be used as a voltage source) is present on this pin. *Note:* The interlocks must be satisfied and the set point must be within the output power range before unit will deliver power. See "Output Electrical Specifications" on page 3-12 for the output power range specification. See "RF power enable (pins 4 and 6)" on page 4-26 for the wiring diagram.
5	6	*FORWARD/LOAD POWER SET POINT*	Analog input	This analog signal provides a linearly scaled control of the forward or load output power depending on the regulation mode (1 V per 1 kW output power). See "Forward/load power set point (pins 5 and 6)" on page 4-25 for the wiring diagram. *Note:* The interlocks must be satisfied and the set point must be within the Output power range before unit will deliver power. See "Output Electrical Specifications" on page 3-12 for the Output power range specification.
6		*SIGNAL COMMON*	Chassis ground	This pin is signal common. Also connected to Apex generator chassis ground.

Table 4-3. *User Port (15-pin) Connector Pins for Option D (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
7	6	*RF ON STATUS*	Digital output	+ 5 VDC on this pin represents RF ON. See "RF on status (pins 7 and 6)" on page 4-26 for the wiring diagram.
8	6	*EXTERNAL BIAS*	Voltage reference	+ 15 VDC provided to the User port through a 5.62 kΩ resistor. See "External bias (pins 8 and 6)" on page 4-27 for the wiring diagram.
9	6	*RF ON BIAS*	Voltage reference	+15 VDC provided to the User port through a 1.1 kΩ resistor. It can be used for a switch or relay contact closure to enable RF ON (pin 4). See "RF on bias (pins 9 and 6)" on page 4-28 for the wiring diagram.
10		*UNASSIGNED*		
11	6	*INTERLOCK*	Analog Input	Connect pins 11 and 6 to close the interlock and allow RF output to be enabled. See "Interlock (pins 11 and 6)" on page 4-29 for the wiring diagram.
12	6	*RESERVED for PULSING ENABLE*	Digital Input	This pin is currently reserved for future use. *Note:* Pulsing parameters are set via the digital/serial interface.

Table 4-3. *User Port (15-pin) Connector Pins for Option D (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
13	6	*FWD/LOAD POWER REGULATION*	Digital Input	Load power regulation is enabled when a 4 V to 30 V input is present on this pin. *Note:* Forward power regulation is the default. See "FWD/LOAD power regulation (pins 13 and 6)" on page 4-28 for the wiring diagram.
14		*UNASSIGNED*		
15		*UNASSIGNED*		

WIRING DIAGRAMS FOR OPTION D 15-PIN USER PORT

The diagrams in this section provide wiring information to properly connect to the Apex 15-pin configuration D User port.

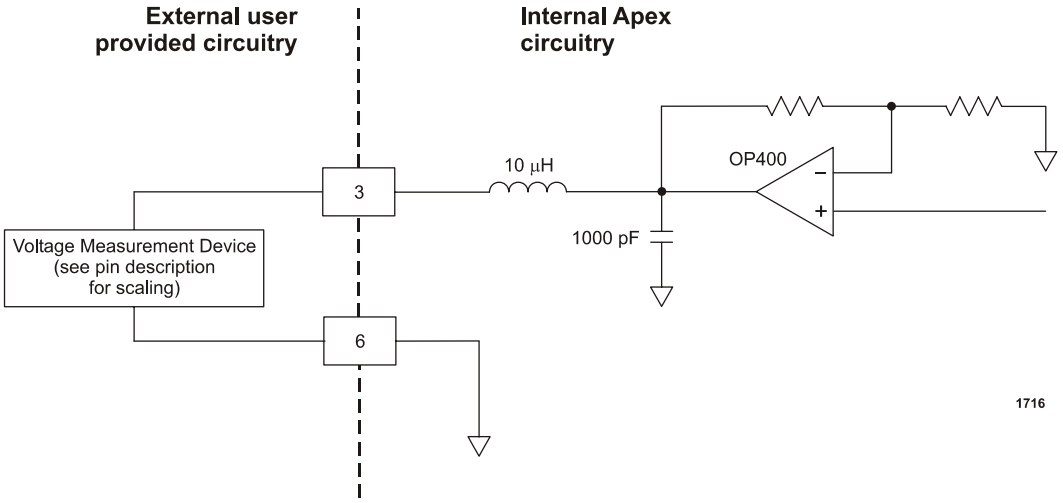


Figure 4-16. *Forward/load power monitor (pins 3 and 6)*

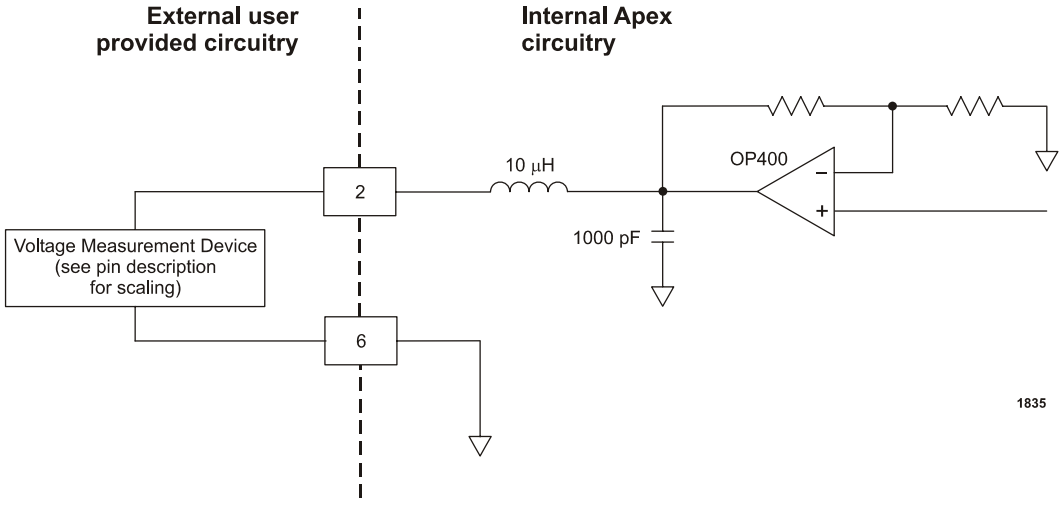


Figure 4-17. *Reflected power monitor (pins 2 and 6)*

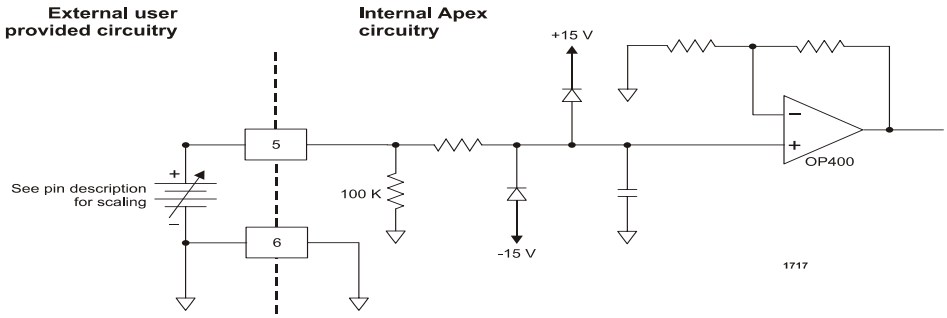


Figure 4-18. *Forward/load power set point (pins 5 and 6)*

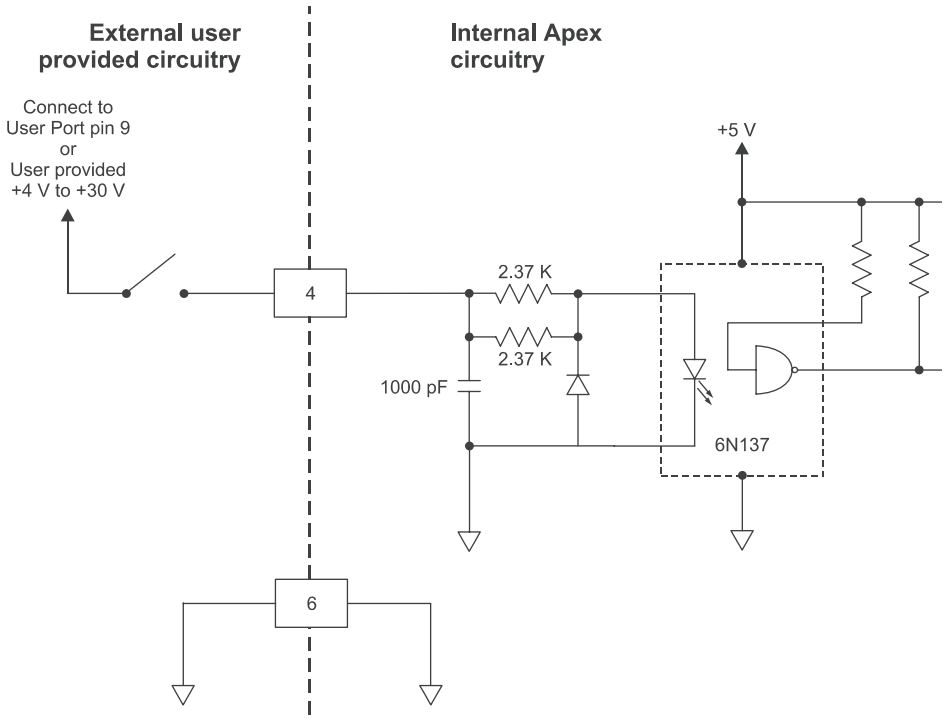


Figure 4-19. *RF power enable (pins 4 and 6)*

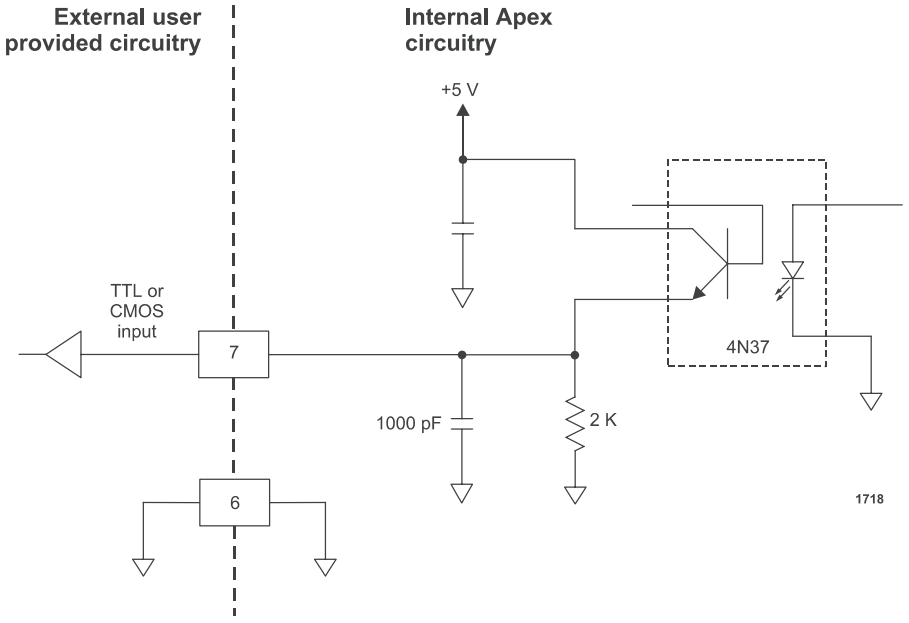


Figure 4-20. *RF on status (pins 7 and 6)*

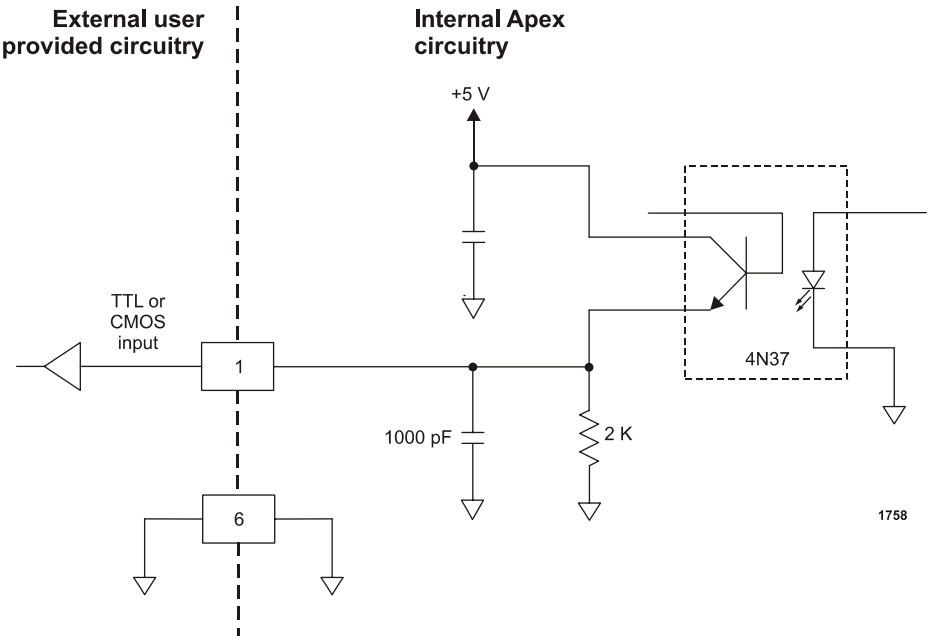


Figure 4-21. *Power limit status (pins 1 and 6)*

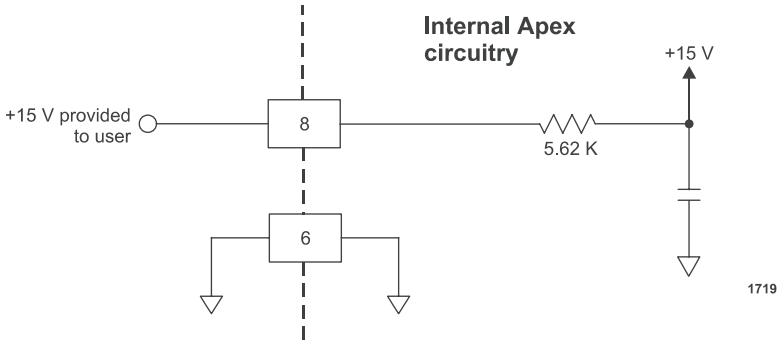


Figure 4-22. *External bias (pins 8 and 6)*

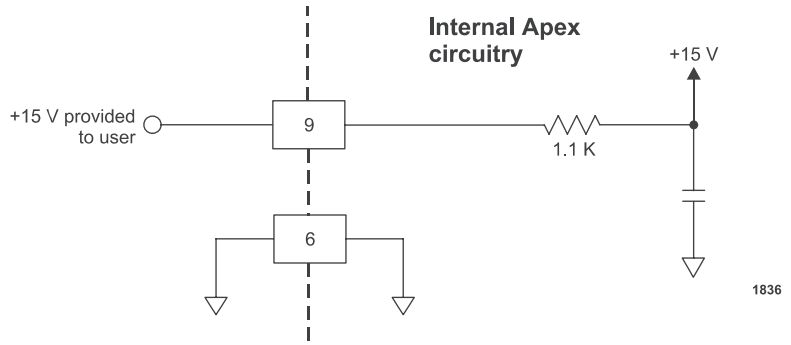


Figure 4-23. *RF on bias (pins 9 and 6)*

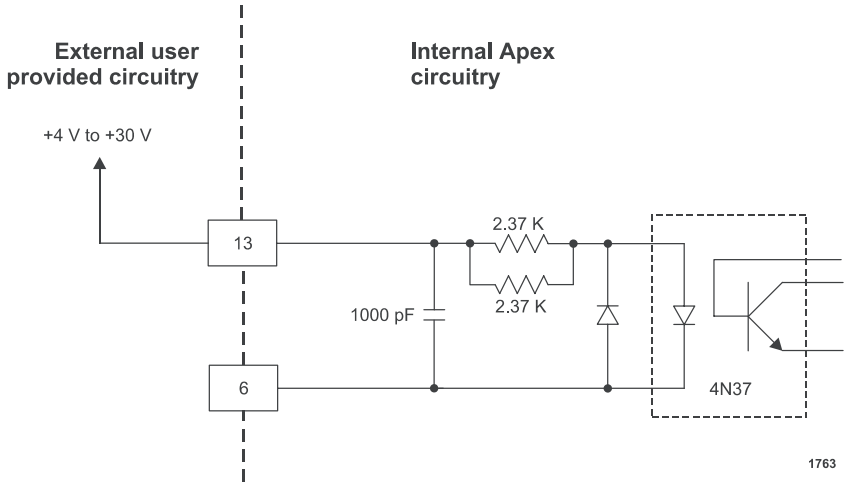


Figure 4-24. *FWD/LOAD power regulation (pins 13 and 6)*

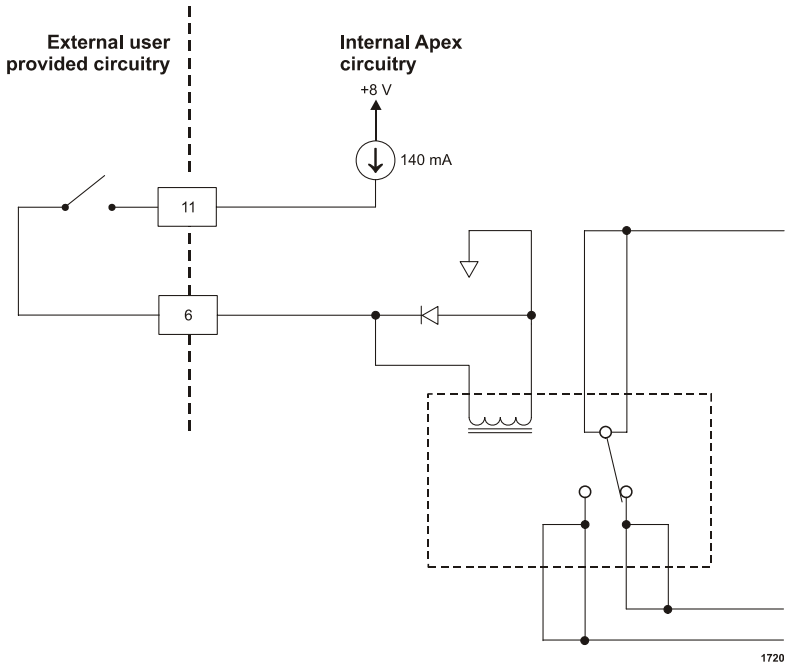


Figure 4-25. *Interlock (pins 11 and 6)*

15-Pin User Port (Exclusive—Option E)

The following section describes the Apex 15-pin User port (configuration E). To determine if your Apex unit has this interface, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Apex 15-pin User port (configuration E) option
PIN position 8, (A 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 16 17) **option E**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

The User port uses a 15-pin, shielded, female, subminiature-D connector.

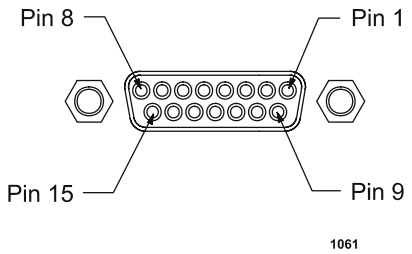


Figure 4-26. *User Port connector 15 pin, option E*

This 15-pin User port option offers only basic control and monitoring capability.

Unless otherwise specified, all analog signals are 0 to 10 V, while all digital signals are 0 to 15 V.

SATISFYING MINIMAL REQUIREMENTS FOR OPTION E 15-PIN USER PORT

Regardless of whether you are controlling and monitoring the generator through the User port or through another port, two User port signals *must* be satisfied for the Apex unit to be operational: *RF POWER ENABLE* (pins 4 and 9) and *INTERLOCK* (pins 11 and 12). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled and the interlock satisfied.

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the Host port, for example) before powering up the unit. The control mode can be set through a Host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder two jumpers on a mating connector: one between pins 4 and 9 to satisfy the *RF POWER ENABLE* signal and one between pins 11 and 12 to satisfy the *INTERLOCK* signal. To determine the physical location of these pin numbers on the User port, see "User Port connector 15 pin, option E" on page 4-30.

If desired, you can add an emergency off switch in series with the *RF POWER ENABLE* signal (pins 4 and 9) or tie your system interlocks in series with the generator *INTERLOCK* signal (pins 11 and 12) by following the connections for those pins described in "Pin Descriptions for Option E User Port" on page 4-31 and "Wiring Diagrams for Option E User Port" on page 4-37.

INTERFACE CABLING REQUIREMENTS FOR OPTION E USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded, 15-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

PIN DESCRIPTIONS FOR OPTION E USER PORT

Table 4-3 provides the connector pin information for the User port interface.

Table 4-4. *User port (15-pin) connector pins, option E*

Signal Pin	Return Pin	Name	Signal Type	Description
1	10, 13, 14, 15	*+24V (User Provided)*	Voltage Input	+ 24 V provided by user for devicenet LEDs, used for DeviceNet isolation. See "DeviceNet LEDs (pins 1,10,13,14 and 15)" on page 4-38 for the wiring diagram.
2	6	*REFLECTED POWER MONITOR*	Analog output	This analog signal provides a linearly scaled readback of reflected power. 0 V to 10 V = 0 to maximum rated power output as defined by the configuration PIN in position 2 in "Apex PIN Positions and Associated Options" on page 1-5. See "Reflected power monitor (pins 2 and 6)" on page 4-38 for the wiring diagram.

Table 4-4. *User port (15-pin) connector pins, option E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
3	6	*FORWARD / LOAD POWER MONITOR*	Analog output	This analog signal provides a linearly scaled readback of the forward power (when the generator is operated in forward power regulation mode) or the load power (when operated in load power regulation mode). 0 V to 10 V = 0 to maximum rated power output as defined by configuration PIN in position 3 in "Apex PIN Positions and Associated Options" on page 1-5. See "Forward/load power monitor (pins 3 and 6)" on page 4-39 for the wiring diagram.
4	6	*RF POWER ENABLE*	Digital input	A 4 to 30 V input (pin 9, RF ON BIAS, can be used as a voltage source) on this pin enables RF output. See "RF power enable (pin 4 and 6)" on page 4-39 for the wiring diagram. The interlocks must be satisfied and the set point must be within the output power range before unit will deliver power. See "Output Electrical Specifications" on page 3-12 for the output power range specification.

Table 4-4. *User port (15-pin) connector pins, option E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
5	6	*FORWARD / LOAD POWER SET POINT*	Analog input	This analog signal provides a linearly scaled control of the forward or load output power depending on the regulation mode. 0 V to 10 V = 0 to maximum rated power output as defined by the configuration PIN in position 2 in "Apex PIN Positions and Associated Options" on page 1-5. See "Forward/load power set point (pins 5 and 6)" on page 4-40 for the wiring diagram. *Note:* The interlocks must be satisfied and the set point must be within the output power range before unit will deliver power. See "Output Electrical Specifications" on page 3-12 for the output power range specification.
6		*SIGNAL COMMON*	Chassis ground	Common for signal pins 2, 3, and 5. Connected to the Apex generator chassis ground.

Table 4-4. *User port (15-pin) connector pins, option E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
7	8	*RF ON STATUS*	Digital output	When an RF ON STATUS condition is detected, a low (opto-coupler output) impedance is created between this pin and pin 8 (6 mA maximum). See "RF on status (pins 7 and 6)" on page 4-26 for the wiring diagram.
8	7	*RF ON STATUS RETURN*	Digital output	See pin 7.
9		*+15 VDC*	Voltage reference	+ 15 VDC provided to the User port through a 1.1 kΩ resistor. Can be used for a switch or relay contact closure to enable RF ON (pin 4). See "+15 VDC (pins 9 and 6)" on page 4-41 for the wiring diagram.
10		*MODULE STATUS LED OUTPUT (GREEN)*	Digital output	This pin provides the output for remote DeviceNet LED and is connected to the emitter of an opto-coupler. The user must limit the current draw through this pin to 45 mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See "DeviceNet LEDs (pins 1,10,13,14 and 15)" on page 4-38 for the wiring diagram.

Table 4-4. *User port (15-pin) connector pins, option E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
11	12	*INTERLOCK*		When connected externally, these pins close the interlock and allow RF output to be enabled. See "Interlock (pins 11 and 12)" on page 4-41 for the wiring diagram.
12		*INTERLOCK RETURN*		See pin 11
13		*NETWORK STATUS LED OUTPUT (GREEN)*	Digital output	This pin provides the output for remote DeviceNet LED and is connected to the emitter of an opto-coupler. The user must limit the current draw through this pin to 45 mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See "DeviceNet LEDs (pins 1,10,13,14 and 15)" on page 4-38 for the wiring diagram.

Table 4-4. *User port (15-pin) connector pins, option E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
14		*MODULE STATUS LED OUTPUT (AMBER)*	Digital output	This pin provides the output for remote DeviceNet LED and is connected to the emitter of an opto-coupler. The user must limit the current draw through this pin to 45 mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See "DeviceNet LEDs (pins 1,10,13,14 and 15)" on page 4-38 for the wiring diagram.
15		*NETWORK STATUS LED OUTPUT (AMBER)*	Digital output	This pin provides the output for remote DeviceNet LED and is connected to the emitter of an opto-coupler. The User must limit the current draw through this pin to 45 mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See "DeviceNet LEDs (pins 1,10,13,14 and 15)" on page 4-38 for the wiring diagram.

WIRING DIAGRAMS FOR OPTION E USER PORT

The diagrams in this section provide wiring information to properly connect to the Apex 15-pin User port configuration E.

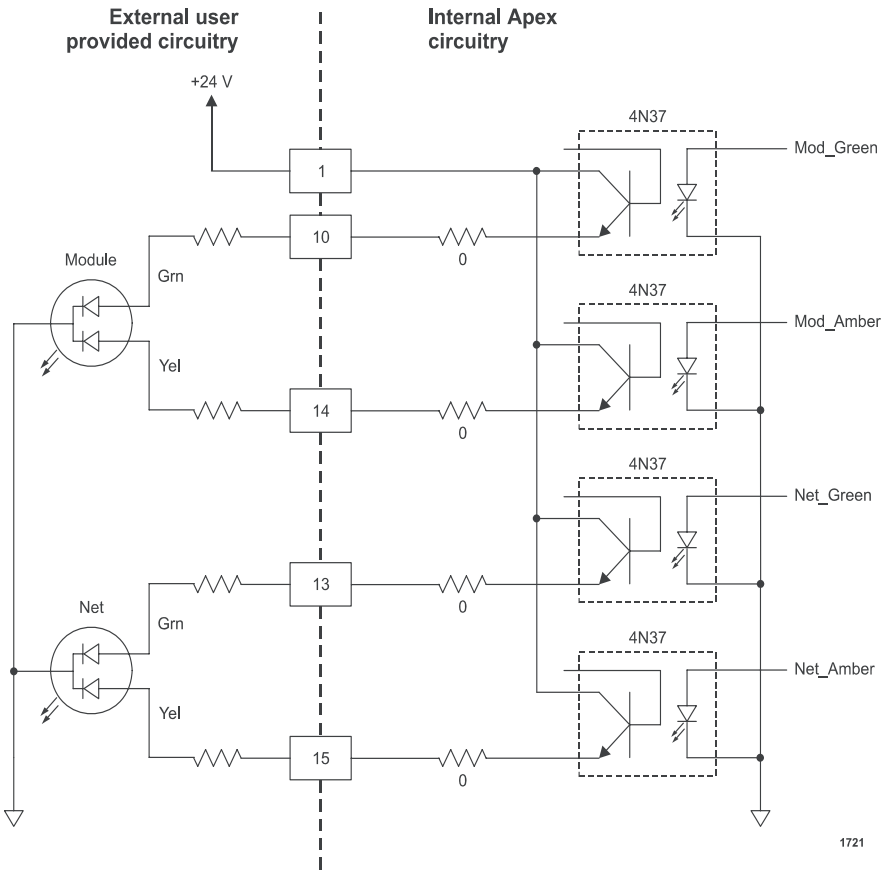


Figure 4-27. *DeviceNet LEDs (pins 1,10,13,14 and 15)*

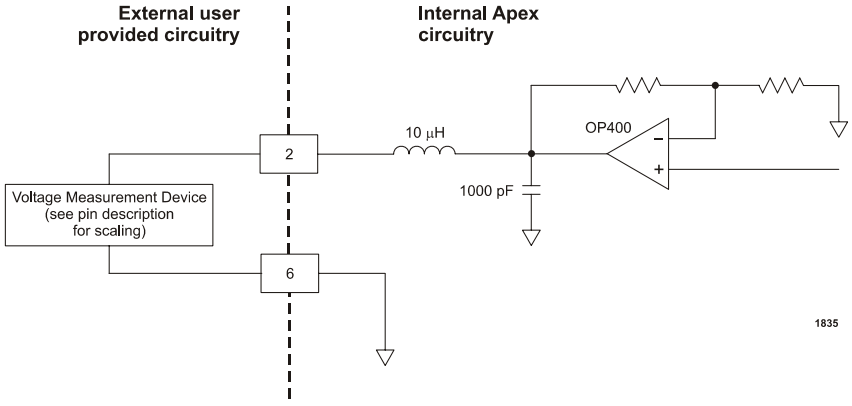


Figure 4-28. *Reflected power monitor (pins 2 and 6)*

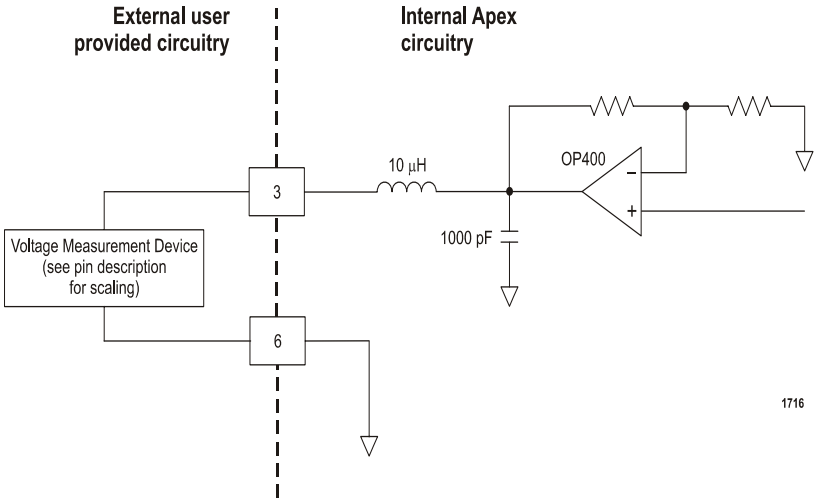


Figure 4-29. *Forward/load power monitor (pins 3 and 6)*

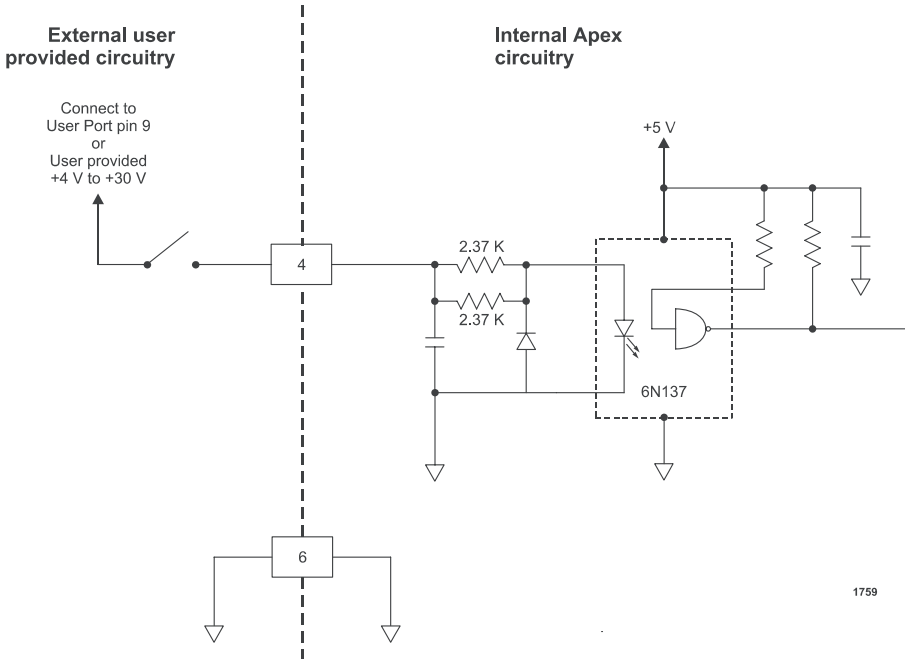


Figure 4-30. *RF power enable (pin 4 and 6)*

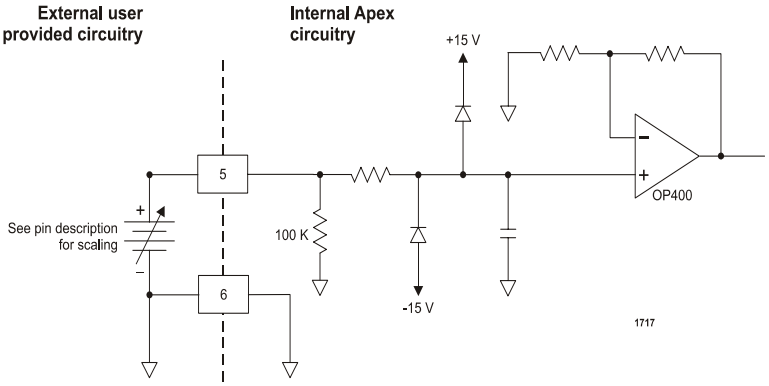


Figure 4-31. *Forward/load power set point (pins 5 and 6)*

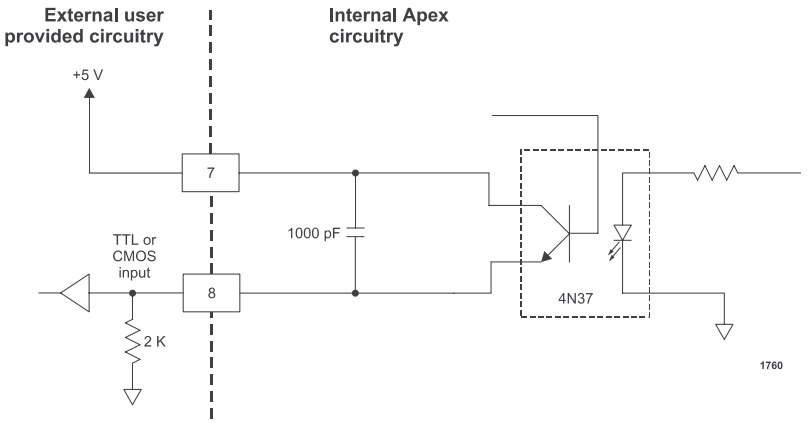


Figure 4-32. *RF on status (pins 7 and 8)*

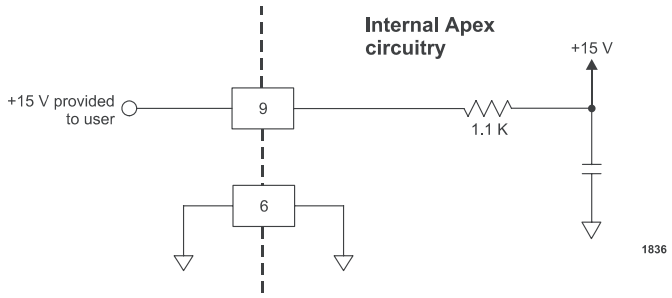


Figure 4-33. *+15 VDC (pins 9 and 6)*

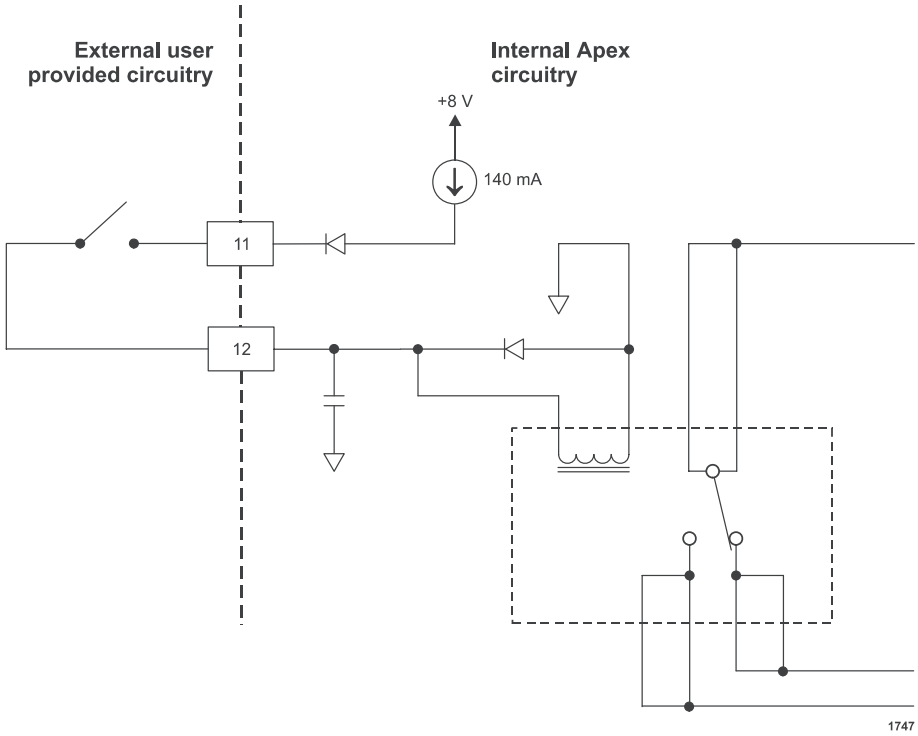


Figure 4-34. *Interlock (pins 11 and 12)*

25-Pin User Port (Exclusive—Option K)

The following section describes the Apex 25-pin User port (configuration K). To determine if your Apex unit has this interface, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Apex 25-pin User port (configuration K) option
PIN position 8, (A 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 16 17) **option K**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

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

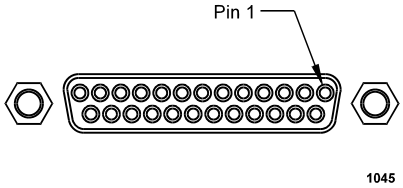


Figure 4-35. *User port connector 25 pin, option K*

SATISFYING MINIMAL REQUIREMENTS FOR THE 25-PIN USER PORT

Regardless of whether you are controlling and monitoring the generator through the User port or through another port, two User port signals *must* be satisfied for the Apex unit to be operational: *RF PWR ON* (pin 18) and *INTERLOCK LOOP* (pins 14 and 1). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled and the interlock satisfied.

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the host port, for example) before powering up the unit. The control mode can be set through a host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder two jumpers on a mating connector: one between pins 18 and 5 to satisfy the *RF PWR ON* signal and one between pins 14 and 1 to satisfy the *INTERLOCK* signal. To determine the physical location of these pin numbers on the User port, see "User port connector 25 pin, option K" on page 4-42.

If desired, you can add an emergency off switch in series with the *RF PWR ON* signal (pin 18) and/or tie your system interlocks in series with the generator *INTERLOCK* signal (pins 14 and 1) by following the connections for those pins described in "User port (25-pin) connector pins for Option K" on page 4-43.

INTERFACE CABLING REQUIREMENTS FOR 25-PIN USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

PIN DESCRIPTIONS FOR THE OPTION K 25-PIN USER PORT

Table 4-1 provides the connector pin descriptions for this User port interface. The pin numbers are arranged in signal pairs.

Table 4-5. *User port (25-pin) connector pins for Option K*

Signal Pin	Return Pin	Name	Signal Type	Description
2		*CHASSIS GROUND*	Chassis ground	Chassis ground
4	2	*15 VOLT VDC*	Analog output	A + 15 VDC (+/- V), referenced to chassis ground, auxiliary supply for external use (100 mA maximum).

Table 4-5. *User port (25-pin) connector pins for Option K (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
13	2	*PULSING ENABLE*	Digital input	Applying a positive DC voltage between 4 V and 30 V to this pin causes the generator to enable pulsing of the output RF power of the unit. If there is no connection to pin 13, the generator will default to regular power delivery.
14	1	*INTERLOCK*	Digital input	This pin closes the interlock and enables RF output when connected externally to pin 1.
15	2	*15 VOLT DC*	Analog output	+ 15 VDC (+/- V), referenced to chassis ground, auxiliary supply for external use (100 mA maximum).
16	3	*FORWARD/ LOAD REGULATION*	Digital input	Applying a positive DC input voltage between 4 V and 30 V sets the unit to load power regulation mode. If there is no connection on pin 8, the unit will default to forward power regulation.
18	5	*RF POWER ON*	Digital input	When a positive voltage of between 4 V and 30 V is applied to this pin, RF output is enabled. A voltage of < 15 VDC or an open interlock disables RF output.
19	6	*RF ON STATUS*	Digital output	When the generator delivers RF power, a low (opto-coupler output) impedance is created between these two pins (6 mA maximum).
20	7	*GENERATOR STATUS (POWER LIMIT)*	Digital output	A high (opto-coupler output) impedance is created between these two pins (6 mA maximum) when the generator is operating properly.

Table 4-5. *User port (25-pin) connector pins for Option K (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
21	8	*LOW SCALE ENABLE*	Digital input	When a positive voltage of between 4 V and 30 V is applied to this pin, low scale is enabled. A voltage of < 15 VDC or an open interlock disables low scale.
22	9	*RF SET POINT*	Analog input	A 0 V to 10 V signal applied to this pin linearly controls the RF output of the unit. 10 V equals maximum rated output. The unit will provide no output for set point signal representing 1% or less of full rated output (10 V = 5000 W).
23	10	*LOAD POWER*	Analog output	This 0 V to 10 V analog signal provides a linearly scaled readback of load power (10 V= 5000 W).
24	11	*REFLECTED POWER*	Analog output	This 0 V to 10 V analog signal provides a linearly scaled readback of reflected power (10 V= 5000 W).
25	12	*FORWARD POWER*	Analog output	This 0 to 10 V analog signal provides a linearly scaled readback of forward power (10 V= 5000 W).

WIRING DIAGRAMS FOR OPTION K USER PORT

The diagrams in this section provide wiring information to properly connect to the Apex 25-pin User port configuration K.

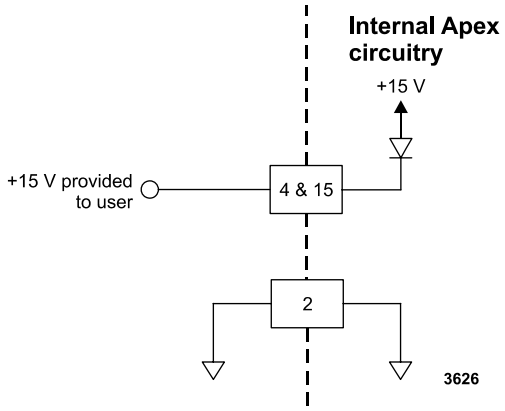


Figure 4-36. *+15 VDC (pins 4 and 15, and 2)*

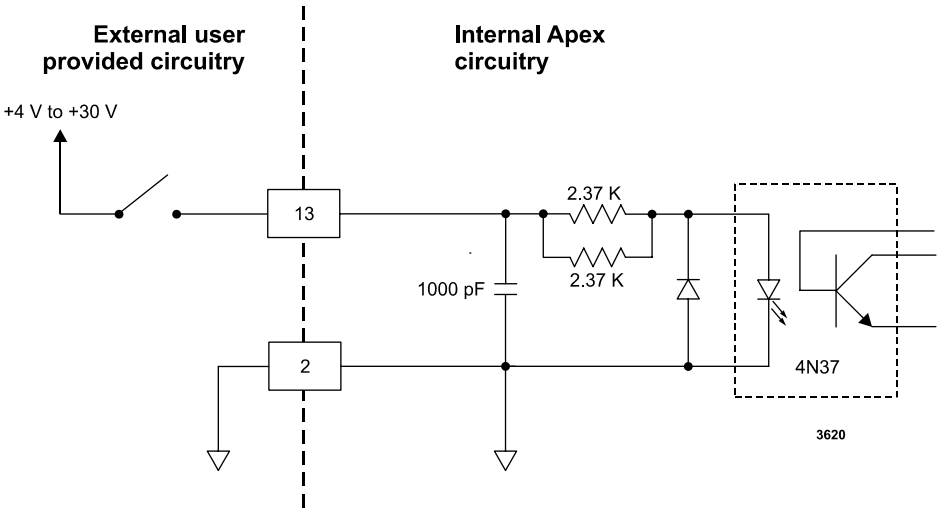


Figure 4-37. *Pulsing enable (pins 13 and 2)*

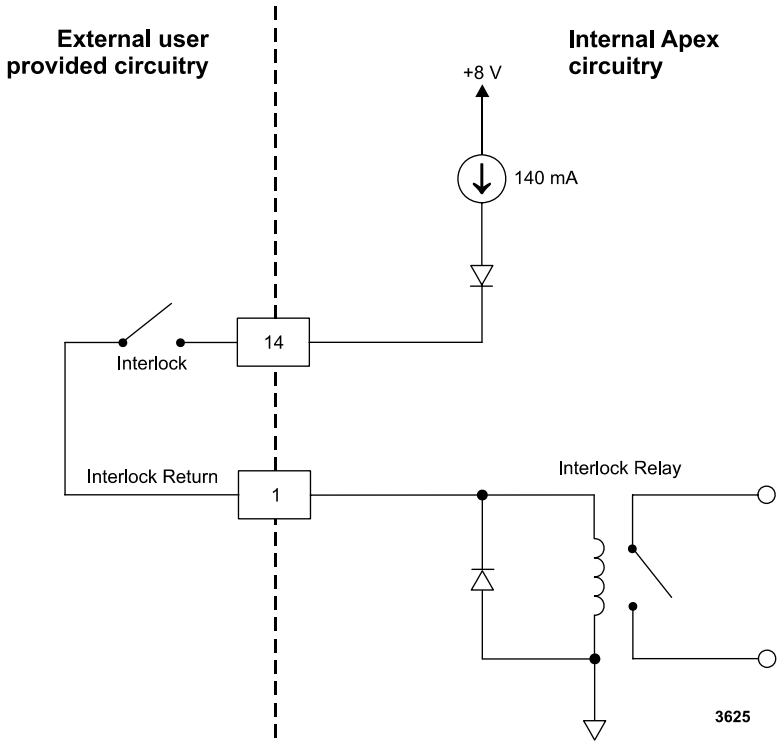


Figure 4-38. *Interlock (pins 14 and 1)*

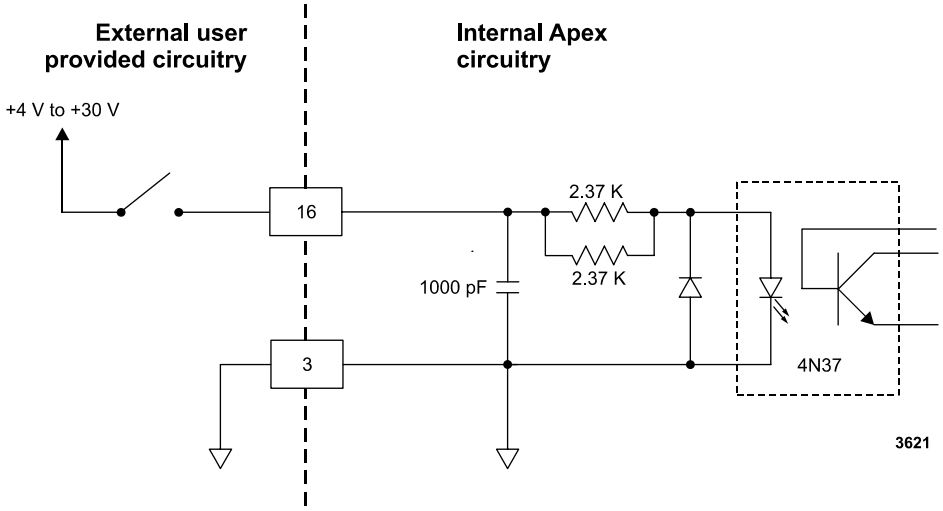


Figure 4-39. *FWD/ load power regulation (pins 16 and 3)*

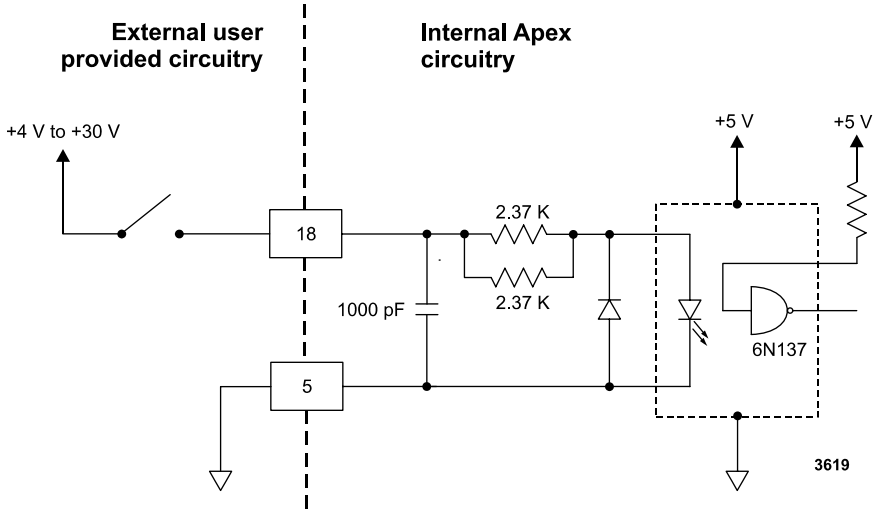


Figure 4-40. *RF power on (pins 18 and 5)*

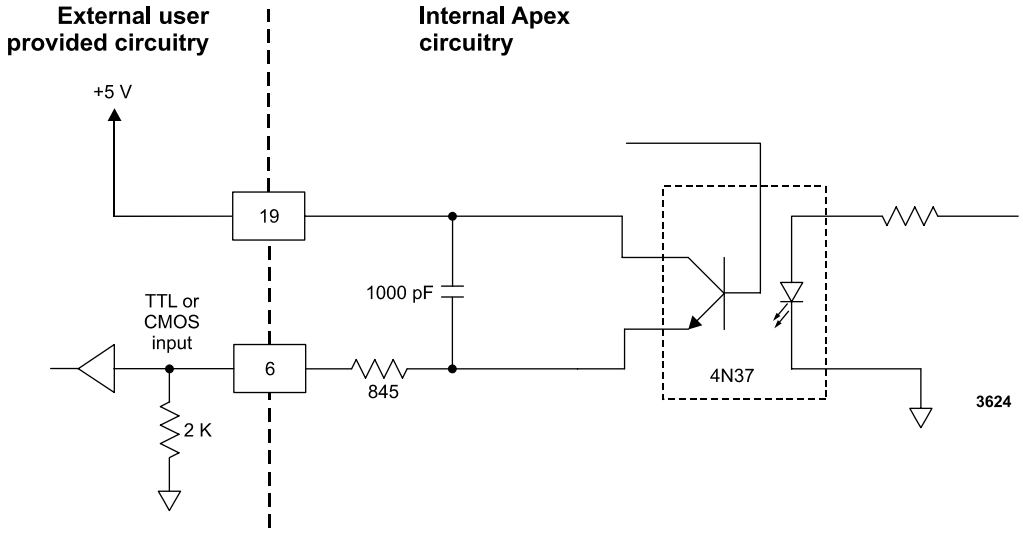


Figure 4-41. *RF on status (pins 19 and 6)*

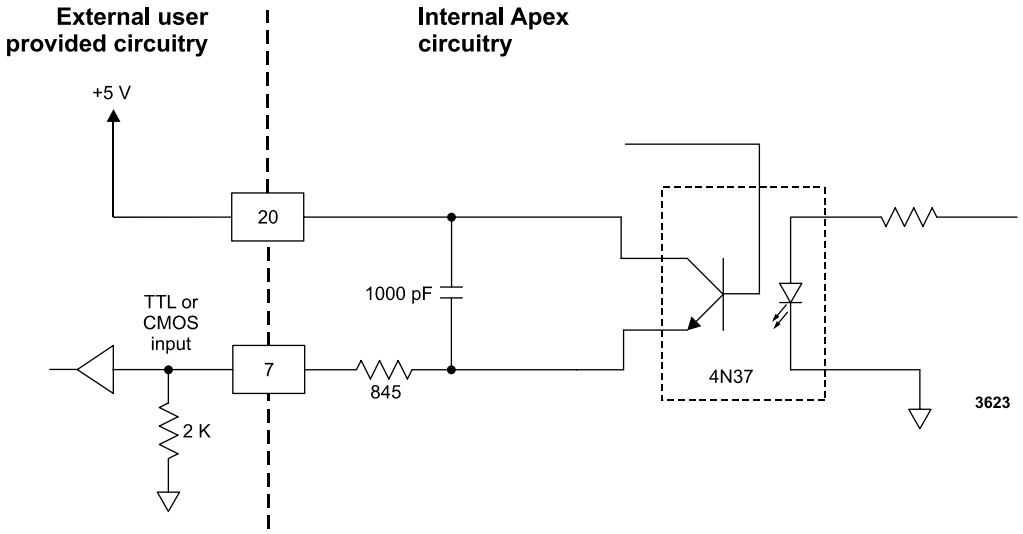


Figure 4-42. *Generator status (pins 20 and 7)*

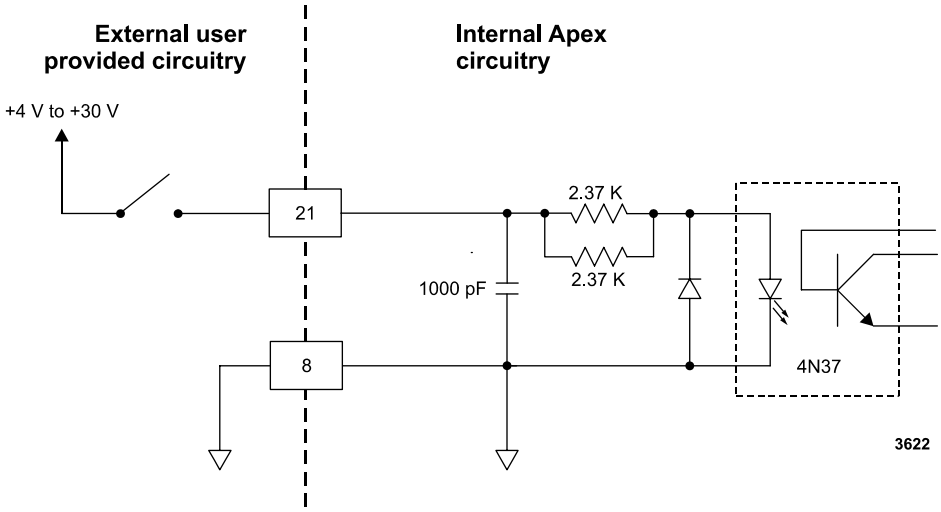


Figure 4-43. *Low scale enable (pins 21 and 8)*

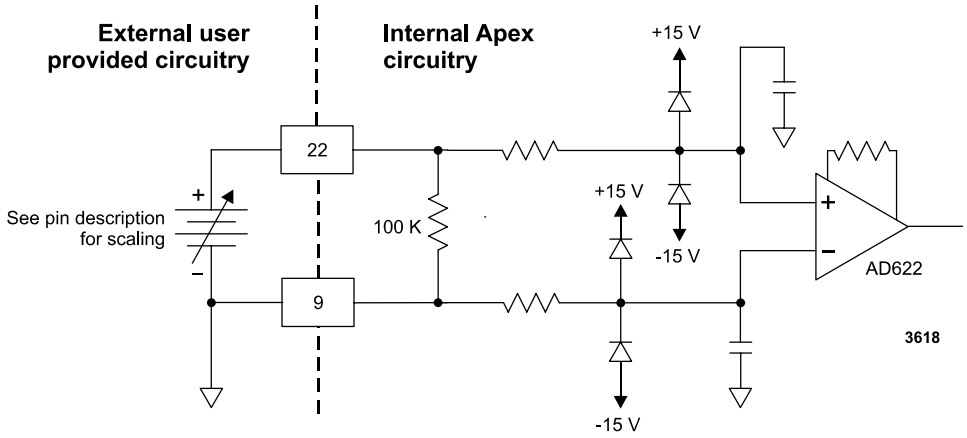


Figure 4-44. *RF set point (pins 22 and 9)*

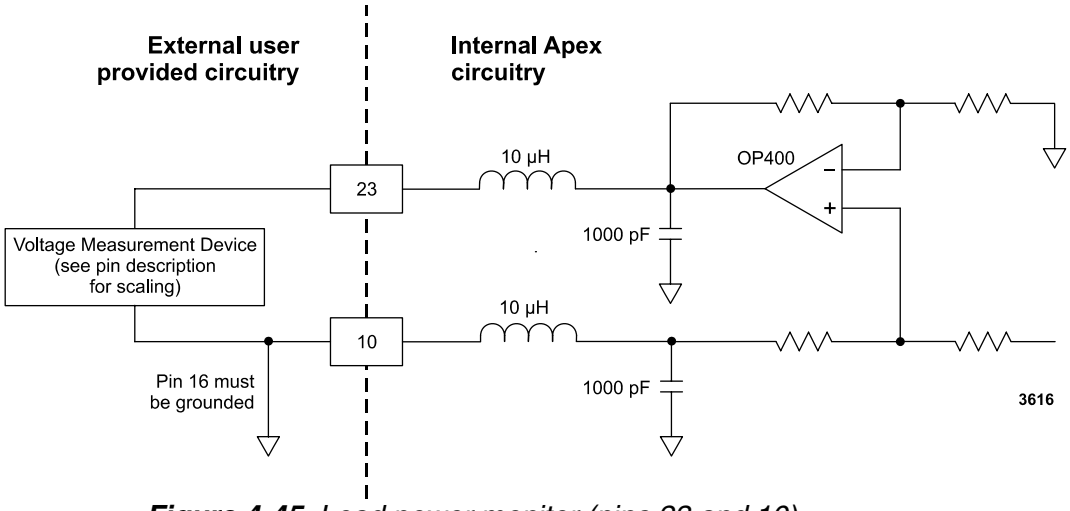


Figure 4-45. *Load power monitor (pins 23 and 10)*

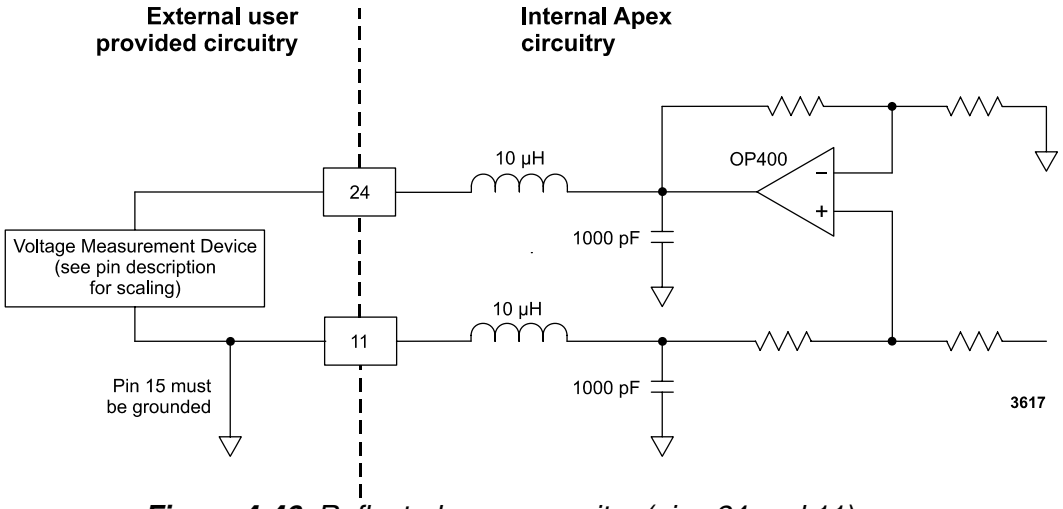


Figure 4-46. *Reflected power monitor (pins 24 and 11)*

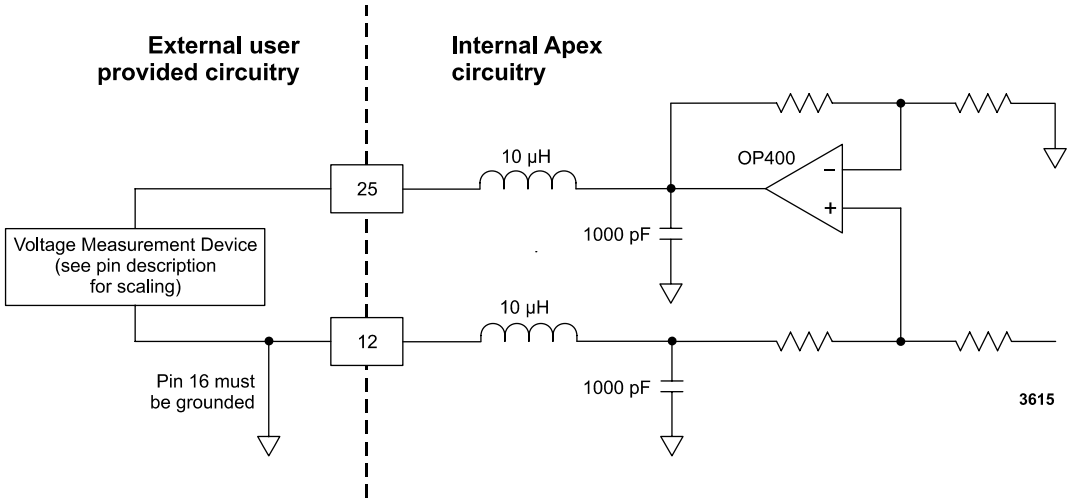


Figure 4-47. *Forward power monitor (pins 25 and 12)*

25-Pin/15-Pin User Ports (Exclusive—Option R)

The following sections describes the Apex option R 25-pin and 15-pin User ports. To determine if your Apex unit has this interface, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Apex 25-pin/ 15-pin User port (configuration R) option
PIN position 8, (A 1 2 3 4 5 6 7 **8** 9 10 11 12 13 14 15 16 17) **option R**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

CONNECTORS FOR OPTION R USER PORTS

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

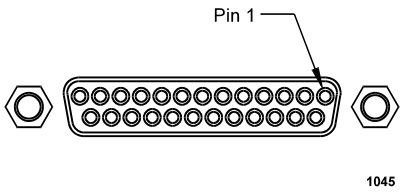


Figure 4-48. *User port connector, 25-pin, option R*

The 15-pin User port uses a shielded, female, subminiature-D connector.

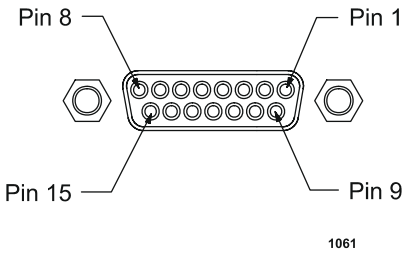


Figure 4-49. *User port connector, 15-pin, option R*

SATISFYING MINIMAL REQUIREMENTS FOR THE OPTION R 25-PIN USER PORT

Regardless of whether you are controlling and monitoring the generator through the User port or through another port, two User port signals *must* be satisfied for the Apex unit to be operational: *RF PWR ON* (pin 18) and *INTERLOCK LOOP* (pins 14 and 1). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled and the interlock satisfied.

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the host port, for example) before powering up the unit. The control mode can be set through a host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder two jumpers on a mating connector: one between pins 18 and 5 to satisfy the *RF PWR ON* signal and one between pins 14 and 1 to satisfy the *INTERLOCK* signal. To determine the physical location of these pin numbers on the User port, see "User port connector, 25-pin, option R" on page 4-52.

If desired, you can add an emergency off switch in series with the *RF PWR ON* signal (pin 18) and/or tie your system interlocks in series with the generator *INTERLOCK* signal (pins 14 and 1) by following the connections for those pins described in "Pin Descriptions for the Option R 25-Pin User Port" on page 4-54.

INTERFACE CABLING REQUIREMENTS FOR THE OPTION R 25-PIN USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded, 25-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

PIN DESCRIPTIONS FOR THE OPTION R 25-PIN USER PORT

Table 4-6. *User port (25-pin) connector pins for option R*

Signal Pin	Return Pin	Name	Signal Type	Description
1	14	*INTLK B*	Interlock	Interlock loop for use with pin 14.
2		*CHASSIS GROUND*	Chassis ground	Chassis ground
4	N/A	*LF GENERATOR KEY*	N/A	No connection.
13	2	*PULSING ENABLE*	Digital input	Applying a positive DC voltage between 4 V and 30 V to this pin causes the generator to enable pulsing the output RF power of the generator. No connection to this pin causes the generator to default to regular power delivery.
14	1	*INTLK A*	Interlock	Interlock loop for use with pin 1. Generator to provide mechanical switch closure. External loop resistance must be < 15Ω
15	2	*15 VOLT DC*	Analog output	A + 15 VDC (± V), referenced to chassis ground, auxiliary supply for external use (100 mA maximum).
16	3	*FORWARD/ LOAD REGULATION*	Digital input	Applying a positive DC voltage between 4 V and 30 V to this pin causes the unit to regulate on load power. No connection to this pin causes the generator to default to forward power regulation.
17	N/A	*HF GENERATOR KEY*	N/A	No connection.
18	5	*RF POWER ON*	Digital input	Applying a positive voltage of between 4 V and 30 V causes the RF output to be enabled. A voltage of < 1.5 VDC or an open input disables RF output.

Table 4-6. *User port (25-pin) connector pins for option R (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
19	6	*RF ON STATUS*	Digital output	When the generator delivers RF power, a low (opto-coupler output) impedance is created between these two pins (10 mA maximum).
20	7	*GENERATOR STATUS (POWER LIMIT)*	Digital output	When the generator is operating properly, a low (opto-coupler output) impedance is created between these two pins (10 mA maximum).
21	8	*LOW SCALE ENABLE*	Digital input	Applying a positive voltage of between 4 V and 30 V to this pin enables low scale. A voltage of < 1.5 VDC or an open input disables low scale.
22	9	*RF SET POINT*	Analog input	Applying a 0 V to 10 V signal to this pin linearly controls the RF output of the unit. 10 V = maximum rated output The unit will provide zero output for set point signals representing 1% or less of full rated output.
23	10	*LOAD POWER*	Analog output	This 0 V to 10 V analog signal provides a linearly scaled readback of load power. 0 V to 10 V = 0 W to 5000 W
24	11	*REFLECTED POWER*	Analog output	This 0 V to 10 V analog signal provides a linearly scaled readback of reflected power. 0 V to 10 V = 0 W to 5000 W
25	12	*FORWARD POWER*	Analog output	This 0 V to 10 V analog signal provides a linearly scaled readback of load power. 0 V to 10 V = 0 W to 5000 W

WIRING DIAGRAMS FOR OPTION R 25-PIN USER PORT

The diagrams in this section provide wiring information to properly connect to the Apex 25-pin User port configuration R.

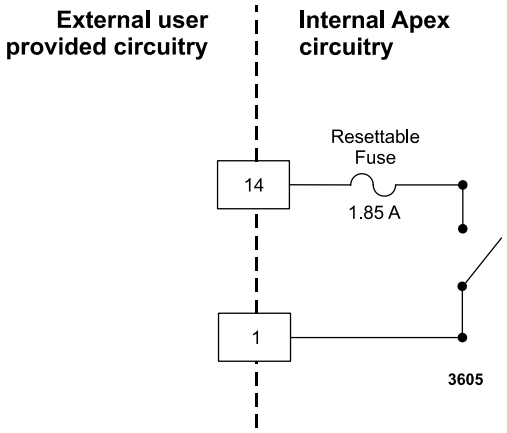


Figure 4-50. *Interlock loop (pins 14 and 1)*

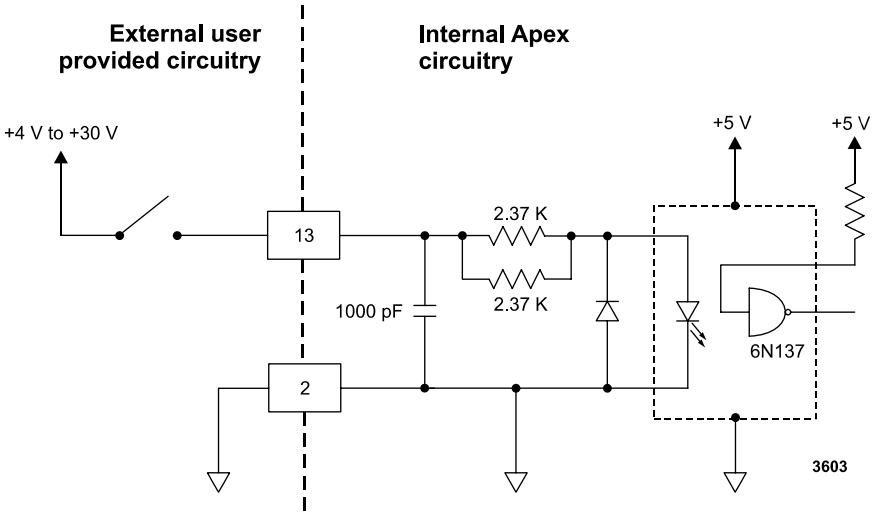


Figure 4-51. *Pulsing enable (pins 13 and 2)*

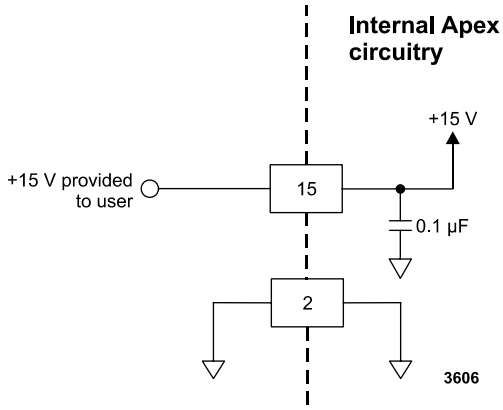


Figure 4-52. *+15 VDC (pins 15 and 2)*

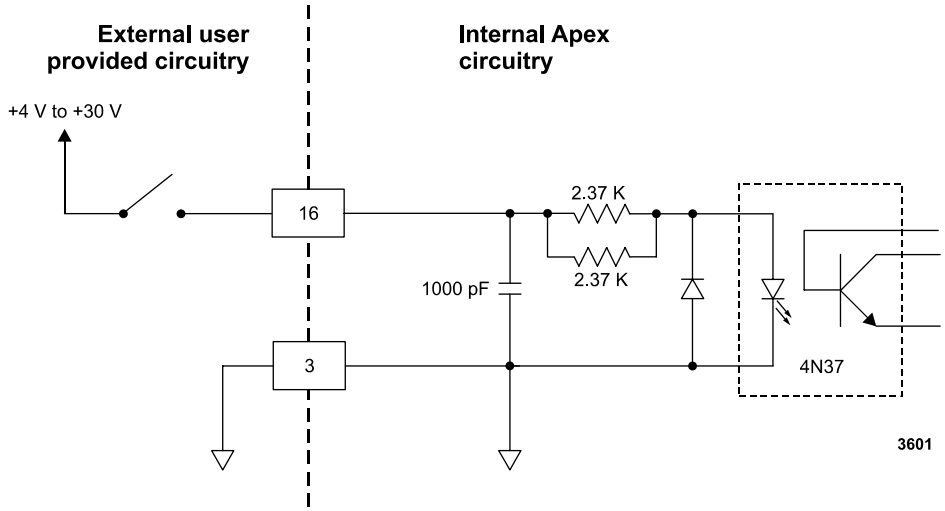


Figure 4-53. *FWD/ load power regulation (pins 16 and 3)*

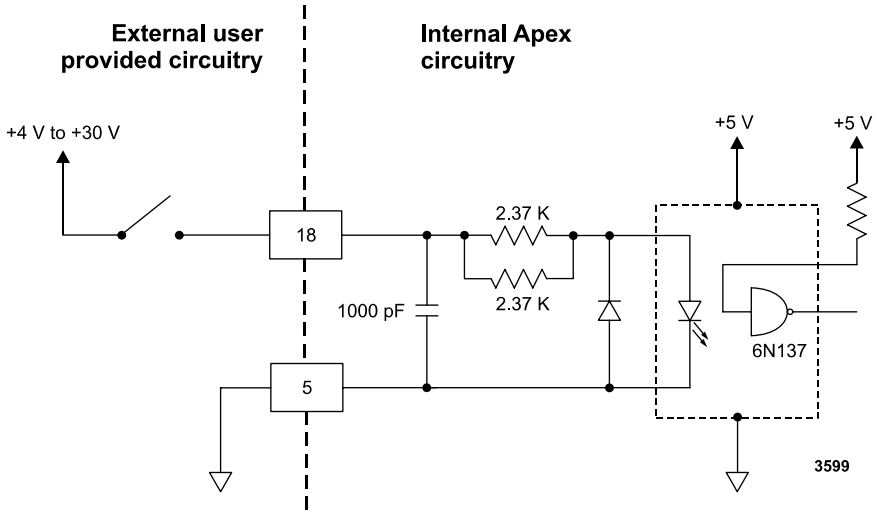


Figure 4-54. *RF power on (pins 18 and 5)*

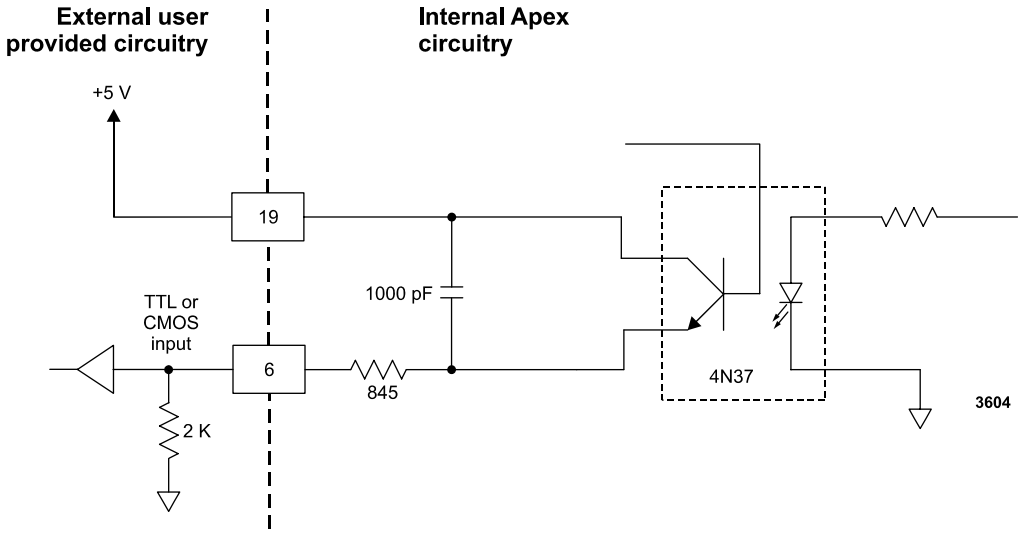


Figure 4-55. *RF on status (pins 19 and 6)*

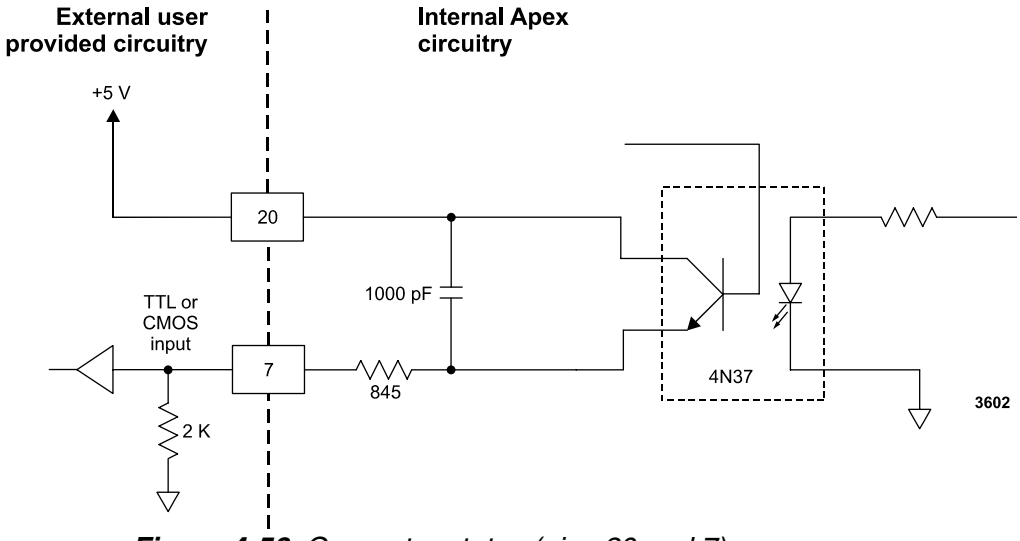


Figure 4-56. *Generator status (pins 20 and 7)*

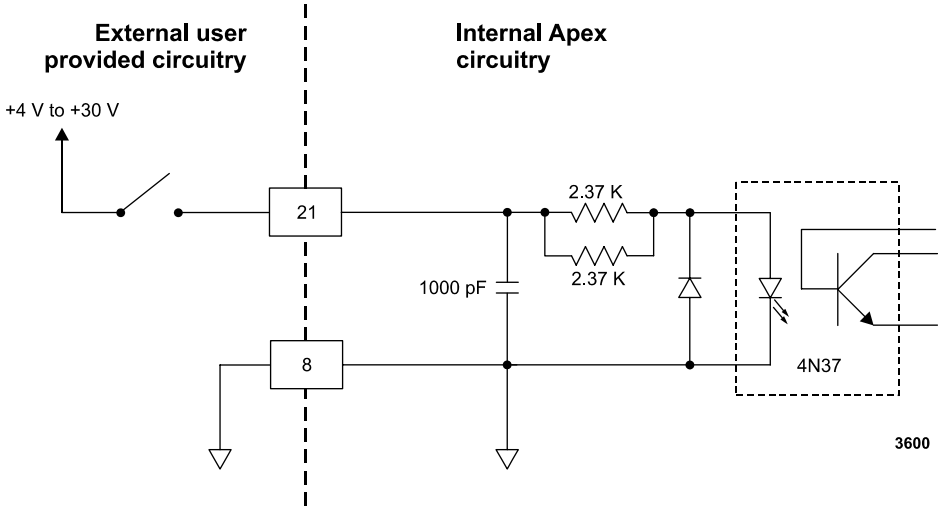


Figure 4-57. *Low scale enable (pins 21 and 8)*

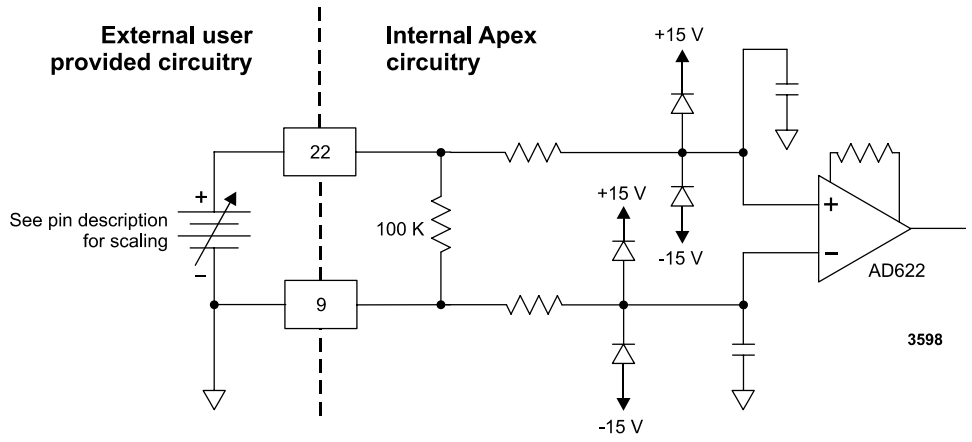


Figure 4-58. *RF set point (pins 22 and 9)*

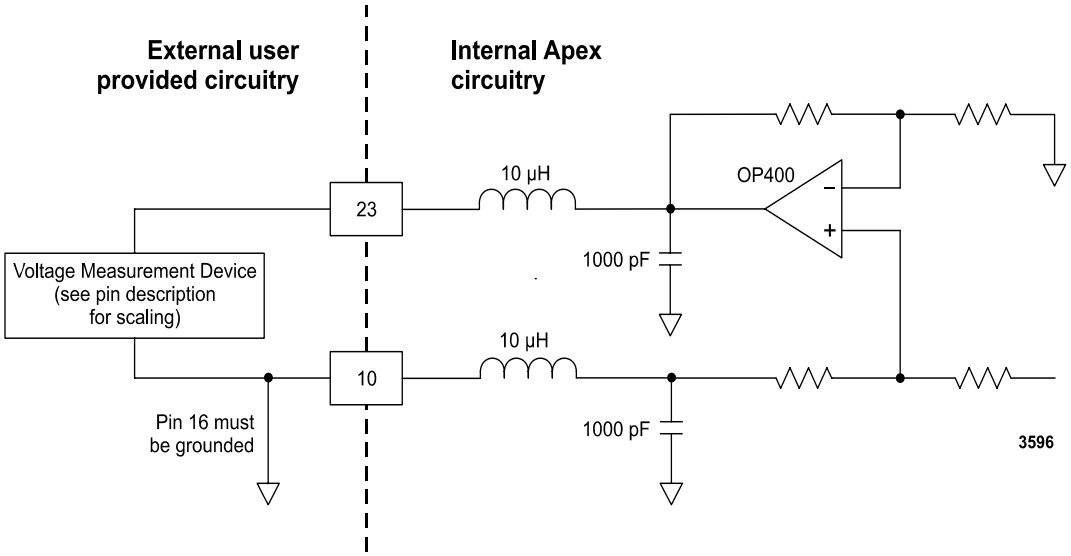


Figure 4-59. *Load power monitor (pins 23 and 10)*

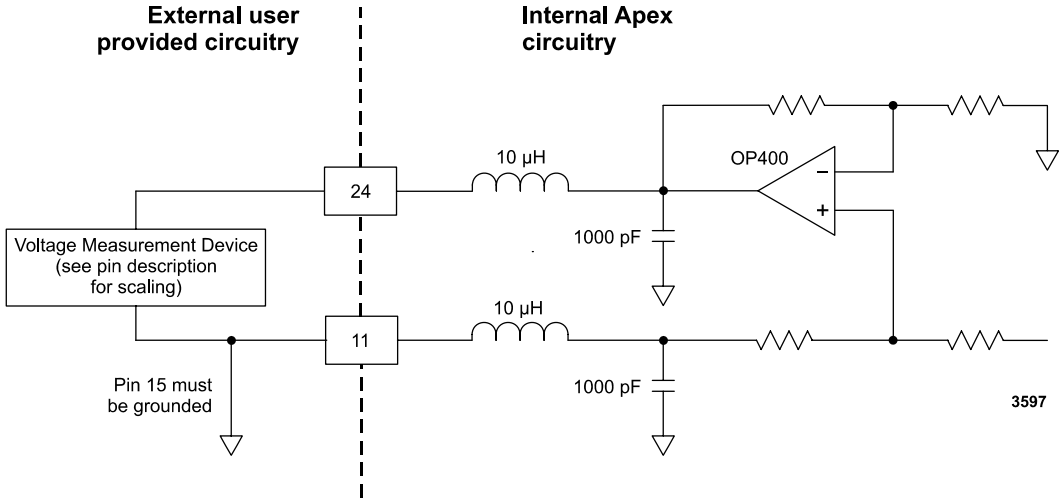


Figure 4-60. *Reflected power monitor (pins 24 and 11)*

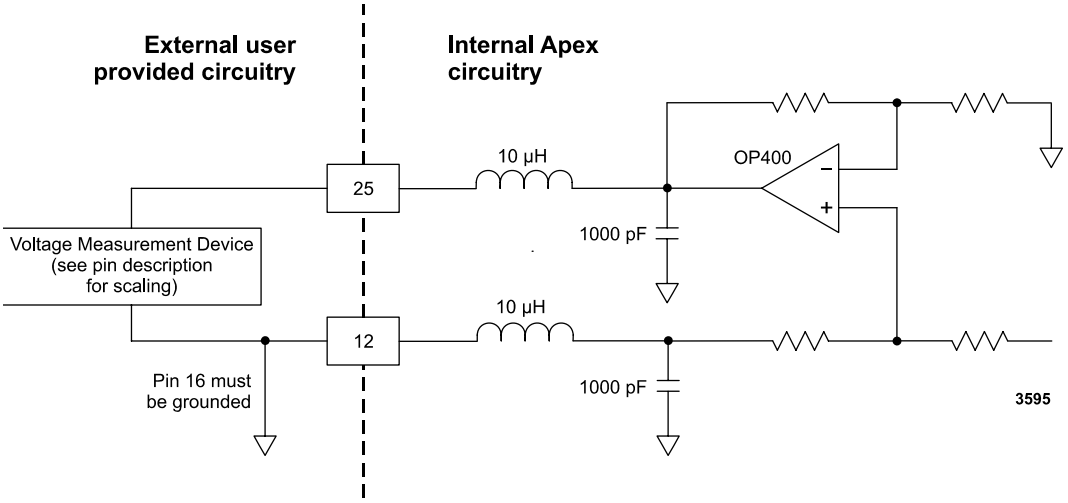


Figure 4-61. *Forward power monitor (pins 25 and 12)*

SATISFYING MINIMAL REQUIREMENTS FOR THE OPTION R 15-PIN USER PORT

Regardless of whether you are controlling and monitoring the generator through the User port or through another port, two User port signals *must* be satisfied for the Apex unit to be operational: *RF POWER ENABLE* (pins 4 and 9) and *INTERLOCK* (pins 11 and 6). In other words, even if you are controlling the generator through the serial port interface, the RF signal must be enabled and the interlock satisfied.

Note: If you are controlling your generator through a port other than the User port, make sure that the control mode is set appropriately (to host mode to control through the Host port, for example) before powering up the unit. The control mode can be set through a Host port command.

If you are not using the User port to control or monitor the unit, you can use a "dummy" or "cheater" plug to satisfy these two signals, thereby ignoring the User port. To make such a plug, solder two jumpers on a mating connector: one between pins 4 and 9 to satisfy the *RF POWER ENABLE* signal and one between pins 11 and 6 to satisfy the *INTERLOCK* signal. To determine the physical location of these pin numbers on the User port, see "User port connector, 15-pin, option R" on page 4-52.

If desired, you can add an emergency off switch in series with the *RF POWER ENABLE* signal (pins 4 and 9) or tie your system interlocks in series with the generator *INTERLOCK* signal (pins 11 and 6) by following the connections for those pins described in "User port (15-pin) connector pins for option R" on page 4-63.

INTERFACE CABLING REQUIREMENTS FOR THE OPTION R 15-PIN USER PORT

The cable used to connect the Apex generator's User port to the system controller must be a shielded,15-wire I/O cable. Twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the Apex generator must be tied to a local earth ground through an adequately sized copper grounding strap.

PIN DESCRIPTIONS FOR THE OPTION R 15-PIN USER PORT

Table 4-7. *User port (15-pin) connector pins for option R*

Signal Pin	Name	Signal Type	Description
1	*SET POINT STATUS*	Digital output	Logic high (+ 5 V) indicates that an internal power limit has been encountered. When RF power is enabled, a low level (0 V) indicates that the generator is “at set point”.
2	*REFLECTED POWER MONITOR*	Analog output	This signal represents the reflected power as measured at the output of the generator. This signal is scaled at 1 kW per volt. The maximum reflected power is 1000 W.
3	*FORWARD POWER MONITOR*	Analog output	This signal represents the forward power as measured at the output of the generator. This signal is scaled at 1 kW per volt.
4	*RF POWER ON*	Digital input	This signal is used to activate the RF output of the generator. A voltage level of 4 V to 30 V on pin 4 enables the RF power. If pin 4 is open or grounded, RF power is inhibited.
5	*SET POINT*	Analog input	This 0 V to 10 V signal defines the desired set point for the generator’s RF output. It is scaled to represent 0 W to 5000 W.
6	*GROUND*	Ground reference	This pin is referenced to the signal/ chassis ground in the generator.
7	*RF ON STATUS*	Digital output	A logic high (= 5 V) indicates that the RF power is present at the output of the generator. A logic low level indicates that the RF power is inhibited. The interlock loop must be closed and the *RF POWER ON* signal must be active to enable RF power.
8	*EXTERNAL BIAS*	Reference voltage	This pin is tied to the generator’s + 15 V VDC through a 5.63 Kohm resistor. The intended use of this pin is for notifying the user that AC power is enabled within the generator.

Table 4-7. *User port (15-pin) connector pins for option R (Continued)*

Signal Pin	Name	Signal Type	Description
9	*RF ON BIAS*	Reference voltage	This pin is tied to the generator's + 15 V VDC through a 1.21 KΩ resistor. The intended use of this pin is to enable RF power by externally jumpering it to pin 4.
10	*(RESERVED)*	Open	This pin is not connected.
11	*INTERLOCK*	Interlock	This pin is part of a series interlock string, which must be satisfied to enable AC power in the generator. Pin 11 must be grounded to enable RF power (a contact resistance of 15 Ω or less to ground will satisfy the interlock criteria).
12	*(RESERVED)*	Open	This pin is not connected.
13	*(RESERVED)*	Open	This pin is not connected.
14	*(RESERVED)*	Open	This pin is not connected.
15	*(RESERVED)*	Open	This pin is not connected.

WIRING DIAGRAMS FOR OPTION R 15-PIN USER PORT

The diagrams in this section provide wiring information to properly connect to the Apex 15-pin User port configuration R.

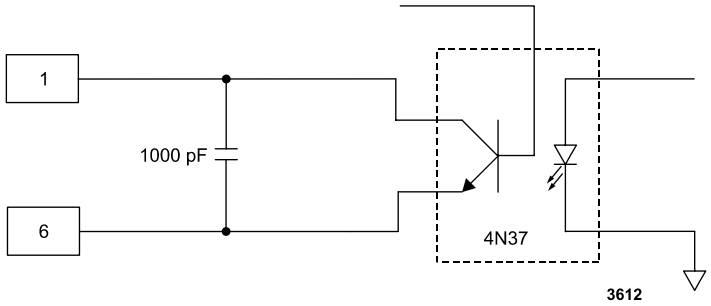


Figure 4-62. *Set point status (pins 1 and 6)*

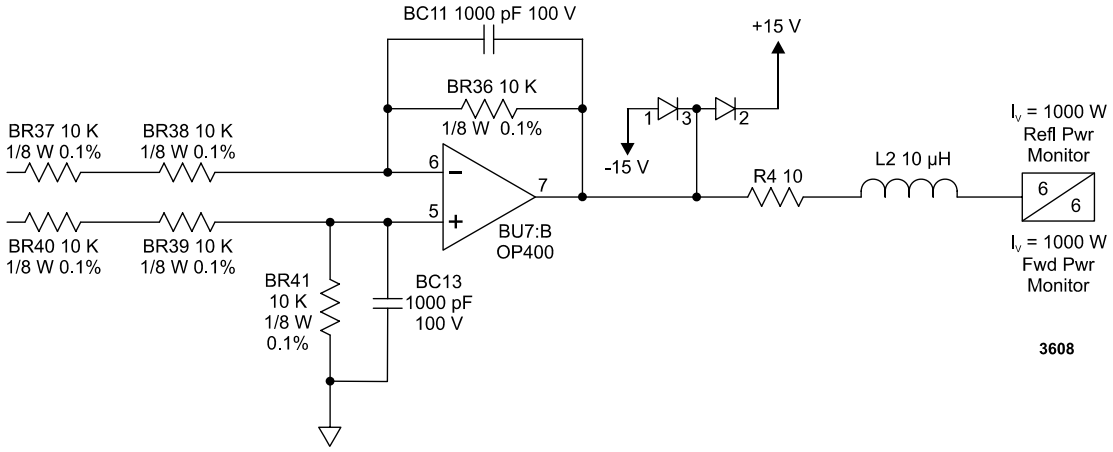


Figure 4-63. *Reflected power monitor (pins 2 and 6)*

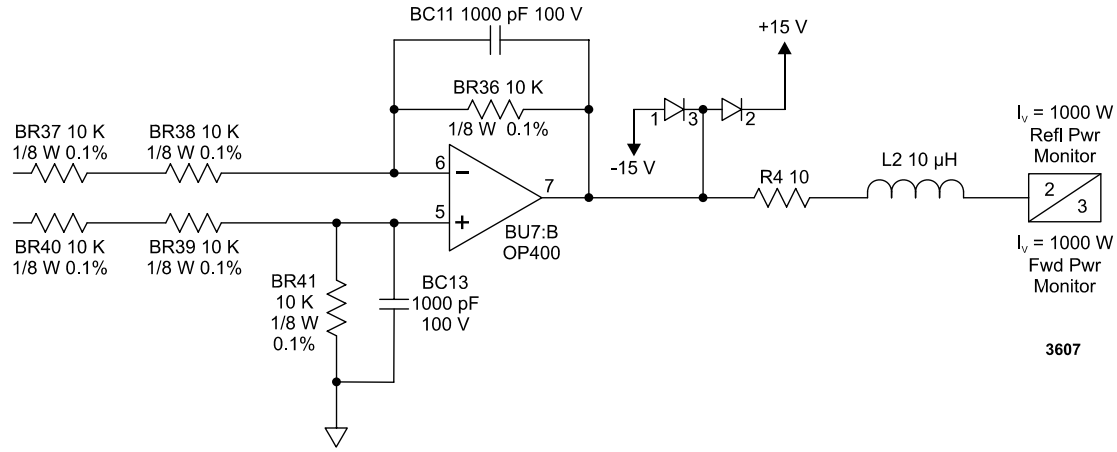


Figure 4-64. *Forward power monitor (pins 3 and 6)*

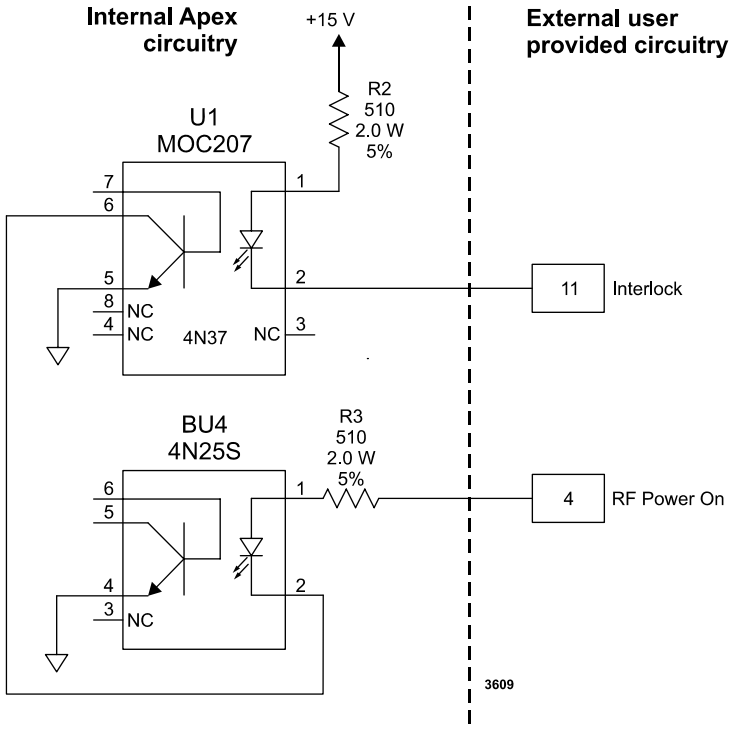


Figure 4-65. *Interlock/ RF power on (pins 11 and 4)*

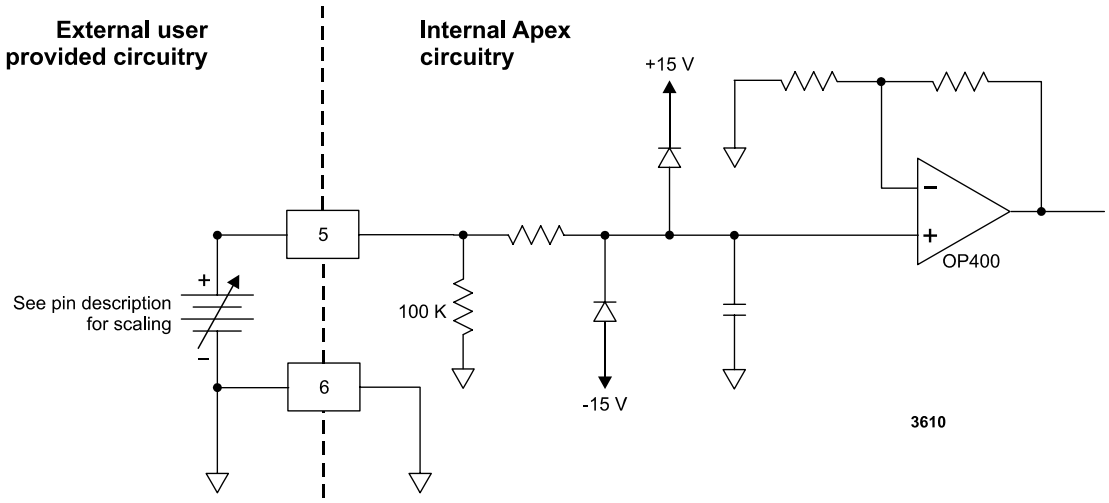


Figure 4-66. *Set point (pins 5 and 6)*

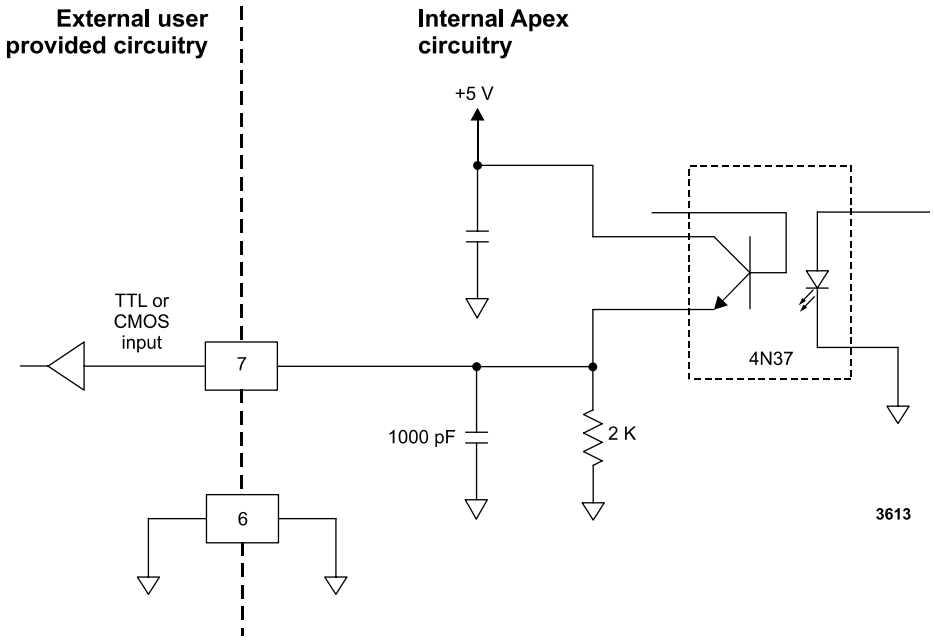


Figure 4-67. *RF on status (pins 7 and 6)*

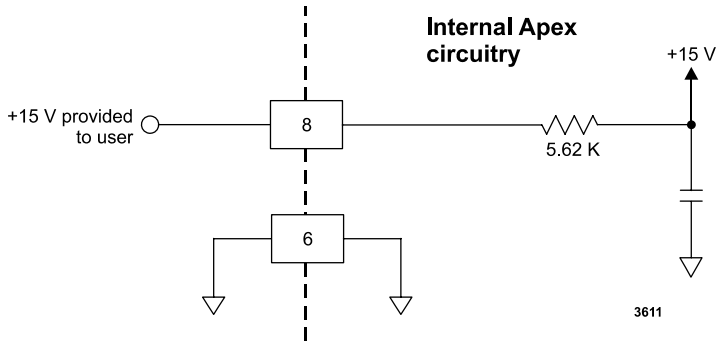


Figure 4-68. *External bias (pins 8 and 6)*

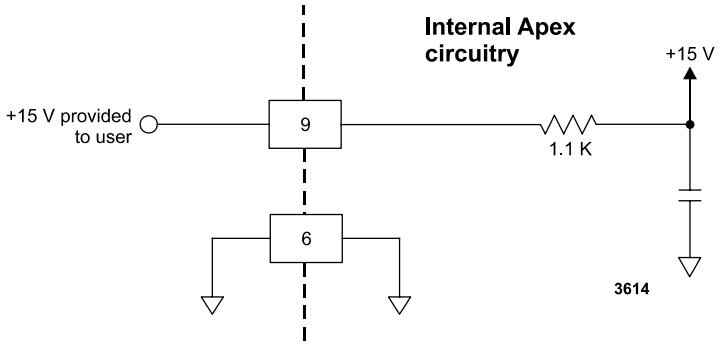


Figure 4-69. *RF on bias (pins 9 and 6)*

9-PIN INTERLOCK INTERFACE

The 9-pin interlock interface port is for use with the option R15-pin user port only. It provides verification of interlock.

Pins 3 and 7 of the 9-pin port are connected together. This can be used to verify that your cable is attached to the 9-pin port.

Pins 2 and 6 provide a contact closure report when the Interlock on the Apex generator is satisfied by the attachment of the RF output coax to the LC connector on the generator.

Pin 1 is chassis ground.

Pins other than those listed above are not used.

Table 4-8. *9-pin interlock interface, option R*

Signal Pin	Signal Name	Description
1	*GND*	Ground, chassis
2	*COMMON*	Contact closure to Pin 6
3	*JUMPER*	Connected to Pin 7
4	*OPEN*	No connection
5	*OPEN*	No connection
6	*NORMALLY OPEN*	Contact closure to Pin 2
7	*JUMPER*	Connected to Pin 3
8	*OPEN*	No connection
9	*OPEN*	No connection

APEX HOST PORT OPTIONS

The following sections provide information for each of the Host port options available with the 500 W to 5.5 kW Apex generator. These options are:

Not all of these sections apply to any one Apex unit. To identify the section or sections that apply to your unit, see "Using this Manual to Find Information About Your Generator" on page 1-1. Each of these sections also contains a PIN configuration note, which will help you confirm whether or not a particular section applies to your unit.

Host Port—RS-232 With AE Bus

This section describes the RS-232, AE Bus Host port interface, which is the standard Apex option. To determine if your Apex unit has this serial interface, use the PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
RS-232, AE Bus Host port option
PIN position 6, (A 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15 16 17) **option 0**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

This Apex Host port, which is the standard, or default option, uses an RS-232 signal format and AE Bus communication protocol. Refer to "AE Bus Protocol" on page 4-72 for details on the communications protocol.

AE manufactures an interface software, Virtual Front Panel, which allows you to use a computer to communicate with the Apex unit through the RS-232 AE Bus port. For more information about this software, contact "AE Global Services" on page 6-8.

AE can also provide a sample host software for this port. For information, contact AE Global Services.

Before controlling/monitoring the Apex generator through this port, you need to ensure that the required User port inputs are satisfied and that the control is properly set. The required User port inputs are identified under the Satisfying Minimal Requirements section for your User port.

To determine which User port you have, see the information for PIN position 8 in "Apex PIN Positions and Associated Options" on page 1-5. The control mode is usually set to the User port as default when this host port option is installed. To change the control mode to host, see commands 14 (sets control mode) and 155 (reads control mode) in the "AE Bus Host Port Commands" on page 4-77. The control mode setting is stored in volatile memory so it will need to be set whenever the AC input is powered up.

AE BUS HOST PORT CONNECTOR

The RS-232, AE Bus Host port is a 9-pin, female, shielded, subminiature-D connector.

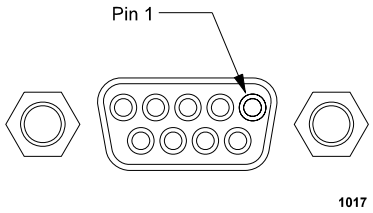


Figure 4-70. *RS-232, AE Bus Host port connector*

The signals available at the RS-232, AE Bus Host port conform to the RS-232 interface standards. Each generator is factory preset for a baud rate of 19.2 kb and "RS-232, AE Bus Host Port Pin Descriptions" on page 4-71 describes the RS-232, AE Bus Host pin signals.

To Connect the Computer to the Apex unit:

Use a standard RS-232 cable that is no longer than 50 feet in length. This cable has a 9-pin, shielded, female, subminiature-D end and a 9-pin male, subminiature-D end. AE does NOT supply a cable. If you do NOT have the appropriate cable, you can purchase a standard serial cable at a local computer or electronics store.

Note: The cable must be intended for use between a computer and a peripheral, that is a cable that is wired straight through (pin 1 on one connector is connected with pin 1 on the other connector, pin 2 is connected to pin 2 and so on.) A cable meant to create an interface between two computers will NOT work in this connection.

Note: To reduce EMI, avoid routing the cable close to AC input or DC output cables.

Table 4-9. *RS-232, AE Bus Host Port Pin Descriptions*

Signal 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	*RESERVED*	Reserved for future use
7	*RESERVED*	Reserved for future use
8	*RESERVED*	Reserved for future use
9	*RESERVED*	Reserved for future use

RS-232, AE BUS HOST PORT CABLING REQUIREMENTS

The cabling requirements for the RS-232 and AE Bus requires a standard DB-9 male to female extension cable.

COMMUNICATING THROUGH THE RS-232, AE BUS HOST PORT

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

- RS-232 protocol
- Baud rate of 19.2 kbps
- Apex generator unit address of 1
- Odd parity
- One start bit, eight data bits, one stop bit
- Low-order bytes are transmitted before high-order bytes.

The time-out period for the Apex generator is factory set at 0.75 s (that is, no more than 0.75 s can elapse between bytes, or the unit will reset and begin looking for a new message packet). This value can be changed using command **40**.

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

Note: The Apex 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 Apex generator.

The AE Bus message packet combines chunks of information 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 4-71):

- Header (address and the length of Data field)
- Command (see the AE Bus command list later in this chapter)
- Optional length byte
- Data
- Checksum (aids in error checking)

Figure 4-71 shows the organization of these data fields in the AE Bus message packet. The subsequent paragraphs describe each data field in detail.

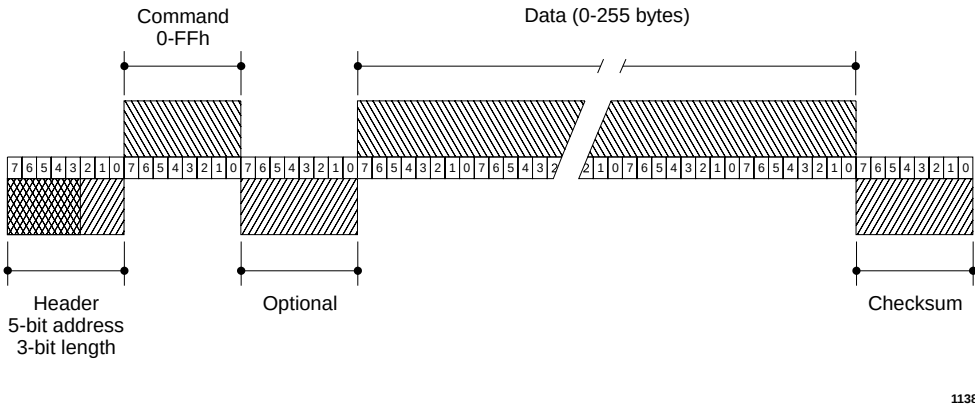


Figure 4-71. *Graphic representation of a RS-232, AE Bus message packet*

Header

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's

destination (to an Apex generator, for example). If the packet is going to the host, the address specifies the packet's origin (from the Apex 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 back to the host).

The remaining three bits (bits 0, 1, and 2) tell the receiving unit how long the Data field is so that the unit can determine when the entire message has been received.

Note: The value in these bits should refer only to the number of actual data bytes. Do not include the checksum byte when calculating the value for these bits (see "Checksum" on page 4-73).

Command

This field contains a one-byte value: 00h to FFh (0 to 255). If the message packet originates with the host computer, this value specifies the purpose of the message packet. If the message originates with the Apex generator, the value specifies the command to which it is responding. See "AE Bus Host Port Commands" on page 4-77 for a complete list of commands.

Optional Length Byte

This field supplements the Header field and exists only when the length bits in the Header field contain a value of 7. Under those circumstances, the Optional field contains a one-byte value (between 0 and 255) indicating the number of data bytes.

Data (Data Bytes)

The Data field can contain from 0 to 255 bytes of binary data, which are interpreted in various ways, depending on the value that appears in the Command field. The Data field typically contains data or a Command Status Response (CSR) (see "Creating an Ideal Communications Transaction" on page 4-74), depending on what was requested. Since some commands do not require data, sometimes the Data field is not present.

If the value specified in the length bits of the Header field is 0 to 6, the Apex generator expects 0 to 6 bytes of data. However, if the value in the Header field is 7, the Apex generator looks for an additional eight-bit byte after the Command field (the Optional field) and uses this value for the data byte count.

Checksum

This one-byte field is the last one in the packet. The content depends on the value of 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 packet has likely been received intact.

Only after the checksum of a message packet is validated (having no parity errors, and the address is valid) will the Apex generator act on the message (which consists of the contents of the command and, if appropriate, the data fields).

CREATING AN IDEAL COMMUNICATIONS TRANSACTION

Figure 4-72 is a simplified graphic showing the steps in an ideal communications transaction between a host computer and the Apex generator.

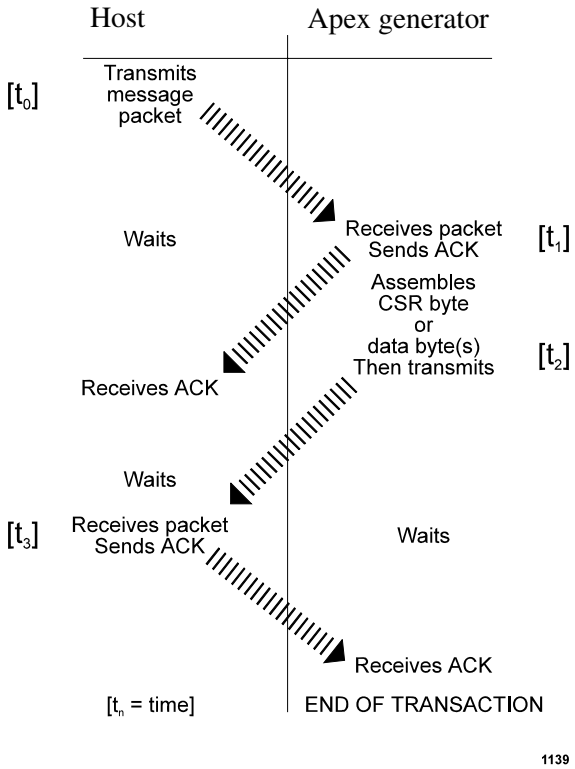


Figure 4-72. *AE Bus communications transaction*

First, the host computer sends a message packet to the Apex 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

Once the Apex generator receives the message packet, the Apex generator verifies that the message is intended for it and not for another unit on the network. At this time, the Apex generator also analyzes the checksum to verify that the message was received correctly.

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

If the Apex 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 1-byte data value (CSR code) to the host (see "Command Status Response (CSR) Codes" that follow). CSR code 0 is sent when the command has been accepted.

If the host receives a NAK from the Apex 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, it waits for the requested data or status information or 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.

Meanwhile, the Apex generator has prepared a message packet with the requested information or appropriate CSR code, which it then transmits to the host. The host determines by means of the checksum if the message is complete. If the host detects an error in the transmission (by using the Checksum), it can request the packet be sent again by transmitting a NAK.

If the Apex generator receives an ACK, it returns to the normal waiting state. If the Apex generator receives a NAK, it retransmits the message packet. The Apex generator continues to retransmit in response to NAK transmissions until the host stops the cycle. If the Apex generator receives no response, it assumes an ACK and returns to the waiting state.

HOST/APEX COMMUNICATIONS TRANSACTION EXAMPLE

Figure 4-73 is a simplified graphic showing the steps in an example communications transaction between a host computer and an Apex generator.

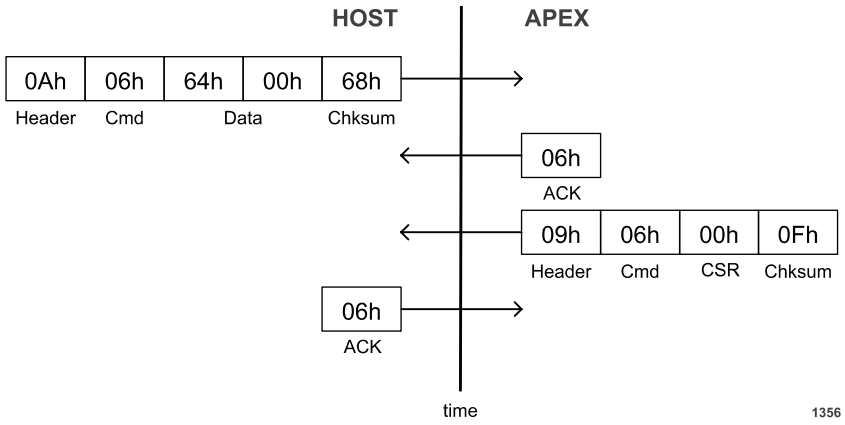


Figure 4-73. *AE Bus communications transaction example*

COMMAND STATUS RESPONSE (CSR) CODES—RS-232, AE BUS HOST

When the host sends an executable command or a command requesting a change in a parameter setting, the Apex generator returns a command status response (CSR) code indicating whether the command was accepted or rejected and, if rejected, why. Table 4-10 defines how these CSR codes should be interpreted.

Table 4-10. *CSR codes for RS-232, AE Bus host*

Value	Meaning
0	Command accepted
1	Wrong control mode
2	Output is on
4	Data is out of range
5	User off active
7	Active fault(s) exist
8	Ramp is in progress
9	Data byte count is incorrect
16	Target life
19	Recipe active
30	EEPROM read/write
50	Frequency out of range
51	Duty cycle out of range

Table 4-10. *CSR codes for RS-232, AE Bus host*

52	Minimum on/off time violated (on/off time must be ≥ 10 µs).
53	Arc suppression is enabled
54	Pulsing is enabled
99	Command not implemented

AE BUS HOST PORT COMMANDS

Table 4-11 lists the command set for the RS-232, AE Bus Host port.

Table 4-11. *Host port commands for RS-232 with AE Bus*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
1 **RF off**	Requests RF output off; request is always honored regardless of which interface has control. Readback command is **162**.	0	1
2 **RF on**	Requests RF output on; host control must have been selected.	0	1
3 **regulation select**	Sets the method of output regulation (forward power (6), load (7), and ext. (8)). Readback command is **164**.	1 data byte 8-bit value	1
4 **fwd power limit**	Specifies maximum forward power that can be delivered. Accepts a value of 0 to full scale power. *Note:* When in load regulation mode, this limit represents the maximum load power that can be delivered. Readback command is **169**.	2 data bytes 16-bit value	1
5 **refl pwr limit**	Specifies maximum reflected power that can be tolerated. Accepts a value of 0 to 1100 W, or 20% of full-rated power. Readback command is **170**.	2 data bytes 16-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
6 **ext feedback limit**	Specifies the maximum external feedback level. Accepts a value from 0 to the maximum external feedback value. *Note:* This command sets the value at which the set point is limited during external regulation Readback command is **171**.	2 data bytes 16-bit value	1
8 **set point**	Specifies the output set point level for whatever method of output regulation has been selected. Accepts a value of 0 to full scale power when forward or load power regulation is selected. Regular units report in units of watts. HALO units report in units of tenths of watts.	2 data bytes 16-bit value	1
9 **max ext feedback**	Specifies the external feedback value that corresponds to 10 V on the User port; requires data bytes arranged as follows: • Bytes 0 and 1 = a 16-bit value in the range of 100 to 10,000. • Byte 2 = not used (set to 0)	3 data bytes 16-bit value 8-bit value	1
11 **select active target**	Specifies which target is active; accepts a value of 1 to 4. (Readback command is **156**.)	1 data byte 8-bit value	1
12 **set target life**	Sets the life (in kWh) of the target you specify. Requires five data bytes arranged as follows: • Byte 0 = the target number • Bytes 1, 2, 3, and 4 = target life in kWh *Note:* Two decimal places are implied—to get 1 kWh, send a value of 100. Readback command is **157**.	5 data bytes 8-bit value 32-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
14 control transfer	Sets the active control mode of the generator. Possible choices are: • 2 = host • 4 = User port (analog)	1 data byte 8-bit value	1
15 out-of-set point timer	Specifies how long the generator can produce output that is not equal to the programmed set point level. Accepts a value of 0 to 599 s. (0 disables the timer) Readback command is **184**.	2 data bytes 16-bit value	1
16 allowable deviation	Specifies a percentage that the generator can be out of set point before it starts the out-of-set point timer. Accepts a value of 1 to 99%. Readback command is **185**.	1 data byte 8-bit value	1
19 number of recipe steps	Specifies the number of recipe steps. Send 1 data byte that indicates the number of recipe steps (0 through 7). *Note:* 0 disables recipe mode	1 data byte 8-bit value	1
22 recipe step/set point	Specifies set point for a recipe step. Send 3 data bytes. • Byte 0 = recipe step number (can be 1 through 7) • Bytes 1 and 2 = set point value (send least significant byte first); the value must be within the operating range of the Apex unit (see "Output Electrical Specifications" on page 3-12)	3 data bytes 8-bit value 16-bit value	1
23 recipe step/run time	Sets the run time for the specified recipe step. Send 3 data bytes. • Byte 0 = recipe step number (1 through 7) • Bytes 1 and 2 = run time in hundredths of seconds or in joules (if the recipe is set for joules mode; see CMD **28** to set recipe type); send least significant byte first	3 data bytes 8-bit value 16-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
28 recipe type	Sets the recipe for time or joules mode. Send one data byte indicating the recipe type: • 1 = time mode • 2 = joule mode	1 data byte 8-bit value	1
31 set set point ramping parameters	Sets the set point ramping mode and ramp parameters. The ramp up and down parameters can be set independently. The set point ramp parameters can be set while the output is on. The ramp parameters are not allowed to change during a set point ramp that is currently in progress. In either operating mode, the set point is updated at 10ms intervals. • Bytes 0 and 1 = Ramp Mode ◗ 0 = Disabled. ◗ 1 = Watts per second. In this mode, the ramp parameters represent the ramp rate in Watts per second. The minimum ramp rate in this mode is 1 W/sec. ◗ 2 = Timed. In this mode, the ramp parameters represent the time in ms. The minimum ramp time in Timed mode is 20 ms. • Bytes 2 and 3 = Ramp up (watts per second or time in ms) • Bytes 4 and 5 = Ramp down (watts per second or time in ms)	6 data bytes 16-bit value	0

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
36 set arc suppression time/ disable arc handling	Sets the arc suppression time, meaning the time in µs that RF output is turned off when an arc is first detected. • Byte 0 (8-bit value) = arc suppression parameter selection ▸ 0 = Arc suppression time in µs. Minimum time = 2µs Maximum time = 511µs This is the amount of time the RF output is turned off when an arc is first detected. Note that the RF off time is automatically increased to handle hard arcs and resets to the specified time upon quenching a hard arc. Setting the arc suppression time to zero (0) disables the arc suppression algorithms, but leaves arc counting enabled. ▸ 1 = Initial Delay Time in ms. Minimum time = 20 ms Maximum time = 10,000 ms or 10 sec This is the amount of time that must elapse after turning the RF output on a non-zero set point before the arc suppression algorithm will turn off the RF output due to an arc condition. Arc counting is also disabled during the Initial Delay Time. (continued on next page)	3 data bytes 1 8-bit value 1 16-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
36 set arc suppression time/ disable arc handling (continued)	(continued from previous page) ▸ 2 =Set point Delay Time in ms. Minimum time = 20 ms Maximum time = 245 ms This is the amount of time that must elapse after a significant change to the power set point before the arc suppression algorithm will turn off the RF output due to an arc condition. Arc counting is also disabled during the Set point Delay Time. ▸ 3 = Number of Attempts. Minimum = 0 Maximum = 250 This is the maximum number of times the arc suppression algorithm will attempt to quench the arc before asserting the Arc Suppression Fault. A value of zero disables the Arc Suppression Fault and allows the arc suppression algorithm to attempt to quench the arc indefinitely. • Bytes 1 and 2 (16-bit value) = Arc Suppression Parameter	3 data bytes 1 8-bit value 1 16-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
39 **set AEbus watchdog timer value**	Sets the timeout value for the AEbus watchdog timers in milliseconds. Serial ports 1 and 2 are enabled independently. A value of 0 disables the timers. Byte 0 = Logical Serial Port Number (1 or 2) Bytes 1 and 2 = Watchdog Timer Value *Note:* In the Apex, logical port 1 is physical port 1, logical port 2 is physical port 0.	3 data bytes 8-bit value 16-bit value	1
40 **host port timeout value**	Sets the Host port timeout value. Accepts a value of 2 to 500, representing 0.02 to 5.0 s. (Readback command is **140**.)	2 data bytes 16-bit value	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
84 **set arc suppression potentiometer sensitivity values**	Sets the arc suppression potentiometer sensitivity values. • Byte 0 (8-bit value) = This value is an offset value that is added to the base value stored within the unit during calibration. If the sum of the base plus offset values exceeds 255, the resulting value is truncated to 255. • Byte 1 (8-bit value) = potentiometer device number ▸ 4 = Device 1 (digital potentiometer 1) ▸ 5 = Device 2 (digital potentiometer 2) • Byte 2 = potentiometer channels ▸ When byte 1 = 4: • 0 = potentiometer channel 0 (upper limit offset) • 1 = potentiometer channel 1 (upper limit multiplier) • 2 = potentiometer channel 2 (lower limit offset) • 3 = potentiometer channel 3 (lower limit multiplier) ▸ When byte 1 = 5: • 0 = potentiometer channel 0 (absolute reflected limit)	3 data bytes 3 8-bit values	1
93 **set pulsing frequency**	Sets the RF pulsing frequency in Hz. Accepts a value of 150 to 50000. Minimum frequency is dependant on the PIN number of generator. Read back with command **193**.	4 data bytes 32-bit value	1
96 **set pulsing duty cycle**	Sets the RF pulsing duty ON time in increments of 1%. This value can range from 1% to 90%. Minimum Duty Cycle is dependant on the PIN number of the generator. Minimum On or OFF time is >= 10uS.	2 data bytes	1

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
128 read supply type	Requests the generator type; returns 4 ASCII characters.	0	4 data bytes 4 ASCII characters
129 read supply size	Requests the output capacity of the generator; returning packet contains 4 ASCII characters.	0	4 data bytes 4 ASCII characters
130 read firmware version number	Requests the version number of the firmware. The returning packet contains 7 ASCII characters—a 7-digit number. This command is used in conjunction with CMD **198** to obtain the version/revision number of the firmware.	0	7 data bytes 7 ASCII characters
139 read AEbus watchdog timer value	Returns the current value of the AEbus watchdog timer for the serial port selected by the transmitted data byte (1 or 2). *Note:* The watchdog timer value is set and reported in milliseconds, but stored internally in 10mS increments. The value received is truncated down to the nearest 10mS interval and stored. Therefore, the value reported is the truncated value, not the value originally transmitted.	1 data byte 8-bit value	2 data bytes 16-bit value
140 read host time-out value	Requests the serial Host port time-out value (002 to 500 representing 0.02 to 5.00 s).	0	2 data bytes 16-bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
151 report set point ramping parameters	Reports the set point ramping mode and ramp parameters. The ramp up and down parameters are independent. • Bytes 0 and 1 = Ramp Mode ▸ 0 = Disabled. ▸ 1 = Watts per second. In this mode, the ramp parameters represent the ramp rate in Watts per second. The minimum ramp rate in this mode is 1 Watt per second. ▸ 2 = Timed. In this mode, the ramp parameters represent the time in ms. The minimum ramp time in Timed mode is 20 ms. • Bytes 2 and 3 = Ramp up (watts per second or time in ms) • Bytes 4 and 5 = Ramp down (watts per second or time in ms)	0	6 data bytes 16-bit value
154 read regulation mode	Requests regulation mode (set with CMD **3**). Returning values: • 6 = Forward • 7 = Delivered or Load • 8 = External (DC Bias)	0	1 data byte 8-bit value
155 read control method	Requests control mode (set by CMD **14**). Returning values: 2 = host, 4 = analog	0	1 data byte 8-bit value
156 read active target	Requests the number of the active target (set by CMD **11**)	0	1 data byte 8-bit value
157 read target life	Requests the amount of life remaining in the target you specify (set by CMD **12**). This command requires 1 data byte to specify the number of the target you request (1 to 4). *Note:* Two decimal places are implied 100 = 1 kWh	1 data byte 8-bit value	4 data bytes 32-bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
162 read process status	Requests report on process status; returning packet contains the following bytes arranged as follows: • Byte 1: ▸ 0 = unassigned ▸ 1 = unassigned ▸ 2 = recipe run is active ▸ 3 = unassigned ▸ 4 = unassigned ▸ 5 = output power (0 = off, 1 = on) ▸ 6 = RF on requested ▸ 7 = set point status (0 = within tolerance, 1 = out of tolerance) • Byte 2: ▸ 0 = end of target life ▸ 1 = unassigned ▸ 2 = unassigned ▸ 3 = overtemperature ▸ 4 = unassigned ▸ 5 = unassigned ▸ 6 = unassigned ▸ 7 = interlock open • Byte 3—fault flags ▸ 0 = nonmaskable interrupt ▸ 1 = bus fault ▸ 2 = high bus voltage ▸ 3 = unassigned ▸ 4 = low bus voltage ▸ 5 = out of set point ▸ 6 = unassigned interrupt ▸ 7 = unassigned (continued on next page)	0	4 data bytes 4—8-bit values

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
162 (continued) read process status	(continued from previous) • Byte 4—fault flags ▸ 0 = current limit ▸ 1 = reserved ▸ 2 = Profibus error ▸ 3 = unassigned ▸ 4 = unassigned ▸ 5 = extended fault status ▸ 6 = unassigned ▸ 7 = CEX is locked	0	4 data bytes 4—8-bit values
164 read set point/ regulation mode	Requests output set point level (set by CMD **8**) and whatever method of output regulation has been selected (set by CMD **3**). The return packet is arranged as follows: • Bytes 0 and 1 = set point value • Byte 2 = method of output regulation	0	3 data bytes 16-bit value 8-bit value
165 read forward power	Requests a snapshot of forward power level at that instant. Regular units report in units of watts. HALO units report in units of tenths of watts.	0	2 data bytes 16-bit value
166 read reflected power	Requests a snapshot of reflected power level at that instant. Regular units report in units of watts. HALO units report in units of tenths of watts.	0	2 data bytes 16-bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
167 read delivered power	Requests a snapshot of load power level at that instant *Note:* Response contains 2 data bytes. Both bytes represent delivered power or real power (LSB first). It returns the delivered power in watts if measurement system is a Directional Coupler. If measurement system is a VI sensor, it returns real power in watts.	0	2 data bytes 16-bit value
168 read ext feedback (dc bias)	Requests a snapshot of external feedback level at that instant. Data bytes 0 and 1 represent External feedback (LSB first). It returns the external feedback (DC Bias).	0	2 data bytes 16-bit value
169 read fwd pwr limit	Requests programmed limit for forward power (set by CMD **4**). *Note:* The response returns the user forward power limit in watts.	0	2 data bytes 16-bit value
170 read refl pwr limit	Requests reflected power limit (set by CMD **5**). *Note:* The response contained in data bytes 0 and 1 represent user reflected power limit in watts.	0	2 data bytes 16-bit value
171 read ext feedback limit	Requests external feedback limit (set by CMD **6**) *Note:* The response in data bytes 0 and 1 represent the user external feedback limit (LSB first). It returns the user external feedback limit.	0	2 data bytes 16-bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
184 read out-of-set point interval	Requests how long the generator is programmed to produce output that is not equal to the programmed set point level before shutting output off (set with CMD **15**). *Note:* Data bytes 0and 1 represent the unsigned integer value for out of set point time interval (LSB first). It reports how many seconds the generator will produce output that is not equal to the set point before turning the output off.	0	2 data bytes 16-bit value
185 read allowable deviation	Requests what percentage the generator can be out of set point before it starts the out-of-set-point timer (set with CMD **16**). Reports the allowable set point deviation *Note:* The response reports the percentage (1 to 99) and the supply can be out of set point before turning on the out-of-set-point timer.	0	1 data byte 8-bit value
188 read recipe step set points/run times	Reports the set points and run times for each of the 7 recipe steps. For each recipe step, 4 data bytes are returned, indicating: • First 2 bytes = recipe step set point in watts • Second 2 bytes = recipe step run time in hundredths of seconds or joules, depending on the recipe mode (recipe mode is reported by CMD **189**)	0	28 data bytes 14 16-bit values

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
189 read recipe steps, status, and mode	Reports the number of steps in the recipe, the status of the most recent recipe run, and the recipe mode (time or joules). Returns 3 data bytes: • Byte 0 = number of recipe steps • Byte 1 = recipe status: ▸ bit 0 = ignition (1 = ignition detected; 0 = ignition not detected) ▸ bits 1, 2, and 3 = the most recently completed step number ▸ bits 4–7 = reserved or unassigned • Byte 2 = recipe mode (1 = time, 2 = joule)	0	3 data bytes 3 8-bit values
193 read pulsing frequency	Requests the RF pulsing frequency in Hz (set with CMD **93**). *Note:* The response contains 4 data bytes. All represent frequency (LSB first).	0	4 data bytes 32-bit value
196 read pulsing duty cycle	Requests the duty cycle in% ON time *Note:* The response contains 2 data bytes which represent duty cycle (LSB first) in percent on time.	0	2 data bytes 16-bit value
198 read firmware revision level	Requests the revision level of the firmware. The returning packet contains three ASCII characters—one letter, followed by a two-digit number. Used in conjunction with CMD **130** to obtain the version/revision of the firmware.	0	3 data bytes 3 ASCII characters

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
199 report arc events and potentiometer sensitivity	Reports values for the selected arc data or potentiometer sensitivity value. Send 1 data byte (8-bit value) indicating the value to read back: • Byte 0: ▸ 1 = Arc events per run ▸ 2 = Arc events per second ▸ 3 = Arc suppression time ▸ 4 = Reserved ▸ 5 = Reserved ▸ 6 = Digital potentiometer 1 sensitivities values ▸ 7 = Digital potentiometer 2 sensitivity values ▸ 8 = Initial delay time in ms ▸ 9 = set point delay time in ms ▸ 10 = Number of attempts before failing (continued on next page)	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
199 (continued) report arc events and potentiometer sensitivity	(continued) Returns 4 data bytes. The interpretation of the data returned depends on the value sent. • For arc events per run: ▸ Bytes 0 through 3 (32-bit value) = the number of arc events during the current RF ON cycle. An RF On command resets the arc counter to zero (0). • For arc events per second: ▸ Bytes 0 through 3 (32-bit value) = the number of arc events per second during the current RF ON cycle. An RF ON command resets the arc counter to zero (0) • For arc suppression time: ▸ Bytes 0 through 3 (32-bit value) = the initial time in µs the output is turned off when an arc occurs • For digital potentiometer 1 sensitivity values: ▸ Byte 0 (8-bit value) = Potentiometer Channel 0 (upper limit offset) ▸ Byte 1 (8-bit value) = Potentiometer Channel 1 (upper limit multiplier) ▸ Byte 2 (8-bit value) = Potentiometer Channel 2 (lower limit offset) ▸ Byte 3 (8-bit value) = Potentiometer Channel 3 (lower limit multiplier) (continued on next page)	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
199 (continued) report arc events and potentiometer sensitivity	(continued from previous page) • For digital potentiometer 2 sensitivity values: ▸ Byte 0 (8-bit value) = Potentiometer Channel 0 (Absolute reflected limit) ▸ Byte 1 (8-bit value) =(reserved) ▸ Byte 2 (8-bit value) = (reserved) ▸ Byte 3 (8-bit value) = (reserved) • For initial delay time: ▸ Bytes 0 through 3 (32-bit value) = the initial delay time in ms • For set point delay: ▸ Bytes 0 through 3 (32-bit value) = the set point delay time in ms • For number of attempts: ▸ Bytes 0 through 3 (32-bit value) = the number of attempts before failing Set these value with commands **36** and **84**.	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values
201 read unit on events	Reports a count of unit on events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 data bytes 32-bit value
202 read output on events	Reports a count of output on events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 data bytes 32-bit value
203 read overtemp events	Reports a count of overtemp events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 bytes 32 bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
205 read run time	Requests the amount of time (in seconds) that the generator was producing output. *Note:* The response contains 4 bytes which represent a 32-bit time (LSB first). It returns the amount of time in seconds that the unit was producing output.	0	4 data bytes 32-bit value
210 read extended faults, warnings and shutdowns	Returns extended faults, warnings, and shutdowns *Note:* The response contains 16 data bytes which represents faults, warnings and shutdowns. All undefined bits are Byte 0 reserved for future use. • bit 0 = ripple warning (0 = inactive, 1 = active) • bit 1 = ripple failure (0 = inactive, 1 = active) • bit 2 = temperature rate failure (0 = inactive, 1= active) • bit 3 = AEbus Watchdog Timer Fault on Serial Port 1 (0=inactive, 1=active) • bit 4 = AEbus Watchdog Timer Fault on Serial Port 2. • bit 5 = reserved • bit 6 = condensation fault (0 = inactive, 1 = active) • bit 7 = unsafe voltage dropout fault (0 = inactive, 1 = active)	0	16 data bytes 8-bit value

Table 4-11. *Host port commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
221 read PIN number	Returns a string that represents the AE product identification number (PIN). The actual PIN length is 18 characters; however, the response packet is 25 characters. *Note:* Response contains 25 return data points in packet (LSB first). the actual PIN length is 18 characters; however, the response packet is 25 characters.	0	25 data bytes 25 ASCII characters
223 read error code register	Retrieves the error code. These codes are available in "Error code table" on page 6-5. *Note:* Response contains 1 data byte that is the error code.	0	1 data byte 8-bit value
228 read cold plate temperature in degrees celsius	Retrieves the temperature of the cold plate in degrees celsius.	0	2 data bytes 16-bit value
231 Report unit serial number	Reports the serial number of the unit. Bytes 0, 1,2, and 3 = an unsigned long integer representing the unit's serial number		4 data bytes 32-bit value

Host Port—Profibus

The Apex generator provides a serial communications interface through the **PROFIBUS** (Process Field Bus) port. This interface allows the Apex generator to interface with a PROFIBUS Master, which resides in a programmable logic controller (PLC). For a complete list of available functions, see "PROFIBUS Commands" on page 4-105.

These sections provide useful information needed to set up your system using a PLC.

To determine if your Apex unit has this serial interface, use the PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Profibus Host port option
PIN position 6, (A 1 2 3 4 5 **6** 7 8 9 10 11 12 13 14 15 16 17) **option 2**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

PROFIBUS CONNECTOR

The **PROFIBUS** Host port on the generator is a 9-pin, female, subminiature-D connector and an eight-switch DIP located beneath the connector, which is used to set the Apex generator's network address (see "Setting the Network Address with the Profibus DIP Switch" on page 4-100).

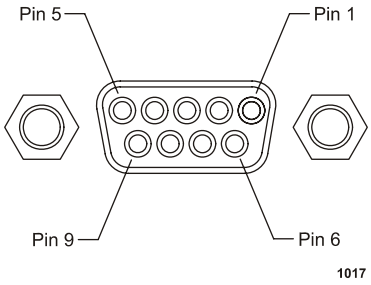


Figure 4-74. *PROFIBUS port connector*

PROFIBUS PORT PIN AND SIGNAL DESCRIPTIONS

Table 4-12 provides descriptions for the **PROFIBUS** Host port pins.

Table 4-12. *Profibus Host Port Pins*

Signal Pin	Name	Description
1	*UNASSIGNED*	
2	*UNASSIGNED*	
3	*A*	Data bus A
4	*UNASSIGNED*	
5	*ISOLATED GND*	Isolated ground
6	*ISOLATED +5 V*	Isolated +5 V
7	*UNASSIGNED*	
8	*B*	Data bus B
9	*UNASSIGNED*	

PROFIBUS CABLING AND TERMINATION

The cable used for the **PROFIBUS** interface must be RS-485 shielded twisted pair compatible with **PROFIBUS** standard communication requirements. Maximum segment lengths depend on the baud rate.

Table 4-13. *Baud rate and cable lengths*

Baud Rate	Length
1.5 M	200 meters
12 M	100 meters

Terminate each segment at both ends, and power the termination at all times. If a segment has more than 31 devices, then you must use a repeater.

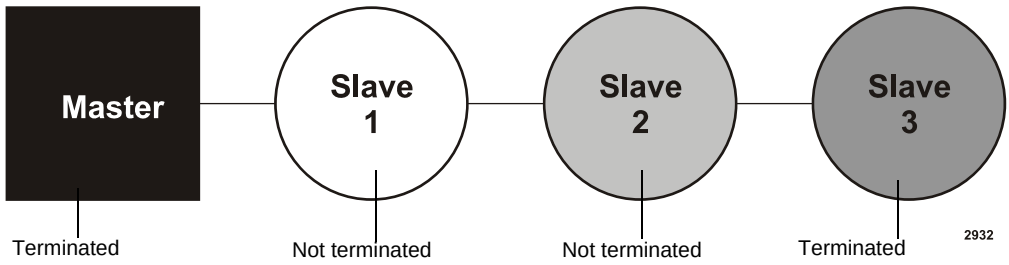


Figure 4-75. *Example of a segment*

AE PROFIBUS PROTOCOL

PROFIBUS is an interface that lets you communicate with the Apex generator from a PROFIBUS Master. AE manufactures a certified PROFIBUS, which means the interface is tested and certified to work with PROFIBUS Masters described in the DIN 19245 PROFIBUS Standard DP, part III. Any PROFIBUS Master that complies with this standard can communicate with AE's certified PROFIBUS.

Note: AE's PROFIBUS protocol does not support the following functions: address changing through the Master, freeze/unfreeze modes, or sync modes.

Note: Before controlling/monitoring the Apex generator through the host port, you need to ensure that the required User port inputs are satisfied and that the control mode is properly set. The required User port inputs are identified under the Satisfying Minimal Requirements section for your User port. To determine which User port you have, see the PIN position 8 in "Apex PIN Positions and Associated Options" on page 1-5. The control mode is usually set to the PROFIBUS as default when this host port option is installed. To ensure the control mode is set to host, see commands 14 (sets control mode) and 155 (reads control mode) in the "Profibus Host Port Commands" on page 4-106.

PROFIBUS GSD Files

GSD files are computer files that most programmable logic controllers (PLCs) use to configure PROFIBUS slaves. These files are device-specific and contain information on features found in that device.

Figure 4-76. *AE PROFIBUS GSD file: aec0021A.gsd*

For general PROFIBUS information and specific information about GSD files, visit the following Web site:

Setting the Network Address with the Profibus DIP Switch

You can set the Apex generator's PROFIBUS address to an even-numbered address from 2 through 126. Your unit has an external DIP switch adjacent to the PROFIBUS port, and you can change the unit address with that switch.

You cannot change the unit address from the PROFIBUS master.

To Set the Unit PROFIBUS Address Through an External DIP Switch:

Figure 4-77 shows a **PROFIBUS** port and DIP switch. As shown in the illustration, the DIP switch has numbered switch labels (**1** through **8**).

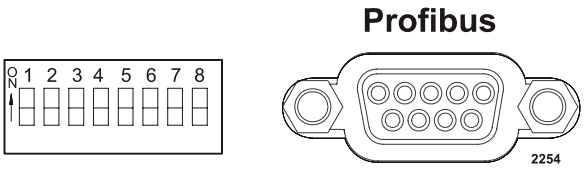


Figure 4-77. *PROFIBUS port and DIP switch*

One side of the DIP switch shows the switch numbers (**1** through **8**). Switch 8 is the MSB. Positioning a switch toward the number indicates a "1" binary. To enter the unit address, set the DIP switch positions for binary representation of the desired address, with switch 8 as the MSB. For example, to set an address of 4, set the switches to 0010 0000.

Placing a switch in the "up" position (toward the number) is the same as indicating "1" binary. The following example demonstrates switch settings for an address of 12: 0000 1100 = 0x0Ch = 12.

PROFIBUS Baud Rate

The baud rate is set by the PROFIBUS Master. The PROFIBUS slave adjusts automatically to the rate of the PROFIBUS Master system. Baud rates are available in discrete steps from 9.6 kbits to 12 Mbits.

PROFIBUS Master Reset Command

Send the **master reset command**, PROFIBUS command **119**, when the Apex generator experiences an explicit clear fault (such as a PROFIBUS error fault). Advanced Energy also recommends sending this command at the startup of PROFIBUS communications to clear any existing fault indications.

PROFIBUS Watch Dog Timer

As a safety feature, the PROFIBUS maintains a watch dog timer that shuts off the Apex generator's output if the PROFIBUS Master stops communicating. The watch dog timer maintains a value for time (between 10 milliseconds and 10 minutes) that the Apex generator waits between commands from the Master. The timer counts down this time in 10 millisecond increments.

If the PROFIBUS system does not calculate the watch dog timer value for you or if you want to modify the existing watch dog timer value, then you may enter a timer value by using the PROFIBUS Set_Prm function call (see DIN 19245 PROFIBUS Standard Part III) through the PROFIBUS Master. To get the actual wait time value, the Apex generator microprocessor uses the numbers you enter in octet 2 and 3 of the Set_Prm, multiplies them together, and then multiplies the result by 10 ms. Therefore, when using the Set_Prm function call, calculate the numbers for octet 2 and 3 accordingly. Remember, the values for octet 2 and 3 must not equal zero.

Note: You can also disable the watch dog timer through the PROFIBUS Master.

PROFIBUS-Specific Errors

In the event of a PROFIBUS error, the Apex generator turns off output power and sets the PROFIBUS fault status bit. All PROFIBUS errors are treated as explicit clear faults, which means that you must send PROFIBUS command **119** (the **master reset command**) in the next download packet to clear the faults and resume operation.

PROFIBUS Data Consistency

Some PLCs have a problem with *data consistency*, that is, the ability to complete the message packet construction before sending the packet to the Apex generator. Data inconsistency most often results in inappropriate value changes at the Apex generator.

This problem occurs because most PLCs share a memory block with the PROFIBUS interface. The PLC places data/packet information in the memory block, and the PROFIBUS interface reads the memory block for the next data/packet to transmit. Data inconsistency problems occur when the PLC updates the data from high to low memory locations without signaling the PROFIBUS interface that the update is complete. (If the PLC were to notify the PROFIBUS interface, then there would be data consistency.) As a result, the PROFIBUS interface sends the memory block regardless of where the PLC is in its update of that memory block.

Transmission Rates and The Handshake Feature

Recent technological improvements have made it possible for some PLCs to send commands faster than the Apex generator can respond. This situation can cause the Apex generator to have intermittent failures in responding to or executing commands.

In response to this issue, AE has developed a handshake feature, which echoes back the last sent command in byte 13 of the upload packet.

This feature allows you to send a command and wait for verification that the command was accepted before sending the next command. Using the handshake feature has the following benefits:

- It simplifies the programming of PLCs that interact with AE products.
- It increases the bandwidth of the PROFIBUS channel by eliminating wasted time.
- It provides immediate feedback regarding command execution.
- It increases the reliability of PROFIBUS communications.

Note: You can choose not to use the handshake feature, but if you do so, do not send commands to the Apex generator at a rate faster than one command per 20 milliseconds.

PROFIBUS COMMAND STRUCTURE

PROFIBUS commands include both a download packet (outbytes) and an upload packet (inbytes).

The following sections describe the download and upload packets in more detail.

PROFIBUS Download Packet

The download packet for PROFIBUS contains four bytes, as shown in Table 4-14.

Table 4-14. *Configuration of PROFIBUS download packet bytes*

Byte	Description
0	Command
1	Data byte (LSB)
2	Data byte
3	Data byte (MSB)

In the download packet, bytes 1, 2, and 3 make up the data field and contain information defined by the command.

Note: When the data exceeds one byte, the packet sends the least significant byte (LSB) before the most significant byte (MSB).

Profibus Upload Packet

During every PROFIBUS data exchange, the Apex generator supplies a 14-byte response, or upload packet, to the download packet. Table 4-15 defines the bytes contained in the upload packet.

Table 4-15. *Configuration of PROFIBUS upload packet (Inbytes)*

Byte	Description
0	Status flags—first byte
1	Status flags—second byte
2	Delivered power low
3	Delivered power high
4	Forward power low
5	Forward power high
6	Reflected power low
7	Reflected power high
8	Data byte (LSB) or CSR if applicable (Handshake)
9	Data byte
10	Data byte
11	Data byte
12	Data byte (MSB)
13	Data field definition CMD (Handshake)

PROFIBUS Upload Packet Data Bytes 0 and 1

Bytes 0 and 1 of the upload packet contain information about the status of the Apex generator (in the form of status bit flags). Table 4-16 defines these status bit flags.

Table 4-16. *Upload Status Bytes*

First Status Bit	8 = Control mode (with bit 9) 9 = Control mode (00 = User, 10 = Profibus) 10 = set point status OK 11 = Reserved 12 = End of Target Life (EOTL) 13 = Active toggle bit 14 = Bus fault (high or low) 15 = Reserved
Second Status Bit	0 = Reserved 1 = Overtemperature condition 2 = Interlock mechanism open 3 = Momentary power failure 4 = Reserved 5 = Reserved 6 = Reserved 7 = Output is on

In the first status byte, bit 13 (the active toggle bit) indicates, the status of the Profibus interface. After the Apex generator has powered up, this bit's continuous change indicates that the Profibus interface is ready. During operation, a cessation of this change indicates that a communication problem exists.

PROFIBUS Upload Packet Data Bytes 8 through 13

In the upload packet, bytes 8, 9, 10, 11, and 12 make up the data field and contain information defined by byte 13, the command number.

Note: When the reply data extends over more than one byte, the PROFIBUS sends the least significant byte (LSB) before the most significant byte (MSB). Byte 13 references the requesting command.

Refresh Rates in the Upload Packet

Due to the data exchange speed, attempting to refresh all the data in any given upload packet would consume too much of the unit processing resources. Therefore, the generator refreshes and returns the upload packet at timed intervals. These intervals vary depending on the relative importance of the data. The list below shows which data are refreshed at each rate. In all cases, the times shown are the longest possible; the actual rate is often shorter.

- 10 ms handshake refresh (timer is reset with every received command)

  This refresh rate is reserved for echoing back the last command sent and, when applicable, its CSR code.

- 20 ms refresh (timer is reset with every received command)

  This refresh rate is reserved for the three high priority signals in the status bytes: joules reached, output on, and faults active.

- 100 ms refresh (timer is reset with every received command)

  This refresh rate is used for the following information:

  - Output readback data
  - Command echo and data for commands **128** through **230**
  - Low priority signals in the status bytes: control mode bits
  - Live update commands (live update commands are reporting commands that continue to refresh the reply data)

PROFIBUS COMMANDS

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

PROFIBUS Command Status Response (CSR) Codes

When the Apex generator receives a command requesting a change in unit operation (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 4-10 to interpret the CSR codes.

Table 4-17. *PROFIBUS CSR codes*

Value	Meaning
0	Command accepted
1	Command rejected because the unit is in the wrong control mode
2	Command rejected because output is on
3	Command rejected because ramp is in progress
4	Command rejected because the data sent is out of range
5	Command rejected because corresponding **User** port signal is off
7	Command rejected because active fault(s) exist in the Apex generator
9	Command rejected because the data byte count is incorrect

Table 4-17. *PROFIBUS CSR codes (Continued)*

16	Command rejected because the target life is expired
19	Command rejected because recipe mode is active
30	Command rejected because EEPROM read/write
53	Command rejected because arc suppression is enabled
54	Command rejected because pulsing is enabled
99	Command not implemented
119	PROFIBUS fault cleared

PROFIBUS Command Set

The Apex generator PROFIBUS serial communication interfaces have two types of commands:

- Commands **1** through **127** request a change to the Apex 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 "PROFIBUS Command Status Response (CSR) Codes" on page 4-105.
- Command numbers **128** through **255** request information from the unit, such as output unit settings and statistics. The unit responds to these commands by sending the data requested.

Table 4-18 lists the command set for the Profibus Host port.

Table 4-18. *Profibus Host Port Commands*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
0 **NULL Command**	Requests RF output off; request is always honored, regardless of which interface has control. *Note:* This is the Profibus NULL Command		
1 **RF off**	Requests RF output off; request is always honored regardless of which interface has control. Readback command is **162**.	0	1

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
2 **RF on**	Requests RF output on; host control must have been selected.	0	1
3 **regulation select**	Sets the method of output regulation (forward power—6, load—7, and ext—8). Readback command is **164**.	1 data byte 8-bit value	1
4 **fwd pwr limit**	Specifies maximum forward power that can be delivered; accepts a value of 0 to full scale power. (Readback command is **169**.) *Note:* When in load regulation mode, this limit represents the maximum load power that can be delivered.	2 data bytes 16-bit value	1
5 **refl pwr limit**	Specifies maximum reflected power that can be tolerated; accepts a value of 0 to 1100W or 20% of full scale power. Readback command is **170**.	2 data bytes 16-bit value	1
6 **ext feedback limit**	Specifies the maximum external feedback level; accepts a value from 0 to the maximum external feedback value. This command sets the value at which the set point is limited during external regulation. Readback command is **171**.	2 data bytes 16-bit value	1
8 **set point**	Specifies the output set point level for whatever method of output regulation has been selected. Accepts a value of 0 to full scale power when forward or load power regulation is selected.	2 data bytes 16-bit value	1
9 **max ext feedback**	Specifies the external feedback value that corresponds to 10 V on the User port; requires data bytes arranged as follows: Bytes 0 and 1 = a 16-bit value in the range of 100 to 10000. Byte 2 = not used (set to 0)	3 data bytes 16-bit value 8-bit value	1

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
11 select active target	Specifies which target is active; accepts a value of 1 to 4. (Readback command is **156**.)	1 data byte 8-bit value	1
12 set target life	Sets the life (in kWh) of the active target. Requires three data bytes (24-bit value): First, second and third bytes = target life in kWh. Two decimal places are implied—to get 1 kWh, send a value of 100. (Readback command is **157**.)	3 data bytes 24-bit value	1
14 control transfer	Sets the active control mode of the generator; possible choices are: 2 = host, 4 = User port (analog).	1 data byte 8-bit value	1
15 out-of-set point timer	Specifies how long the generator can produce output that is not equal to the programmed set point level. Accepts a value of 0 to 599 s. (0 disables the timer.) (Readback command is **184**.)	2 data bytes 16-bit value	1
16 allowable deviation	Specifies a percentage that the generator can be out of set point before it starts the out-of-set point timer. Accepts a value of 1 to 99%. (Readback command is **185**.)	1 data byte 8-bit value	1
19 number of recipe steps	Specifies the number of recipe steps. Send 1 data byte that indicates the number of recipe steps (0 through 7). *Note:* 0 disables recipe mode	1 data byte 8-bit value	1
22 recipe step/ set point	Specifies set point for a recipe step. Send 3 data bytes. • Byte 0 = recipe step number (can be 1 through 7) • Bytes 1 and 2 = set point value (send least significant byte first); the value must be within the operating range of the Apex unit (see "Output Electrical Specifications" on page 3-12)	3 data bytes 8-bit value 16-bit value	1

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
23 recipe step/ run time	Sets the run time for the specified recipe step. Send 3 data bytes. • Byte 0 = recipe step number (1 through 7) • Bytes 1 and 2 = run time in hundredths of seconds or in joules (if the recipe is set for joules mode; see CMD **28** to set recipe type); send least significant byte first	3 data bytes 8-bit value 16-bit value	1
28 recipe type	Sets the recipe for time or joules mode. Send one data byte indicating the recipe type: • 1 = time mode • 2 = joules mode	1 data byte 8-bit value	1
31 set set point ramping parameters	Sets the set point ramping mode and ramp parameters. The ramp up and down parameters can be set independently. The set point ramp parameters can be set while the output is on. The ramp parameters are not allowed to change during a set point ramp that is currently in progress. In either operating mode, the set point is updated at 10ms intervals. • Byte 0 = Ramp Mode ▸ 0 = Disabled. ▸ 1 = Ramp rate up (watts per second) ▸ 2 = Ramp rate down (watts per second) ▸ 3 = Ramp time up (time in ms) ▸ 4 = Ramp time down (time in ms) • Bytes 1 and 2 = Respective ramp rate up, ramp rate down, ramp time up, or ramp time down	3 data bytes 1 8-bit value 1 16-bit value	0

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
36 set arc suppression time/ disable arc handling	Sets the arc suppression time, meaning the time in µs that RF output is turned off when an arc is first detected. • Byte 0 (8-bit value) = arc suppression parameter selection ▸ 0 = Arc suppression time in µs. Minimum time = 2µs Maximum time = 511µs This is the amount of time the RF output is turned off when an arc is first detected. Note that the RF off time is automatically increased to handle hard arcs and resets to the specified time upon quenching a hard arc. Setting the arc suppression time to zero (0) disables the arc suppression algorithms, but leaves arc counting enabled. ▸ 1 = Initial Delay Time in ms. Minimum time = 20 ms Maximum time = 10,000 ms or 10 sec This is the amount of time that must elapse after turning the RF output on before the arc suppression algorithm will turn off the RF output due to an arc condition. Arc counting is also disabled during the Initial Delay Time. (continued on next page)	3 data bytes 1 8-bit value 1 16-bit value	1

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
36 set arc suppression time/ disable arc handling (continued)	(continued from previous page) ▸ 2 =Set point Delay Time in ms. Minimum time = 20 ms Maximum time = 245 ms This is the amount of time that must elapse after a significant change to the power set point before the arc suppression algorithm will turn off the RF output due to an arc condition. Arc counting is also disabled during the Set point Delay Time. ▸ 3 = Number of Attempts. Minimum = 0 Maximum = 250 ▸ This is the maximum number of times the arc suppression algorithm will attempt to quench the arc before asserting the Arc Suppression Fault. A value of zero disables the Arc Suppression Fault and allows the arc suppression algorithm to attempt to quench the arc indefinitely. • Byte 1 (8-bit value) = Arc Suppression Parameter Selection (LSB first) • Bytes 2 and 3 (16-bit value) = Arc Suppression Parameter	3 data bytes 1 8-bit value 1 16-bit value	1

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
84 set arc suppression potentiometer sensitivity values	Sets the arc suppression potentiometer sensitivity values. • Byte 0 (8-bit value) = This value is an offset value that is added to the base value stored within the unit during calibration. If the sum of the base plus offset values exceeds 255, the resulting value is truncated to 255. • Byte 1 (8-bit value) = potentiometer device number ▸ 4 = Device 1 (digital potentiometer 1) ▸ 5 = Device 2 (digital potentiometer 2) • Byte 2 = potentiometer channels ▸ When byte 1 = 4: • 0 = potentiometer channel 0 (upper limit offset) • 1 = potentiometer channel 1 (upper limit multiplier) • 2 = potentiometer channel 2 (lower limit offset) • 3 = potentiometer channel 3 (lower limit multiplier) ▸ When byte 1 = 5: • 0 = potentiometer channel 0 (absolute reflected limit)	3 data bytes 3 8-bit values	1
119 Profibus Reset/ Explicit Fault clear	Clears profibus fault and error code register *Note:* The CSR returned is 119, Profibus fault cleared.	0	1
128 supply type	Requests the generator type; returns 4 ASCII characters.	0	4 data bytes 4 ASCII characters
129 supply size	Requests the output capacity of the generator; returning packet contains 4 ASCII characters.	0	4 data bytes 4 ASCII characters

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
130 read mainframe software version number	Requests the version number of the mainframe software. The returning packet contains 5 ASCII characters—a 5-digit number representing the last 5 digits of the software part number. The first two digits "74" are implied. This command is used in conjunction with **CMD 198** to obtain the version/revision number of the mainframe software.	0	5 data byte 5 ASCII characters
151 report set point ramping parameters	Reports the set point ramping mode and ramp parameters. The ramp up and down parameters are independent. • Byte 0 = Ramp Mode ▸ 0 = Disabled. ▸ 1 = Watts per second. In this mode, the ramp parameters represent the ramp rate in Watts per second. The minimum ramp rate in this mode is 1 Watt per second. ▸ 2 = Timed. In this mode, the ramp parameters represent the time in ms. The minimum ramp time in Timed mode is 20 ms. • Bytes 1 and 2 = Ramp up (watts per second or time in ms) • Bytes 3 and 4 = Ramp down (watts per second or time in ms)	0	5 data bytes 1 8-bit value 2 16-bit values
154 read regulation mode	Requests regulation mode (set with CMD **3**). Returning values: • 6 = Forward • 7 = Delivered or Load • 8 = External (DC Bias)	0	1 data byte 8-bit value
155 read control method	Requests control mode (set by **CMD 14**). Returning values: 2 = host, 4 = analog.	0	1 data byte 8-bit value

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
156 read active target	Requests the number of the active target (set by **CMD 11**).	0	1 data byte 8-bit value
157 read target life	Requests the amount of life remaining (set by **CMD 12**) in the active target. Two decimal places are implied— 100 = 1 kWh.	0	4 data bytes 32-bit value

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
162 read process status	Requests report on process status; returning packet contains the following bytes arranged as follows. • Byte 0: ▸ 0 = unassigned ▸ 1 = unassigned ▸ 2 = recipe run is active ▸ 3 = unassigned ▸ 4 = unassigned ▸ 5 = output power (0 = off, 1 = on) ▸ 6 = RF On requested ▸ 7 = set point status (0 = within tolerance, 1 = out of tolerance) • Byte 1: ▸ 0 = end of target life ▸ 1 = unassigned ▸ 2 = unassigned ▸ 3 = overtemperature ▸ 4 = unassigned ▸ 5 = unassigned ▸ 6 = unassigned ▸ 7 = interlock open • Byte 2—fault flags: ▸ 0 = nonmaskable interrupt ▸ 1 = bus fault ▸ 2 = high bus voltage ▸ 3 = unassigned ▸ 4 = low bus voltage ▸ 5 = out of set point ▸ 6 = unassigned interrupt ▸ 7 = unassigned (continued on following page)	0	4 data bytes four 8-bit values

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
162 (continued) read process status	(continued from previous page) • Byte 3—fault flags: ▸ 0 = current limit ▸ 1 = contactor failure ▸ 2 = Profibus error ▸ 3 = unassigned ▸ 4 = unassigned ▸ 5 = extended fault status ▸ 6 = unassigned ▸ 7 = CEX is locked	0	4 data bytes four 8-bit values
164 read set point/ regulation mode	Requests output set point level (set by **CMD 8**) and whatever method of output regulation has been selected (set by **CMD 3**). The return packet is arranged as follows: First and second bytes = set point value. Third byte = method of output regulation.	0	3 data bytes 16-bit value 8-bit value
165 read forward power	Requests a snapshot of forward power level at that instant.	0	2 data bytes 16-bit value
166 read reflected power	Requests a snapshot of reflected power level at that instant.	0	2 data bytes 16-bit value
167 read delivered power	Requests a snapshot of load power level at that instant.	0	2 data bytes 16-bit value
168 read ext feedback (dc bias)	Requests a snapshot of external feedback level at that instant.	0	2 data bytes 16-bit value
169 read fwd pwr limit	Requests programmed limit for forward power (set by **CMD 4**).	0	2 data bytes 16-bit value

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
170 read refl pwr limit	Requests reflected power limit (set by **CMD 5**).	0	2 data bytes 16-bit value
171 read ext feedback limit	Requests external feedback limit (set by **CMD 6**).	0	2 data bytes 16-bit value
184 read out-of-set point interval	Requests how long the generator is programmed to produce output that is not equal to the programmed set point level before shutting output off (set with **CMD 15**).	0	2 data bytes 16-bit value
185 read allowable deviation	Requests what percentage the generator can be out of set point before it starts the out-of-set point timer (set with **CMD 16**).	0	1 data bytes 8-bit value
188 read recipe step set points/run times	Reports the set point and run time for the recipe step specified by the transmitted data byte. 4 data bytes are 8 bit value returned, indicating: • Bytes 0 and 1 = recipe step set point in watts • Bytes 2 and 3 = recipe step run time in hundredths of seconds or joules, depending on the recipe mode (recipe mode is reported by CMD **189**)	1 data byte	4 data bytes 2 16-bit values

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
189 read recipe steps, status, and mode	Reports the number of steps in the recipe, the status of the most recent recipe run, and the recipe mode (time or joules). Returns 3 data bytes: • Byte 1 = number of recipe steps • Byte 2 = recipe status: ▸ bit 0 = ignition (1 = ignition detected; 0 = ignition not detected) ▸ bits 1, 2, and 3 = the most recently completed step number ▸ bits 4–7 = reserved or unassigned • Byte 3 = recipe mode (1 = time, 2 = joule)	0	3 data bytes 3 8-bit values
198 read mainframe software revision level	Requests the revision level of the mainframe software. The returning packet contains three ASCII characters—one letter, followed by a two-digit number. Used in conjunction with **CMD 130** to obtain the version/revision of the mainframe software.	0	3 data bytes 3 ASCII characters

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
199 report arc events and potentiometer sensitivity	Reports values for the selected arc data or potentiometer sensitivity value. Send 1 data byte (8-bit value) indicating the value to read back: • Byte 0: ▸ 1 = Arc events per run ▸ 2 = Arc events per second ▸ 3 = Arc suppression time ▸ 4 = Reserved ▸ 5 = Reserved ▸ 6 = Digital potentiometer 1 sensitivities values ▸ 7 = Digital potentiometer 2 sensitivity values ▸ 8 = Initial delay time in ms ▸ 9 = set point delay time in ms ▸ 10 = Number of attempts before failing (continued on next page)	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
199 (continued) report arc events and potentiometer sensitivity	(continued) Returns 4 data bytes. The interpretation of the data returned depends on the value sent. • For arc events per run: ▸ Bytes 0 through 3 (32-bit value) = the number of arc events during the current RF ON cycle. An RF On command resets the arc counter to zero (0). • For arc events per second: ▸ Bytes 0 through 3 (32-bit value) = the number of arc events per second during the current RF ON cycle. An RF ON command resets the arc counter to zero (0) • For arc suppression time: ▸ Bytes 0 through 3 (32-bit value) = the initial time in µs the output is turned off when an arc occurs • For digital potentiometer 1 sensitivity values: ▸ Byte 0 (8-bit value) = Potentiometer Channel 0 (upper limit offset) ▸ Byte 1 (8-bit value) = Potentiometer Channel 1 (upper limit multiplier) ▸ Byte 2 (8-bit value) = Potentiometer Channel 2 (lower limit offset) ▸ Byte 3 (8-bit value) = Potentiometer Channel 3 (lower limit multiplier) (continued on next page)	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
199 (continued) report arc events and potentiometer sensitivity	(continued) • For digital potentiometer 2 sensitivity values: ▸ Byte 0 (8-bit value) = Potentiometer Channel 0 (Absolute reflected limit) ▸ Byte 1 (8-bit value) =(reserved) ▸ Byte 2 (8-bit value) = (reserved) ▸ Byte 3 (8-bit value) = (reserved) • For initial delay time: ▸ Bytes 0 through 3 (32-bit value) = the initial delay time in ms • For set point delay: ▸ Bytes 0 through 3 (32-bit value) = the set point delay time in ms • For number of attempts: ▸ Bytes 0 through 3 (32-bit value) = the number of attempts before failing Set these value with commands **36** and **84**.	1 data byte 8-bit value	4 data bytes 32-bit value or 4 data bytes 4 8-bit values
201 read unit on events	Reports a count of unit on events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 data bytes 32-bit value
202 read output on events	Reports a count of output on events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 data bytes 32-bit value
203 read overtemp events	Reports a count of overtemp events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).	0	4 bytes 32 bit value
205 read run time	Requests the amount of time (in seconds) that the generator was producing output.	0	4 data bytes 32-bit value

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
206 read total energy output	Requests the total amount of energy (in kWh) delivered by the generator.	0	4 data bytes 32-bit value
210 extended faults, warnings and shutdowns	Reports extended faults, warnings and shutdowns. The transmitted databyte specifies which of the 16 possible fault status bytes will be returned. Valid values are 0 to 15. All undefined bits are reserved for future use. One fault status byte is returned as specified below. Byte 0: • bit 0 = ripple warning (0 = inactive, 1 = active) • bit 1 = ripple failure (0 = inactive, 1 = active) • bit 2 = temperature rate failure (0 = inactive, 1 = active) • bit 3 = AEbus Watchdog Timer fault serial port 1 (0 = inactive, 1 = active) • bit 4 = AEbus Watchdog Timer fault on serial port 2 (0 = inactive, 1 = active) • bit 5 = reserved • bit 6 = condensation fault (0 = inactive, 1 = active) • bit 7 = unsafe voltage dropout fault (0 = inactive, 1 = active)	1 data byte 8 bit value	1 data byte 8 bit value
223 read error code register	Retrieves the error code, these codes are available in Chapter 6 in this manual. *Note:* The response contains 1 databyte which is the error code.	0	1 data byte 8 bit value

Table 4-18. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit (Host) Data Bytes	Number of Response Data Bytes
228 read cold plate temperature	Retrieves cold plate temperature in degrees celsius.	0	2 data bytes 16 bit value
231 read unit serial number	Reports serial number of the unit. Bytes 0, 1, 2, 3, and 4 = an unsigned long integer representing the unit's serial number.	0	4 data bytes 32 bit value

Host Port—DeviceNet

The Advanced Energy Apex DeviceNet interface operates as a slave on the DeviceNet network. The unit supports Explicit Messages and Polled I/O Messages of the predefined master/slave connection set. It does not support the Explicit Unconnected Message Manager (UCMM).

The DeviceNet interface responds to poll requests in less than one millisecond. Explicit requests are serviced in under two millisecond.

DEVICENET™ PORT

The DeviceNet™ system enables basic control of the Apex generator through a 5-pin serial **DeviceNet** port. The Apex 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.

DEVICENET™ PORT CONNECTOR

The **DeviceNet** connector is either a 5-pin, 12-millimeter "Micro" Lumberg RSF 5/0.5 or Turck FS 4.5 series connector.

Figure 4-78 illustrates the **DeviceNet** port. This port is a round, five-pin, male connector, electrically isolated from the power supply.

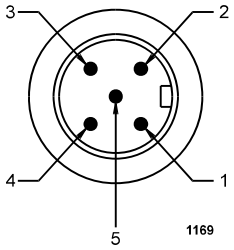


Figure 4-78. *DeviceNet™ port connector*

DEVICENET™ PORT PIN DESCRIPTIONS

Table 4-19 provides the connector pin descriptions for the **DeviceNet** port interface.

Table 4-19. *DeviceNet™ port pin descriptions*

Pin Number	Pin Name
1	Drain
2	V+
3	V-
4	CAN_H
5	CAN_L

CONTROL PANEL LEDS

The rear panel of the Apex generator 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. It indicates whether the device has power and is operating properly. “Module status (MOD) LED” on page 4-125 describes the LED states and associated unit status.

Table 4-20. *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. “Network status (NET) LED” on page 4-126 describes the LED states and associated unit status.

Table 4-21. *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 baud rate. Each time the DeviceNet interface is energized the switch settings are read by the DeviceNet master.

Data Rate Rotary Switch

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

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

Node Address Rotary Switches

Use the **NODE ADDRESS** rotary switches, **MSD** (most significant digit) and **LSD** (least significant digit), to select the unit's 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) let you configure the MAC ID through the DeviceNet master.

Note: 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 do not, one side will fault when the network is brought up.

SATISFYING DEVICENET™ MINIMUM REQUIREMENTS

Regardless of whether you are controlling and monitoring the unit through the **Apex generator User** port or through another port, the *INTERLOCK LOOP* signal of the **Apex generator User** port *must* be satisfied for the Apex generator to operate. In other words, even if you are controlling the Apex generator through the **DeviceNet** interface, the interlock signal must be satisfied.

If you are not controlling or monitoring the unit through the **Apex generator User** port, you can use a *dummy* or *cheater* plug to satisfy these two signals and thereby ignore the **Apex generator User** port. To make a dummy plug, solder a jumper on a mating conductor between the interlock pins to satisfy the *INTERLOCK LOOP* signal. To determine the physical location of these pin numbers on the **Apex generator User** port, see "Apex User Port Options" on page 4-4 and consult the appropriate User Port section for your option.

DEVICENET™ INTERFACE INFORMATION AND SUPPORTED FEATURES

The Advanced Energy DeviceNet interface operates as a slave on the 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 supported features and provide information necessary to add an Advanced Energy power supply to a DeviceNet network. Additional information is located 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 4-22.

Note: In Table 4-22, xxxxxx = Node address

Table 4-22. *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 4-23.

Table 4-23. *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 4-24. These object classes are discussed in detail in the sections that follow.

Table 4-24. *DeviceNet™ supported object classes*

CAN Identifier	GROUP 2 Message Type
01 (0x05)	Identity (see page 4-129 for more information)
02 (0x0E)	Router (see page 4-131 for more information)
03 (0x10)	DeviceNet (see page 4-131 for more information)
04 (0x4B)	Assembly (see page 4-133 for more information)
05 (0x05)	Connection (see page 4-134 for more information)
76 (0x4C)	Application (see page 4-137 for more information)

Identity Object—Class Code: 01 (0x01)

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

- Class attributes are listed in Table 4-25.
- Instance attributes are listed in Table 4-26.
- Common services are listed in Table 4-27.

Table 4-25. *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 4-26. *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

Table 4-26. *Identity object instance attributes*

Attribute	Access	Name	Type	Value
7	Get	Product Name	STRUCT OF	
		Length	UDINT	6
		Name	STRING []	

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

- Bit 0 = Owned
  - 0 = Not owned
  - 1 = Owned (allocated)
- Bit 1 = Reserved (0)
- Bit 2 = Configured (0)
- Bit 3 = Reserved (0)
- Bit 4 through 7 = Vendor specific (0)
- Bit 8 = Minor configuration fault
  - 0 = No fault
  - 1 = Minor fault
- Bit 9 = Minor device fault
  - 0 = No fault
  - 1 = Minor device fault
- Bit 10 = Major configuration fault
  - 0 = No fault
  - 1 = Major fault
- Bit 11 = Major device fault
  - 0 = No fault
  - 1 = Major device fault
- Bits 12 through 15 = Reserved (0)

Note 2: This number is an unique serial number.

Table 4-27. *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.

- Class attributes are listed in Table 4-28.
- Instance 1 attributes are listed in Table 4-29.
- Common services are listed in Table 4-30.

Table 4-28. *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 4-29. *Router object instance 1 attributes*

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

Table 4-30. *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.

- Class attributes are listed in Table 4-31.
- Instance 1 attributes are listed in Table 4-32.
- Common services are listed in Table 4-33.

Table 4-31. *DeviceNet™ object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 4-32. *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. Value returned will be switch value unless 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. Value returned will be switch value unless in **PGM** range. In the **PGM** range the value returned 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 = If possible reset CAN chip

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 (always 0)

Table 4-33. *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.

- Class attributes are listed in Table 4-34.
- Instance 100 attributes are listed in Table 4-35.
- Instance 101 attributes are listed in Table 4-36.
- Common services are listed in Table 4-37.

Table 4-34. *Assembly object class attributes*

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

Table 4-35. *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 4-36. *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 is defined as:

- Bit 0 = POS
  - 0 = Power off

- 1 = Power On

- Bit 1 = SPS
  - 0 = Not at set point
  - 1 = At set point
- Bit 2 = TS
  - 0 = Overtemperature
  - 1 = Not at Overtemperature
- Bit 3 = Unused
- Bit 4 = INTS
  - 0 = Interlock not engaged
  - 1 = Interlock engaged
- 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/ Power Off

- 0 = Power off
- 1 = Power on

Table 4-37. *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 II slave device, the unit supports one explicit message connection and one POLL message condition.

- Class attributes are listed in Table 4-38.
- Instance 1 attributes (explicit message) are listed in Table 4-39.
- Instance 2 attributes (poll message) are listed in Table 4-40.
- Common services are listed in Table 4-41.

Table 4-38. *Connection object class attributes*

Attribute	Access	Name	Type	Value
1	Get	Revision	UINT	1

Table 4-39. *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
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 4-40. *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

Table 4-40. *Connection object instance 2 attributes (poll message)*

Attribute	Access	Name	Type	Value
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
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 4-41. *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)

Table 4-42. *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 4-43. *Application object instance 1 attributes*

Attribute	Access	Name	Type	Value
1	Get	Power	UINT	Note 1 below
3	Get	NOT IMPLEMENTED	UINT	Note 3 below
4	Get/Set	NOT IMPLEMENTED	UINT	Note 4 below
5	Get	Status	USINT	Note 5 below
6	Get	Maximum Power	UINT	Note 6 below
7	Get	NOT IMPLEMENTED	UINT	Note 7 below
8	Get	NOT IMPLEMENTED	USINT	Note 8 below
9	Get	DC Bias	INT	VOLTS

Table 4-43. *Application object instance 1 attributes (Continued)*

Attribute	Access	Name	Type	Value
10	Get	NOT IMPLEMENTED	STRUCT of INT	Real and Imaginary impedance in tenths of ohms
11	Get	Power Margin	INT	Watts
12	Get/Set	NOT IMPLEMENTED	USINT	Note 9 below
13	Get	DNET APP SW PN	SHORT_ STRING	The DeviceNet application software number
14	Get	DNET CFG SW PN	SHORT_ STRING	The DeviceNet configuration Software number
15	Get	Apex SW PN		The Apex application software number
16		not implemented		
17	Get	NOT IMPLEMENTED	USINT	Degrees C

Table 4-44. *Application object common services*

Service Code	Class	Instance	Service Name
14	Yes	Yes	Get_Attribute_Single
16	No	Yes	Set_Attribute_Single

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

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

Note 5: The status byte is defined as follows:

- Bit 0 = POS
  - 0 = Power off
  - 1 = Power on
- Bit 1 = SPS
  - 0 = Not at set point

- 1 = At set point

- Bit 2 = TS
  - 0 = Overtemperature
  - 1 = Not at Overtemperature
- Bit 3 = ARCD
  - 0 = No arc detected
  - 1 = Arc detected
- Bit 4 = Not used
- Bit 5 = INTS
  - 0 = Interlock not engaged
  - 1 = Interlock engaged
- Bits 6 and 7 = Not used

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

Note 7: Not used

Note 8: Not used

Note 9: A reset request performs the following:

- Bit 0 = Series 3 (0 = pin diode not selected, 1 = pin diode selected)
- Bit 1 = Series 1 (0 = pin diode not selected, 1 = pin diode selected)
- Bit 2 = Shunt 1 (0 = pin diode not selected, 1 = pin diode selected)
- Bit 3 = Shunt 2 (0 = pin diode not selected, 1 = pin diode selected)
- Bit 4 = Series 2 (0 = pin diode not selected, 1 = pin diode selected)
- Bit 5 = chamber/50 ohm (0 = 50 ohm port, 1 = Chamber port)
- Bit 6 = not used
- Bit 7 = not used

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

- Class attributes are listed in Table 4-45.
- Instance 1 attributes are listed in Table 4-46.
- Common services are listed in Table 4-47.

Table 4-45. *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 4-46. *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 4-47. *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
  - 0 = Power off

- 1 = Power on

- Bit 1 = SPS
  - 0 = Not at set point
  - 1 = At set point
- Bit 2 = TS
  - 0 = Overtemperature
  - 1 = Not at overtemperature
- Bit 3 = Not used
- Bit 4 = INTS
  - 0 = Interlock not engaged
  - 1 = Interlock engaged
- 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 Apex generator is energized (powers on), it defaults to User control mode. However, engaging the **DeviceNet** port from the DeviceNet master places the generator under DeviceNet control until the next time power is cycled.

Adding The Apex generator to a DeviceNet™ Network

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

- Satisfy all interlocks on the Apex generator **User** port (see "Satisfying DeviceNet™ Minimum Requirements" on page 4-127 for more information).
- Ensure the existing DeviceNet network conforms to the ODVA DeviceNet specification (version 2.0 or later) published by the Open DeviceNet Vender Association (available from the ODVA web site at: http://www.odva.org).
- Connect the **DeviceNet** port to the network (see "DeviceNet™ Port Pin Descriptions" on page 4-124 for connector pin information).
- Select the appropriate MAC ID and transmission baud rate (see "Control Panel Rotary Switches" on page 4-126 for more information).
- Read the section titled, "DeviceNet™ Interface Information and Supported Features" on page 4-127.

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 Apex 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 4-134.

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 4-48. *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)			
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: In this bit:

- 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.

- 0 = Interlock not satisfied
- 1 = Interlock satisfied

Table 4-49. *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: The 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: The 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. Thus they have analog scaling associated with them.

The Apex 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 4-134 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

DeviceNet uses unsigned binary to represent from zero to the full-rated output power of the Apex generator. To calculate the digital value and corresponding value of output power, use the following equation:

$$2^N\text{-}1 = (\text{full-rated output power in kW} \times 2^N\text{-}1) / 2^N$$

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 4095 (or 0FFFh).

The Apex generator DeviceNet interface supports explicit messaging so that you can receive information about system parameters—for instance, Max Power. For more information about this type of messaging, refer to "Connection Object—Class Code: 05 (0x05)" on page 4-134 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 this information:

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

Note 1: The Max 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 Max 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

This chapter guides you through the process of installing, setting up, and operating an Apex generator. It includes the following sections:

Because Apex generators are equipped with varying options, not all of the information in this chapter applies to every Apex generator. In places where the information is option-specific, configuration notes are used to identify the PIN position and option associated with the information. For information on using the Apex PIN to locate the information in this manual that is applicable to your unit, see "Apex PIN Positions and Associated Options" on page 1-5.

INSTALLING THE GENERATOR

To install the Apex generator follow these steps:

Unpacking

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

Grounding

The unit provides two threaded grounding holes (one is a metric A-6, the other is a 5/16" x 18 US). A suitable chassis ground connection made to either of these holes prevents or minimizes radio frequency interference.

See Figure 5-1 and Figure 5-2 for standard connection information for 208 V units and 400 V units.

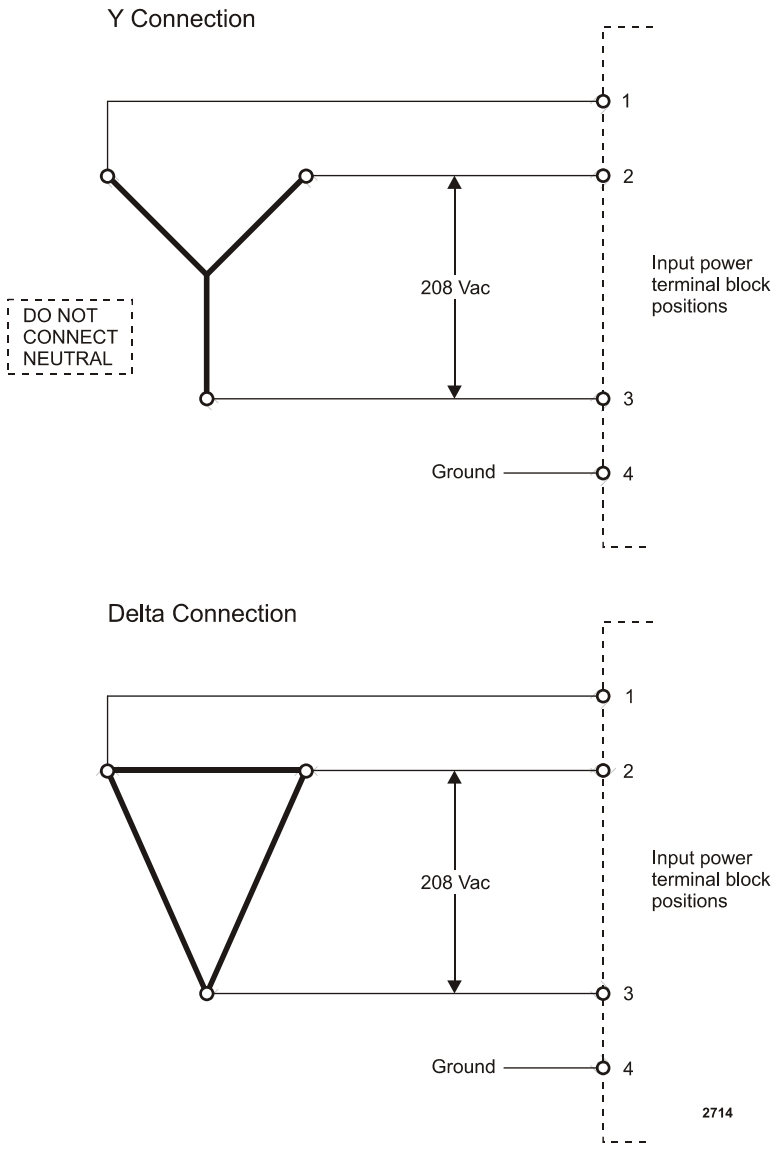


Figure 5-1. *Standard connection for 208 V units*

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

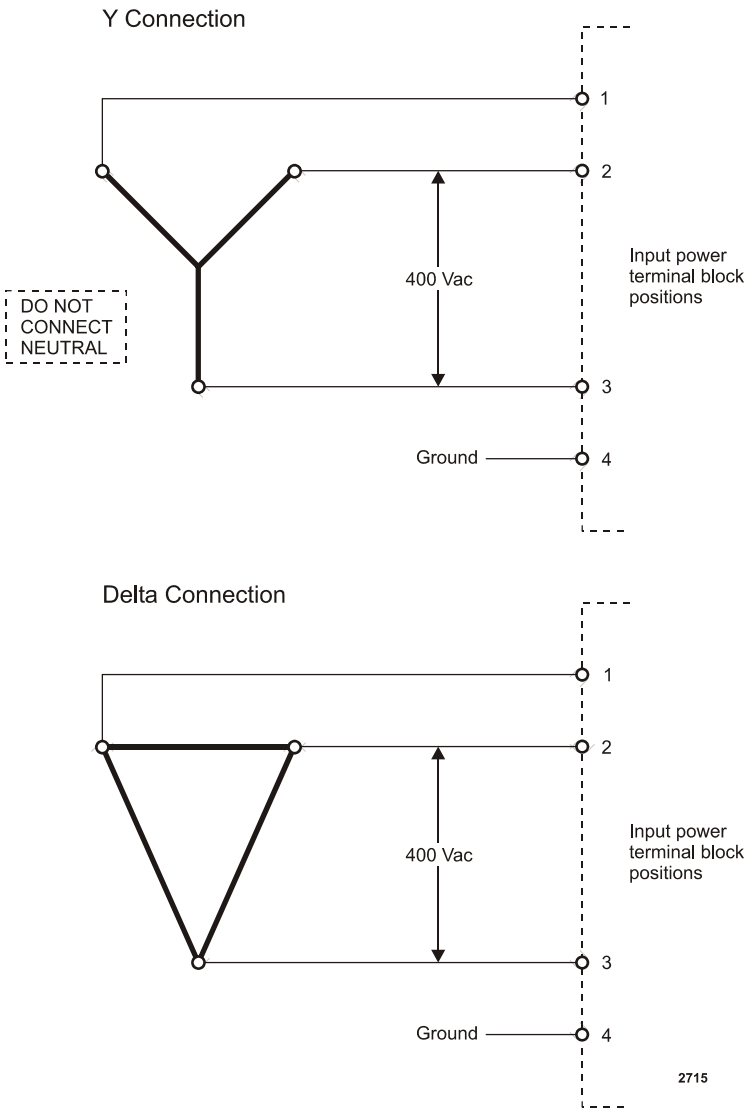


Figure 5-2. *Standard connection for 400 V units*

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

Spacing Requirements

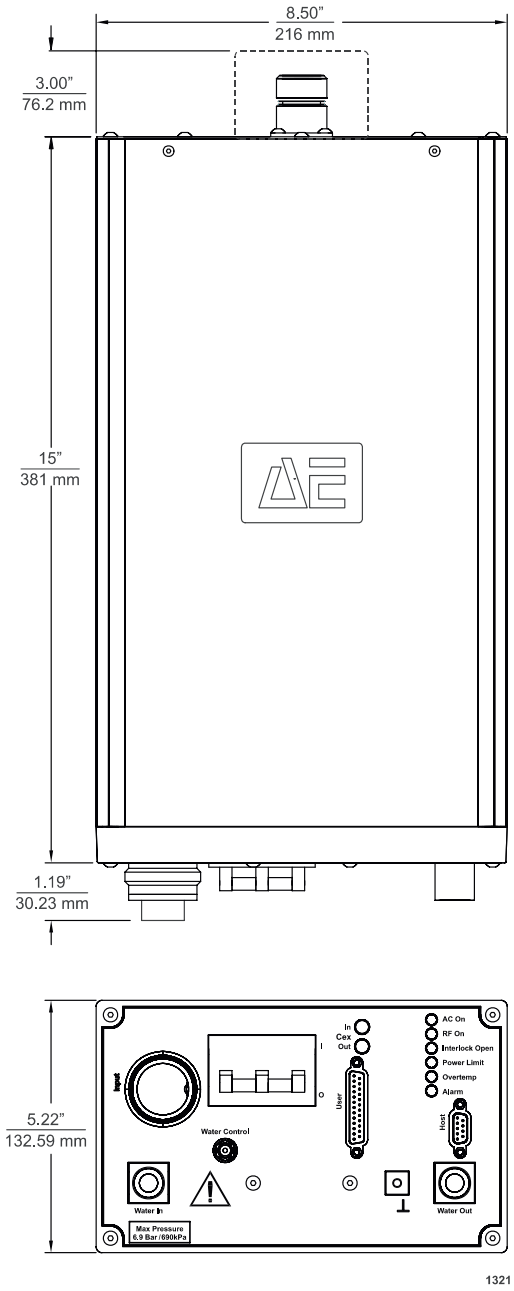


Figure 5-3. *Apex dimensions*

Mounting the Generator

Refer to “Apex dimensions” on page 5-5 for dimensions to aid in proper mounting of the Apex generator.

Connecting Cooling Water

This generator is water cooled. Do not operate it until water is connected and the cooling requirements are met. For information on cooling requirements, see “Cooling Specifications” on page 3-17.

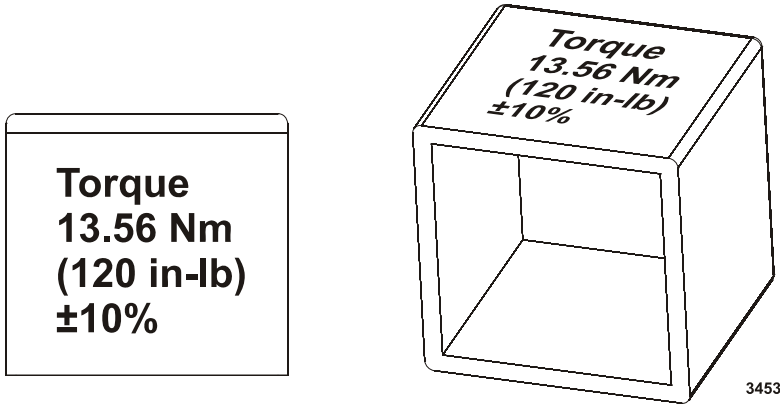
⚠ CAUTION:
If you connect the cooling water on multiple units in series, be sure that input water temperature to all units is less than the maximum input water temperature.

⚠ CAUTION:
Do not use de-ionized water for cooling purposes. De-ionized water causes both corrosion and erosion of cooling manifolds.

Apex water fittings vary depending on the option installed on the generator. Water fittings are identified by the option in PIN position 16 (for information about using the PIN to identify and find information about your generator, see “Using this Manual to Find Information About Your Generator” on page 1-1).

To Connect Cooling Water:

1. Connect the input and output water connections and torque to 13.56 Nm (120 in-lb) ±10%. There will be a vinyl sleeve on each water connection manifold that also specifies the required torque value.



2. Turn on the water and ensure that there are no leaks.
3. Be sure that the flow rate, pressure, and temperature are within the minimum specifications required to operate the generator (see "Cooling Specifications" on page 3-17).

Installing the Optional Water Control

The Apex generator provides a 2-pin connector for use in controlling an externally-mounted, user-supplied, electronically activated water control valve. The generator provides contact closure between the two pins whenever cooling water flow is required. Cooling water is required whenever the generator's RF output power is enabled.

If the RF output has been disabled for more than 30 minutes, the generator will call for cooling water only as needed. A thermal switch on the unit's coldplate signals the need for water flow when the plate temperature exceeds 35ºC (95ºF) and resets when the temperature falls below 28ºC (82ºF). This feature can be useful for minimizing condensation in the generator when the RF output is not enabled.

If a water control valve is necessary for a given application, the user must supply a solenoid-activated water valve in-line with the cooling water supply to the generator and provide the AC or DC power necessary for activating the valve. The water control port on the unit is rated for voltages up to 30 VDC and 30 VAC with currents not to exceed 3 A. All cabling to the water connector control valve solenoid and 2-pin port must meet applicable electrical safety standards.

CONNECTOR AND WIRING DIAGRAM FOR OPTIONAL WATER CONTROL

The optional water control connector is a 2-pin miniature LEMO connector, part number ECGOB302CLL.

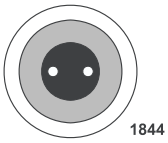


Figure 5-4. *Water control valve connector, LEMO*

The user must supply the power for the water control valve.

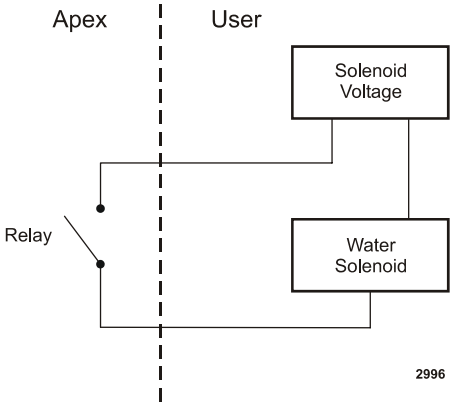


Figure 5-5. *Water control valve diagram*

Connecting Output Power

> **WARNING:**
> **The generator must be installed so the output connections are inaccessible to the user.**

Apex output connectors vary depending on the option installed on the generator. The output connector option is identified by the option in PIN position 11 (for information about using the PIN to find information about your generator, see "Using this Manual to Find Information About Your Generator" on page 1-1).

There are five output connector options:

- 7/16 connector (PIN 11, option 1)
- SQS™ connector (PIN 11, option 2)

- LC connector (PIN 11, option 3)
- HN connector (PIN 11, option 4)
- N connector (PIN 11, option 5)

Figure 5-6 provides a basic drawing of the output connectors.

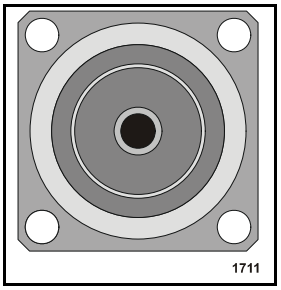


Figure 5-6. *Output connector*

For all the output connectors, the center pin provides the RF output connection, while the outer cable provides a ground connection.

LC CONNECTOR INTERLOCK CALIBRATION

ATTENTION:

This interlock calibration procedure should only be used with the following two Apex generator part numbers:
3156115-211
3156115-222
Do not use this procedure if you have a unit with an LC connector that is not option -211 or -222.

CAUTION:

Failure to perform calibration on the indicated unit part numbers may result in damage to the unit interlock switch.

The units that require LC connector calibration will be shipped with a blue tag, shown in Figure 5-7. These units will also have the LC connector interlock assembly shown in Figure 5-8.

Failure to perform the calibration on the indicated unit part numbers (3156115-211 and 3156115-222) may have one of the following possible outcomes.

- Attachment of the LC coax connector will not result in a satisfactory interlock condition.
- Attachment of the LC coax connector will damage the interlock switch inside the generator (requiring it to be sent back for repair).

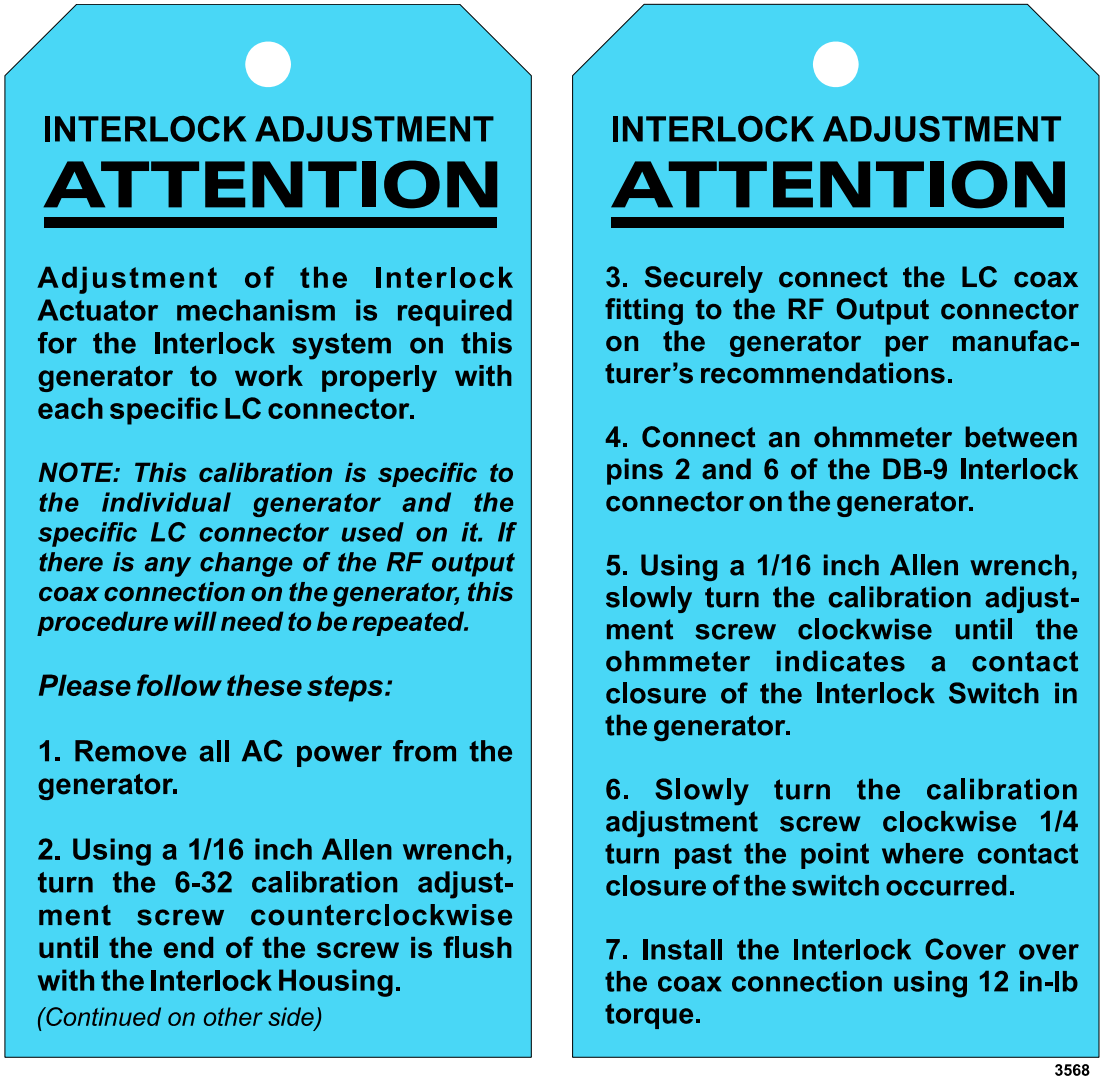


Figure 5-7. *LC connector interlock calibration tag*

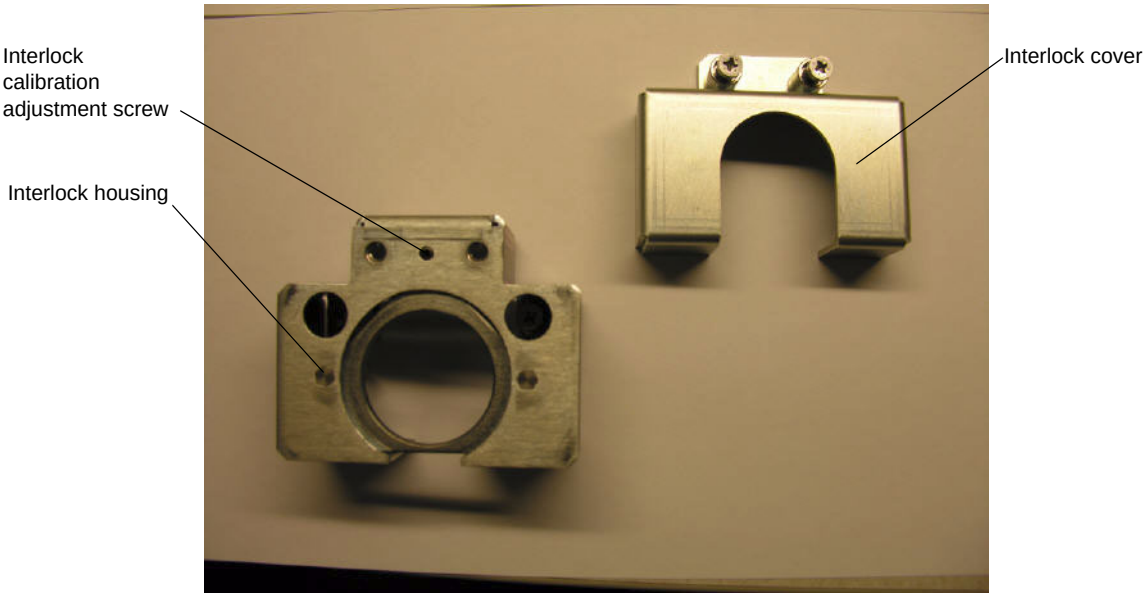


Figure 5-8. *Interlock assembly for LC connector*

To Calibrate the LC Connector Interlock:

CAUTION:
The calibration is specific to the individual generator and the specific LC connector used on it. If there is any change of generator or LC connector on the system, the calibration procedure will need to be repeated.

1. Remove all AC power from the generator.
2. Using a 1/16 inch Allen wrench, turn the 6-32 calibration adjustment screw counterclockwise until the end of the screw is flush with the interlock housing.
3. Securely connect the LC coax fitting to the RF output connector on the generator per manufacturer's recommendations.
4. Connect an ohmmeter between pins 2 and 6 of the DB-9 interlock connector on the generator.
5. Using a 1/16 inch Allen wrench, slowly turn the calibration adjustment screw clockwise until the ohmmeter indicates a contact closure of the interlock switch in the generator.
6. Slowly turn the calibration adjustment screw clockwise 1/4 turn past the point where contact closure of the switch occurred.
7. Install the interlock cover over the coax connection using 12 in-lb torque.

Connecting Input Power

Apex input power connectors vary depending on the option installed on the generator. The output connector option is identified by the option in PIN position 13 (for information about using the PIN to find information about your generator, see "Using this Manual to Find Information About Your Generator" on page 1-1).

- "ODU Connector" (PIN 13, options A and K)
- "Harting Han Q 5/0 Connector" (PIN 13, options D and L)
- "Harting Han Q 4/2 Connector" (PIN 13, option W)
- "Harting Han Modular (40 A) Connector" (PIN 13, option R)
- "Non-Terminated, Four-Conductor Pigtail" (PIN 13, options B and C)

DANGER:

Before making any input line power connection, turn off circuit breakers supplying input power to the Apex generator.

DANGER:

Non-standard connectors for input and/or output power must be inaccessible to the user.

CAUTION:

If your unit does not have a circuit breaker, install and operate it with a circuit breaker on the AC input to provide over-current protection. The circuit breaker must have a trip value as specified in the line current section of "Input Power Specifications" on page 3-11. The circuit breaker switch must be easily accessible and near the device. Circuit breaker or disconnect device must lock-out/ tag-out all sources of input power.

ODU CONNECTOR

Figure 5-9 shows the ODU input connector. The pin numbers are labeled in the illustration.

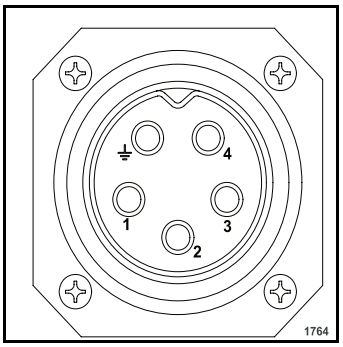


Figure 5-9. *ODU input connector*

Table 5-1 provides pin descriptions for the ODU input connector.

Table 5-1. *ODU Pin Descriptions*

Pin	Description
1	Phase
2	Phase
3	Phase
4	No connection
5 or Ground	Ground

HARTING HAN Q 5/0 CONNECTOR

Figure 5-10 shows the Harting Han Q 5/0 input connector, and Table 5-2 shows the pin descriptions.

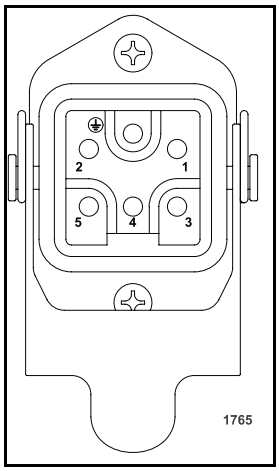


Figure 5-10. *Harting Han Q 5/0 connector*

Table 5-2. *Harting Han Q 5/0 pin descriptions*

Pin	Description
1	Phase
2	Phase
3	Phase
4	No connection
5	EMI shield ground
Gnd	Safety earth ground

HARTING HAN Q 4/2 CONNECTOR

Figure 5-11 shows the Harting Han Q 4/2 input connector, and Table 5-3 shows the pin descriptions.

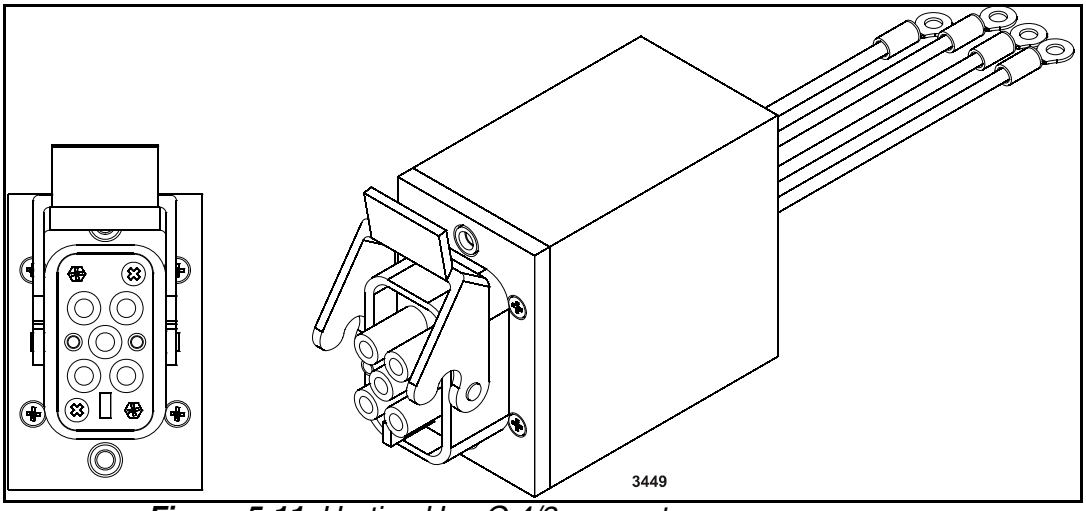


Figure 5-11. *Harting Han Q 4/2 connector*

Table 5-3. *Harting Han Q 4/2 pin descriptions*

Pin	Description
1	Phase
2	Phase
3	Phase
4	Ground
Gnd	Safety earth ground

HARTING HAN MODULAR (40 A) CONNECTOR

Figure 5-12 shows the Harting Han modular (40 A) input connector, and Table 5-3 shows the pin descriptions.

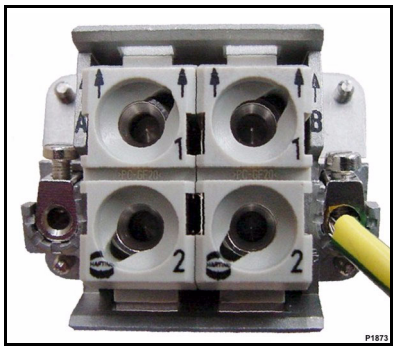


Figure 5-12. *Harting Han (40 A) modular connector*

Table 5-4. *Harting Han modular (40 A) pin descriptions*

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

NON-TERMINATED, FOUR-CONDUCTOR PIGTAIL

Table 5-5 provides pin descriptions for the nonterminated, four-conductor input options.

Table 5-5. *Non-terminated, four-conductor pin descriptions*

Pin	Description
1	Phase (black)
2	Phase (black)
3	Phase (black)
Ground	Green or Green/yellow stripe

Connecting I/O and Auxiliary Connectors

The I/O and auxiliary connections that you make will depend on the options installed in your Apex unit and on how you choose to control the unit. Apex generators have a variety of I/O and auxiliary connector options. Use the PIN from the Apex unit and "Apex PIN Positions and Associated Options" on page 1-5 to identify the options installed on the unit. (For more information, see "Using this Manual to Find Information About Your Generator" on page 1-1.)

WARNING:
RISK OF DEATH OR BODILY INJURY
Disconnect 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 there are no leaks.

Note: Either cable connectors or interlock covers must be installed to allow the generator to operate.

TO CONTROL THE GENERATOR THROUGH A USER PORT

Apex user port options are identified by PIN position 8, and they are discussed individually in "Apex Host Port Options" on page 4-69. Use the generator's PIN and "Apex PIN Positions and Associated Options" on page 1-5 to identify the appropriate user port section of the manual for your unit.

To connect to the User port, install the appropriate I/O cable (cable requirements are identified in the individual User port sections).

TO CONTROL THE GENERATOR THROUGH A HOST PORT

Apex host port options are identified by PIN position 6, and they are discussed individually in "Apex Host Port Options" on page 4-69. Use the generator's PIN and "Apex PIN Positions and Associated Options" on page 1-5 to identify the appropriate host port section of the manual for your unit.

To Connect to an Apex Host Port:

1. Ensure that the required User port inputs are satisfied. The required User port inputs are identified under the Satisfying Minimal Requirements section for your

User port. To determine which User port you have, see the information for PIN position 8 in "Apex PIN Positions and Associated Options" on page 1-5.

2. Connect and secure the appropriate serial cable to the Apex unit and the host (cable requirements are identified in the individual Host port sections).

FIRST TIME OPERATION

The first time you operate the Apex generator do the following.

Note: This section refers to status LEDs for verification of proper operation. If your Apex unit does not have LEDs, refer to the Apex Virtual Front Panel or respective I/O status indicators for verification.

1. Use the preceding installation instructions to install the generator.
2. Turn on the system circuit breakers and apply AC input to the unit.
3. When the generator received AC input, it performs self-diagnostics. If the **POWER LIMIT** LED flashes on power up, the unit has detected an error, and you will not be able to turn RF output on. Cycle AC power. If the **POWER LIMIT** LED persists flashing, call AE Global Services.
4. Verify that the **AC ON** LED is lit.
5. Verify that the **ALARM** LED is *not* lit.
6. Verify that the **INTERLOCK** LED is lit.
7. Send RF on command and verify that the **RF ON** LED is on.
8. Request a set point and verify that the **POWER LIMIT** LED is not lit.
9. If the Apex unit is delivering power and the **POWER LIMIT** LED is not lit, the unit is functioning properly. If the unit is not delivering power or the **POWER LIMIT** LED is lit, consult "Troubleshooting Checklist" on page 6-1.

NORMAL OPERATION

Each time the generator is powered on, the generator runs the self-diagnostics procedure to ensure the generator is functioning properly. See "First Time Operation" on page 5-18 to verify proper first time operation.

Specific operating techniques vary depending on the control and monitoring interface. If you are using Virtual Front Panel to operate the generator, see the User Manual that came with the software for further operational instructions.

Your Apex unit may come with some of the following features. See the following sections for more information about these features, if your unit has them, and how to configure them:

THE COMMON EXCITER (CEX) MODE OF OPERATION (OPTIONAL)

Understanding the CEX Mode of Operation

In the common exciter (CEX) mode of operation, more than one Apex generator is coupled into the same plasma. In this type of operation, slight differences in output frequency or phase of the RF energy can create "beat" frequencies that may even be visible in the plasma and which may have adverse affects on the plasma process. To prevent unwanted beat frequencies, two Apex generators can be phase-locked together so that they run at the same frequency and with a fixed phase relationship between their outputs. This locking ensures repeatable RF characteristics within the plasma.

When operating in CEX mode, one Apex unit is the "master" and the other is the "slave." The CEX output of the master is connected to the CEX input of the slave. If the slave unit receives a signal of the proper frequency and amplitude at its CEX input, it automatically phase locks to that signal and tracks the master unit's oscillator.

More than two slave generators can be locked together to a single master unit by "daisy chaining" the CEX outputs and inputs. That is, the CEX output of the master is connected to the CEX input of the first slave; the CEX output of the first slave is connected to the CEX input of the second slave, and so on. Also, any number of Apex generators can be locked to a single system oscillator as slave units by supplying each unit with a signal of the proper frequency and amplitude at its CEX input. (CEX input signal requirements are indicated in "Electrical Specifications for Apex Features" on page 3-15.)

The phase relationship between the RF is fixed by the length of the cable used to interconnect the generator's CEX outputs and inputs. At 13.56 MHz, a single wavelength (360º of phase rotation) is approximately 48 feet in typical 50 Ω coaxial cable. The use of a very short CEX interconnecting cable (as supplied in the hardware kit) between two generators results in little phase shift. Varying this length of using commercially available phase shifters inserted in the interconnection path can provide more control of this relationship.

PULSING OUTPUT

Some Apex units have a pulsing option, which allows you to produce either pulsed RF output or standard, steady output. To determine if your Apex unit has this option, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Pulsing option
PIN position 14, (A 1 2 3 4 5 6 7 8 9 10 11 12 13 **14** 15 16 17) **option 1**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

For units that have the pulsing option, pulsing output can be enabled or disabled. All pulsing settings are made only through the AE Bus Host port. If you are using Virtual Front Panel, see the Virtual Front Panel User Manual for an explanation of making these settings. If you are not using Virtual Front Panel, see "Host Port—RS-232 With AE Bus" on page 4-69 for information about communicating through the Host port and for the commands that control pulsing.

Understanding Pulsing

When pulsing is enabled, the Apex generates pulses of RF output based on frequency and duty-cycle settings.

- The frequency defines the length of pulsing cycles, that is, the amount of time between each RF-on event. Valid frequencies are between 150 Hz and 50,000 Hz.
- The duty cycle sets the percentage of each pulsing cycle for which output is *on*. Values can be set from 1 to 90 percent. For example, if you set the duty cycle percentage to 15 percent, then during each pulsing cycle, output will be on 15 percent of the time and off 85 percent of the time.

Note: Pulsing settings can not be changed when RF output is on. You must turn output off before changing any pulsing settings.

Enabling and Setting Pulsing

To enable pulsing, send a valid set of frequency and duty cycle settings to the Apex generator (see Host port commands **93** and **96** in "Host port commands for RS-232 with AE Bus" on page 4-77). Sending an invalid combination of settings disables pulsing. Host port commands **193** and **196** read back these pulsing settings.

Pulsing settings are not saved when the Apex unit is turned off. To return pulsing settings to default, cycle power to the Apex unit.

THE ARC HANDLING AND DETECTION SYSTEM

Some Apex units have an arc handling system. This system is responsible for detecting and handling arcs. To determine if your Apex unit has this system, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Arc Detection option
PIN position 12, (A 1 2 3 4 5 6 7 8 9 10 11 **12** 13 14 15 16 17) **option 3**.
(When identifying the PIN position, remember that the A at the beginning of the PIN is not counted as a position. The PIN *option* is the number or letter you should look for in the specified position.)

For more information about the PIN and for a complete list of how PIN positions correspond to Apex product options, see "Apex PIN Positions and Associated Options" on page 1-5.

Understanding Arc Handling

The arc handling system detects arcs based on reflected power. The system handles arcs by turning RF off for a period of time.

Figure 5-13 shows a block diagram of the arc handling system. The reflected power is filtered by both a slow and a fast filter. The output of the slow filter tracks slow changes in reflected power. Adding offset o_1 and a fraction, k_1, of the forward power

to the output of the slow filter creates an upper limit. Subtracting an offset o_2 and a fraction, k_2, of the forward power creates a lower limit. If the output of the fast filter either exceeds the upper limit or drops below the lower limit, an arc is detected.

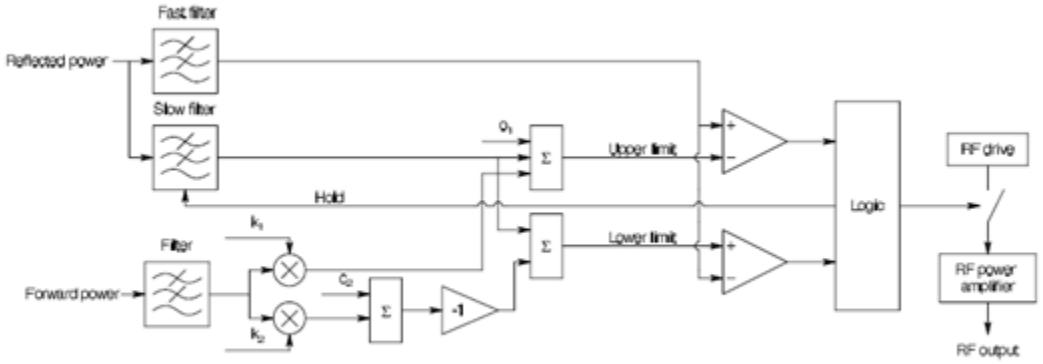


Figure 1: Block diagram of the arc handling system.

Figure 5-13. *Block diagram of the arc handling system*

As soon as an arc is detected, the output of the slow filter is frozen. The output of the slow filter thus maintains the reflected power level at the start of the arc, and since it is slow, it maintains the conditions present before the arc started. In response to the arc, RF is turned off for a period of time. When RF is turned back on, a period of time (2 to 511µs, ± 2µs) is allowed to allow the plasma to settle down, and then the output is compared with the upper and lower limits.

If the output of the fast filter stays between the limits for a second period of time (2 times the arc shutdown time), the slow filter is allowed to follow changes in reflected power (by removing the hold signal). However, if within the second period of time, the output of the fast filter goes outside the limits (that is, an arc is detected), the hold signal to the filter is not removed and RF is turned off for double the previous turn-off time.

This process repeats until either the output of the fast filter returns to a value between the limits (that is, the arc is quenched), or the process repeats a maximum number of times (1 to 250 times, 0 = infinite attempts), after which the generator turns off with an error condition to protect processing equipment.

Setting Up the Arc Handling System

The arc handling system is designed to maintain sensitivity and false detection rates over a variety of operating conditions. The detection system uses five digital potentiometers to set the sensitivity of the system. To account for differences in offsets in the electronics, base values for the potentiometers are calculated in the factory and stored in EEPROM.

The actual values that the potentiometers are set to is the sum of these base values and sensitivity values that can be set by the user. By splitting the potentiometers this way, different units should behave the same if given the same sensitivity values by the user. The sensitivity values can be set using the Apex Virtual Front Panel (VFP, which can be purchased separately from Advanced Energy) and/or AE Bus and PROFIBUS commands. The values are then stored in NVRAM.

Note: Currently only four of the potentiometers are used. The fifth potentiometer, which will be able to set an absolute maximum for reflected power, is not yet available for use. To enable an absolute value of reflected power as an arc detection trip, please contact Advanced Energy® Global Services.

To Map, Set, and Read Arc Handling Parameters:

- Using AE Bus: See commands **36**, **84**, and **199** in "Host port commands for RS-232 with AE Bus" on page 4-77
- Using PROFIBUS: See commands **36**, **84**, and **199** in "Profibus Host Port Commands" on page 4-106
- Using the block diagram: See Table 5-6

Table 5-6. *Mapping of arc detection parameters to the offsets and multipliers*

Description	Block Diagram (see Figure 5-13)	Screen Description in Virtual Front Panel	Device/ Potentiometer Allocation in AE Bus/ Profibus
Upper limit offset	o_1	HI offset	Device 1, Potentiometer 0
Upper limit multiplier	k_1	HI mult	Device 1, Potentiometer 1
Lower limit offset	o_2	LO offset	Device 1, Potentiometer 2
Lower limit multiplier	k_2	LO mult	Device 1, Potentiometer 3
Absolute reflected limit	N/A	Refl lim	Device 2, Potentiometer 0

LEARN MORE ABOUT SETTING SENSITIVITY VALUES

The sensitivity values set in the factory should be close to the most sensitive values that you would typically use. Once on the actual user system, the sensitivity values should be optimized on the system. This process really depends on the user's process, but in general you would set o_1 and o_2 (with k_1 and k_2 set to 0) such that the false detection rate is acceptable using a low power process and then check the performance at a higher power process. If more false alarms are generated with the high power process, k_1 and k_2 can be increased to decrease the sensitivity at high power. This way the sensitivity tracks the process power and a wider range of process powers can be maintained.

Troubleshooting and Global Services

See this information to troubleshoot your Apex generator:

TROUBLESHOOTING CHECKLIST

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

Troubleshooting Check	Action
Is the **AC ON** LED lit?	**If No**: There may be an external line fault. Verify that the circuit breaker is on, and check input voltage. Send an RF Off command to reset the unit. If this LED remains unlit, call AE Global Services.
Is the **ALARM** LED lit?	**If Yes:** This fault will generate error data that is provided through the serial port. See the Error Code table.
Is the **OVERTEMP** LED flashing or on solid?	**If Flashing:** The internal cold plate temperature is approaching the shutdown limit. This LED state does not affect RF output. **If On Solid**: The cold plate temperature has exceeded the limit, disabling output. This fault will clear when the cold plate temperature falls below warning levels. Make sure the unit is receiving specified cooling.
Is the **INTERLOCK** LED lit?	**If No:** The interlock is not satisfied or was interrupted. Make sure the RF output cover is firmly attached and ensure the interlock pins on the **User** port are satisfied. Once interlock is satisfied, send an RF Off command to reset the unit.

Troubleshooting Check	Action
Is the **RF ON** LED flashing?	**If Yes and if AC input has just been enabled:** The unit may be in User control mode and receiving an RF On command at the **User** port. Verify that the **User** port and control mode are properly set up. Then, send an RF Off command to reset the unit. This LED also flashes when output has been latched off due to a fault or interlock interrupt. Clear the fault or reestablish interlock, then send an RF Off command to reset the indicators. If still flashing, go through this checklist again.
Is the **RF ON** LED lit?	**If No:** Send an RF OFF command, then send an RF On command.
Is the **POWER LIMIT** LED lit?	**If Yes:** The generator is unable to supply the requested power set point level due to a limiting condition. If this lit LED is accompanied by a high reflected power reading, there is probably an external load condition that the generator is protecting itself from. Call AE Global Services, or consult "Power Limit LED Troubleshooting" on page 6-2 and "External Load Checks - Open/Short RF Output Path" on page 6-3.
Turn off AC power and make these checks.	• Check for visible damage to the unit, cables, and connectors. • Ensure all unit connectors are installed correctly and are fastened tightly. • Check whether any system-related circuit breakers have been tripped. • Ensure ground connections are adequate and secure.
Turn AC power on. Is the **POWER LIMIT** LED flashing at turn on?	**If Yes**: Call AE Global Services. **If No:** Send an RF On command, and your unit should be operating properly.
If you are unable to resolve issues with your unit using this checklist, call AE Global Services.	

ADDITIONAL TROUBLESHOOTING

Power Limit LED Troubleshooting

When lit, the **POWER LIMIT** LED indicates that the generator is unable to supply the requested power set point level due to a limiting condition. When an internal protection limit is exceeded, the RF output is limited, but not shut off. If this LED is lit

along with a high reflected power reading, the generator is probably protecting itself in response to an external load condition. See "External Load Checks - Open/Short RF Output Path" on page 6-3.

To troubleshoot this error:

- Disable the output and rear circuit breaker (if your Apex generator has one)
- Inspect and evaluate the unit's RF output connector, output cable, tuner and chamber.
- Look for signs of arcing and heat stress.
- Verify high impedance between the center conductor and outer shields on the connectors and cables.
- Verify cable continuity. Swap suspected cables or units with known good cables or units.

If the problem cannot be isolated after following these steps, see "External Load Checks - Open/Short RF Output Path" on page 6-3 or contact "AE Global Services" on page 6-8.

External Load Checks - Open/Short RF Output Path

DANGER:

RISK OF DEATH OR BODILY INJURY. Use suitable precautions. The output connector contains high voltages that could cause serious injury or death.

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

To Troubleshoot RF Output:

1. Turn the rear circuit breaker off to ensure that there is no RF power at the output of the unit.
2. To troubleshoot the Apex 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.
3. To troubleshoot 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 Apex.

4. To troubleshoot the tuner and the chamber:

   The only way to truly isolate the tuner or the chamber is to swap the tuner or the Apex unit with another known good unit.

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 readings close to the Apex generator reflected power limit? See "Electrical Specifications" on page 3-11.

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

TROUBLESHOOTING USING ERROR CODES

Error codes indicate a fault or warning condition in the Apex generator. See:

- "Accessing Error Codes" on page 6-4: Explains how you can access unit error codes.
- "Error code table" on page 6-5: Describes available error codes, the problem indicated by each code, and suggested actions to clear the error.

Accessing Error Codes

You can access Apex generator error codes in two ways:

- You can use serial communication (the AE Bus Host port) to request a report of active warning or fault error codes (see command **223** in "Host Port Commands for RS-232 with AE Bus" on page 4-49). Once you have received a list of active errors, see "Troubleshooting Using Error Codes" on page 6-4 to look up these error codes and troubleshoot the associated faults or warnings.

- You can use the Apex generator VFP (Virtual Front Panel) program to look up active error codes. Use the help system that came with the VFP program if you have trouble finding the list of active error codes. Once you have the list of active error codes, see "Error code table" on page 6-5 to look up these error codes and troubleshoot the associated faults or warnings.

  Note: Virtual Front Panel allows you to control and monitor your Apex generator using a personal computer via serial communication. If you did not purchase the VFP program with your unit and would like a copy of the program, contact "AE Global Services" on page 6-8.

Table 6-1. *Error code table*

Error Code	Error Code Description	Solution
E000	No Error	
E001 Out of set point timer expired	If the unit is unable to reach or maintain the programmed output level within a specified amount of time, the output shuts off and this error code is reported. This timer is enabled and set through the serial communications port.	To avoid this error, you can disable the timer, increase the amount of allowable time, or try to determine why the unit is not reaching set point. To reset the Apex generator and clear this error, the unit must receive an RF output disable signal or command from either the user port or serial I/O.
E004 Over temperature shutdown	This error is the same as when the **OVERTEMP** LED is on solid,	See "Troubleshooting Checklist" on page 6-1.
E011 Low bus voltage limit	The bus voltage is basically rectified input voltage. If the bus voltage measures too low (E011) or too high (E012), then the input voltage is too low or high, respectively.	Make sure that input voltage is within specification see "Electrical Specifications" on page 3-11. To reset the Apex generator and clear this error, the unit must receive an RF output disable signal or command from either the user port or serial I/O.

Table 6-1. *Error code table (Continued)*

Error Code	Error Code Description	Solution
E012 High bus voltage limit	The bus voltage is basically rectified input voltage. If the bus voltage measures too low (E011) or too high (E012), then the input voltage is too low or high, respectively.	Make sure that your input voltage is within specification see "Electrical Specifications" on page 3-11. To reset the Apex and clear this error, the unit must receive an RF output disable signal or command from either the User port or serial I/O.
E016 Current limit	Internal failure.	Contact "AE Global Services" on page 6-8.
E017 EEPROM failure	This verifies that the option called out in PIN position 6 is actually installed.	Contact "AE Global Services" on page 6-8.
E018 Arc suppression fault	Arc suppression settings are not in working ranges.	Modify the arc suppression time using AE Bus or PROFIBUS command **36**.
E020 User interlock open	Both the **INTERLOCK** LED and the RF output will remain off until the interlock is satisfied and an RF off command is given.	Make sure that the RF output cover is firmly attached and ensure the interlock pins on the user port are satisfied. Refer to "Apex User Port Options" on page 4-4.
E025 Target life expired	When the user set target life ends, this error code is reported. The output will not be turned off when this error is reported. However, if output is turned off while this error is active, it cannot be turned on until a new target life is set.	Set new target life. To reset the Apex generator, send an RF off command.
E029 Ripple Current Error (missing phase)	The input line voltage is rectified internally to a bus voltage. The Apex generator monitors the bus voltage for excessive ripple. If excessive ripple is detected, this error is displayed. A missing phase on the input line voltage or an unstable plasma may cause this error.	Verify that all three phases are present on the input voltage lines and that the plasma is stable. If the problem persists contact "AE Global Services" on page 6-8.

Table 6-1. *Error code table (Continued)*

Error Code	Error Code Description	Solution
E033 Temperature rate threshold error	The Apex generator monitors the rate at which the cold plate temperature is changing. If the temperature increases too fast, the Apex generator protects itself by shutting the output off.	To reset the Apex generator and clear this error, the unit must receive an RF off command from either the user port or serial I/O. If error code does not clear or if the output does not come on, the cooling plate temperature exceeded the over temperature shutdown threshold. See "Troubleshooting Checklist" on page 6-1.
E034	AE Bus communication watchdog timer fault on serial port 1.	Verify serial cable is connected. Continuously send AE Bus commands while enabled.
E035	AE Bus communication watchdog timer fault on serial port 2.	Verify serial cable is connected. Continuously send AE Bus commands while enabled.
E037	Condensation error	Wait for water to evaporate. Remove generator from water pan.
E038	Unsafe voltage error	Return unit. Contact "AE Global Services" on page 6-8.
E050 DeviceNet Error	DeviceNet error	Verify DeviceNet cable is connected.
E051 Profibus Watch Dog expired	PROFIBUS watch dog expired	Verify serial cable is connected. Have the master reestablish communications and send a "master reset" to clear the error. See "Host Port—Profibus" on page 4-96.
E054 Profibus SPC has taken itself off-line	PROFIBUS SPC has taken itself off-line	Cycle Apex generator power off and on and reestablish communications between the master and the slave.

Table 6-1. *Error code table (Continued)*

Error Code	Error Code Description	Solution
E055 Profibus memory buffer overflow	PROFIBUS memory buffer overflow	Increase the time between packets being sent to the unit via the PROFIBUS master. See "PROFIBUS Command Structure" on page 4-102.
E059 Profibus master released slave	PROFIBUS master released slave	To recover from the "off state," have a Profibus master establish communications with the Apex unit and send a "master reset" to clear the Apex unit's display. See "Host Port—Profibus" on page 4-96.
E101 Measurement PCB ID is incorrect	Configuration error.	Contact "AE Global Services" on page 6-8.
E105 User set point scale factor does not match	Configuration error.	Contact "AE Global Services" on page 6-8.
E111 Overtemp warning or shutdown value is out of range	Configuration error.	Contact "AE Global Services" on page 6-8.

AE GLOBAL SERVICES

Please contact AE Global Services if you have questions or problems that cannot be resolved by working through the provided troubleshooting procedures.

When you call Global Services, make sure to have the unit serial number and part number. These numbers are available on unit labels.

Advanced Energy World Headquarters, 24 x 7 Technical Support

Table 6-2. *AE Global Services contact information*

Office	Contact
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA	Phone (24 hrs/day, 7 days/week): 800.446.9167 or + 1.970.221.0108 Fax (M–F, 7:00 am – 5:30 pm MST): + 1.970.407.5981 Email: technical.support@aei.com We will respond to email by the next business day. For Aera flow product support, call 800.MFC.AERA (800.632.2372) For Sekidenko thermal product support, contact thermalapplications@aei.com
If you would prefer to contact a local or regional sales or service office, visit the Advanced Energy web site for current contact information: • http://www.advanced-energy.com and click on **Sales & Support**	

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 Services and discuss the problem with a representative. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Global Services to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

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 (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. 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 by AE Global Services

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 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.

Units that are returned without authorization from AE Global Services and that are found to be functional will not be covered under the warranty. 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.

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