USER MANUAL

Apex™ Generator

1 to 5.5 kW

5708009-C

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Advanced Energy Industries, Inc.
1625 Sharp Point Drive
Fort Collins, CO 80525 USA
970.221.4670

technical.support@aei.com

User Manual

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ADVANCED ENERGY®

⚠ 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. 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.

All information herein is subject to periodic updates. Inquiries concerning this manual should be directed to AE. Information provided by AE is believed to be correct and reliable. However, no responsibility is assumed by AE unless otherwise expressly taken.

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Advanced Energy Industries, Inc.

1625 Sharp Point Drive

Fort Collins, Colorado 80525 USA

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Chapter 1

Introduction

This chapter contains several kinds of introductory information.

- "Using this Manual to Find Information for Your Generator" on page 1-1 provides important instructions on locating the information in this manual that is applicable to your Apex unit.
- "Interpreting the Manual and Unit Labels" on page 1-9 provides information on interpreting the type conventions, safety warnings, and labels found in this manual and on the Apex unit.
- "Safety" on page 1-12, "Product Safety/Compliance" on page 1-12, and "Installation Requirements" on page 1-15 provide important safety and compliance information about the Apex generator.

READ THIS SECTION!

To ensure safe operation, you should read and understand this manual before you attempt to install or operate the Apex unit. At a minimum, read and heed "Safety" on page 1-13.

USING THIS MANUAL TO FIND INFORMATION FOR 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 that specific unit.

Understanding PIN Numbers and Apex Configuration

The options installed on any Apex generator (that is, the configuration of the generator) are defined by an PIN number that is located on the serial number tag of the generator. Figure 1-1 is an example of a serial number tag.

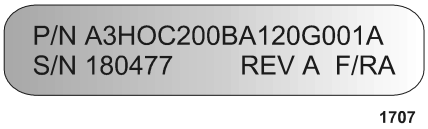
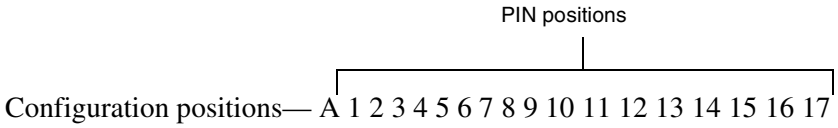


Figure 1-1. *Serial number identification tag*

The PIN 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.

Using the PIN to Locate Information in the Manual

This manual uses the PIN to help you identify the manual sections that apply to your unit. To begin using the manual, you will need to first find and record the PIN on your unit as you may want to refer to it frequently as you work with the manual.

Once you have located the PIN, you are ready to begin using the manual.

The manual provides two basic tools to help you use the PIN in locating correct information for your unit.

- The next section, "Using the PIN to Identify Apex Options", 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 will also see Configuration Notes similar to the following example. These configuration notes are placed at the beginning of many manual sections that provide option-specific information, and they provide information about the PIN position and option described in that section. These

notes are best used to confirm that a particular section of the manual applies to the option installed on a specific Apex unit. They also refer back to Table 1-1, which provides complete configuration information

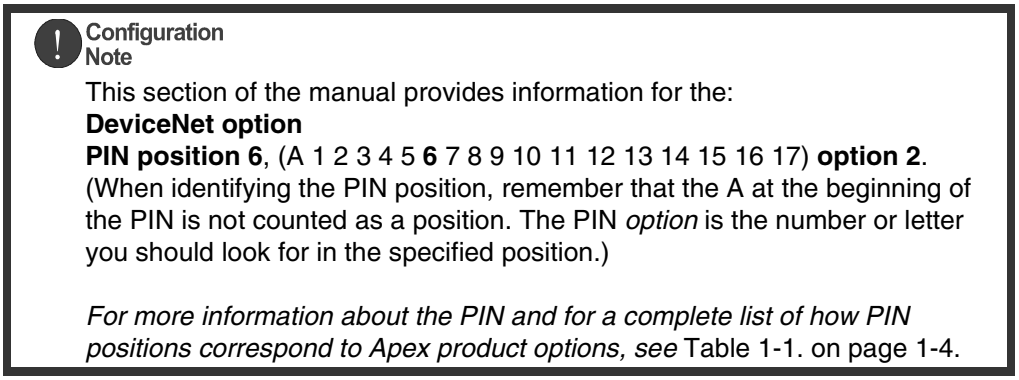


Figure 1-2. *Example configuration note*

Using the PIN to Identify Apex Options

Table 1-1 shows all the options associated with each PIN position. When appropriate, it also provides 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). Then find that position in the PIN for your Apex unit (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 configurations are currently available and this manual does not cover all currently available options. (Some options are covered in other manuals). Therefore, 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 unities the manual that came with that specific unit. Contact AE for any questions about availability of specific configurations. (For contact information, see “AE Customer Support” on page 6-11.)

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

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
1	Output frequency	**0—N/A** **1—4 MHZ, ±0.005%** **2—12.56 MHz, ±0.005%** **3—13.56 MHZ, ±0.005%** **4—27.12 MHz, ±0.005%** **5—40.68 MHz, ±0.005%** For more information on frequency and other specifications, see “Electrical Specifications” on page 3-5.
2	Power output	**A—1000 W** **B—1500 W** **C—2000 W** **D—3000 W** **E—4000 W** **F—5500 W** **G—8000 W** **H—10000 W** **J—5000 W** **K—1000 HALO** **L—1500 HALO** **M—3500 W** **N—7000 W** For more information on power output and other specifications, see “Electrical Specifications” on page 3-5.

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** **2—reserved** **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, without breaker** **5—220,208 to 229 Vac, 1 phase, 47/63 Hz w/o breaker** For more information on input voltage and other specifications, see “Electrical Specifications” on page 3-5.
4	Packaging	**A—frame mount (≤ 5500 W)** **B—frame mount with rack ears (1/2 rack) (utilities)** **C—integrated rack mount** **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—exclusive option #4** **K—on board frame mount, opposite end LED’s** **L—on board frame mount, opposite end LED’s w/4 handles** **M—on board frame mount, opposite end LED’s w/2 handles** **N—frame mount w/ rack ears (1/2 rack) (opposite)**

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** **2—integrated rack mount with passive digital display** (see "Apex Status Indicators (LEDs)" on page 4-79) **3—N/A** **4—exclusive option #1** For panel illustrations, see "Apex Panel Illustrations" on page 4-80.
6	Serial I/O	**0—default (RS-232 with AE Bus)** (see "Host Port—RS-232 With AE Bus" on page 4-37) **1—Multidrop RS-485 with AE Bus** (Currently NOT available) **2—DeviceNet** (see "Host Port—DeviceNet" on page 4-72) **3—Profibus** (see "Host Port—Profibus" on page 4-58) **4—exclusive option #1** **5—DeviceNet (serial)** **6—exclusive option #3** **7—exclusive option #2**
7	Serial Port 2	**0—default** (no secondary serial port) **1—RS 232** **2—RS 485**

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

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
8	User port options	**A—no User port** **B—25-pin APEX standard** (see "25-Pin Apex Standard User Port" on page 4-2) **C—25-pin custom RFG compatible** **D—15-pin, exclusive option #2** (see "15-Pin User Port (Exclusive—Option D)" on page 4-16) **E—15-pin, exclusive option #3** (see "15-Pin User Port (Exclusive—Option E)" on page 4-26) **F—N/A** **G—exclusive option #4**
9	Output impedance	**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**
10	On-board RF output connector location	**0—opposite end from water connections** **1—utilities end (near water connections)**

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

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
11	Output connector	**0—exclusive option #1** **1—7/16 connector**) **2—SQS™ connector** **3—LC connector** **4—HN** **5—N** **6—exclusive option #2** For further information see "Connecting Output Power" on page 5-5.
12	RF measurement	**0—directional coupler** **1—V/I sensor**
13	AC power input	**A—ODU connector** (see "ODU Connector" on page 5-7) **B—Non-terminated 3 m, 4-conductor, shielded pigtail** (see "NonTerminated, four-Conductor Pigtail" on page 5-8) **C—Non-terminated 12′, 4-conductor, pigtail** (see "NonTerminated, four-Conductor Pigtail" on page 5-8) **D—Harting Type Han-Q** (see "Harting Type Han-Q Connector" on page 5-9) **E—4-terminal, stud mount** **F—15´ 4-conductor, with a Hubbell CS8365C plug** **G—5´ Harting** **H—Term 3m, 4 cond, shielded pigtail Marinco 3015P** **J—5' terminated, 4 conductor, SH with contact LS1 BF.F6 5+PE (30A)** **K—ODU connector with 20 degree rotation** **L—Harting Type Han-Q (16A) rotated 180 degrees** **M—6',4 conductor with #10 ring lugs on each wire**
14	Pulsing	**0—no pulsing** **1—pulse** (see "Understanding and Setting Up Pulsing Output" on page 5-13)

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

PIN Position	Apex Feature	Options, Descriptions, and Cross-References
15	CEX	**0—default** (no CEX) **1—CEX add** (see "To Use the Common Exciter (CEX) Feature (optional)" on page 5-12) **2—CEX w/1 Meter Cable** (see "To Use the Common Exciter (CEX) Feature (optional)" on page 5-12)
16	Water fitting threads	**0—default to 3/8 BSP female (metric threads)** **1—3/8 NPT female** **2—3/8 BSP to 1/2" NPT** For information on connecting the water, see "Connecting Cooling Water" on page 5-4.
17	Custom configuration	**A—standard configurations** **B—exclusive option #1** **C—exclusive option #2** **D—exclusive option #3** **E—exclusive option #4**

INTERPRETING THE MANUAL AND UNIT LABELS

The following sections provide information to help you interpret the use of type in the manual as well as frequently used graphics in the manual. It also provides a reference chart to help you understand the labels that may be used on the Apex unit.

Type Conventions

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

- Pin and signal names appear in capitalized italics (*DUTY CYCLE.A*).
- Labels that are on the unit (switches, indicators, etc.) generally appear in boldface capital letters (**MODIFY**); however they appear as you see them on the unit. Exceptions are port names, which simply begin with a capital letter (User port).
- Commands (**162**) and command names (**setpoint**) appear in boldface lowercase letters.
- *Italic* refers to any new or unfamiliar term.

Icons (Symbols)

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

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

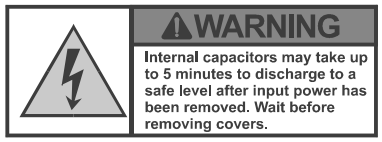
DANGER:
This box identifies hazards that could result in severe personal injury or death.

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

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

The following symbols could appear on labels on your unit.

Capacitor charge



1745

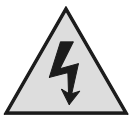
Hazardous Voltage

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

1154

SAFETY

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

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

PRODUCT SAFETY/COMPLIANCE

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

Directives and Standards

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

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

Directive	Description
89/336/EEC	EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive).
47 CFR Part 18	Code of Federal Regulations - Limits and Methods of Measurement of Radio Interference Characteristics of Industrial, Scientific, and Medical Equipment.
EN 50082-2	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 1-3. *Safety*

Directive	Description
73/23/EEC	EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive).
SEMI S2-0200	Safety Guidelines for Semiconductor Manufacturing Equipment
UL 1012	Power units other than class 2
EN 50178	Electronic Equipment For Use In Electrical Power Installations
CSA C22.2 No. 107.1-95	General Use Power Supplies—Industrial Products

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

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 TÜV Product Services

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

INSTALLATION REQUIREMENTS

In order for proper installation to be completed on the Apex generator, please take note of the following warning boxes and the information contained in them. By meeting all the criteria in these boxes, proper installation of the Apex generator will be accomplished.

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

⚠ WARNING:
RISK OF DEATH OR BODILY INJURY. Disconnect and 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.

- This device must be used in an overvoltage category II installation only.
- Before making any other connection, connect the auxiliary Protective Earth ground conductor on the rear panel.
- Use only a shielded 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 Table 3-2. on page 3-5.

Theory

GENERAL DESCRIPTION

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

The Apex products can be configured to three basic package styles. 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 and common exciter (CEX) phase lock operation.

FUNCTIONAL DESCRIPTION

In the following section, an overview of the functional description about the Apex products is discussed. Covered in the section is regulation, cooling, interlock, optional water solenoid, grounding and protection. These general descriptions are important to the User since they allow the User to become familiar with the functions of the Apex generator.

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.

Grounding

The Apex generator has two holes located on the rear panel to attach the system RF ground to. One is a tapped M-6 hole, the other is a 5/16″ x 18 tapped hole. Either hole may be used to provide an appropriate ground. Select the appropriate hole depending on whether you use metric or American fasteners.

Protection

The Apex generator protects itself from damage from the following conditions.

- Any unmatched load condition at the generator output. Output power fold-back (limiting) occurs as required by the generator protection circuits.
- Any internal over current condition not directly related to the output load condition as protected by current limiting or fuse.
- Excessive internal temperature. (This condition may be caused by lack of proper cooling water flow, excessive ambient operating temperature, or other causes.)
- Any combination of input ac line phase drop out.
- Input line brown-out (under voltage) or over voltage.
- Any User/ port pin shorted to chassis or another port pin.

THEORY OF OPERATION

In this section a bock diagram is designed to help the User understand the process by which the Apex generator works. Following the diagram is an explanation of the diagram in a table to help the User utilize the Apex unit as well. Figure 2-1 and Table 2-1 describe the basic operation of the Apex generator.

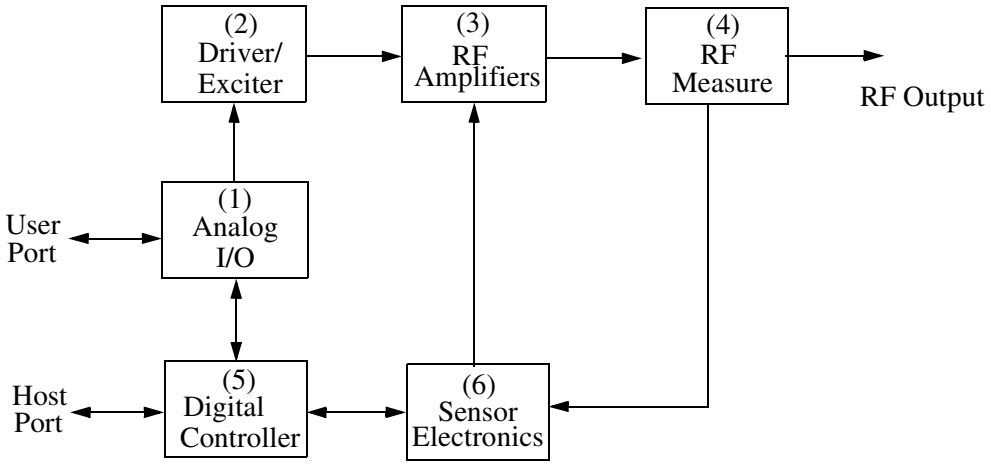


Figure 2-1. *Theory of operation block diagram*

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.

Chapter 3

Specifications

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

In some cases, specifications for all Apex units 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, provide 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 for Your Generator" on page 1-1.

PHYSICAL SPECIFICATIONS

Table 3-1 describes the physical specifications of the Apex generator. In some cases, the specifications for all 1 to 5.5 kW Apex 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 Apex unit, see "Using this Manual to Find Information for Your Generator" on page 1-1.

Table 3-1. *Physical Specifications*

Description	PIN Option—Specification
Packaging *Note:* Varies according to the option defined by PIN position 4.	**A**—frame mount (≤ 5500 Watts) **B**—frame mount w/rack ears (1/2 rack) (rack ears on same end of the unit as the water connectors) **C**—integrated rack mount **D**—1/2 dual integrated rack mount (left) **E**—1/2 dual integrated rack mount (right) **F**—exclusive option #1 **G**—exclusive option #2 **H**—exclusive option #3 **J**—exclusive option #3 **K**—on-board frame mount, opposite end LEDs **L**—on-board frame mount, opposite end LEDs, with 4 handles **M**—on board frame mount, opposite end LEDs, with 2 handles **N**—frame mount with rack ears (1/2 rack) (opposite end from water connectors)
Size	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) See Figure 5-1 on page 5-3 *Note:* The size of the unit depends on configuration of your Apex unit. These dimensions are for the drawing in Chapter 5. See Figure 5-1 on page 5-3.
Weight	18.2 kg (40 lbs.)
Clearance	No special requirements

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

Description	PIN Option—Specification
AC power input connector *Note:* Varies according to the option defined by PIN position 13.	**A**—ODU connector (see "ODU Connector" on page 5-7) **B**—Non-terminated 3 m, 4-conductor, shielded pigtail (see "NonTerminated, four-Conductor Pigtail" on page 5-8) **C**—Non-terminated 12¢, 4-conductor, pigtail (see "NonTerminated, four-Conductor Pigtail" on page 5-8) **D**—Harting Type Han-Q (see "Harting Type Han-Q Connector" on page 5-9) **E**—4-terminal, stud mount **F**—15´ 4-conductor, with a Hubbell CS8365C plug **G**—5´ Harting **H**—Term 3m, 4 cond, shielded pigtail Marinco 3015P **J**—5' terminated, 4 conductor, SH with contact LS1 BF.F6 5+PE (30A) **K**—ODU connector with 20 degree rotation **L**—Harting Type Han-Q (16A) rotated 180 degrees **M**—6',4 conductor with #10 ring lugs on each wire
RF output connector *Note:* Varies according to the option defined by PIN position 11.	**0**—exclusive option #1 **1**—7/16 connector (see "Connecting Output Power" on page 5-5) **2**—SQS'connector (see "Connecting Output Power" on page 5-5) **3**—LC connector (see "Connecting Output Power" on page 5-5) **4**—HN (see "Connecting Output Power" on page 5-5) **5**—N (see "Connecting Output Power" on page 5-5) **6**—exclusive option #2
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)

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

Description	PIN Option—Specification
Water control connectors	Switchcraft™ #L712A
User port (analog I/O) connector *Note:* Varies according to the option defined by PIN position 8.	**A**—no analog port **B**—25-pin APEX standard (see "25-Pin Apex Standard User Port" on page 4-2) **C**—25-pin custom RFG compatible **D**—15-pin, exclusive option #2 (see "15-Pin User Port (Exclusive—Option D)" on page 4-16) **E**—15-pin, exclusive option #3 (see "15-Pin User Port (Exclusive—Option E)" on page 4-26) **F**—N/A **G**—exclusive option #4
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 4-37) **1—**9-pin, shielded, female, subminiature-D (Currently NOT available) **2**—5-pin, male, Lumberg RSF 5/0.5 or Turck FS 4.5 (see "Host Port—DeviceNet" on page 4-72) **3—**9-pin, shielded, female, subminiature-D (see "Host Port—Profibus" on page 4-58) **4**—exclusive option #1 **5**—5-pin, male, Lumberg RSF 5/0.5 or Turck FS 4.5 **6—**9-pin, shielded, female, subminiature-D **7**—exclusive option #2
CEX connector	Female LIMO#EPL.00.250.NTN
Coolant connectors *Note:* Varies according to the option defined by PIN position 16.	**0—**3/8 BSP female **1—**3/8 NPT adapters (adapters from 3/8 BSP female threads in the manifold)(increases unit length) **2—**3/8 BSP to 1/2″ NPT For information on connecting the water, see "Connecting Cooling Water" on page 5-4.

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

Description	PIN Option—Specification
Panel *Note:* Varies according to the option defined by PIN position 5.	**0**—on-board frame mount **1**—Integrated rack-mount with blank panel **2**—Integrated rack-mount with passive digital display **3**—Integrated rack-mount with active digital display **4**—exclusive option #1
RF measurement option *Note:* Varies according to the option defined by PIN position 12.	**0**—Coupler **1**—V/I probe

ELECTRICAL SPECIFICATIONS

Table 3-2, Table 3-3, and Table 3-4 describe the input power, output power, and other electrical specifications for the Apex generator. In some cases, the specifications for all 1 to 5.5 kW Apex 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 unit, see “Using this Manual to Find Information for Your Generator” on page 1-1.

Input Power Specifications

Table 3-2 describes the input power specifications for the Apex generator.

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 **1**—400 V nominal, 360 to 440 Vac, 3ϕ **2**—n/a **3**—208 V nominal, 187 to 229 Vac, 3ϕ **4**—400 V nominal, 360 to 440 Vac, 3ϕ

Table 3-2. *Input Power Specifications (Continued)*

Description	PIN Option and Specification
Line frequency	47 to 63 Hz
Line current	Typical A/ϕ and circuit breaker rating for units with 208 Vac nominal input (PIN position 3, options 0 and 3) • 1500 W/13.56 MHz—9 A/ϕ; 15 A breaker • 3000 W/13.56 MHz—14 A/ϕ; 25 A breaker • 5500 W/13.56 MHz—25 A/ϕ; 40 A breaker Typical A/ϕ and circuit breaker rating for units with 400 Vac nominal input (PIN position 3, option 1) • 3000 W/13.56 MHz—9 A/ϕ; 15 A breaker • 5500 W/13.56 MHz—15 A/ϕ; 25 A breaker

Output Electrical Specifications

Table 3-3 describes the output specifications for the Apex generator.

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**—1000 W **B**—1500 W **C**—2000 W **D**—3000 W **E**—4000 W **F**—5500 W **J**—5000 W **K**—1000 W high accuracy low output (HALO) **L**—1500 W HALO minimum into a 50 Ω, non-reactive load **M**—3500 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
Delivered power into 2:1 VSWR loads *Note:* Varies according to the option defined by PIN position 2.	**B—**1.5kW = 1125W **D—**3kW = 2000W **F—**5.5kW = 3350W
Delivered power into 3:1 VSWR loads *Note:* Varies according to the option defined by PIN 2.	**B—**1.5kW = 650W **D—**3kW = 1200W **F—**5.5kW = 1900W

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

Description	PIN Option and Specification
Output protection—Apex generators sense and employ several parameters for protection	
Reflected power limit	20% of maximum forward power for units rated for less than 5500 W. 1000 W for 5500 W units. (PIN position 2 defines the maximum forward power rating for the unit.)
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 except the HALO will allow setpoints between 1% and 100% of full scale. The exception is the HALO 1.5k generator depicted by "L" in position 2 of the PIN number. This allows setpoints from 5 watts to 1500 watts.
Output power regulation accuracy	
Into 50 Ω non-reactive load	• ± 1% of setpoint or ± 0.1% of full-rated output, whichever is greater (all PIN position 2 options but K and L) • ≤ ±1% of setpoint or 0.25 W, whichever is greater (PIN position 2, option K & L)
Into 3:1 VSWR non-reactive load	± 3% of setpoint (load power regulation), over all load phase angles, or ± 0.25% of full-rated output, which ever is greater
Load regulation as a function of line regulation	Less than 0.1% change in output power for 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
Cooling water temperature range	+5°C to +35°C
Spurious outputs—Referenced to fundamental signal at full-rated output when operated in a 50 Ω non-reactive load	
Harmonic related	-40 dBc
Non-harmonic related	-50 dBc

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

Description	PIN Option and Specification
Warm up	Approximately 2 s from ac-on to RF-on
RF On Response time	< 7 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 setpoints > 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

Other Electrical Specifications

Table 3-4 describes the other electrical specifications for the Apex generator.

Table 3-4. *Other Electrical Specifications*

Description	PIN Option and Specification
Efficiency (line to load)	60%, typical @ full-rated power, nominal line
Power factor	> 0.96
Maximum leakage current	3.5 mA
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. *Other Electrical Specifications (Continued)*

Description	PIN Option and Specification
CEX In	• Required signal amplitude range of +2 dBm to +10 dBm • Generator operating frequency ±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 ±0.005% • Output impedance of 50 Ω, less than 1.5:1 VSWR

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 Specification*

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 ≤ 3kW 7.6 1pm (2 gpm) For > 3kW 11.4 1pm (3 gpm)
Pressure	
Minimum pressure differential (supply to drain) required to achieve specified minimum flow rates)	For ≤ 3kW 0.9 Bar (13psi) For > 3kW 2 Bar (29 psi)

Table 3-5. *Cooling Specification (Continued)*

Description	Specification
Maximum pressure rating	6.9 Bar (100 psi)
Heat removal	• For 1.5 kW, 3410 BTU/hour, 1000W at full rated output power • For 3 kW, 6825 BTU/hour, 2000W at full rated output power • For 5.5 kW, 12,500 BTU/hour, 3660W 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.

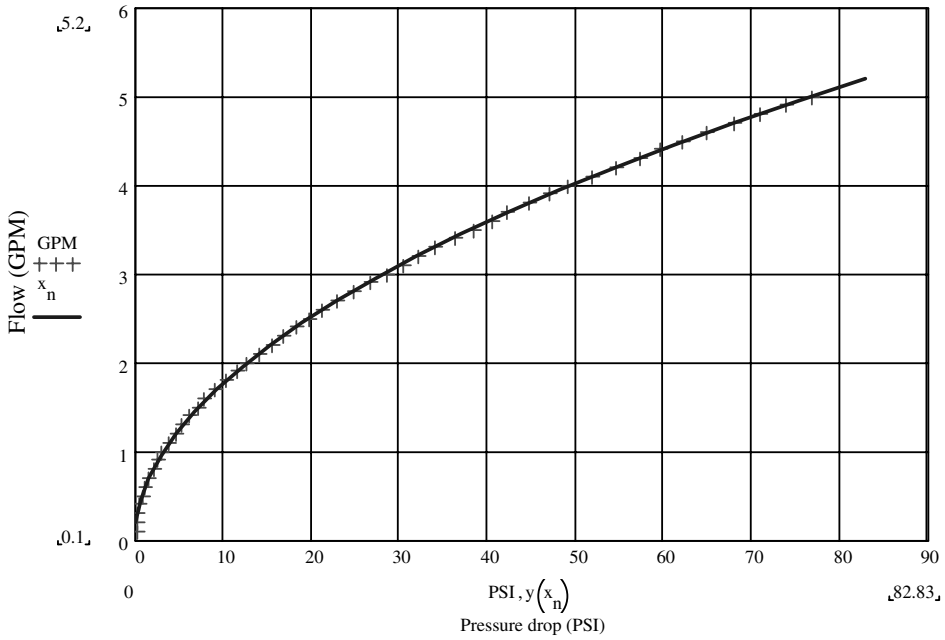


Figure 3-1. *Flow Rate vs. Pressure Drop*

The following graph shows how Water Flow vs. Inlet Temp for all three Apex Units. It represents the inlet temperature rising as flow rate increases.

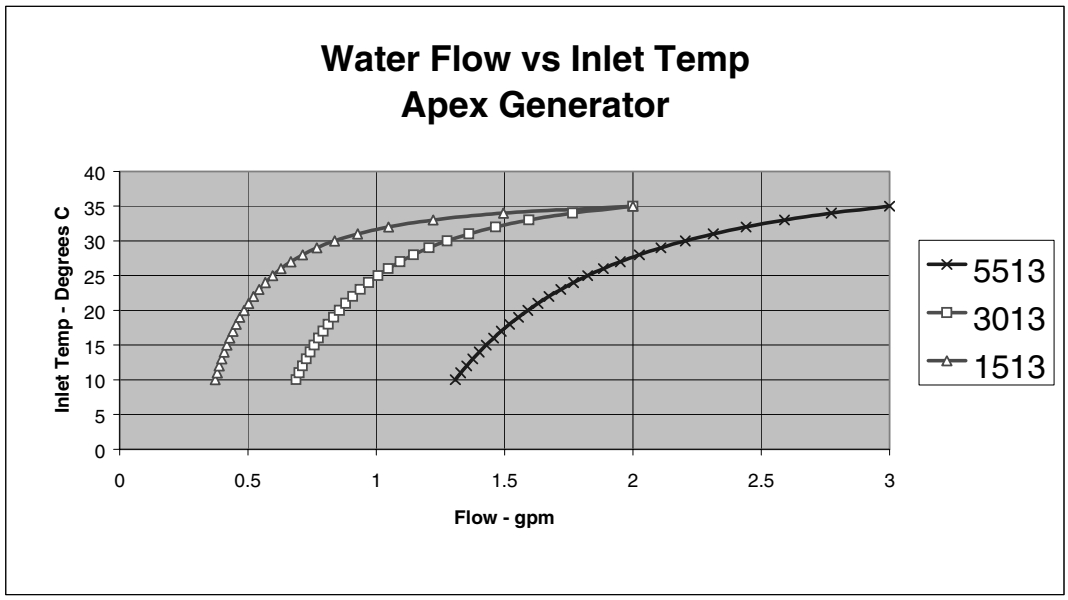


Figure 3-2. *Water flow vs. Inlet Temperature*

Note: 5513 = 5500W and 13.56 MHz
3013 = 3000W and 13.56 MHz
1513 = 1500W and 13.56 MHz

ENVIRONMENTAL SPECIFICATIONS

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

Table 3-6. *Climatic Specifications*

	Temperature	Relative Humidity	Air Pressure
Operating	Class 3K3 5°C to +40°C +41°F to +104°F	Class 3K2 10% to 85% [1] +2 g/m^3 to +25 g/m^3	Class 3K3 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Storage	Class 1K4 -25°C to +55°C -13°F to +131°F	Class 1K3 5% to 95% +1 g/m^3 to +29 g/m^3	Class 1K4 80 kPa to 106 kPa 800 mbar to 1060 mbar (approximately 2000 m above sea level)
Transportation	Class 2K3 -25°C to +70°C -13°F to +158°F	Class 2K3 95%[2] +60 g/m^3 [3]	Class 2K3 66 kPa to 106 kPa 660 mbar to 1060 mbar (approximately 3265 m above sea level)

[1] Non-condensing

[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

Chapter 4

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 User Port Options” on page 4-2, contains a subsection for each of the User port options available with the Apex 1 to 5.5 kW generator. These subsections are:
  - “25-Pin Apex Standard User Port” on page 4-2
  - “15-Pin User Port (Exclusive—Option D)” on page 4-16
  - “15-Pin User Port (Exclusive—Option E)” on page 4-26
- The second section of the chapter, “Apex Host Port Options” on page 4-37, contains a subsection for each of the serial Host port options available with the Apex 1 to 5.5 kW generator. These subsections are:
  - “Host Port—RS-232 With AE Bus” on page 4-37
  - “Host Port—Profibus” on page 4-58
  - “Host Port—DeviceNet” on page 4-72
- The third section of the chapter, “Apex Status Indicators (LEDs)” on page 4-79, contains information on interpreting the LED indicators that appear on some Apex units.
- The final section of the chapter, “Apex Panel Illustrations” on page 4-80, 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 for 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 USER PORT OPTIONS

The following sections provide information for each of the User port options available with the 1 to 5.5 kW Apex generator. These options are:

- "25-Pin Apex Standard User Port" on page 4-2
- "15-Pin User Port (Exclusive—Option D)" on page 4-16
- "15-Pin User Port (Exclusive—Option E)" on page 4-26

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 for 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 Table 1-1. on page 1-4.

This User port is the standard option.

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

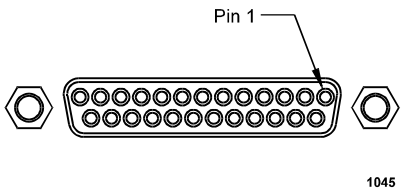


Figure 4-1. *User Port connector 25 Pin APEX Standard*

Unless otherwise specified, all analog signals are 0 to 10 V while all digital signals are 5 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 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 two jumpers on a mating connector: one between pins 4 and 9 to satisfy the *RF PWR ON* signal and one between pins 10 and 23 to satisfy the *INTERLOCK LOOP* signal. To determine the physical location of these pin numbers on the User port, see Figure 4-1 on page 4-2.

If desired, you can add an emergency off switch in series with the *RF PWR ON* signal (pin 4) 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 4-3 and "Wiring Diagrams for the Standard 25-Pin User Port" on page 4-9.

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 4-1. *User Port 25-Pin APEX Standard Pin Descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1		*SETPOINT 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 10V = 0 to maximum rated power output as defined by configuration PIN in Table 1-1 position 2 in Table 1-1. See Wiring Diagram 4-2. Pin 15 must be grounded.
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 10V = 0 to maximum rated power output as defined by configuration PIN position 2 in Table 1-1. See Wiring Diagram 4-1. for wiring diagram. Pin 16 must be grounded

Table 4-1. *User Port 25-Pin APEX Standard Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
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 Wiring Diagram 4-5. *Note:* The interlocks must be satisfied and the setpoint must be within the Output power range before unit will deliver power. See Table 3-3. on page 3-6 for the Output power range specification.
5	18	*SETPOINT*	Analog input	This pin linearly controls the RF output of the generator. 0 to 10V = 0 to maximum rated power output as defined by configuration PIN position 2 in Table 1-1. See Wiring Diagram 4-3. *Note:* Setpoint must be greater than 1% of full rated output before unit will deliver power.

Table 4-1. *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). 0 to 10V = 0 to maximum rated power output as defined by configuration PIN position 2 in Table 1-1. See Wiring Diagram 4-6. *Note:* When using this regulation feature, the setpoint must be given at pin 5 (SETPOINT). Setpoints cannot be established through the serial interface at this time.

Table 4-1. *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 Wiring Diagram 4-4. *Note:* When using this regulation feature, the setpoint must be given at pin 5 (SETPOINT). Setpoints 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 Wiring Diagram 4-7.
9		*OVERTEMP RETURN*	Digital Output	See Signal pin 22
10	23	*INTERLOCK LOOP*		This pin when connected externally to pin 23 closes the interlock and allows the RF output to be enabled. See Wiring Diagram 4-12.

Table 4-1. *User Port 25-Pin APEX Standard Pin Descriptions (Continued)*

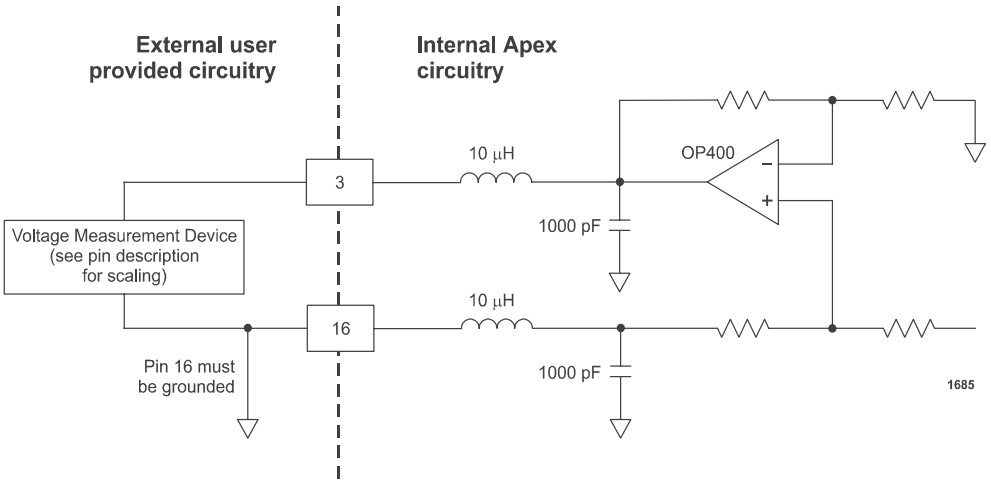
Signal Pin	Return Pin	Name	Signal Type	Description
11		*DC BUS OK RETURN*	Digital Output	See Signal Pin 24
12	25	*CEX LOCK*	Digital output	When the generator is successfully phase-locked to an external oscillator, a low (opto-coupler output) impedance is created between this pin and return pin 25. (6 mA max) See Wiring Diagram 4-11.
13	21	*+15 VDC*	Analog output	This pin, referenced to ground, provides a +15 Vdc auxiliary supply for external use. See Wiring Diagram 4-13.
14	1	*SETPOINT STATUS*	Digital output	When the output is equal to the requested setpoint, a low (opto-coupler output) impedance is created between this pin and pin 1. (6 mA max). See Wiring Diagram 4-8. *Note:* This condition is also referred to as the generator being at setpoint.
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
18		*SETPOINT 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

Table 4-1. *User Port 25-Pin APEX Standard Pin Descriptions (Continued)*

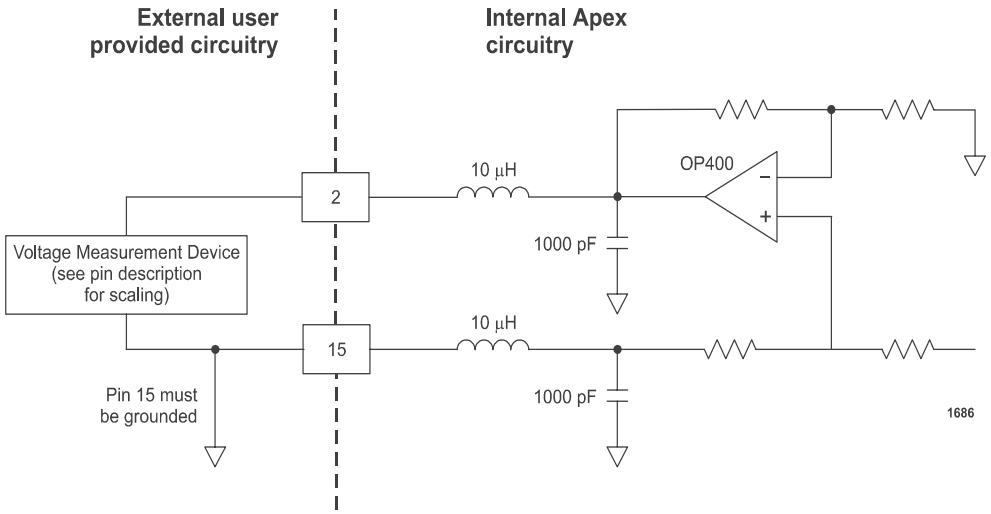
Signal Pin	Return Pin	Name	Signal Type	Description
22	9	*OVERTEMP*	Digital output	When an internal overtemperature shutdown condition is detected, a low (opto-coupler output) impedance is created between this pin and pin 9 (6 mA max). See Wiring Diagram 4-9. *Note:* This pin only detects a overtemp shutdown 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 (6mA max). See Wiring Diagram 4-10.
25		*CEX LOCK RETURN*	Digital Output	See pin 12

WIRING DIAGRAMS FOR THE STANDARD 25-PIN USER PORT

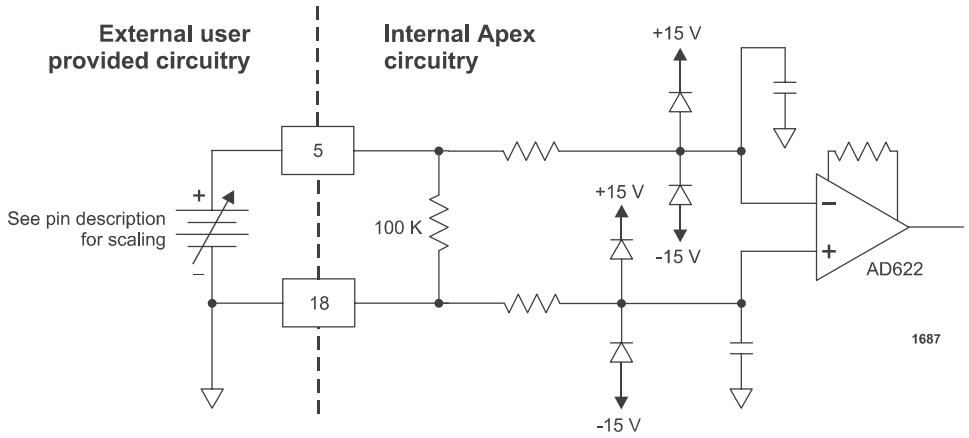
The diagrams in this section provide wiring information to properly connect to the Apex standard 25-pin User port.



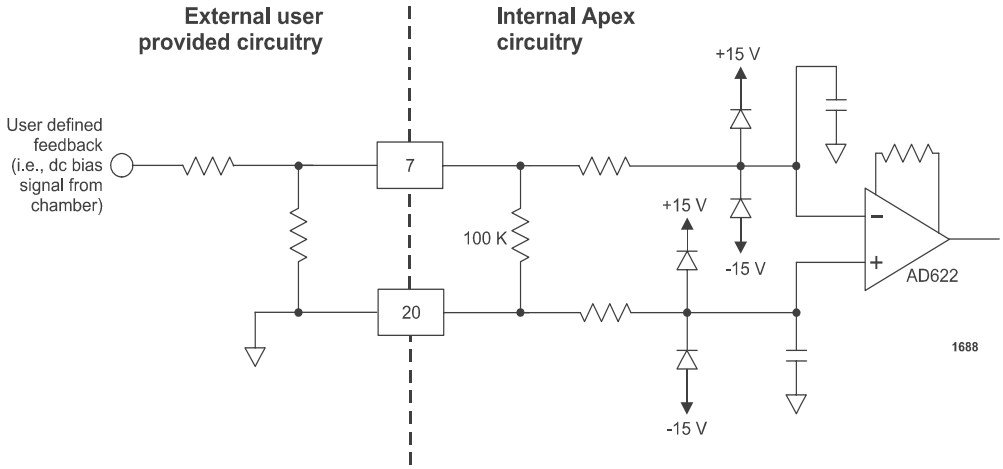
Wiring Diagram 4-1. *Forward/Load power monitor (pins 3 and 16)*



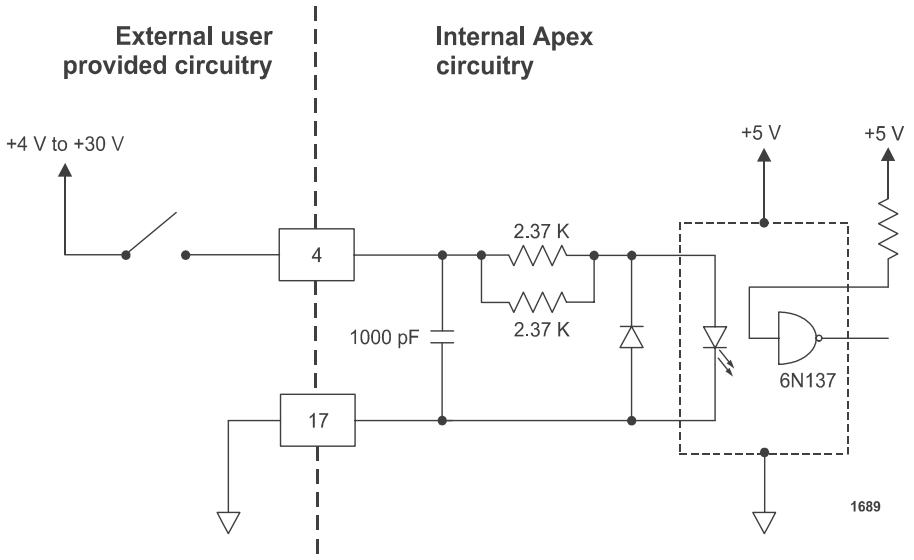
Wiring Diagram 4-2. *RFL PWR monitor (pins 2 and 15)*



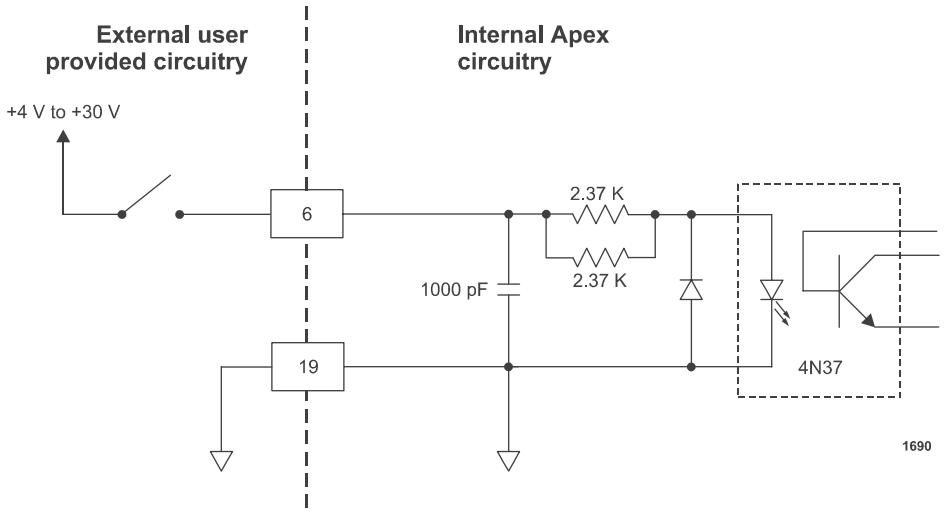
Wiring Diagram 4-3. *Setpoint (pins 5 and 18)*



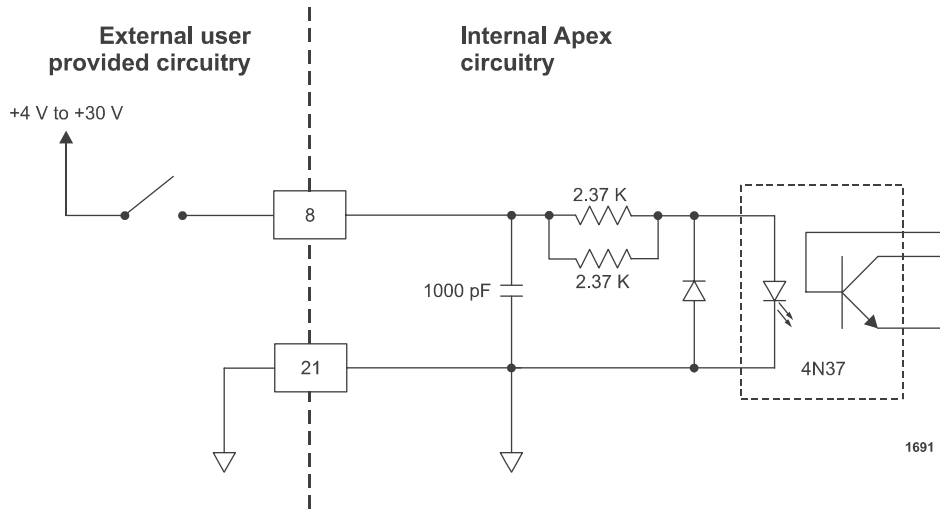
Wiring Diagram 4-4. *DC Bias Input (pins 7 and 20)*



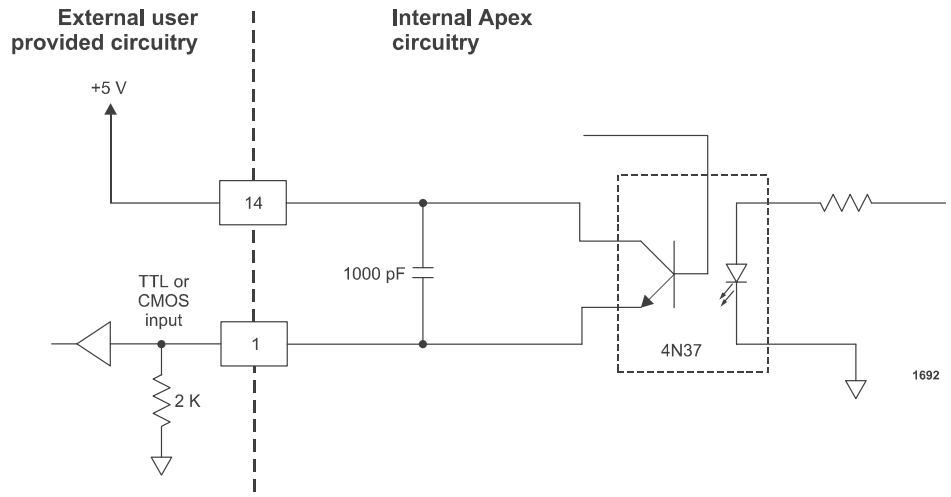
Wiring Diagram 4-5. *RF Power On (pins 4 and 17)*



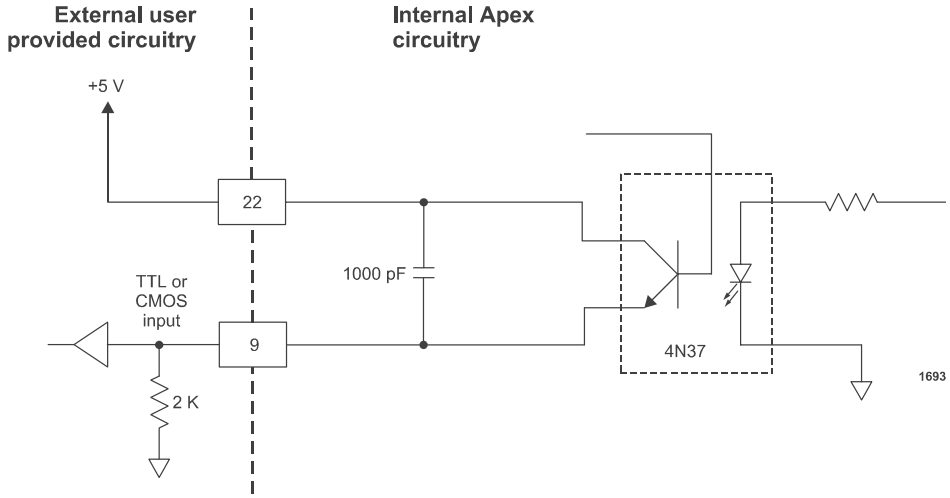
Wiring Diagram 4-6. *DC Bias/Power Regulation (pins 6 and 19)*



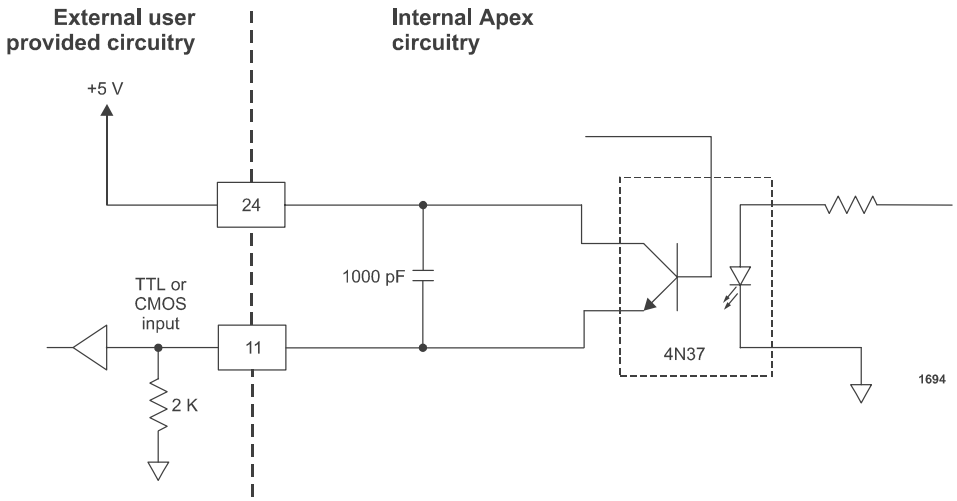
Wiring Diagram 4-7. *FWD/Load Power Regulation (pins 8 and 21)*



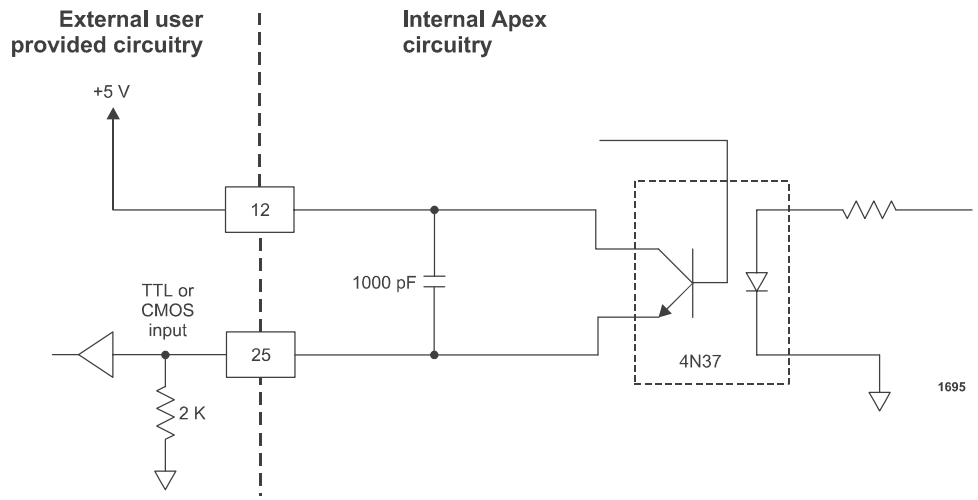
Wiring Diagram 4-8. *Setpoint Status (pins 14 and 1)*



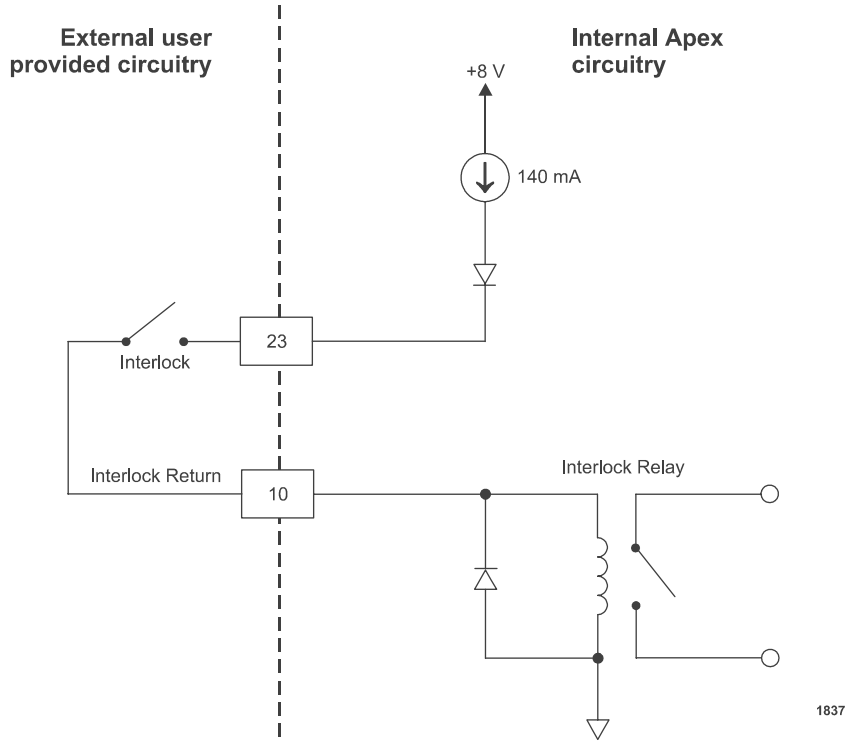
Wiring Diagram 4-9. *Overtemp (pins 22 and 9)*



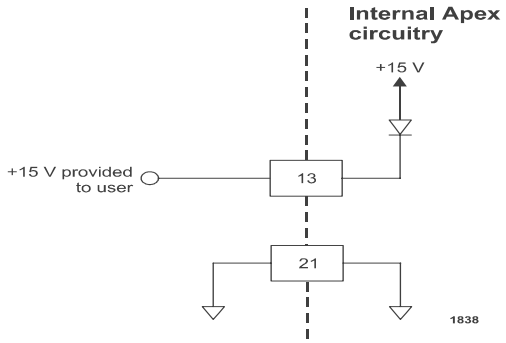
Wiring Diagram 4-10. *DC Bus OK (pins 24 and 11)*



Wiring Diagram 4-11. *CEX Lock (pins 12 and 25)*



Wiring Diagram 4-12. *Interlock Loop (pins 10 and 23)*



Wiring Diagram 4-13. *+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 standard 25-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 Table 1-1. on page 1-4.

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.

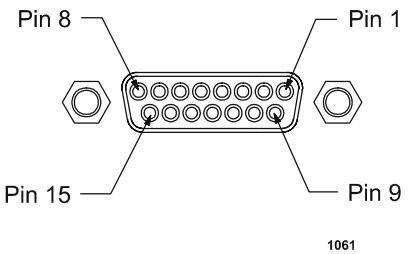


Figure 4-2. *User port connector 15 Pin Exclusive for configuration D*

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 Figure 4-2 on page 4-17.

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 "Pin Descriptions for Option D User Port" on page 4-18 and "Wiring Diagrams for Option D 15-Pin User Port" on page 4-20.

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 10V while all digital signals are 0 to 5V.

PIN DESCRIPTIONS FOR OPTION D USER PORT

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

Table 4-2. *User Port (15-pin) Connector Pins Exclusive for Configuration 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 Wiring Diagram 4-19.
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 Wiring Diagram 4-15.
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 Wiring Diagram 4-14.

Table 4-2. *User Port (15-pin) Connector Pins Exclusive for Configuration D (Continued)*

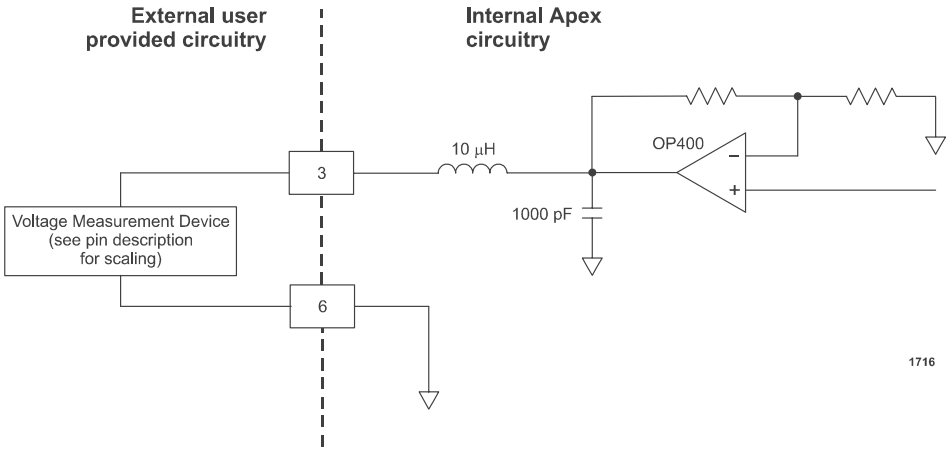
Signal Pin	Return Pin	Name	Signal Type	Description
4	6	*RF POWER ENABLE*	Digital input	RF output is enabled when a 4 to 30 V input (pin 9, RF ON BIAS, can be used as a voltage source) is present on this pin. *Note:* The interlocks must be satisfied and the setpoint must be within the Output power range before unit will deliver power. See Table 3-3. on page 3-6 for the Output power range specification. See Wiring Diagram 4-17.
5	6	*FORWARD/LOAD POWER SETPOINT*	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 Wiring Diagram 4-16. *Note:* The interlocks must be satisfied and the setpoint must be within the Output power range before unit will deliver power. See Table 3-3. on page 3-6 for the Output power range specification.
6		*SIGNAL COMMON*	Chassis ground	This pin is Signal Common. Also connected to Apex generator chassis ground.
7	6	*RF ON STATUS*	Digital output	+ 5 Vdc on this pin represents RF ON. See Wiring Diagram 4-18.
8	6	*EXTERNAL BIAS*	Voltage reference	+15 Vdc provided to the User port through a 5.62 kΩ resistor. See Wiring Diagram 4-20.

Table 4-2. *User Port (15-pin) Connector Pins Exclusive for Configuration D (Continued)*

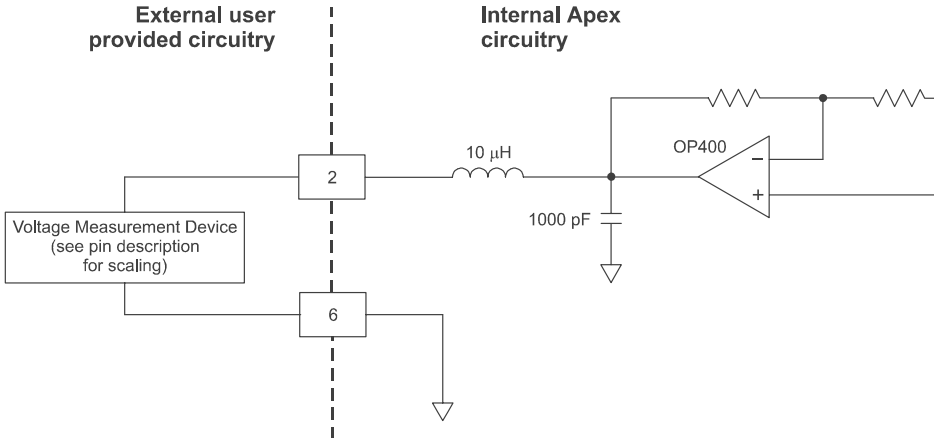
Signal Pin	Return Pin	Name	Signal Type	Description
9	6	*RF ON BIAS*	Voltage reference	+15 Vdc provided to the User port through a 1.1 kΩ resistor. It can be used for a switch or relay contact closure to enable RF ON (pin 4). See Wiring Diagram 4-21.
10		*UNASSIGNED*		
11	6	*INTERLOCK*	Analog Input	When connected together, these pins close the interlock and allows RF output to be enabled. See Wiring Diagram 4-23.
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.
13	6	*FWD/LOAD POWER REGULATION*	Digital Input	Load Power Regulation is enabled when a 4 to 30V input is present on this pin. *Note:* Forward Power Regulation is the default. See Wiring Diagram 4-22.
14		*UNASSIGNED*		
15		*UNASSIGNED*		

WIRING DIAGRAMS FOR OPTION D 15-PIN USER PORT

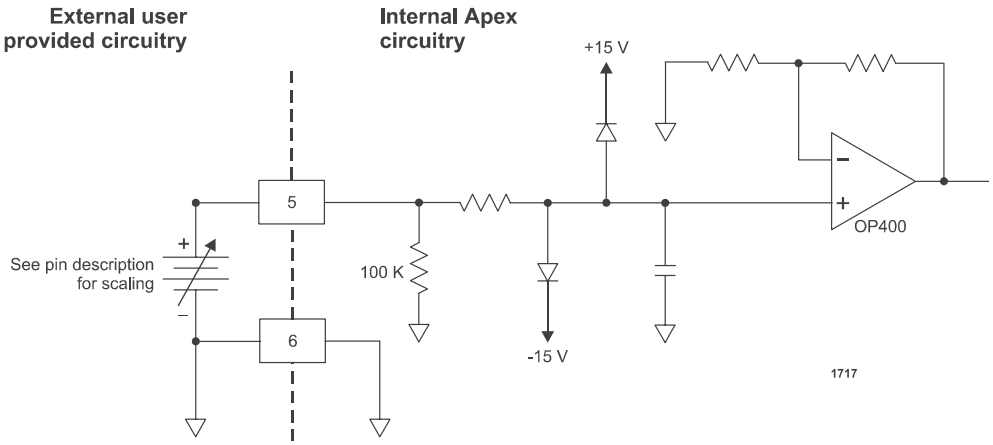
The diagrams in this section provide wiring information to properly connect to the Apex 15-pin configuration D User port.



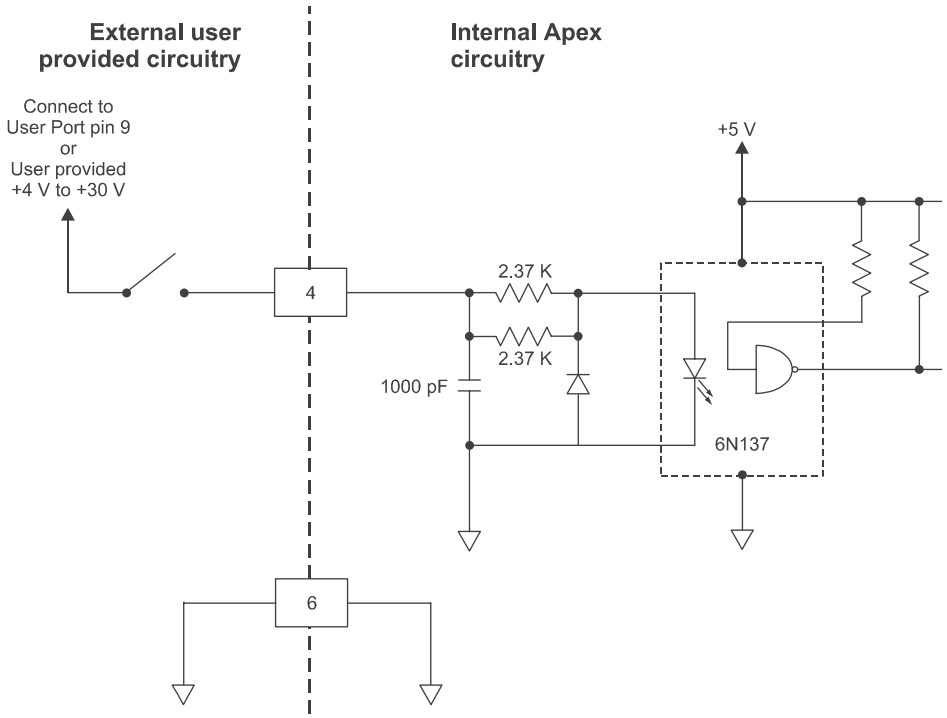
Wiring Diagram 4-14. *Forward/Load Power monitor (pins 3 and 6)*



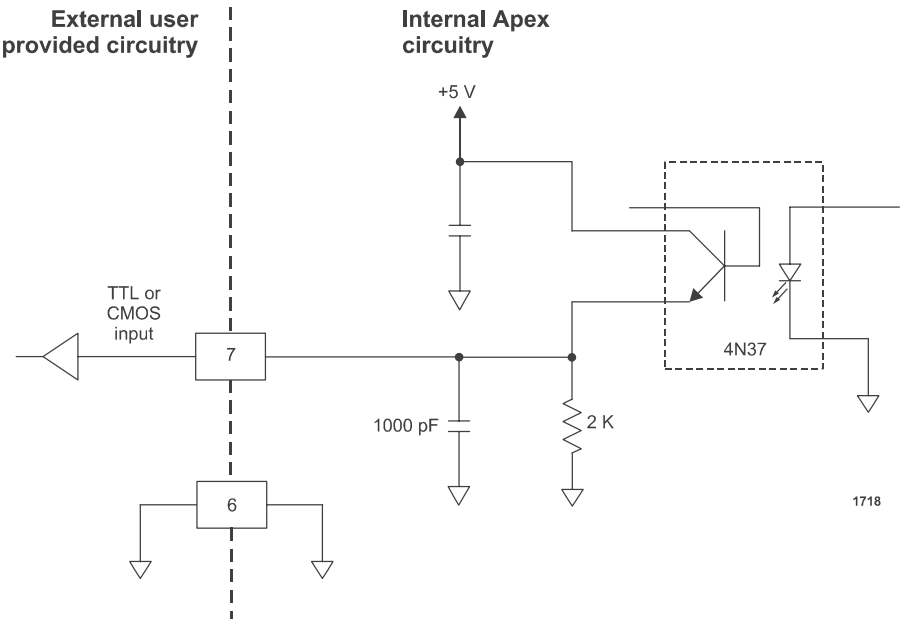
Wiring Diagram 4-15. *Reflected power monitor (pins 2 and 6)*



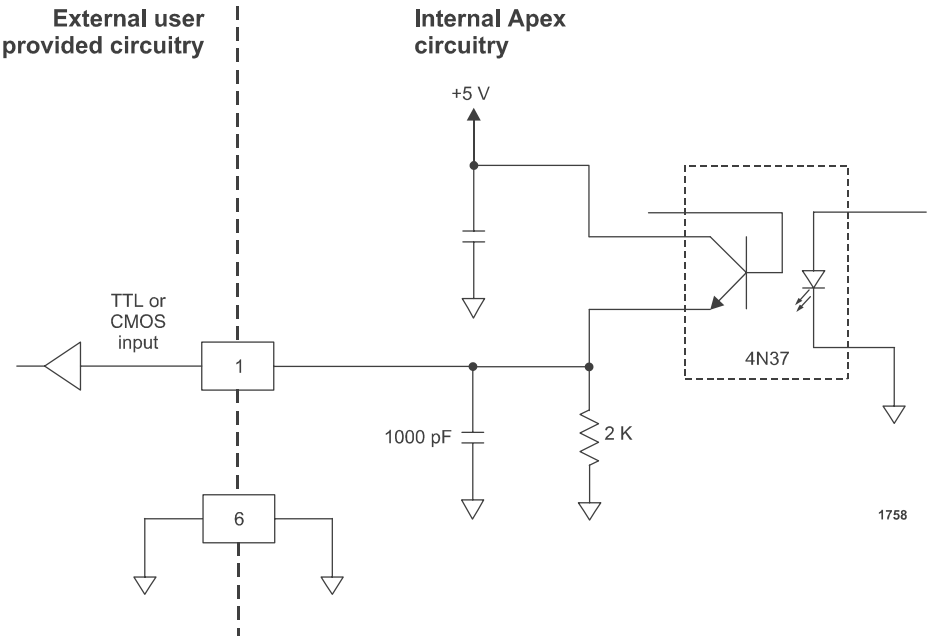
Wiring Diagram 4-16. *Forward/Load Power setpoint (pins 5 and 6)*



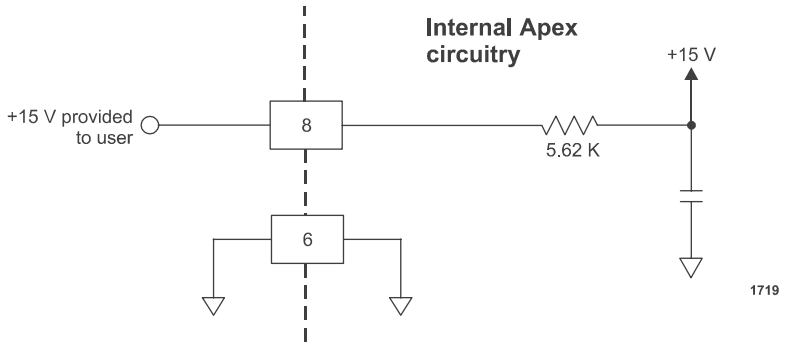
Wiring Diagram 4-17. *RF power enable (pins 4 and 6)*



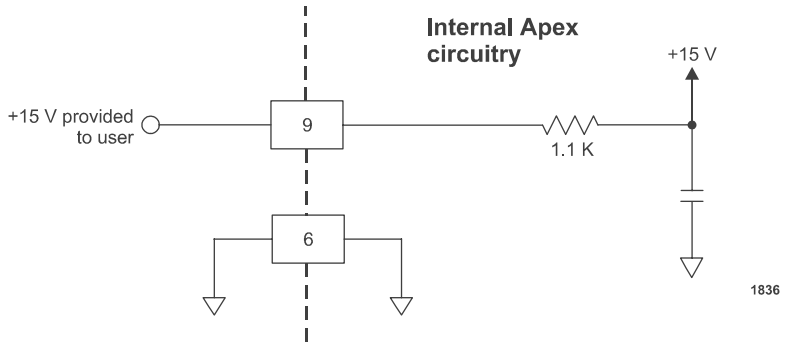
Wiring Diagram 4-18. *RF on status (pins 7 and 6)*



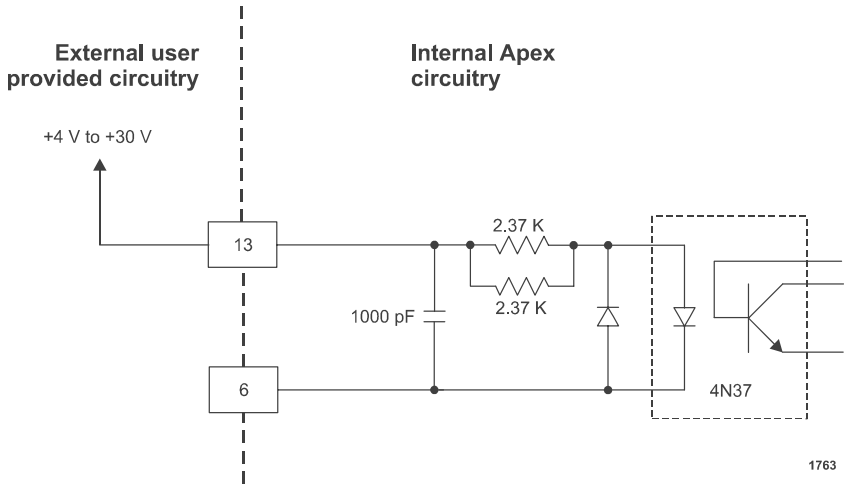
Wiring Diagram 4-19. *Power limit status (pins 1 and 6)*



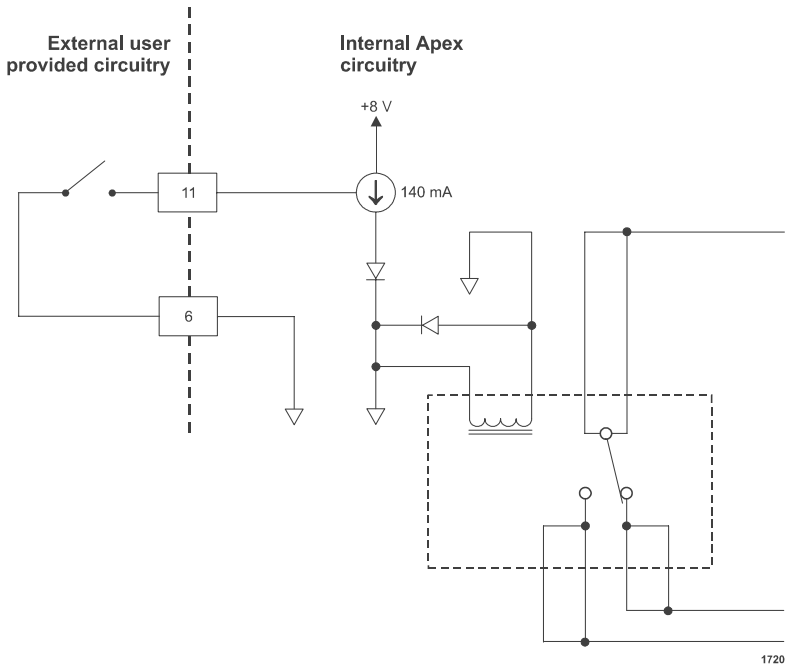
Wiring Diagram 4-20. *External bias (pins 8 and 6)*



Wiring Diagram 4-21. *RF on bias (pins 9 and 6)*



Wiring Diagram 4-22. *FWD/LOAD Power Regulation (pins 13 and 6)*



Wiring Diagram 4-23. *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 Table 1-1. on page 1-4.

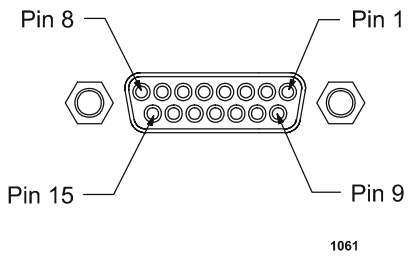


Figure 4-3. *User Port connector 15 pin exclusive for Configuration E*

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.

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 Figure 4-3 on page 4-26.

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 Description for Option E User Port" on page 4-27 and "Wiring Diagrams for Option E User Port" on page 4-32.

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 DESCRIPTION FOR OPTION E USER PORT

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

Table 4-3. *User Port (15-pin) Connector Pins Exclusive for Configuration E*

Signal Pin	Return Pin	Name	Signal Type	Description
1		*+24V (User Provided)*	Voltage Input	+24V provided by user for devicenet LEDs, used for DeviceNet isolation. See Wiring Diagram 4-24.
2	6	*REFLECTED POWER MONITOR*	Analog output	This analog signal provides a linearly scaled readback of reflected power. 0 to 10V = 0 to maximum rated power output as defined by configuration PIN in Table 1-1 position 2 in Table 1-1. See Wiring Diagram 4-25.
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 to 10V = 0 to maximum rated power output as defined by configuration PIN in Table 1-1 position 3 in Table 1-1. See Wiring Diagram 4-26.

Table 4-3. *User Port (15-pin) Connector Pins Exclusive for Configuration E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
4		*RF POWER ENABLE*	Digital input	This pin represents RF output being enabled when a 4 to 30V input (pin 9, RF ON BIAS, can be used as a voltage source) is present on this pin. See Wiring Diagram 4-27. *Note:* The interlocks must be satisfied and the setpoint must be within the Output power range before unit will deliver power. See Table 3-3. on page 3-6 for the Output power range specification.
5	6	*FORWARD / LOAD POWER SETPOINT*	Analog input	This analog signal provides a linearly scaled control of the forward or load output power depending on the regulation mode. 0 to 10V = 0 to maximum rated power output as defined by configuration PIN in Table 1-1 position 2. See Wiring Diagram 4-28. *Note:* The interlocks must be satisfied and the setpoint must be within the Output power range before unit will deliver power. See Table 3-3. on page 3-6 for the Output power range specification.

Table 4-3. *User Port (15-pin) Connector Pins Exclusive for Configuration E (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
6		*SIGNAL COMMON*	Chassis ground	Common for signal pins 2, 3, and 5. Connected to the Apex generator chassis ground.
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 (6mA max). See Wiring Diagram 4-29.
8		*RF ON STATUS RETURN*	Digital output	See pin 7
9		*+15 Vdc*	Voltage reference	+15 Vdc provided to the User port through a 1.1kΩ resistor. Can be used for a switch or relay contact closure to enable RF ON (pin 4). See Wiring Diagram 4-30.
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 45mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See Wiring Diagram 4-24.

Table 4-3. *User Port (15-pin) Connector Pins Exclusive for Configuration E (Continued)*

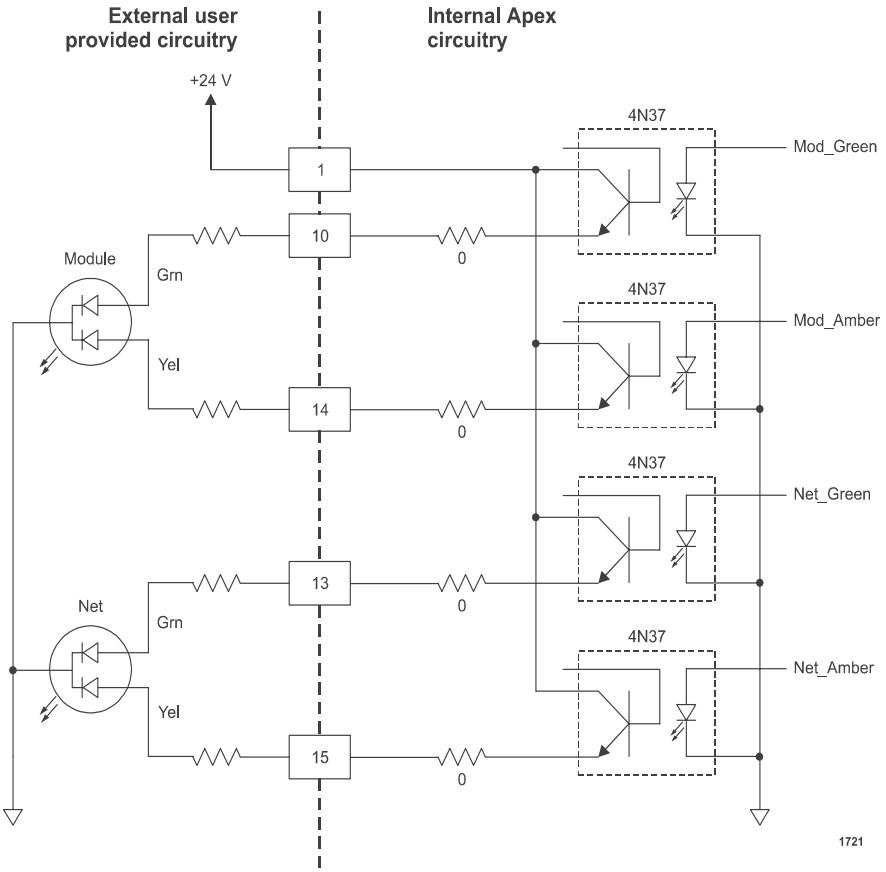
Signal Pin	Return Pin	Name	Signal Type	Description
11	12	*INTERLOCK*		When connected externally, these pins close the interlock and allows RF output to be enabled. See Wiring Diagram 4-31.
12		*INERLOCK RETURN*		See pin 11
13		*NETWORK STATUS LED OUTPUT (GREEN)*	Digital output	This pin provides the output 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 45mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See Wiring Diagram 4-24.

Table 4-3. *User Port (15-pin) Connector Pins Exclusive for Configuration E (Continued)*

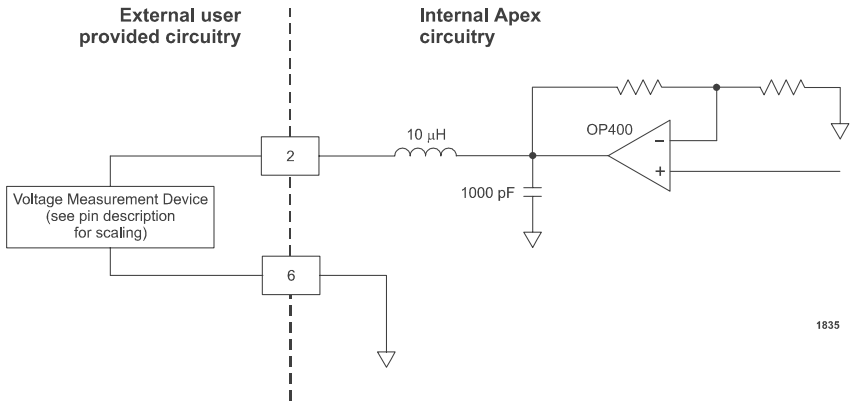
Signal Pin	Return Pin	Name	Signal Type	Description
14		*MODULE STATUS LED OUTPUT (AMBER)*	Digital output	This pin provides the output for remote DeviceNet LED and is connected to the emitter of an opto-coupler. The User must limit the current draw through this pin to 45mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See Wiring Diagram 4-24.
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 45mA or less. *Note:* Defined by DeviceNet Specification, Release 2.0 See Wiring Diagram 4-24.

WIRING DIAGRAMS FOR OPTION E USER PORT

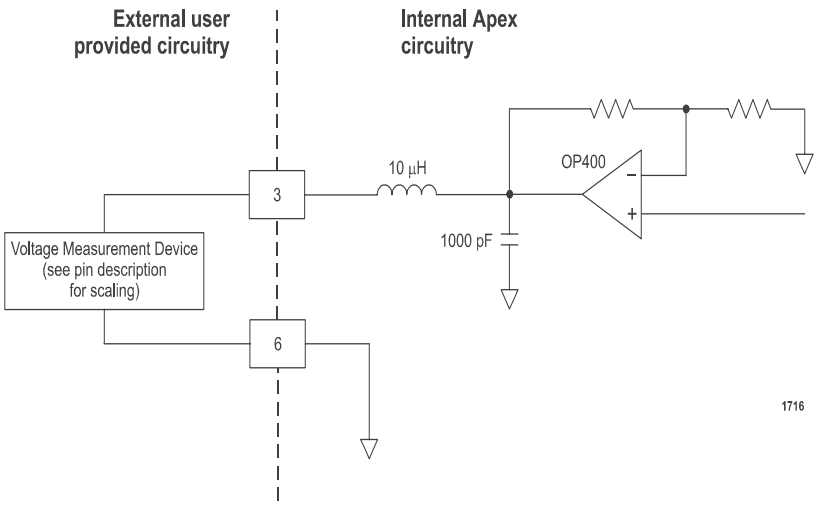
The diagrams in this section provide wiring information to properly connect to the Apex 15-pin User port configuration E.



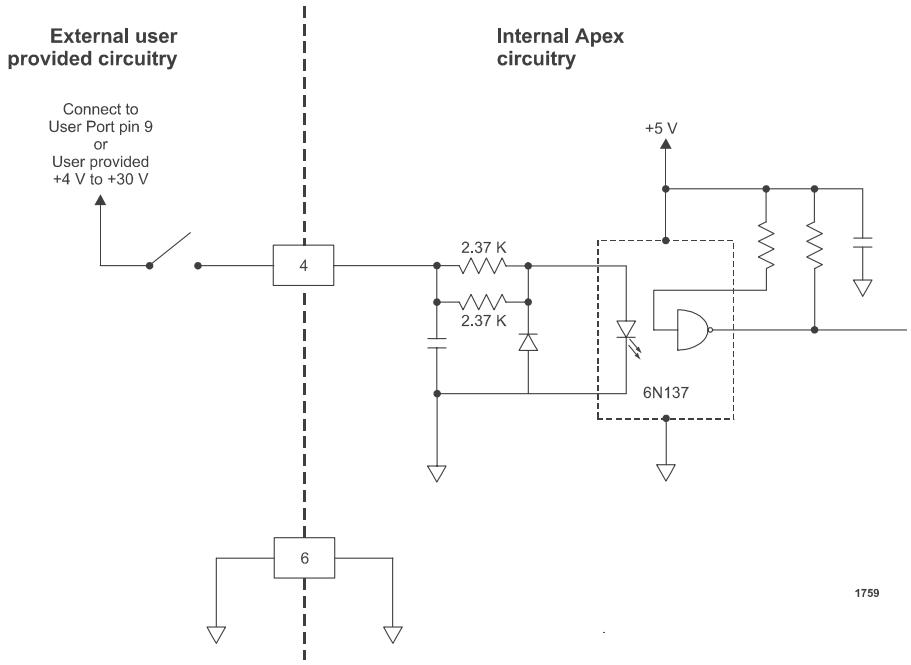
Wiring Diagram 4-24. *DeviceNet LEDs (pins 1,10,13,14 and 15)*



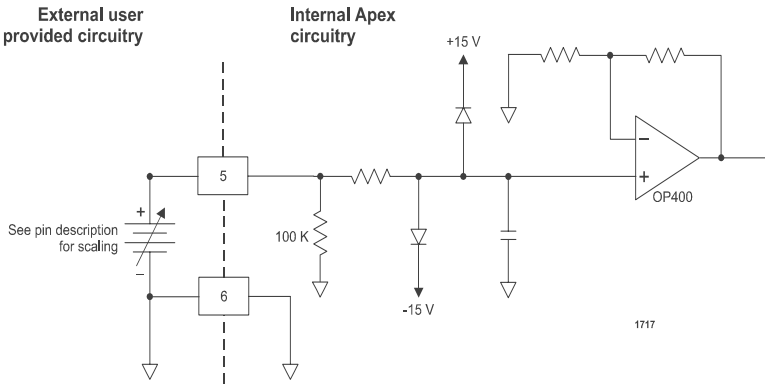
Wiring Diagram 4-25. *Reflected power monitor (pins 2 and 6)*



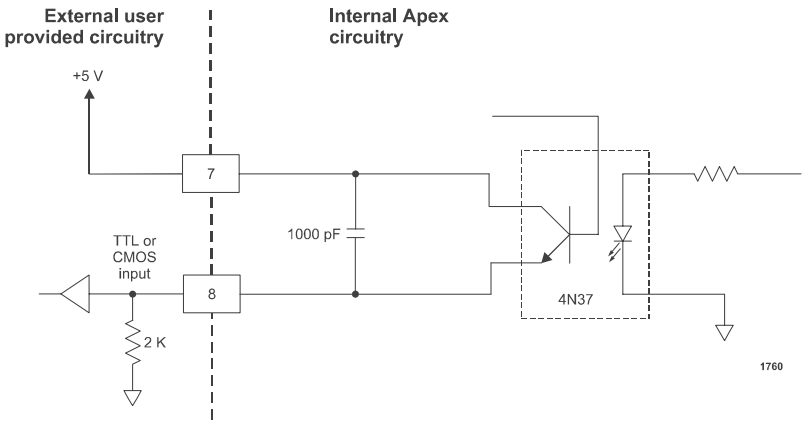
Wiring Diagram 4-26. *Forward/Load Power Monitor (pins 3 and 6)*



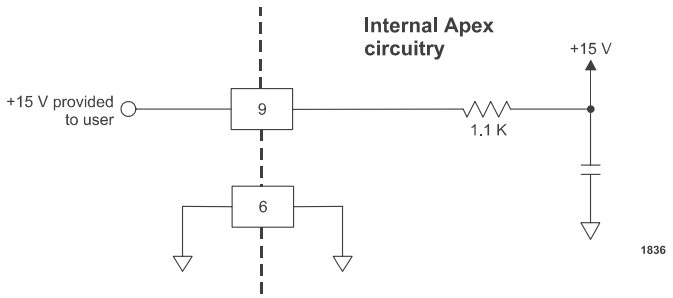
Wiring Diagram 4-27. *RF Power Enable (pin 4 and 6)*



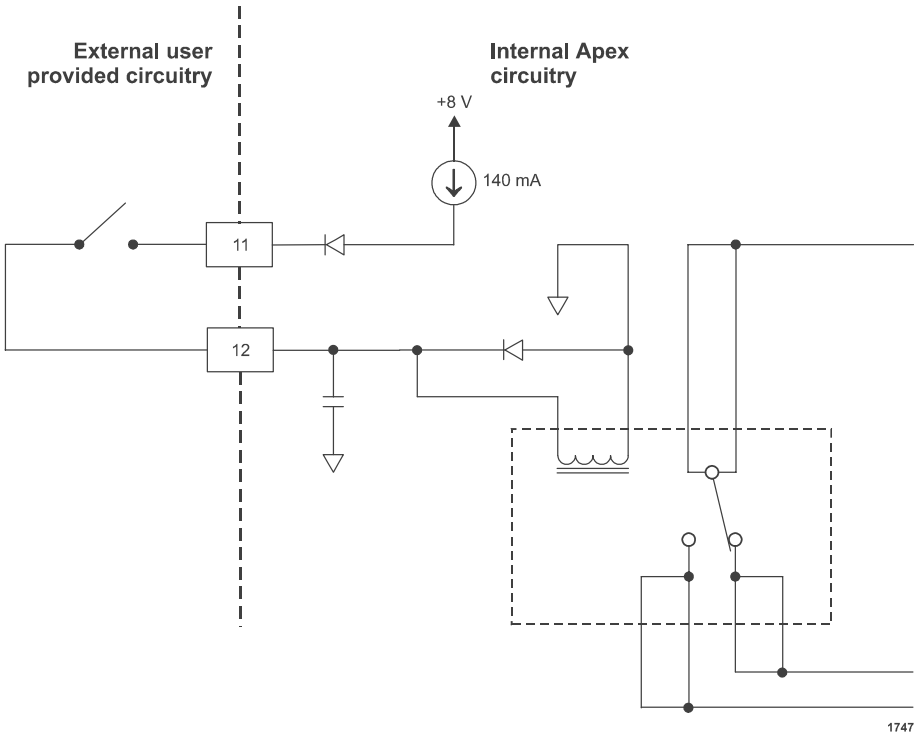
Wiring Diagram 4-28. *Forward/Load Power Setpoint (pins 5 and 6)*



Wiring Diagram 4-29. *RF on status (pins 7 and 8)*



Wiring Diagram 4-30. *+15 Vdc (pins 9 and 6)*



Wiring Diagram 4-31. *Interlock (pins 11 and 12)*

APEX HOST PORT OPTIONS

The following sections provide information for each of the Host port options available with the 1 to 5.5 kW Apex generator. These options are:

- "Host Port—RS-232 With AE Bus" on page 4-37
- "Host Port—Profibus" on page 4-58
- "Host Port—DeviceNet" on page 4-72

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 for 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 Table 1-1. on page 1-4.

This Apex Host port, which is the standard, or default option, uses an RS-232 signal format and AE Bus communication protocol. Refer to "Communicating Through the RS-232, AE Bus Host Port" 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, or to obtain a limited-time evaluation copy,

contact AE Global Support or your AE sales representative. (For contact information, see “AE Customer Support” on page 6-11.) AE can also provide a simple host software for this port. For information, contact AE Global Support.

Note: 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 Table 1-1. on page 1-4. 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 Command Set for the RS-232, AE Bus Host Port on page 4-45. The control mode setting is stored in volatile memory so it will need to be set whenever the AC input is powered up.

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

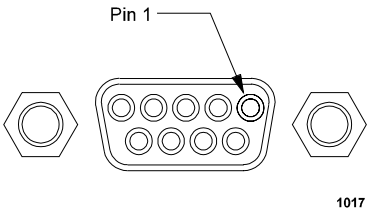


Figure 4-4. *RS-232, AE Bus Host port connector*

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 Table 4-4 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 4-4. *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 0.02 s (that is, no more than 0.02 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 4-5.):

- 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 4-5. shows the organization of these data fields in the AE Bus message packet. The subsequent paragraphs describe each data field in detail.

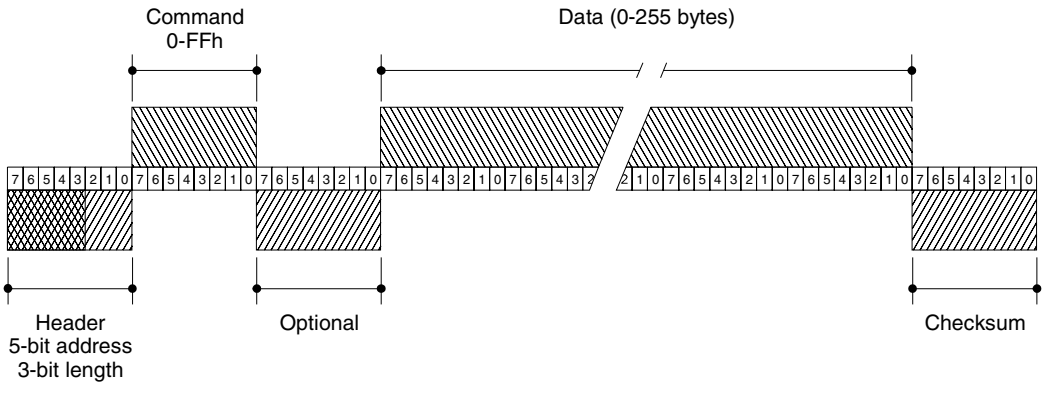


Figure 4-5. *Graphic representation of a RS-232, AE Bus message packet*

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 4-42).

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 "Host Port Commands for RS-232 with AE Bus" on page 4-45 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 4-42), 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 4-6. is a simplified graphic showing the steps in an ideal communications transaction between a host computer and the Apex generator.

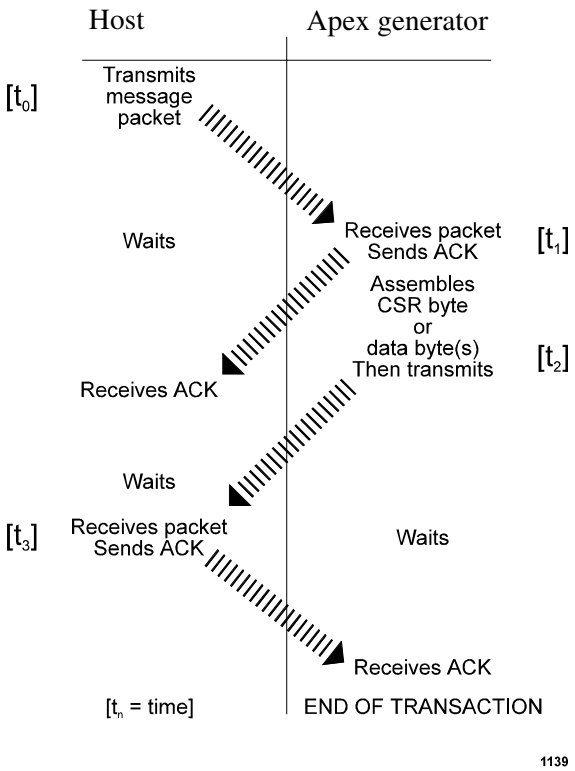


Figure 4-6. *AE Bus communications transaction*

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 4-7 is a simplified graphic showing the steps in an example communications transaction between a host computer and an Apex generator.

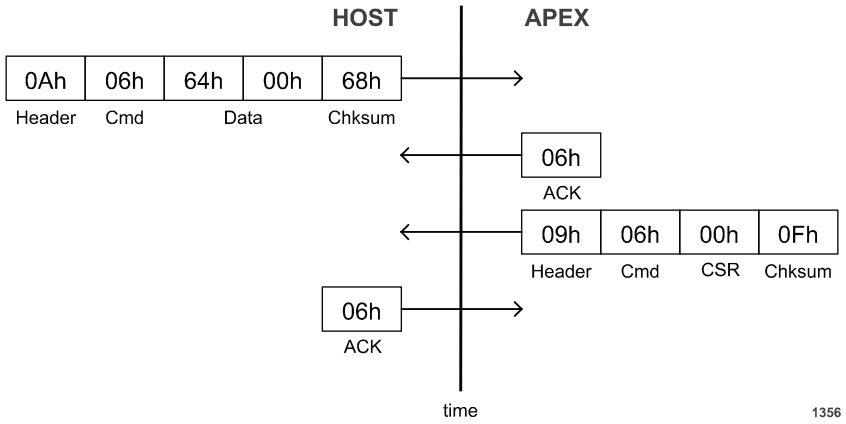


Figure 4-7. *AE Bus communications transaction example*

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 4-5 defines how these CSR codes should be interpreted.

Table 4-5. *CSR Codes for RS-232, AE Bus Host*

Value	Meaning
0	Command accepted
1	Wrong control mode
2	Output is on
3	Output is off
4	Data is out of range
5	User off active
7	Active fault(s) exist
9	Data byte count is incorrect
14	CMD not accept
16	T life
19	Recipe active
30	EPROM read/write
50	Frequency out of range

Table 4-5. *CSR Codes for RS-232, AE Bus Host*

51	Duty cycle out of range
52	Minimum on/off time violated (on/off time must be ≥ 10 µs).
99	Command not implemented

COMMAND SET FOR THE RS-232, AE BUS HOST PORT

Table 4-6 lists the command set for the RS-232, AE Bus Host port.

Table 4-6. *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 pwr limit	Specifies maximum forward power that can be delivered; accepts a value of 0 to 8000 W (for the 8 kW option) or 0 to 10000 W (for the 10 kW option). (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 2000 W. (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. (Readback command is **171**.) *Note:* This command sets the value at which the setpoint is limited during external regulation	2 data bytes 16-bit value	1

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
8 setpoint	Specifies the output setpoint level for whatever method of output regulation has been selected. Accepts a value of 0 to 8000 W (for the 8 kW option) or 0 to 10000 W (for the 10 kW option) 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: • First/second byte = a 16-bit value in the range of 500 to 5000. • Third byte = the number of decimal places (0 to 4) used to display the external feedback signal on the operator panel.	3 data bytes 16-bit value 8-bit value	
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: • First byte = the target number • Second, third, fourth, fifth bytes = target life in kWh *Note:* A decimal is implied—to get 1 kWh, send a value of 100. (Readback command is **157**.)	5 data bytes 8-bit value 32-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-setpoint timer	Specifies how long the generator can produce output that is not equal to the programmed setpoint level. Accepts a value of 0 to 599 s. (Readback command is **184**.)	2 data bytes 16-bit value	1

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
16 allowable deviation	Specifies a percentage that the generator can be out of setpoint before it starts the out-of-setpoint 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 5).	1 data byte 8-bit value	
22 recipe step/ setpoint	Specifies setpoint for a recipe step. Send 3 data bytes. • byte 1 = recipe step number (can be 1 through 7) • bytes 2 and 3 = setpoint value (send least significant byte first); the value must be within the operating range of the Apex unit (see "Output Electrical Specifications" on page 3-6)	3 data bytes 8-bit value 16-bit value	
23 recipe step/ run time	Sets the run time for the specified recipe step. Send 3 data bytes. • byte 1 = recipe step number (1 through 7) • bytes 2 and 3 = 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	
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	
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 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
69 set serial port address and baud rate	Sets the serial port address and baud rate. Send 3 data bytes: • byte 1: bits 0 through 4 set serial port address (addresses 1 through 31 are supported) bits 5 and 6 are unused bit 7 selects communication protocol (0 = RS-232, 1 = RS-485) • Bytes 2 and 3 = baud rate (send least significant byte first) Valid baud rates depend on the communication protocol selected in byte 1: For RS-232, send 1200, 4800, 9600, or 19200 For RS-485, send 9600, 19200, 38400, or 57600 Read back with CMD **212**.	3 data bytes 8-bit value 16-bit value	

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
86 Set point diode 1 latch	Sets the pin diode 1 latch. Send 1 data byte. • byte 1 = latch *Note:* byte 1 bits on a standard 5 pin unit: 0: Series 3 1: Series 1 2: Shunt 1 3: Shunt 2 4: Series 2 5: chamber / 50 ohm 6: Unused 7: Unused *Note:* byte 1 bits on a 2 pin unit: 0: Unused 1: Series 1 2: Unused 3: Shunt 2 4: Unused 5: Unused 6: Unused 7: Unused	1 data byte 8-bit value	
93 set pulsing frequency	Sets the RF pulsing frequency in Hz. Accepts a value of 150 to 50000. 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 10% to 90%. Minimum On or OFF time is >= 10uS.	2 data bytes	
119 Profibus Reset/ Explicit Fault clear	Clears profibus fault and error code register		
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 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of 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 7 ASCII characters—a 7-digit number. This command is used in conjunction with CMD **198** to obtain the version/revision number of the mainframe software.	0	7 data bytes 7 ASCII characters
140 report 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
154 report regulation mode	Requests regulation mode (set with CMD **3**). Returning values: • 6 = Forward • 7 = Delivered or Load • 8 = External (DC Bias)		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:* A decimal is implied—100 = 1 kWh,	1 data byte 8-bit value	4 data bytes 32-bit value

Table 4-6. *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. 1st status byte: 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 = setpoint status (0 = within tolerance, 1 = out of tolerance) 2nd status byte: 0 = end of target life 1 = unassigned 2 = unassigned 3 = overtemperature 4 = unassigned 5 = unassigned 6 = unassigned 7 = interlock open 3rd status byte—fault flags 0 = nonmaskable interrupt 1 = bus fault 2 = high bus voltage 3 = unassigned 4 = low bus voltage 5 = out of setpoint 6 = unassigned interrupt 7 = unassigned 4th status byte—fault flags 0 = current limit 1 = contactor failure 2 = Profibus error 3 = unassigned 4 = unassigned 5 = unassigned 6 = unassigned 7 = CEX is locked	0	4 data bytes 4—8-bit values

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
164 read setpoint/ regulation mode	Requests output setpoint 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 = setpoint 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. 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
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 1 and 2 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.		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 1 and 2 represent user reflected power limit in watts.		2 data bytes 16-bit value

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
171 read ext feedback limit	Requests external feedback limit (set by CMD **6**) *Note:* The response in data bytes 1 and 2 represent the user external feedback limit (LSB first). It returns the user external feedback limit.		2 data bytes 16-bit value
173 report power dissipation	Reports dissipated power *Note:* The response in data bytes 1 and 2 represent dissipated power (LSB first). It returns dissipated power.		2 data bytes 16-bit value
184 read out-of-setpoint interval	Requests how long the generator is programmed to produce output that is not equal to the programmed setpoint level before shutting output off (set with CMD **15**). *Note:* Data bytes 1 and 2 represent the unsigned integer value for out of setpoint time interval (LSB first). It reports how many seconds the generator will produce output that is not equal to the setpoint before turning the output off.		2 data bytes 16-bit value
185 read allowable deviation	Requests what percentage the generator can be out of setpoint before it starts the out-of-setpoint timer (set with CMD **16**). Reports the allowable setpoint deviation *Note:* The response reports the percentage (1 to 99) and the supply can be out of setpoint before turning on the out-of-setpoint timer.		1 data byte 8-bit value

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
188 report recipe step setpoints/ run times	Reports the setpoints and run times for each recipe step. The number of data bytes returned depends on the number of steps in the recipe. For each recipe step, 4 data bytes returned, indicating: • First 2 bytes = recipe step setpoint 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 **188**)		Varies; sends 4 data bytes for each recipe step
189 report 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 indicates ignition (1 = ignition detected; 0 = ignition not detected) bits 1, 2, and 3 indicate the most recently completed step number bits 4–7 are reserved or unassigned • Byte 3 = recipe mode (1 = time, 2 = joule)		
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).		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.		2 data bytes 16-bit value
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.		3 data bytes 3 ASCII characters

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
201 report 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).		4 data bytes 32-bit value
202 report 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).		4 data bytes 32-bit value
203 report overtemp events	Reports a count of overtemp events *Note:* The response contains 4 bytes which represent a 32-bit count of events (LSB first).		4 bytes 32 bit value
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.		4 data bytes 32-bit value
206 read total energy output	Requests the total amount of energy (in kWh) delivered by the generator. *Note:* The response contains 4 bytes which represent a 32-bit time (LSB first). It returns the amount of energy in kilo watt hours delivered by the unit.		4 data bytes 32-bit value
210 report fault warnings and shutdowns	Returns faults, warnings, and shutdowns *Note:* The response contains 1 data byte which represents fault warnings and shutdowns. • bit 0 indicates ripple warning (0 = inactive, 1 = active) • bit 1 indicates ripple failure (0 = inactive, 1 = active) • bit 2 indicates temperature rate failure (0 = inactive, 1= active)		1 data byte 8-bit value

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
212 report serial port 0 address and baud rate	Returns the serial port 0 address and baud rate (set with CMD **69**). *Note:* The response contains 3 data bytes: • byte 1: bits 0 through 4 = serial port address (addresses 1 through 31 are supported) bits 5 and 6 = unused bit 7 = communication protocol (0 = RS-232, 1 = RS-485) • Bytes 2 and 3 = baud rate		3 data bytes 8-bit value 16-bit value

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
219 report condensed snapshot of generator data	Returns the condensed snapshot of generator data *Note:* The response contains 2 sets of responses for APEX with Directional Coupler and VI System. For Directional coupler the data points are: • 0,1: Forward Power with Bias Correction • 2,3: Reflected Power with Bias Correction • 4,5: Delivered Power with Bias Correction • 6,7 User Setpoint • 8: Regulation Mode (see command 3 for definition) • 9 to 12: Process Status (see command 162 for definition) • 13,14: Cold Plate Temperature (see command 228 for definition) • 15,16: DC Voltage • 17,18: DC current • 19 to 22: Unused APEX with VI Measurement data point definitions: • 0,1: Real Power with Bias Correction • 2,3: Imaginary Power with Bias Correction' • 4,5:VSQ with Bias Correction • 6,7: User Setpoint • 8: Regulation Mode (see command 3 for definition) • 9 to 12: Process Status (see command 162 for definition) • 13,14: Cold Plate Temperature (see command 228 for definition) • 15,16: DC Voltage • 17,18: DC Current		

Table 4-6. *Host Port Commands for RS-232 with AE Bus (Continued)*

Command	Description	Number of Host Data Bytes	Number of Response Data Bytes
219 report condensed snapshot of generator data (cont'd)	• 19,20: Real Impedance • 21,22: Imaginary Impedance		
221 report 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 at least 25 return data points in packet (LSB first). the actual PIN length is 18 characters; however, the response packet is 25 characters.		
223 report error code register	Retrieves the error code *Note:* Response contains 1 data byte that is the error code.		1 data byte 8-bit value

Host Port—Profibus

This section describes the Profibus Host port interface. 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 Table 1-1. on page 1-4.

AE PROFIBUS PROTOCOL

Profibus (Process Field Bus) is an interface that lets you communicate with your Apex generator from a host (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: 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 Table 1-1. on page 1-4. 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 Command Set" on page 4-66.

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 4-60).

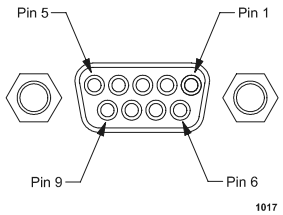


Figure 4-8. *Host port connector with Profibus*

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

Table 4-7 describes the Profibus Host port pins.

Table 4-7. *Profibus Host Port Pins*

Signal Pin	Name	Description
1	*UNASSIGNED*	
2	*UNASSIGNED*	
3	*A*	Data bus A

Table 4-7. *Profibus Host Port Pins*

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

Profibus Type Files (GSD Files)

Type files are computer files that some Programmable Logic Controllers (PLCs) use to compile their Profibus programs. These files are device-specific and contain information on features found in that device. Thus a different type file should be defined for each Profibus device.

For older Siemens Profibus PLCs, the “type file” is proprietary to Siemens Energy & Automation (SE&A); hence, SE&A must create the type file. Newer Profibus PLCs use a non-proprietary equivalent of a “type file,” generally referred to as a “GSD file.” AE does not create or supervise distribution of either kind of type files.

Type files are available on SE&A’s electronic Bulletin Board Services (BBS). You can download the type files through a modem connection. The telephone numbers for SE&A’s Profibus BBSs are:

- USA.: (423) 461-2751
- Europe: 49 911 737972

You can download type files from a World Wide Web site maintained by the Profibus Trade Organization. The address is http:\\www.profibus.com.

Setting the Network Address with the Profibus DIP Switch

Use the DIP switch next to the Profibus port on the rear panel to set the Apex generator's address. Allowable addresses are even numbers between 0 and 126, selected in binary format.

To enter the unit's address, set the switch positions for binary representation, starting with the switch on the left and proceeding to the right (descending order of significance). The switches are numbered 1 through 8. Switch 1 is the most significant byte (MSB), and switch 8 is the least significant byte (LSB).

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.

Note: You cannot change the unit’s address from the Profibus master.

Profibus Termination

Please ensure that you follow proper termination procedures if your Apex is the last slave on the Profibus cable. The termination resistors should be on the connector housing of the Profibus cable (not included).

Profibus Baud Rate

The auto-baud feature of AE’s certified Profibus interface adjusts automatically to the rate of the Profibus master system. Baud rates are available in discrete steps from 9600 bits (9.6 kbits) to 12 Mbits. The auto-baud feature operates much like a modem or FAX machine in that, at startup, there is a small delay while the interface “traverses” the different baud rates and then locks in. Please ensure that your Profibus master allows for this delay.

Profibus Master Reset Command

Send the master reset command, **Command 119**, when the Apex supply has experienced a non-recoverable (“explicit clear”) fault (that is, a configuration fault or a Profibus error fault). We recommend sending this command upon the startup of Profibus communications so that any existing fault indications will be cleared.

Profibus Watch Dog Timer

As a safety feature, the Profibus maintains a watch dog timer that shuts off the Apex supply’s output if the Profibus master stops communicating. The watch dog timer maintains a value for time (between 10 ms and 10 minutes) that the Apex supply waits between commands from the master. The timer counts down this time in 10 ms increments.

If your 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). To get the actual wait time value, the Apex microprocessor uses the numbers you enter to 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 be equal to each other or be zero.

Note: You can disable the watch dog timer through the Profibus master.

Profibus-Specific Errors

In the event of a Profibus error, the Apex generator turns output power off and sets the Profibus fault status bit. All Profibus errors are treated as “explicit clear” type faults; thus you must send **Command 119** (the “master reset” command) in the next download packet to clear them. Once all faults have been cleared, the Apex generator is ready to continue operation.

Profibus Data Consistency

Some PLCs using Profibus interfaces have a problem with data consistency. (We define “data consistency” as the ability to complete the message packet construction before sending the packet to the Apex generator.) This problem most often manifests as mysteriously changed values. That is, values at the Apex generator seem to have changed automatically even though no command has executed, or they appear changed because one data byte contained the data that another data byte should have contained.

The root of the problem is a shared memory block. 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. The problem occurs when the PLC updates the data from High to Low memory locations and does not signal the Profibus interface when 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.

You can create a “work around” to this problem with a command sequence. (For more information about Profibus commands, see the “Host/Apex Software Commands” section later in this chapter.) Here is an example procedure:

1. Send the null command (Command 0). The Apex generator ignores this command.
2. Update the download packet with data for the desired command.
3. Update the packet with the desired command.
4. Send the download packet.
5. Repeat step 1, and continue as needed.

By creating a procedure like this one, you can ensure the data for a command will not be changed before the next download packet is received.

PROFIBUS/APEX SOFTWARE COMMANDS

The new AE Profibus is command-based. We define a download packet ("outbytes") and an upload packet ("inbytes") as described in the following sections of this chapter. Command lists follow.

Note: Response times are very fast. So requested information is available in less than 100 ms. More specifically, a download packet ("outbytes") has high priority for the AE Profibus and is processed immediately. The upload packet has lower priority and is updated every 100 ms, with the exceptions of the "output on" status bit, which is updated every 20 ms.

Profibus Download Packet

The download packet for the AE Profibus contains four bytes, as the following table shows.

Table 4-8. *Configuration of Download Bytes (Outbytes)*

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

In the packet, bytes 1, 2, and 3 comprise the "data field" and contain information defined by the command. Note that when the information extends over more than one byte, the packet sends the least significant byte (LSB) before the most significant byte (MSB); this arrangement is a departure from previous Profibus options we have offered.

Profibus Upload Packet

During every Profibus data exchange, the Apex generator supplies a 14-byte response to a download ("outbytes") packet. The following list shows the response or "upload packet." These bytes are also known as "inbytes."

Table 4-9. *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

Table 4-9. *Configuration of Profibus Upload Packet (Inbytes)*

Byte	Description
4	Forward power low
5	Forward power high
6	Reflected power low
7	Reflected power high
8	Data byte (LSB)
9	Data byte
10	Data byte
11	Data byte
12	Data byte (MSB)
13	Data field definition

Bytes 0 and 1 of the upload packet contain information about the Apex generator; this information appears as status bits (or status “flags”). The following table defines these status bits:

Table 4-10. *Upload Status Bytes*

First Status Bit	8 = Control mode (with bit 9) 9 = Control mode (00 = User, 10 = Profibus) 10 = Setpoint 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 = Contactor not closed 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.

In the packet, bytes 8, 9, 10, 11, and 12 comprise the “data field” and contain information defined by byte 13, the data field definition byte. Note that when the 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.

PROFIBUS COMMAND SET

Table 4-11 lists the command set for the Profibus Host port.

Table 4-11. *Profibus Host Port Commands*

Command	Description	Number of Transmit 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	
2 **RF on**	Requests RF output on; host control must have been selected.	0	
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	
4 **fwd pwr limit**	Specifies maximum forward power that can be delivered; accepts a value of 0 to 8000 W (for the 8 kW option) or 0 to 10000 W (for the 10 kW option). (Readback command is **169**.)	2 data bytes 16-bit value	
5 **refl pwr limit**	Specifies maximum reflected power that can be tolerated; accepts a value of 0 to 20% of full rated power. (Readback command is **170**.)	2 data bytes 16-bit value	
6 **ext feedback limit**	Specifies the maximum external feedback level; accepts a value from 0 to the maximum external feedback value. (Readback command is **171**.) This command sets the value at which the setpoint is limited during external regulation	2 data bytes 16-bit value	
8 **setpoint**	Specifies the output setpoint level for whatever method of output regulation has been selected. Accepts a value of 0 to 8000 W (for the 8 kW option) or 0 to 10000 W (for the 10 kW option) when forward or load power regulation is selected.	2 data bytes 16-bit value	

Table 4-11. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	Number of Response Data Bytes
9 **max ext feedback**	Specifies the external feedback value that corresponds to 10 V on the User2 port; requires data bytes arranged as follows: Second/third byte = a 16-bit value in the range of 500 to 5000. Fourth byte = the number of decimal places (0 to 4) used to display the external feedback signal on the operator panel.	3 data bytes 16-bit value 8-bit value	
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	
12 **set target life**	Sets the life (in kWh) of the active target. Requires three data bytes (24-bit value): Second, third, and fourth bytes = target life in kWh. Two decimals are implied—to get 1 kWh, send a value of 100. (Readback command is **157**.)	3 data bytes 24-bit value	
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	
15 **out-of-setpoint timer**	Specifies how long the generator can produce output that is not equal to the programmed setpoint level. Accepts a value of 0 to 599 s. (0 disables the timer.) (Readback command is **184**.)	2 data bytes 16-bit value	
16 **allowable deviation**	Specifies a percentage that the generator can be out of setpoint before it starts the out-of-setpoint timer. Accepts a value of 1 to 99%. (Readback command is **185**.)	1 data byte 8-bit value	
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 4-11. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit 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. 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
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 (set by **CMD 12**) in the active target you specify. Two decimals are implied— 100 = 1 kWh.	1	4 data bytes 32-bit value

Table 4-11. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit 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. 1st status byte: 0 = unassigned 1 = unassigned 2 = unassigned 3 = unassigned 4 = unassigned 5 = output power (0 = off, 1 = on) 6 = unassigned 7 = setpoint status (0 = within tolerance, 1 = out of tolerance) 2nd status byte: 0 = end of target life 1 = unassigned 2 = unassigned 3 = overtemperature 4 = unassigned 5 = unassigned 6 = unassigned 7 = interlock open 3rd status byte—fault flags: 0 = nonmaskable interrupt 1 = bus fault 2 = high bus voltage 3 = unassigned 4 = low bus voltage 5 = out of setpoint 6 = unassigned interrupt 7 = unassigned 4th status byte—fault flags: 0 = current limit 1 = contactor failure 2 = unassigned 3 = unassigned 4 = unassigned 5 = unassigned 6 = unassigned 7 = CEX is locked		4 data bytes four 8-bit values

Table 4-11. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	Number of Response Data Bytes
164 read setpoint/ regulation mode	Requests output setpoint 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 = setpoint 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
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-setpoint interval	Requests how long the generator is programmed to produce output that is not equal to the programmed setpoint level before shutting output off (set with **CMD 15**).	0	2 data bytes 16-bit value

Table 4-11. *Profibus Host Port Commands (Continued)*

Command	Description	Number of Transmit Data Bytes	Number of Response Data Bytes
185 read allowable deviation	Requests what percentage the generator can be out of setpoint before it starts the out-of-setpoint timer (set with **CMD 16**).	0	1 data bytes 8-bit value
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
205 read run time	Requests the amount of time (in seconds) that the generator was producing output.	0	4 data bytes 32-bit value
206 read total energy output	Requests the total amount of energy (in kWh) delivered by the generator.	0	4 data bytes 32-bit value

Host Port—DeviceNet

This section describes the DeviceNet Host port interface. To determine if your Apex unit has this interface, use the PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
DeviceNet 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 Table 1-1. on page 1-4.

The DeviceNet connector is either a 5-pin, male, Lumberg, RSF 5/0.5m or Turck FS 4.5.

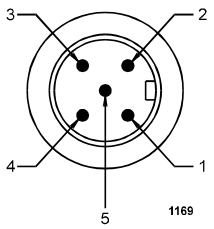


Figure 4-9. *DeviceNet connector*

Table 4-12 describes the DeviceNet port pin signals.

Table 4-12. *Host Port DeviceNet Pins*

Signal Pin	Name	Description
1	*DRAIN*	Shield
2	*V+*	DeviceNet supply
3	*V-*	DeviceNet supply

Table 4-12. *Host Port DeviceNet Pins*

Signal Pin	Name	Description
4	*CAN_H*	DeviceNet data transmit/ receive
5	*CAN_L*	DeviceNet data transmit/ receive

Analog inputs and outputs use the values and equations listed in Table 4-13 to define the voltage ranges and the corresponding digital values (assuming N is the number of bits of resolution available at the DeviceNet interface). Unsigned binary is used to represent the 0 to +10 V range.

Table 4-13. *DeviceNet Voltage Ranges*

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

Note: The conversion is assumed to be linear across the range (a one-bit change always corresponds to the same voltage change in the AI/AO within the hardware capabilities of the device).

DEVICENET INTERFACE CHARACTERISTICS

The device uses rotary switches to set the MAC ID. This allows you to visually verify the MAC ID setting, and simplifies the configuration of replacement parts in field repair situations.

The device is delivered with the baud rate set to 500 KBd which does not change if the device is power-cycled.

The device supports the DeviceNet Duplicate MAC ID Check protocol.

The device 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 master.

Analog outputs automatically set the output voltages to 0 V if too much time elapses after the last Poll Command message received by the device. At this timeout condition, the output of the generator shuts off and goes safe.

DEVICENET ROTARY SWITCHES: BAUD RATE AND ADDRESSING

The DeviceNet interface features three rotary switches, located on the rear, which are read each time the DeviceNet interface powers up. Use the **Data Rate** switch to select a baud rate: 125, 250, or 500 kbaud (0 = 125;1 = 250; 2 = 500 kbaud). The default is 500 kbaud. A switch setting in the *PGM* region lets you configure the baud rate through DeviceNet.

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 Address 1. Table 4-4 describes the RS-232, AE Bus Host pin signals.

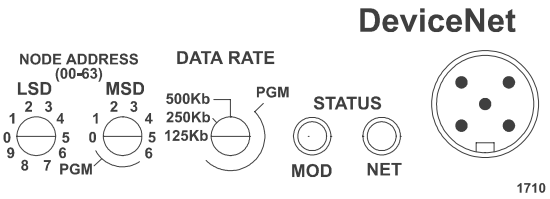


Figure 4-10. *DeviceNet control panel*

Use the **MSD** and **LSD** switches 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 DeviceNet.

DEVICENET CONTROL PANEL LEDS

The rear panel of the Apex generator features two, bi-color LEDs (see Figure 4-20). One is labeled MOD and indicates module status. The other is labeled NET and indicates network status.

Devicenet Module Status LED

The MOD bi-color (amber/green) LED provides device status. It indicates whether the device has power and is operating properly. Table 4-14 shows the LED's various states and meanings

.

Table 4-14. *MOD Status LED*

LED	State	Meaning
Off	No power	the unit is not receiving power.
Green (steady)	Operational	the unit is operating normally.
Flashing Green	Standby	the unit needs maintenance because the configuration is missing, incomplete, or incorrect.
Amber	Unrecoverable Fault	the unit has experienced a fault from which it cannot recover; you may need to replace the unit.
Flashing Amber/Green	Device Self-Testing	the unit is running self diagnostics

Note: For information on LED flash rates, refer to section 8.2.8 of the DeviceNet Specification (revision 2.0).

Note: For information about Module Status LED indications during power-up, refer to Section 8.2.4 of the DeviceNet Specification (revision 2.0).

Devicenet Network Status LED

The **NET** bi-color (amber/green) LED indicates the status of the communication link. The following table shows the LED's various states and their meanings.

Table 4-15. *Network Status LED*

LED	State	Meaning
Off	No power	The unit is not on-line because: • it has not completed the Dup_MAC_ID test yet • it is not receiving power (check the **MOD** LED).
Green (steady)	Link okay	The unit is on-line and allocated to the master

Table 4-15. *Network Status LED (Continued)*

LED	State	Meaning
Flashing green	On-line, not connected	The unit is on-line but has no connections in its existing state because: • the unit has no established connections to other nodes • the unit is not allocated to the master.
Flashing amber	Connection time-out, critical link failure	One or more I/O connections are in the timed-out state.
Amber	Critical link failure	Communication has failed; that is, the unit has detected an error that has made it incapable of communicating on the network.

For information about Module Status LED indications during power-up, refer to Section 8.2.4 of the DeviceNet Specification (revision 2.0).

DEVICENET OPERATION

You may operate your Apex generator either solely through the User port or through the optional DeviceNet port.

Before operating your Apex generator through the DeviceNet port, ensure that your network is connected to the DeviceNet port and the User port. Also, ensure that you have selected an appropriate MAC ID and baud rate (see “DeviceNet Rotary Switches: Baud Rate and Addressing” on page 4-74). Finally, ensure that you have read the information about command and response messages and the DeviceNet LEDs (see “DeviceNet Control Panel LEDs” on page 4-74).

Note: To operate through the DeviceNet port, you must also have a connection through the User port’s interlock pins. For information about User port interlock pins, see the User port section that applies to your Apex unit (“Apex User Port Options” on page 4-2).

⚠ CAUTION:
RF Power Enable can be active through the User port even though DeviceNet is in operation.

DeviceNet is connected through pins 1, 10, 13, 14, and 15 of the User port (See table 4-1).

When the generator powers up, it defaults to user control mode. However, engaging DeviceNet automatically places the generator in host control mode. Note that when the generator is in host control mode, the regulation mode is forward power.

Before operating your Apex generator through the DeviceNet port, ensure that your network is connected to the DeviceNet port and the User port. Also, ensure that you have selected an appropriate MAC ID and baud rate. Finally, ensure that you have read the following information about command and response messages and the DeviceNet LEDs.

DeviceNet Poll Command Message

Note that this device 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 master. Table 4-16 represents the structure of the poll command message.

Table 4-16. *Poll Command Message*

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Power Output Setpoint AI (LSB)							
1	0	0	0	0	Power Output Setpoint AI (MSB)			
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4								PO

Power Output Setpoint 0 to 10 V; 10 V = full output power of the power supply

PO = Power On
1 = turns power supply's output ON
0 = turns power supply OFF

Note: The 16-bit AI should be shifted right four bits and the remaining first four bits should be filled with 0s. This changes the 16-bit AI to a 12-bit AI with a value of 10 V = $OFFF_{hex}$.

Note: Power Output Setpoint values exceeding $OFFF_{hex}$ are limited to $OFFF_{hex}$.

DeviceNet Response Message

Table 4-17 represents the structure of the response message.

Table 4-17. *Response Message*

Byte	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
0	Forward Power Sense AI (LSB)							
1	0	0	0	0	Forward Power Sense AO (MSB)			
2	Reflected Power Sense A1 (LSB)							
3	0	0	0	0	Reflected Power Sense AI (MSB)			
4	Not Used AI (LSB)							
5	0	0	0	0	Not Used AI (MSB)			
6	Not Used AI (LSB)							
7	0	0	0	0	Not Used AI (MSB)			
8				INTS		TS	SPS	POS

Forward Power Sense 0 to 10 V; 10 V = maximum rated power linear
Reflected Power Sense 0 to 10 V; 10 V = maximum reflected power linear
POS = Power on Status; 1 = power output ON, 0 = power output OFF
SPS = Setpoint Status; 1 = setpoint reached, 0 = setpoint not reached
TS = Temperature Status; 1 = GOOD, 0 = OVERTEMP
INTS = Interlock Status; 1 = satisfied, 0 = open

Note: The 16-bit AO is shifted right four bits and the remaining first four bits are filled with 0s. This changes the 16-bit AO to a 12-bit AO with a value of 10 V = $OFFF_{hex}$.

Note: Readbacks exceeding $OFFF_{hex}$ are limited to $OFFF_{hex}$.

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 4-80.

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 Table 1-1. on page 1-4.

Table 4-18. *LED Status Indicators*

Indicator	Description
AC ON	This green LED indicates that ac power is available within the generator and all three phases are present.
RF ON	This green LED indicates that RF power is on (enabled). Depending on the selected setpoint value, RF power may or may not be present at the output connector. A flashing LED indicates an error. See “Troubleshooting guide” on page 6-1.
INTERLOCK	When lit this green LED indicates that the required interlock criteria has 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 guide” 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 guide” on page 6-1.

Table 4-18. *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 guide" on page 6-1 for more information.
ALARM	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 guide" on page 6-1 for more information.

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. These options mean that the presence or absence or certain connectors, the types of connectors, and the locations of certain options (on the front or the rear panel) are variable. The following illustrations show a basic Apex option, with labels for the options that you may or may not have on your Apex unit. To find information about any of these options, see "Using this Manual to Find Information for Your Generator" on page 1-1.

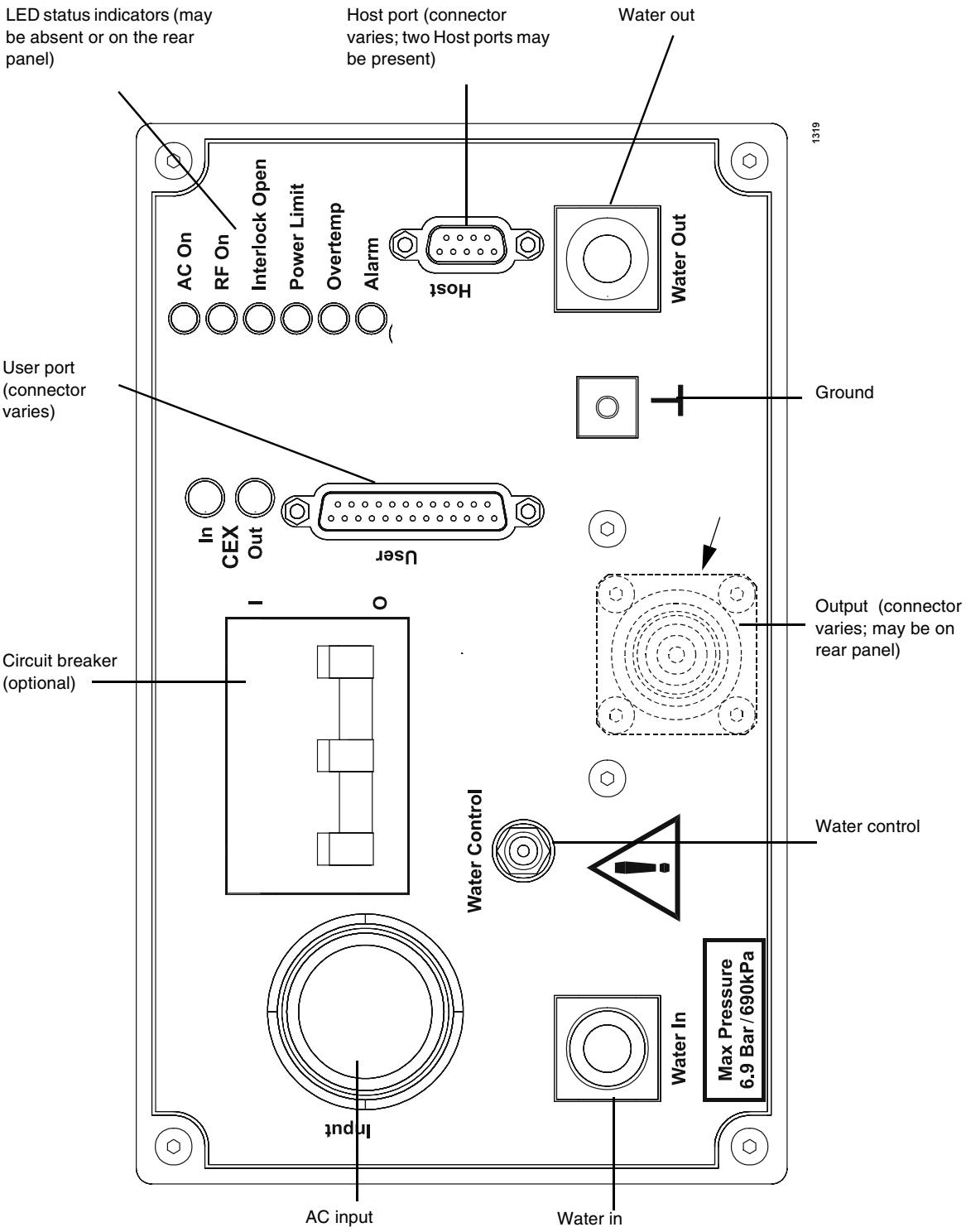


Figure 4-11. *Front Panel*

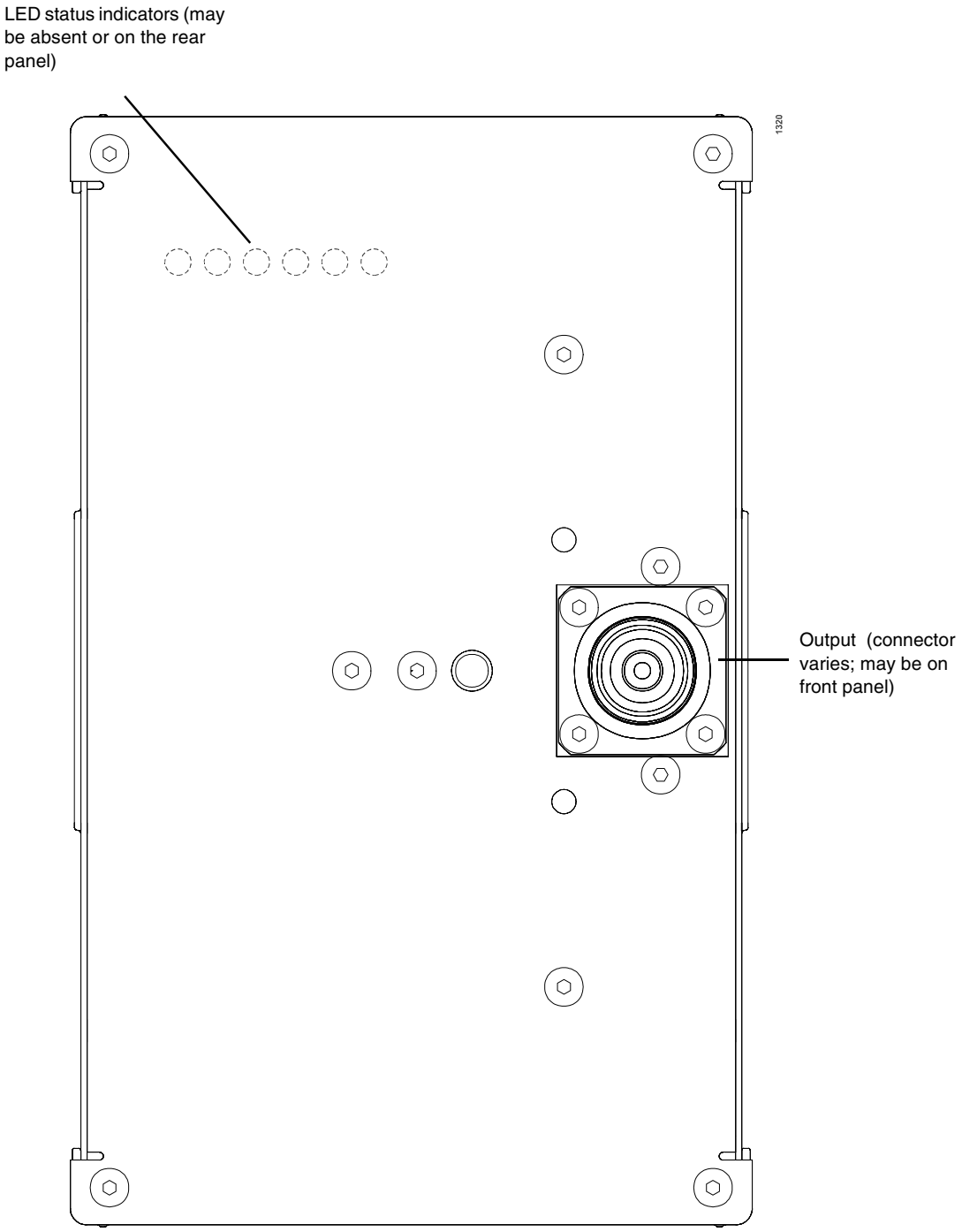


Figure 4-12. *Rear panel*

Chapter 5

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 "Using this Manual to Find Information for Your Generator" on page 1-1.

INSTALLING THE GENERATOR

The following sections provide information to help you install the Apex generator.

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.

Note: For more information about grounding, refer to AE Application Notes titled Grounding p/n 5600031A.

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

Spacing Requirements

The following diagram illustrates the spacing requirements in the installation of an Apex unit.

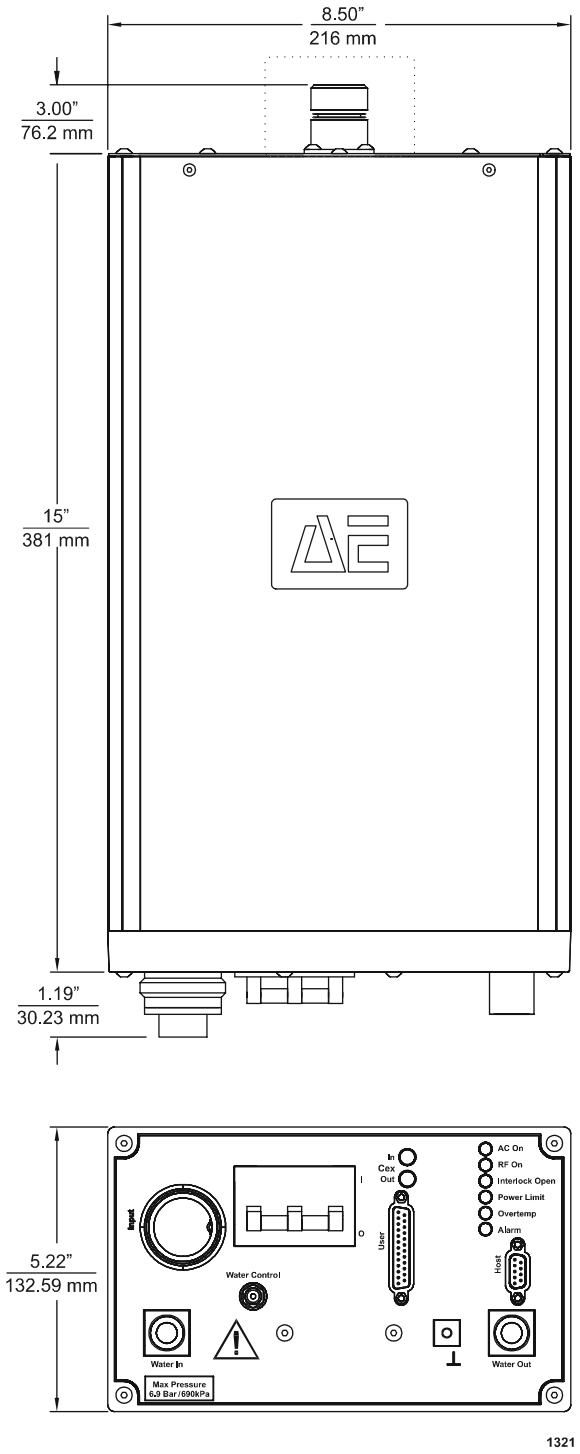


Figure 5-1. *Apex dimensions*

Mounting the Generator

Refer to Figure 5-1 for dimensions used to properly mount 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 3-10.

> ⚠ **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 for Your Generator” on page 1-1).

To Connect Cooling Water:

1. Connect the input and output water connections and tighten securely.
2. Turn on the water and ensure that there are no leaks.
3. Be sure that the flow rate, pressure, and temperature are within the minimum specifications required to operate the generator (see “Cooling Specifications” on page 3-10).

Installing the Optional Water Control

The water control connector is a 2-pin, miniature, power jack, Switchcraft p/n L712A. Table 5-1 and Figure 5-2 provide the connector pin locations and descriptions for the water control connector on the generator. The signals on this connector may be used with an externally mounted water control solenoid to inhibit the flow of water to the

generator when the additional cooling is not required. Water flow is enabled whenever ac is present on the input of the supply and open when ac is absent on the input of the supply.

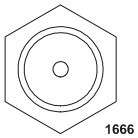


Figure 5-2. *Water control connector*

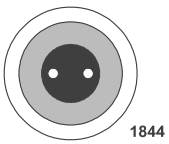


Figure 5-3. *Optional water solenoid connector*

Table 5-1. *Water Control Connector Pins*

Pin	Description
1 (center pin)	+24 V/1A (switched source to enable solenoid)
2 (outer pin)	+24 V return

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 identify and find information about your generator, see “Using this Manual to Find Information for Your Generator” on page 1-1). The following section provides signal pin locations and descriptions to aid in properly connecting output power.

There are five output connector options:

- 7/16 connector (PIN option 1)
- SQS™ connector (PIN option 2)
- LC connector (PIN option 3)
- HN connector (PIN option 4)
- N connector (PIN option 5)

Figure 5-4 provides a basic drawing of the output connectors.

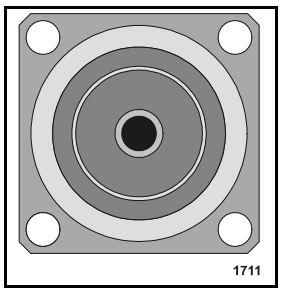


Figure 5-4. *Output connector*

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

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 identify and find information about your generator, see “Using this Manual to Find Information for Your Generator” on page 1-1). The following sections provide signal pin locations and connector illustrations to aid in properly connecting input.

⚠ 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 Table 3-2. on page 3-5.

ODU CONNECTOR

The following section describes the ODU input connector. To determine if your Apex unit has this connector, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
ODU input connector
PIN position13, (A 1 2 3 4 5 6 7 8 9 10 11 12 **13** 14 15 16 17) **option A**. (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 Table 1-1. on page 1-4.

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

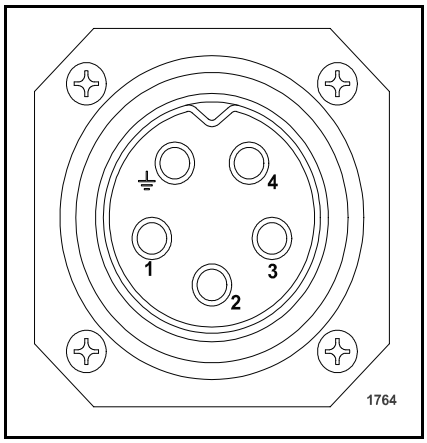


Figure 5-5. *ODU input connector*

Table 5-2 provides pin descriptions for the ODU input connector.

Table 5-2. *ODU Pin Descriptions*

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

NONTERMINATED, FOUR-CONDUCTOR PIGTAIL

The following section describes the nonterminated, four-conductor pigtail input options. To determine if your Apex unit has one of these options, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Nonterminated, four-conductor pigtail input options
PIN position13, (A 1 2 3 4 5 6 7 8 9 10 11 12 **13** 14 15 16 17) **options B and C**
(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 Table 1-1. on page 1-4.

Table 5-3 provides pin descriptions for the nonterminated, four-conductor input options.

Table 5-3. *Nonterminated, Four-Conductor Pin Descriptions*

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

HARTING TYPE HAN-Q CONNECTOR

The following section describes the Harting Type Han-Q input connector. To determine if your Apex unit has this connector, use the configuration PIN from your Apex unit and the following Configuration Note.

Configuration Note

This section of the manual provides information for the:
Harting Type Han-Q input connector
PIN position13, (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 Table 1-1. on page 1-4.

Figure 5-6 shows the Harting Type Han-Q input connector.

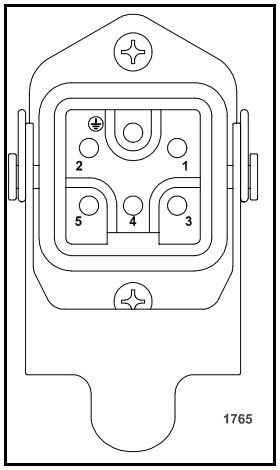


Figure 5-6. *Harting type Han-Q connector*

Table 5-4 provides pin descriptions for the Harting input connector.

Table 5-4. *Harting Type Han-Q Pin Descriptions*

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

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 Table 1-1. on page 1-4 to identify the options installed on the unit. (For more information, see “Using this Manual to Find Information for 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 User Port Options" on page 4-2. Use the generator's PIN and Table 1-1. on page 1-4 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 4-37. Use the generator's PIN and Table 1-1. on page 1-4 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 Table 1-1. on page 1-4.
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).

TO USE THE COMMON EXCITER (CEX) FEATURE (OPTIONAL)

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 units 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 “Other Electrical Specifications” on page 3-9.)

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.

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, the unit has detected an error, and you will not be able to turn RF output on. To troubleshoot an error condition, see Chapter 6, “Troubleshooting and Customer Support.”
4. Verify that the AC ON LED is lit. If it isn’t lit, see “Troubleshooting guide” on page 6-1.

5. Verify that the Alarm LED is *not* lit. If it is lit, see “Troubleshooting guide” on page 6-1.
6. Verify that the Interlock LED is lit. If it is not lit, See “Troubleshooting guide” on page 6-1.
7. Send RF On command and verify that the RF ON LED is on. If it is flashing or is not lit, see “Troubleshooting guide” on page 6-1.
8. Request a setpoint and verify that the Power Limit LED is not lit. If it is lit, see “Troubleshooting guide” on page 6-1.
9. If the Apex unit is delivering power and the power limit LED is not lit, the unit is functioning properly.

NORMAL OPERATION

Each time the generator is powered on, the self-diagnostics procedure is done to ensure the generator is performing correctly. The preceding section, “First Time Operation”, provides detailed instructions that can be used during normal 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.

UNDERSTANDING AND SETTING UP PULSING OUTPUT

As of January 2001, only the AEBus Host Port (PIN 6 option 0) supports pulsing.
Add info about conversion pricing, etc. after unit has been in the field.

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 Table 1-1. on page 1-4.

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 4-37 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 10 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 Table 4-6. on page 4-45). 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.

Troubleshooting and Customer Support

This Chapter addresses the troubleshooting of the Apex unit. It can be used best by knowing what problem you have and then finding the information within each heading item laid out in this chapter. The list of items below will direct you to the section of the chapter in order for quick reference. Here are the following topics covered:

- "Troubleshooting Questions" on page 6-3: This section contains questions that can be easily answered and will guide you through any implications that may be incurred with the Apex generator.
- "Troubleshooting Procedures" on page 6-4: This section explains the procedures needed to get your Apex unit to work while explaining what specific LEDs mean and how they can be handled. The procedure explains what the error means, what can cause the error and how to fix the error.
- "AC On LED not Lit" on page 6-4: This section contains a full list of codes and how they can be solved.
- "AE Customer Support" on page 6-11: This section provides phone numbers and addresses for AE support centers around the world.

TROUBLESHOOTING GUIDE

Before calling AE Customer Support, perform the following steps or procedures. Use this section if you are experiencing any LED issues or operating failures. The guide will help you through the process of getting your Apex unit running.

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

Checks with the Power Off

Before troubleshooting the Apex unit make sure the following are completed:

1. Ensure the power to the unit is off.
2. Check for visible damage to the unit, cables, and connectors.
3. Ensure all unit connectors are installed correctly and are fastened tightly.

4. Check to determine whether any system-related circuit breakers have been tripped.
5. Ensure there is input power to the unit, and ensure the input power meets specifications.
6. Ensure ground connections are adequate and secure.

Troubleshooting Questions

This section lists the steps necessary to get the unit on. Before working through the following questions, check the unit's input and remote power connections to ensure the proper power is being supplied to the unit. If you have a question regarding DeviceNet on the Host port call AE Technical Support.

Note: This section uses status LEDs to verify proper operation. If your unit doesn't have LEDs, refer to the respective I/O status indicators or the Apex Virtual Front Panel for verification,

Use the following troubleshooting questions to troubleshoot the Apex generator.

1. **Is the AC On LED lit?**
   - If *yes*, go to step 2.
   - If *no*, see "AC On LED not Lit" on page 6-4.
2. **Is the Alarm LED lit?**
   - If *yes*, See "Alarm LED Lit" on page 6-4.
   - If *no*, go to step 3.
3. **Is the Overtemp LED flashing?**
   - If *yes*, see "Overtemp LED is Flashing" on page 6-4.
   - If *no,* go to step 4.
4. **Is the Interlock LED lit?**
   - If *yes*, "Interlock LED is not Lit" on page 6-5.
   - If *no*, go to step 5.
5. **Is the RF ON LED flashing?**
   - If *yes*, see "Alarm LED Lit" on page 6-4.
   - If *no*, go to step 6.
6. **Is RF ON LED lit?**
   - If *yes,* go to step 7.
   - If *no,* send RF OFF command.

7. **Is the Power Limit LED lit?**
   - If *yes*, then refer to “Power Limit LED is Lit” on page 6-5.
   - If *no*, your unit is operating properly and delivering the requested power level.
   - If you are still experiencing any issues with the questions you have just gone through, call “AE Customer Support” on page 6-11.

TROUBLESHOOTING PROCEDURES

The following section describes the procedures involved in troubleshooting. Use this section to help you identify what the LEDs described are. If you are looking for a more in depth troubleshooting details, see “Troubleshooting Questions” on page 6-3.

AC On LED not Lit

When the AC On LED is not lit, see Electrical Specifications on page 3-5. There also may be an external line fault. Check input voltage and circuit breaker specifications in “Electrical Specifications” on page 3-5. After correcting, send an RF Off command to reset the unit. If this does not work see “Troubleshooting Questions” on page 6-3.

Alarm LED Lit

When Alarm LED is lit, this means a error has been detected. This is be caused by a fault which creates an error code (Table 6-1. on page 6-7). Call AE Global Support if you have any questions regarding this.

Overtemp LED on Solid

When the Overtemp LED is on solid, the internal cold plate temperature has exceeded the allowable limit. When LED is solid, the output is disabled. The Overtemp and Alarm LEDs latch on until the cold plate temperature falls below the warning temperature level.

To avoid this condition, make sure the unit is receiving proper cooling as outlined in the Coolant Specifications section. See “Cooling Specifications” on page 3-10.

Overtemp LED is Flashing

When flashing, this indicator shows that the internal cold plate temperature is approaching the shutdown limit. This state does not affect RF output.

Take precautions by ensuring that the unit receiving proper cooling as outlined in the Coolant Specifications Section. See Table 3-5. on page 3-10.

Interlock LED is not Lit

When the AC On LED is lit and the Interlock LED is not lit, either the interlock is not satisfied or was interrupted. Both the interlock LED and the RF output will remain off until the interlock is satisfied and an RF off command is given.

To satisfy the interlock, make sure the RF output cover is firmly attached and ensure the interlock pins on the User port are satisfied.

Note: See “Apex User Port Options” on page 4-2 to determine which User port you have. then go to the appropriate User port section and see the pin descriptions table to see how to satisfy the interlock pins. Once the interlock conditions are satisfied, send an RF Off command to reset the generator and LED states.

RF ON LED Flashing

The RF On LED will flash under the following conditions:

- If the RF On LED is flashing right after enabling the AC input, the Apex unit may be in User control mode and receiving an RF On command at the User port. After verifying that the User port and control mode are properly setup for your system, send an RF Off command to reset the unit.
- The RF On LED flashes when the output has been latched off due to a fault or interlock interrupt. After clearing the fault or reestablishing interlock, send an RF Off command to reset the indicators. If this LED is still flashing after resetting, go to “Troubleshooting Questions” on page 6-3 to isolate the error. If the RF On LED stops flashing after resetting, the faults have been cleared. Try normal operation.

Power Limit LED is Lit

When lit, the power limit LED indicates that the generator is unable to supply the requested power setpoint level due to a limiting condition. When an internal protection limit is exceeded, the RF output limited, but not shut off. If this LED is lit along with a high reflected power reading, it is most likely that the generator is protecting itself in response to an external load condition. See “External Load Checks - Open/Short RF Output Path” on page 6-6.

To troubleshoot this error indication, disable the output and rear circuit breaker (if your Apex unit has one). Then 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 trying these tips, contact AE Global Support.

External Load Checks - Open/Short RF Output Path

Use extreme caution as this section is involves troubleshooting the output of the unit.

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

There are 4 basic components that could impede the RF path: the Apex unit output connector, the output cable, the tuner, or the chamber. Follow the steps below.

1. Turn the rear circuit breaker off to ensure that there is no RF power at the output of the unit.
2. For 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. For the output cable
   a. Visually make sure there is a good connection between the output cable and end connectors on both sides of the output cable.
   b. Verify the continuity of the center conductor.
   c. Verify the continuity of the outer shield.
   d. Verify that there is no continuity between the center conductors and outer shields.
   e. Swap cables if possible and retry operating the Apex.
4. For 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. You can also run the unit into a 50Ω dummy load and follow the steps in “Troubleshooting guide” on page 6-1.

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 reflected power limit? See “Electrical Specifications” on page 3-5.

If you answered *yes* to any one of the previous questions and the Apex passed the Internal Diagnostics test, the Apex 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.

ERROR CODES

Error codes indicate a fault condition and report the most recent active error or alarm condition from the Apex unit. You can able to view error codes through a serial communication port such as RS-232. Another way to view error codes is through the Virtual Front Panel which provides an easy way to control an Apex generator through a personal computer. Call AE Global Support for information. The following table explains the specific error code meanings and solutions.

Table 6-1. *Error Code Table*

Error Code	Error Code Description	Solution
E000	No Error	
E001 Out of setpoint 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 setpoint. See “Power Limit LED is Lit” on page 6-5. To clear this error code, you must send an RF OFF command to reset the Apex unit.
E004 Over Temperature Shutdown	This error is the same as when the Overtemp LED is on solid,	See “Overtemp LED on Solid” on page 6-4.

Table 6-1. *Error Code Table (Continued)*

Error Code	Error Code Description	Solution
E009 contactor failed to close	This contactor is part of the input section that follows the interlock condition. The contactor is closed when the interlocks are satisfied and open when an interlock is open. If the interlocks are satisfied and the contactor does not close, this error code is reported.	Call AE Global Support.
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.	Send RF OFF command to reset the error code. If you receive one of these error codes, make sure that input voltage is within specification see “Electrical Specifications” on page 3-5 and send a RF off command to reset the error code.
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.	If you receive one of these error codes, make sure that your input voltage is within specification see “Electrical Specifications” on page 3-5 and send RF OFF command to reset the error code.
E016 Current limit	This usually indicates an internal failure.	Call AE Global Support
E017 EEPROM failure	This verifies that the option called out in PIN position 6 is actually installed.	Call AE Global Support.

Table 6-1. *Error Code Table (Continued)*

Error Code	Error Code Description	Solution
E020 User interlock open	When the AC On LED is lit and the Interlock LED is not lit, this means either the interlock is not satisfied or was interrupted. 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 4-2. or See "Interlock LED is not Lit" on page 6-5.
E025 Target life expired	When the user set target life ends, this error code is reported. The output will not be turned off when the error is reported. However, once the 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 then send RF On command to reset unit.
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 call AE Global Support.
E033 Temperature Rate Threshold error	The Apex unit 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 clear the error, send RF OFF command to reset the unit; 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 "Overtemp LED on Solid" on page 6-4.

Table 6-1. *Error Code Table (Continued)*

Error Code	Error Code Description	Solution
E050 DeviceNet Error	DeviceNet error	Verify DeviceNet cable is connected
E051 Profibus Watch Dog expired	PROFIBUS watch dog expired	Have the master reestablish communications and send a “master reset” to clear the error. See “Profibus Watch Dog Timer” on page 4-61.
E054 Profibus SPC has taken itself off-line	Profibus SPC has taken itself off-line	Cycle the Apex unit’s power off and on and reestablish communications between the master and the slave.
E055 Profibus memory buffer overflow	Profibus memory buffer overflow	Increase the time between packets being sent to the unit via the Profibus master. See “Host Port—Profibus” on page 4-58.
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 4-58.
E101 Measurement PCB ID is incorrect	This indicates a configuration error.	Call AE Global Support.

Table 6-1. *Error Code Table (Continued)*

Error Code	Error Code Description	Solution
E105 User setpoint scale factor does not match	This indicates a configuration error.	Call AE Global Support.
E111 Overtemp warning or shutdown value is out of range	This indicates a configuration error.	Call AE Global Support.

AE CUSTOMER SUPPORT

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

Table 6-2. *Global Support Locations*

Office	Telephone
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA	Phone: 800.446.9167 or 970.221.0108 or 970.221.0156 Fax: 970.407.5981 Email: technical.support@aei.com
AE, Voorhees, NJ 1007 Laurel Oak Road Voorhees, NJ 08043 USA	Phone: 800.275.6971 or 856.627.6100 Fax: 856.627.6159
AE, California 491 Montague Expressway Milpitas, CA 95035 USA	Phone: 408.263.8784 Fax: 408.263.8992
AE, Austin 8900 Cameron Road Suite 100 Austin, TX 78754	Phone: 512.231.4200 Fax: 512.719-9042

Table 6-2. *Global Support Locations (Continued)*

Office	Telephone
AE, GmbH Raiffeisenstrasse 32 70794 Filderstadt (Bonlanden) Germany	Phone: 49.711.77927.0 Fax: 49.711.7778700
AE, Japan KK TOWA Edogawabashi Bldg. 347 Yamabuki-cho Shinjuku-ku, Tokyo Japan	Phone: 81.3.32351511 Fax: 81.3.32353580
AE, Korea Ltd. Gongduk Building, 4th floor 272-6 Seohyun-Dong, Bundang-Gu, Sungam Si Kyunggi, 463-050 Korea	Phone: 82.31.705.1200 Fax: 82.31.705.276
AE, United Kingdom Unit 5, Minton Place, Market Court, Victoria Road Bicester, Oxon OX6 7QB UK	Phone: 44.1869.320022 Fax: 44.1869.325004
AE, Taiwan, Ltd. 10F-6, No. 110, Chung Shan Rd. Sec. 3, Chungho City, Taipei Hsien Taiwan 235	Phone: 886-2-82215599 Fax: 886-2-82215050
AE, China Rm. 910 Anhui Building, No. 6007 Shennan Road, Shenzhen, China 518040	Phone: 86-755-3867986 Fax: 86-755-3867984

RETURNING UNITS FOR REPAIR

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

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

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

WARRANTY

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

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

For a warranty claim to be valid, it must:

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

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

Authorized Returns

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

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

Warranty Statement

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

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