January 2012 57023915-00A

ADVANCED ENERGY®

Cesar® Generator

Water-Cooled

User Manual

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Safety and Product Compliance Guidelines

PRODUCTS DOCUMENTED IN THIS MANUAL

This user manual documents water-cooled Cesar generators.

IMPORTANT SAFETY INFORMATION

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

DANGER, WARNING, AND CAUTION BOXES IN THE MANUAL

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

DANGER:

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

WARNING:

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

CAUTION:

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

SAFETY GUIDELINES

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

Rules for Safe Installation and Operation

Please note the following rules:

- Do not attempt to install or operate this equipment without proper training.
- There are no user-serviceable parts inside the unit. Refer servicing to trained service personnel.
- Ensure that this unit is properly grounded.
- Ensure that all cables are properly connected.
- Verify that input line voltage and current capacity are within specifications before turning on the power supplies.
- Use proper electrostatic discharge (ESD) precautions.
- Always be careful around this equipment.

INTERPRETING PRODUCT LABELS

The following labels may appear on your unit:

1020

CE label

1029

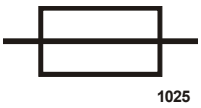
Protective Earth ground

Hazardous voltage

Nonionizing radiation

NRTL: Nationally Recognized Testing Laboratory

Refer to manual for more information



Electrical fuse

PRODUCT COMPLIANCE

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

Product Certification

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

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

- NRTL – Safety certified by CSA International, a Nationally Recognized Testing Laboratory
- CE Marking – Self-declaration, assessed by AE Corporate Compliance
- EMC measurements – Verified by the AE Corporate Compliance Lab and/or an accredited third party lab

Safety and EMC Directives and Standards

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

☞ **Important**

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

☞ **Important**

This equipment must be installed and used in accordance with the Conditions of Use described in this manual. If this equipment is expanded, modified, or installed into a larger system, the user is responsible to guarantee the compliance of the overall system. If this equipment is used with external components, the user must ensure that the Safety and EMC requirements are not violated.

ELECTROMAGNETIC COMPATIBILITY (EMC) DIRECTIVES AND STANDARDS

- **2004/108/EC**

  EC Council directive on the approximation of the laws of the Member States relating to electromagnetic compatibility (EMC Directive)

- **47 CFR Part 18**

  Code of Federal Regulations—Limits and methods of measurement of radio interference characteristics of industrial, scientific, and medical equipment

- **EN 55011**

  Limits and methods of measurement of radio disturbance characteristics of industrial, scientific, medical (ISM) radio frequency equipment (Class A, Group 2) (CISPR 11)

- **EN 61000-6-2**

  Electromagnetic Compatibility (generic immunity standard—industrial)

SAFETY DIRECTIVES AND STANDARDS

- **2006/95/EC**

  EC Council directive on the harmonization of the laws of the Member States relating to electrical equipment designed for use within certain voltage limits (LVD - Low Voltage Directive)

- **EN 61010-1**

  Safety requirements for Electrical Equipment for Measurement, Control, and Laboratory Use - Part 1: General Requirements

Conditions of Use

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

DANGER:

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

- Before making any other connection to this device, connect the auxiliary Protective Earth ground terminal to a local earth ground with a copper wire that is sized according to the applicable requirements.
- 400 V Cesar generators with AC Current ratings above 16 A must be connected to a private low-voltage system interfacing with the public supply only at the medium- or high-voltage level.
- Install and operate this device only in accordance with the listed safety guidelines and all other applicable directives and standards specific to your process and application.
- Install and operate this device in an overvoltage category II or better installation.
- Install and operate this device only in a pollution degree 2 or better environment, which means an indoor location such as a computer room, office, or factory floor where only nonconductive pollution occurs during operation. Occasionally, condensation causes temporary conductivity when the device is not operating.
- To prevent against condensation, install and operate this device with an external water solenoid valve so that water flow is interrupted when the device is not operating.
- Install this device so that it is fully enclosed by a rack or other enclosure. The rack or enclosure must be metal and either reinforced or of sufficient thickness to resist both of the following tests:
  - A steady force of 445 N, applied through a steel hemisphere 12.7 mm in diameter
  - An impact of 7 J, applied by dropping or swinging a 0.53 kg, 50 mm diameter steel sphere
  - Following the tests, there must be still a minimum clearance of 12.7 mm between the rack or enclosure and the power supply. There shall be no deformation of the power supply.
- If this device does not have a circuit breaker, you must install and operate it with a circuit breaker switch on the AC input. The circuit breaker switch must be easily accessible and near the device. The breaker must be marked as the disconnecting device for the equipment.

- You must install and operate this device with a disconnect switch that conforms to the applicable requirements. The switch must be easily accessible and near the device.
- The on/off power switch does not completely disconnect the AC input. You must install an external switch to completely disconnect AC input.
- The AC line cord must be terminated according to the applicable requirements.
- Use only shielded cables on the serial and user communications interfaces.
- Install this device so that the input power connection is inaccessible to the user.
- Install this device so that the output power connection is inaccessible to the user.

INTERLOCKS AND LIMITING CONDITIONS

⚠ WARNING:

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

All Cesar generators have an **Interlock** interface. This interface allows you to integrate any Cesar generator into a system interlock loop that can interrupt the delivered RF power.

Even if you do not connect this Cesar generator into a larger system interlock loop, you must make the proper interlock loop connections for the unit to enable RF power.

The Cesar generator may be shipped with an interlock jumper plug that provides a connection between the **User Port** interlock pins. You can use this jumper plug to satisfy the interlock and enable operation in situations where you do not intend to connect the remaining pins on this port.

☞ **Important**

Using the interlock jumper plug disables the interlock function.

☞ **Important**

Interlock does not switch the generator on/off. If an interlock is not satisfied, the Cesar generator will issue an interlock error. Interlock errors must be resolved, so you must switch RF off (via the RS-232 or **User Port**) or resolve the error (via the front panel) before you can switch on RF power again.

In addition, the Cesar generator includes specific limits that are described in Table 1-1. The errors generated by exceeding these limits are described in "Troubleshooting Using Error Codes" on page 6-6.

Table 1-1. Cesar limiting conditions

Limit	Unit Response and User Resolution
RF power limit	When the unit reaches the forward or reflected power limit, the unit reduces forward power to remain within the limits. Output is not at set point.
Overtemperature	When the unit exceeds the specified maximum temperature, RF power shuts off, and the unit displays an error code.
Current limit	When the voltage or the current exceeds the limit of the internal SMPS, the unit reduces output to remain within the limits. Output is not at set point.
External pulse frequency limit	When the external pulse frequency exceeds the limit, the unit turns RF power off.
Target lifetime limit	The target lifetime warning occurs when the target lifetime reaches the user-set limit. This warning does not affect the operation of the unit.

Product Overview

GENERAL DESCRIPTION

AE Cesar RF power generators are Class E Switched Mode Amplifiers for Radio Frequency (CESAR), a new generation of versatile RF power supplies for semiconductor production, and general plasma processing. This generator employs parallel excited circuitry in a compact, 19″ rack-mountable designs. Typical applications include sputtering, reactive ion etching, RF bias, plasma polymerization, plasma surface treatment, and CO_2 laser systems.

The Cesar generator incorporates advanced switch mode technology. This highly efficient, resonant switching concept results in reduced energy costs, reduced downtimes, and a longer lifetime for the unit.

Designed to regulate power into a broad range of output impedances, the Cesar generator can operate in forward power, real power, or DC bias regulation mode In addition, you can add a cable attenuation variable to the power regulation setting.

Both manual and automatic tuning control support operation into a fixed impedance matching network, which simplifies system complexity, increases reliability, and improves process-to-process repeatability.

You can control and configure the Cesar generator using any of the following methods:

- Remotely through an analog **User Port**.
- Remotely through a communication host port.
- Using the front panel, which features a liquid crystal display (LCD) with an easy-to-use menu.

The Cesar generator operates from an AC power source. The unit can tolerate arbitrary phase rotation of the input power connections. The generator is water-cooled and has all power, interface-port, and water connections at the rear of the generator.

THEORY OF OPERATION

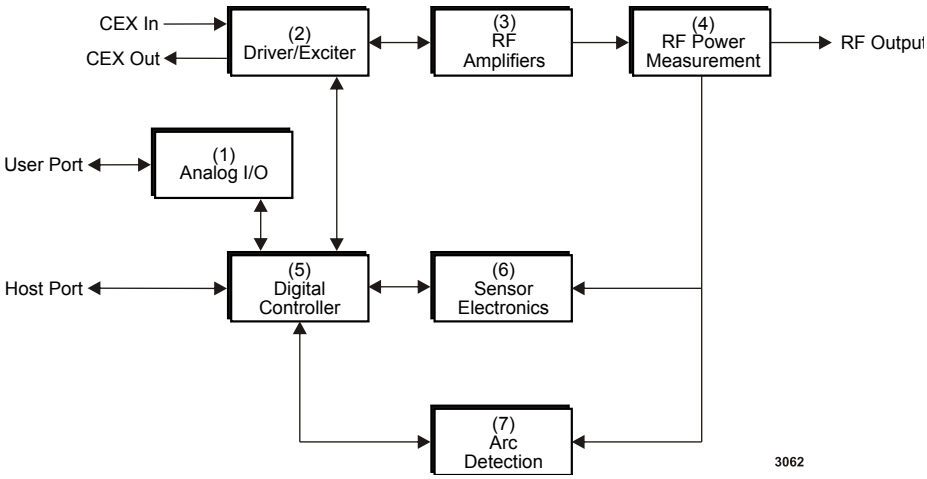


Figure 2-1. Cesar block diagram

Module	Description
(1) Analog I/O	This module provides the **User** interface.
(2) Driver/Exciter	This module generates power at the designated output frequency to drive the main RF sections and contains the CEX functions.
(3) RF Amplifiers	This module generates RF power.
(4) RF Power Measurement	This module samples the output signal and sends it to the sensor electronics.
(5) Digital Controller	This module is the main processor and data acquisition section. It also provides host communications through a host port.
(6) Sensor Electronics	This module detects RF samples and sends them to the microprocessor.
(7) Arc Detection	The arc handling system is responsible for detecting and handling arcs. Detection is based on reflected power. Suppression is done by turning RF off for a period of time.

Specifications

PHYSICAL SPECIFICATIONS

Table 3-1. Physical specifications

Description	Specification
General physical specifications	
Size	132.5 ± 0.5 mm (H) x 483 mm (W) x 551 mm (D) 5.2″ (H) x 19″ (W) x 21.6″ (D) Dimensions include front panel mounting extensions. Dimensions do not include RF output or other connectors.
Weight	32.5 kg (72 lb)
Mounting	
Clearance	6 cm (2.36″) required on each side for airflow; 10.16 cm (4″) required at rear for cable connections
Mounting	19″ rack-mounting holes are provided on the generator front panel.
Connectors	
AC input power	Open mains cable
RF output	7/16 Type, female connector
User port connection (Analog I/O)	There are two analog interface options available for the Cesar generator: • 25-pin subminiature-D male • 15-pin subminiature-D male
Host port connection (serial I/O)	The Cesar generator has three host port communication interface options: • An **RS-232** 9-pin, female, shielded, subminiature-D connector • A **PROFIBUS** 9-pin, female, subminiature-D connector • An **Ethernet** Modbus/TCP connection
Arc detection monitor	9-pin connector This connector is included only if your unit has the arc detection feature.

Table 3-1. Physical specifications (Continued)

Description	Specification
CEX	CEX BNC, female
Coolant connectors	Stainless steel hose connector, including sleeve nut for plastic hoses of a 10 mm outer diameter and an 8 mm inner diameter If your unit uses the Rectus water connectors: 1/4″ quick connect stainless steel connectors: • Water Out: RECTUS, Series 86, G1/4, Plug • Water In: RECTUS, Series 86, G1/4, Coupling
Front panel display	LCD graphic display

ELECTRICAL SPECIFICATIONS

Table 3-2. Electrical specifications

Description	Specification
Electrical requirements	
AC input voltage	See **AC Voltage** on your unit's product label. One of the following: • 200 V (180 VAC to 220 VAC), 3 φ, with ground (PE) Maximum phase to ground/Cesar chassis voltage: 115 V ±10%. • 400 V (360 VAC to 440 VAC), 3 φ, with ground (PE) Maximum phase to ground/Cesar chassis voltage: 230 V ±10%. wye connection only
AC line frequency	50 Hz to 60 Hz
AC input current	See the product label on your unit for the **AC Current** 3 x your unit’s line current at nominal line voltage at full power

Table 3-2. Electrical specifications (Continued)

<table>
<tr><th>Description</th><th>Specification</th></tr>
<tr><td>Input power</td><td>Varies by model:
<table>
<tr><th>Input power</th><th>Model number</th><th>AC input current per phase</th></tr>
<tr><td>4300 VA</td><td>200 V models: 0220, 0420, 1320, 2720, 4020</td><td>16 A</td></tr>
<tr><td>4750 VA</td><td>400V models: 0220, 0420, 1320</td><td>8 A</td></tr>
<tr><td>4825 VA</td><td>400 V models: 2720, 4020</td><td>8 A</td></tr>
<tr><td rowspan="2">5400 VA</td><td>200 V models: 0225, 0425, 1325</td><td>20 A</td></tr>
<tr><td>400 V models: 0225, 0425, 1325</td><td>13 A</td></tr>
<tr><td>6150 VA</td><td>200 V models: 0230, 0430, 1330</td><td>20 A</td></tr>
<tr><td>6230 VA</td><td>400 V models: 0230, 0430, 1330</td><td>13 A</td></tr>
<tr><td>7370 VA</td><td>200 V models: 2730</td><td>26 A</td></tr>
<tr><td>8000 VA</td><td>200 V models: 2740, 4040</td><td>35 A</td></tr>
<tr><td>8775 VA</td><td>400 V models: 2740, 4040</td><td>20 A</td></tr>
<tr><td>9800 VA</td><td>200 V models: 0250, 0450, 1350</td><td>35 A</td></tr>
<tr><td>10,900 VA</td><td>400 V models: 0250, 0450, 1350</td><td>20 A</td></tr>
</table></td></tr>
<tr><td>Power factor</td><td>60% at full rated power and nominal line into 50 Ω load</td></tr>
<tr><td>Overcurrent protection</td><td>• 200 V units: User must provide circuit breaker 3-phase 40 A circuit breaker with "C" characteristic recommended (for example: Siemens 5SX4340-7) because of inrush current
• 400 V units: User must provide circuit breaker 3-phase 25 A circuit breaker with "C" characteristic recommended (for example: Siemens 5SX4325-7) because of inrush current</td></tr>
</table>

Table 3-2. Electrical specifications (Continued)

Description	Specification
Efficiency (line to load)	65%, typical at full-rated power nominal line, into a 50 Ω load, for all models except the following: • 63%: ◦ 200 V models: 2720, 2730, 2740 ◦ 400 V models: 2720, 2740 • 58%: ◦ 200 V models: 4020, 4040 ◦ 400 V models: 4020, 4040
Power specifications	
RF Frequency	See your unit's product label for the **RF Frequency**. Frequency accuracy is ± 0.005%
Minimum output power	1% of your unit's maximum output power, with the following exceptions: • 30 W for model 1350 200 V • 50 W for model 2730 200 V, model 2740 200 V, and model 2740 400 V • 50 W for model 4040 200 V and 4040 400 V The Cesar generator can operate below this level, but accuracy is not guaranteed.
Maximum output power	See your unit's product label for the **RF Power**.
Delivered power into mismatch	Varies by frequency (see your unit's label for **RF Frequency**): • 2000 W, 3000 W, 4000 W, 5000 W: 20% of nominal power • 2500 W: 16% of nominal power
Maximum reflected power	Varies by frequency (see your unit's label for **RF Frequency**): • 2000 W, 2500 W units: 400 W maximum reflected power • 3000 W units: 600 W maximum reflected power • 4000 W units: 800 W maximum reflected power • 5000 W units: 1 kW maximum reflected power
Load impedance	50 Ω
Maximum RF output voltage	See your unit's product label for the **Maximum RF Output Voltage**.

Table 3-2. Electrical specifications (Continued)

Description	Specification
Harmonics	At full rated output, all harmonics are 45 dB below the RF output signal when operated into a 50 Ω, nonreactive load impedance. All spurious (nonharmonic) outputs are 60 dB below the RF output signal.
RF Power Regulation	1.0% of set point or 0.1% of full rated power, whichever is greater
RF Power Stability	1.0% of set point or 0.2% of full rated power, whichever is greater
RF Pulse frequency	• 1 Hz to 10 kHz for units with RF Frequency of 2 MHz through 4 MHz • 1 Hz to 30 kHz for units with RF Frequency of 13.56 MHz through 60.0 MHz
RF Pulse Duty Cycle	1% to 99%
Arc Handling specifications	
Arc Response Time (t_{ar})	1 µs < t_{ar} < 5 µs Measured from the first viable indication of an arc using an external coupler to measure forward and reflected power until RF is turned off.
Arc Suppression Time	5 µs to 500 µs 0 = disabled
Arc Initial RF-On Delay: Time from RF ON to Arc Suppression Enabled	10 ms to 5000 ms
Arc Set Point Delay: Time from > 10 W set point change to Arc Suppression Enabled	10 ms to 5000 ms
Arc Suppression Attempts	0 to 100 attempts 0 = infinite attempts
CEX Specifications	
CEX input signal	• TTL or Sine; 0 to +10 dBm, 50 Ω for the following models: ◦ 200 V models: 2730, 2740, 4040 ◦ 400 V models: 2740, 4040 • TTL for all others

Table 3-2. Electrical specifications (Continued)

Description	Specification
CEX output signal	• Sine; 7 dBm ± 3 3dB, 50 Ω for the following models: ◦ 200 V models: 2730, 2740, 4040 ◦ 400 V models: 2740, 4040 • TTL for all others

COOLING SPECIFICATIONS

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

Table 3-3. Cooling specifications

Description	Specification
Cooling medium	Air and water
Minimum air flow	118 m^3/h (69.45 cfm)
Cooling water temperature	15°C to 30°C (59°F to 86°F)
Water flow rate (minimum)	7 lpm (1.9 gpm)
Pressure	
Minimum pressure differential (supply to drain) required to achieve specified minimum flow rates	2.5 bar (37 psi)
Maximum pressure rating	8 bar (116 psi)

Table 3-3. Cooling specifications (Continued)

Description	Specification
Contaminates	AE recommends the following specifications for the water used to cool the Cesar 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 < 250 ppm • specific resistivity of 2500 Ω-cm or higher at 25ºC (77ºF) • total dissolved solids (TDS) as estimated by the following: TDS ≤640,000/specific resistivity (in Ω-cm)

ENVIRONMENTAL SPECIFICATIONS

Table 3-4. Environmental standard specifications

Description	Specification
Overvoltage	Category II
Pollution degree	2

Table 3-5. Climatic specifications

	Temperature	Relative Humidity	Air Pressure
Operating	5°C to +35°C +41°F to +95°F	5% to 85%[note 1] +1 g/m^3 to +25 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562′ to -1640′)
Storage	-25°C to +55°C -13°F to +131°F	5% to 95% +1 g/m^3 to +29 g/m^3	78.8 kPa to 106 kPa 788 mbar to 1060 mbar Equivalent altitude: 2000 m to -500 m (6562′ to -1640′)

Table 3-5. Climatic specifications (Continued)

	Temperature	Relative Humidity	Air Pressure
Transportation	-25°C to +70°C -13°F to +158°F	95%[note 2] +60 g/m^3 [note 3]	65.6 kPa to 106 kPa 656 mbar to 1060 mbar Equivalent altitude: 3500 m to -500 m (11480′ to -1640′)

[note 1] Non-condensing, no formation of ice

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

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

Communication Controls

DIAGNOSTIC INTERFACE

Each Cesar generator has a **Diagnostic** interface for use only at authorized service centers. Technicians can check internal commands, calibrate the unit, or flash software using this interface.

ARC DET. MONITOR INTERFACE

The Cesar generator may have an **Arc Det. Monitor** connector, which you can use to connect to an oscilloscope to help determine how to set the arc detection and suppression parameters. When you connect the generator to an oscilloscope via this connector, the generator sends the values to the oscilloscope to help you visualize where the arc suppression parameters are set relative to reflected power.

The arc detection monitor function is intended only for diagnostic purposes. This function should not be used during normal operation.

Related Links

- "The Arc Handling System" on page 5-49

Arc Det. Monitor Connector

The **Arc Det. Monitor** port uses a 9-pin connector.

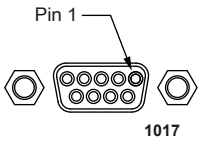


*Figure 4-1. **Arc Det. Monitor** interface connector*

Arc Det. Monitor Pin Descriptions

Table 4-1. Arc Det. Monitor pin descriptions

Pin	Return pin	Name	Description
1	6 through 9	*FORWARD POWER MONITOR*	Forward power measured at the back of the generator. The measured voltage is proportional to the actual forward power.
2	6 through 9	*REFLECTED POWER MONITOR*	Reflected power measured at the back of the generator. The measured voltage is proportional to the actual reflected power.
3	6 through 9	*UPPER LIMIT*	Upper limit set for arc detection, set either via the front panel or the RS-232.
4	6 through 9	*LOWER LIMIT*	Lower limit set for arc detection, set either via the front panel or the RS-232.
5	6 through 9	*ARC DETECTION*	Digital signal: Low (0 V) if reflected power is within the specified limits; high (5 V) if reflected power goes outside the specified limits.
6 through 9		*GROUND*	DC ground connection common to chassis ground.

MATCHING INTERFACE

Each Cesar generator provides a **Matching** interface that allows full communication between the Cesar generator and a VarioMatch or Navio matching network (or other electrically and functionally compatible matching network).

☞ **Important**
This interface will not work with other matching networks unless they are electrically and functionally compatible.

Matching Interface Connector

The **Matching** interface is a 15-pin, subminiature-D, female connector

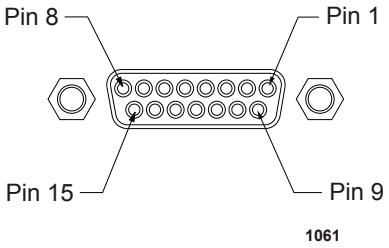


*Figure 4-2. **Matching** interface connector*

Matching Interface Pin Descriptions

*Table 4-2. **Matching** interface pin descriptions*

Pin	Name	Signal type	Level	Description
1	*GROUND*			Connect to the shield of the cable (for example, RC cable).
2	*DECREASE* C_{Load}	Digital Output	Open collector 30 V capable	The output is connected to ground to turn the Load motor counter clockwise.
3	*INCREASE* C_{Load}	Digital Output	Open collector 30 V capable	The output is connected to ground to turn the Load motor clockwise.
4	*DECREASE* C_{Tune}	Digital Output	Open collector 30 V capable	The output is connected to ground to turn the Tune motor counter clockwise.
5	*INCREASE* C_{Tune}	Digital Output	Open collector 30 V capable	The output is connected to ground to turn the Tune motor clockwise.
6	*MEASURE GROUND*			Reference ground for the measurement of analog signals at pins 12 to 14.
7	*NO CONNECTION*			
8	*MANUAL TUNE*	Digital Output	Open collector 30 V capable	To set the VarioMatch or Navio matching network to manual tune control, connect this pin to ground. To set the VarioMatch or Navio matching network to automatic tune control, leave this pin unconnected.

Table 4-2. Matching interface pin descriptions (Continued)

Pin	Name	Signal type	Level	Description
9	*CASE GROUND*			Connect to the shield of the cable.
10	*NO CONNECTION*			
11	*STATUS*	Digital Input	+15 V	This pin connects the +15 V output voltage of the VarioMatch or Navio matching network to indicate if a match network is connected.
12	*DC BIAS MEASURE VOLTAGE*	Analog Input	0 V to 10 V	This pin reads a test voltage of the DC self bias voltage. The scaling is adjustable. For example, in the default configuration of the VarioMatch or Navio matching network, 4000 V bias voltage is equal to 10 V test voltage and is displayed on the front panel as 4000.
13	*POSITION OF TUNE CAPACITOR*	Analog Input	0 V to 10 V	The voltage at this input is proportional to the position of the Tune capacitor. A 10 V reading at this pin is equal to 100% on the front panel display.
14	*POSITION OF LOAD CAPACITOR*	Analog Input	0 V to 10 V	The voltage at this input is proportional to the position of the Load capacitor. A 10 V reading at this pin is equal to 100% on the front panel display.
15	*MATCH IS ACTIVE*	Digital Input	Pull up to 5 V	This input is switched to ground when the VarioMatch or Navio matching network is active (motors are running) and it floats when the matching procedure is complete.

USER PORT

The **User Port** on the Cesar generator provides analog and digital signals for controlling and monitoring the unit.

There are two **User Port** options available for the Cesar generator:

- A 25-pin **User Port**
- A 15-pin **User Port**

This section describes both **User Port** connectors, the minimal connections required to operate the unit, cabling requirements, and detailed information about the **User Port** signals.

Related Links

- "25-Pin User Port" on page 4-5
- "15-Pin User Port" on page 4-17

25-Pin User Port

USER PORT CONNECTOR

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

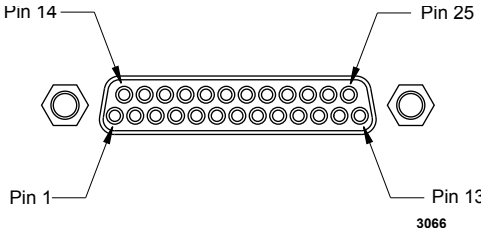


*Figure 4-3. **User Port** connector, 25 Pin*

SATISFYING MINIMAL REQUIREMENTS FOR THE 25-PIN USER PORT

If you do not use the **User Port** to control or monitor the Cesar generator, you still must satisfy the **User Port** *INTERLOCK LOOP* signal to operate the generator.

WARNING:

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

The Cesar generator may be shipped with an interlock jumper plug that provides a connection between the interlock pins. You can use this jumper plug to satisfy the interlock and enable operation in situations where you do not intend to connect the remaining pins on this port.

Using the interlock jumper plug disables the interlock function.

Interlock does not switch the generator on/off. If an interlock is not satisfied, the Cesar generator will issue an interlock error. Interlock errors must be resolved, so you must switch RF off (via the **User Port** or host port) or resolve the error (via the front panel) before you can switch on RF power again.

If you will be using the **User Port**, see pins 10 and 23 in the pin descriptions.

When the interlock is opened and then closed again, you must resolve the interlock error before using the generator again. To resolve the error with the **User Port**, you must switch RF power from on to off. For this reason, never physically connect the *RF POWER ON* pin with *INTERLOCK*. If you do so you many not be able to switch on the generator.

25-PIN USER PORT CABLING REQUIREMENTS

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

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

ACTIVATING THE 25-PIN USER PORT

The Cesar generator can run in front panel control mode, **User Port** remote control mode, or host port remote control mode. You can activate the **User Port** remote control mode using either of the following methods:

- The front panel

- Host port command 14

If **User Port** remote control is activated, it remains active even if the generator is switched off and on. You can deactivate **User Port** remote control via either the front panel or host port command **14**.

WARNING:

RISK OF DEATH OR BODILY INJURY. The Cesar unit will deliver RF power immediately at system power up when all of the following conditions are met: User port is activated; pin 4 (*RF POWER ON*) is activated; and pin 10 (*INTERLOCK LOOP*) is activated.

RESOLVING ERROR DISPLAYS WHEN USING THE 25-PIN USER PORT

If the Cesar generator encounters an error while being operated via the **User Port**, the generator displays the error message on the front panel display and turns off RF power. The Cesar generator continues to show the error message on the front panel until both of the following conditions are met:

- The error condition is gone
- The RF on signal is deactivated

Once the above two conditions are met, the error message is deleted and the Cesar generator shows the normal display.

25-PIN USER PORT PIN DESCRIPTIONS AND WIRING DIAGRAMS

User Port Signal Specifications

Table 4-3. User Port Signal Specifications

Signal Type	Description
Analog Inputs	By default, the **User Port** set point and DC bias input signals (pins 5 and 7) are scaled 0 V to 10 V (physically limited to 10 V). These signals are scalable from 0 V to 2 V up to 0 V to 20 V (physically limited to 10 V) in increments of 0.5 V. You can set the scaling through the **RS-232** port or the **PROFIBUS** port (host port command **30**) or through the front panel menu commands. ☞ **Important** Using lower input voltages decreases resolution. ☞ **Important** Use a range of 0 V to 20 V only for special purposes such as cable attenuation.
Analog Outputs	By default, the **User Port** analog output signals (pins 2 and 3) are scaled 0 V to 10 V (physically limited to 10 V). These signals are scalable from 0 V to 2 V up to 0 V to 20 V (physically limited to 10 V) in increments of 0.5 V. You can set the scaling through the **RS-232** port or the **PROFIBUS** port (host port command **30**) or through the front panel menu commands. ☞ **Important** Using lower input voltages decreases resolution. ☞ **Important** Use a range of 0 V to 20 V only for special purposes such as cable attenuation. These signals are driven by operational amplifiers capable of driving high-capacitance loads such as those expected in shielded interface applications. The user's receiver must present a 10 kΩ (or higher) impedance to these signals. The readback signals represent the forward and reflected power as measured at the output of the generator.
Digital Inputs	Pins 4, 6, 8, and 10 are opto-coupled. The user's signal drives the LED in the opto-coupler through a 4.7 kΩ resistor. A signal level of 4 V to 30 V applied to the input pin activates the signal.
Digital Outputs	The status signals provided by the generator (pins 12, 14, 22, and 24) are opto-coupled with NPN transistor outputs. The collector and emitter of each transistor are provided to the user interface. Each transistor can provide a maximum of 8 mA of collector current and may be operated with a collector-to-emitter voltage of up to 30 V.
Pulse Input	The pulse input (pin 25) is a high-speed opto-coupled input. The user's signal drives the LED in the opto-coupler through a 1.2 kΩ resistor. A signal level of 0 V to 1 V corresponds to low and 4 V to 20 V corresponds to high.

*Table 4-3. **User Port** Signal Specifications (Continued)*

Signal Type	Description
Interlock	The interlock signal (pins 10 and 23) enables the RF power generation. Pin 10 is tied to the generator's +15 V supply. Connecting pin 10 to pin 23 closes the loop, enabling RF power.

User Port Pin Descriptions

This table provides the connector pin descriptions for the 25-pin **User Port**.

*Table 4-4. 25-Pin **User Port** Pin Descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1		Return for pin 14		See pin 14
2	15	*REFLECTED POWER MONITOR*	Analog output	This signal provides a linearly scaled read back of reflected power as measured at the generator output. The default range is 0 V to 10 V, but you can change this range. Default setting: 0 V to 10 V = 0 W to maximum rated power output Pin 15 must be grounded.
3	16	*FORWARD/ LOAD POWER MONITOR*	Analog output	This signal provides a linearly scaled read back of forward power or real power (sometimes called load power) as measured at the generator output. To change control settings, see pin 8. The default range is 0 V to 10 V, but you can change this range. Default setting: 0 V to 10 V = 0 W to maximum rated power output. Pin 16 must be grounded.
4	17	*RF POWER ON*	Digital input	This signal enables or disables RF output. To enable RF output, apply a positive voltage of 4 V to 30 V to this pin. To disable RF output, apply a voltage of 1.5 V or less to this pin ☞ **Important** The interlocks must be satisfied and the setpoint must be within the output power range before unit will deliver power. Pin 17 must be grounded.

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

Signal Pin	Return Pin	Name	Signal Type	Description
5	18	*SET POINT*	Analog input	This signal sets the RF output set point. Depending on the regulation mode, the set point refers to forward power, real power, or DC Bias regulation. The default range is 0 V to 10 V, but you can change this range. A 0 V to 10 V signal applied to this pin linearly controls the set point of the generator. Default setting: 0 V to 10 V = 0 W to maximum rated power output For DC bias regulation, the scaling of the set point must be the same as for the DC bias signal (see pin 7).
6	19	*RF FORWARD POWER/ DC BIAS REGULATION*	Digital input	Use this signal to select DC bias or forward power regulation mode. To regulate on DC bias input, apply a positive voltage of 4 V to 30 V to this pin. To regulate on forward or real power, apply a voltage of 1.5 V or less or an open connection. See pin 8 for switching between forward and real power regulation.
7	20	*DC BIAS INPUT*	Analog input	This input signal is used for DC bias regulation, where the set point is given by pin 5 (scaling must be the same). The signal closes the control loop around external components in the RF path. The default range is 0 V to 10 V, but you can change this range. Default setting: 0 V to 10 V = 0 V to 4000 V Typically, matching networks provide a DC bias voltage monitor signal. When this scaled representation of the DC bias voltage is used for DC bias regulation (see pin 6), the scaling must be the same as for the set point (see pin 5). VarioMatch and Navio matching networks provide a DC bias voltage monitor signal for regulation through the **Matching** interface.

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

Signal Pin	Return Pin	Name	Signal Type	Description
8	21	*RF FORWARD/ LOAD POWER REGULATION*	Digital input	Use this signal to select between RF forward power or real power (sometimes called load power) regulation. Apply a positive DC voltage between 4 V and 30 V to regulate on real power. An open connection to pin 8 or a DC input voltage of less than 1.5 V causes forward power regulation. Real power is defined as forward power minus reflected power. Pin 6 also changes the regulation mode.
9		Return for pin 22		See pin 22.
10	23	*INTERLOCK LOOP*	Digital input	To satisfy the interlock and enable RF power in the generator, close an external loop from pin 23 to pin 10. A resistance of 15 Ω or less across this pin closes the loop. Pin 23 feeds this loop via a current limiting circuit (maximum 120 mA). Alternatively, you can satisfy the interlock by applying a voltage of +4 V to +30 V (referenced to ground) to pin 10.
11		Return for pin 24		See pin 24.
12		*RESERVED*		
13	21	*+15 VDC SUPPLY*	Supply	A nominal +15 VDC output referenced to chassis ground, auxiliary supply for external use (50 mA maximum); no internal limit.
14	1	*SET POINT STATUS*	Digital output	When the generator is out of set point, a low (opto-coupler output) impedance is created between this pin and pin 1 (8 mA maximum).
15		Return for pin 2		See pin 2. Pin 15 must be grounded at the host.
16		Return for pin 3		See pin 3. Pin 16 must be grounded at the host.
17		Return for pin 4		See pin 4.
18		Return for pin 5		See pin 5.
19	N/A	*DC GROUND*	Chassis ground	DC ground connection common to chassis ground.

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

Signal Pin	Return Pin	Name	Signal Type	Description
20		Return for pin 7		See pin 7.
21	N/A	*CHASSIS GROUND*	Chassis ground	DC ground connection common to chassis ground.
22	9	*OVERTEMP*	Digital output	When an internal overtemperature shutdown condition is detected, a low (opto-coupler output) impedance is created between this pin and pin 9 (8 mA maximum). The overtemperature condition can occur in the RF driver, SMPS, or final amplifier.
23	10	Return for pin 10		See pin 10.
24	11	*INTERLOCK SATISFIED*	Digital output	When the interlock is satisfied, a low (opto-coupler output) impedance is created between this pin and return pin 11 (8 mA maximum).
25	19	*BLANKING/ PULSING*	Pulse input	When the unit is set for external pulsing, this pin allows you to pulse (blank) the RF power. Set the required logic for RF on and off through the front panel menu. When the unit is set for internal pulsing, this pin allows you to switch between internal pulsing and continuous wave operation. Select the appropriate function and signal level in the **Pulse Settings** selection in the front panel menu.

Wiring Diagrams for the 25-Pin User Port

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

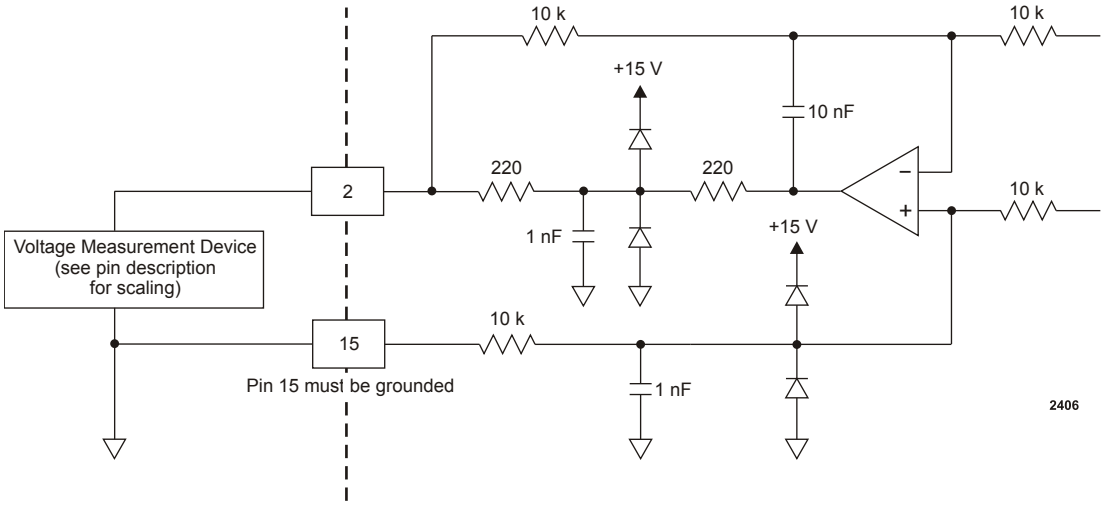


Figure 4-4. REFLECTED POWER MONITOR (pins 2 and 15)

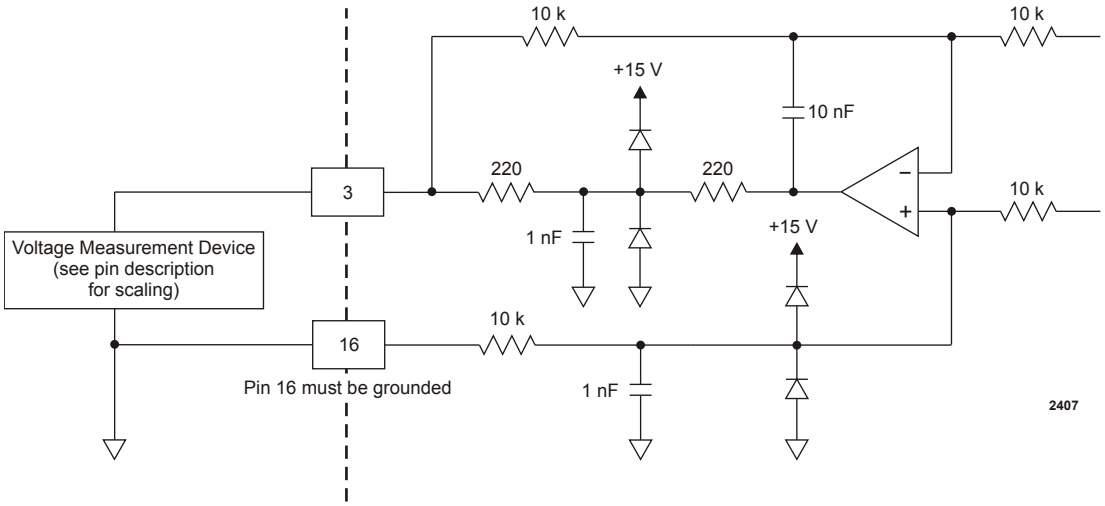


Figure 4-5. FORWARD/LOAD POWER MONITOR (pins 3 and 16)

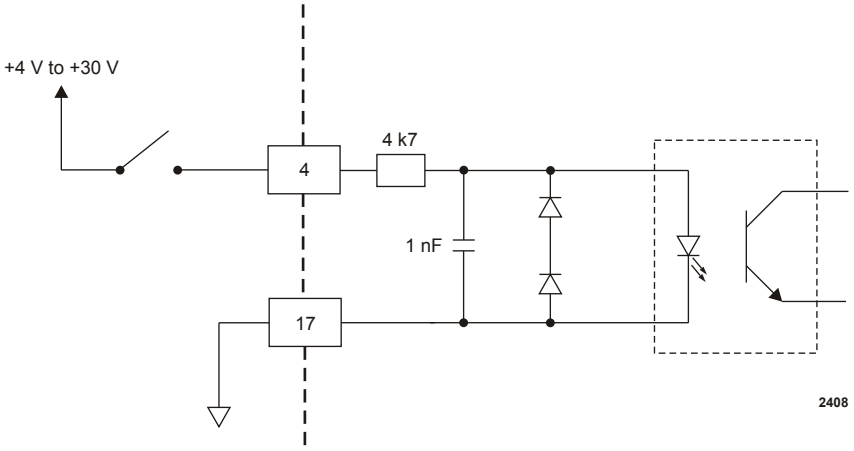


Figure 4-6. RF POWER ON signal wiring (pins 4 and 17)

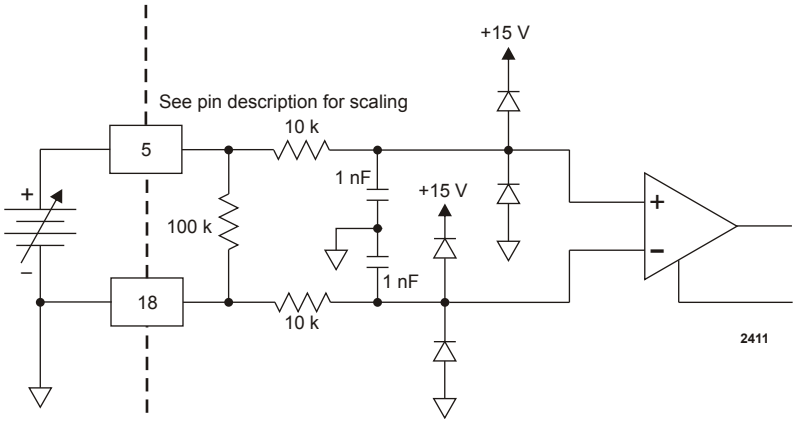


Figure 4-7. SET POINT signal wiring (pins 5 and 18)

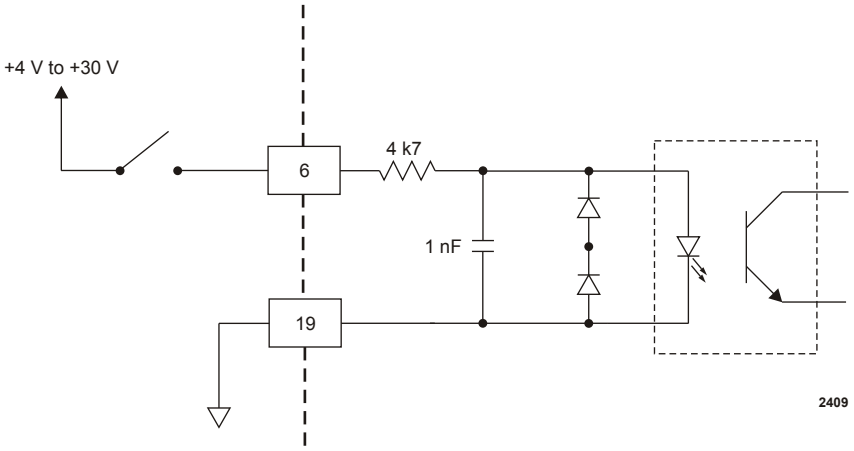


Figure 4-8. RF FORWARD POWER/DC BIAS REGULATION wiring (pins 6 and 19)

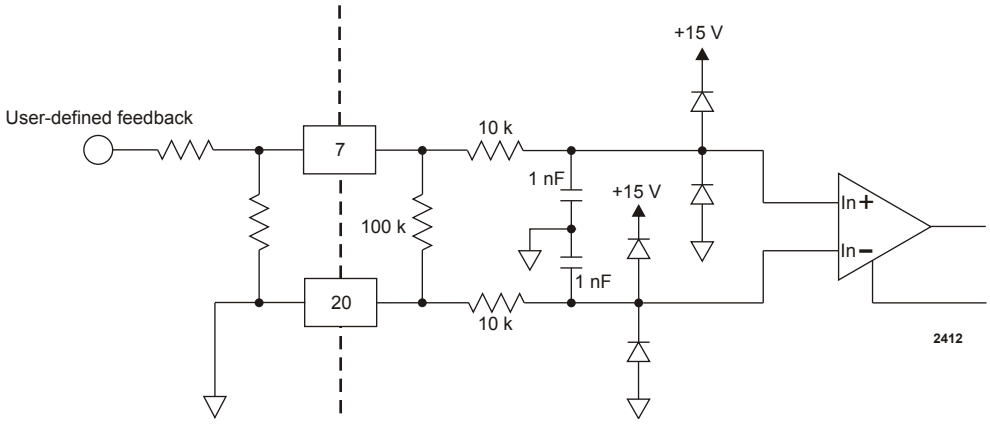


Figure 4-9. DC BIAS MONITOR signal wiring (pins 7 and 20)

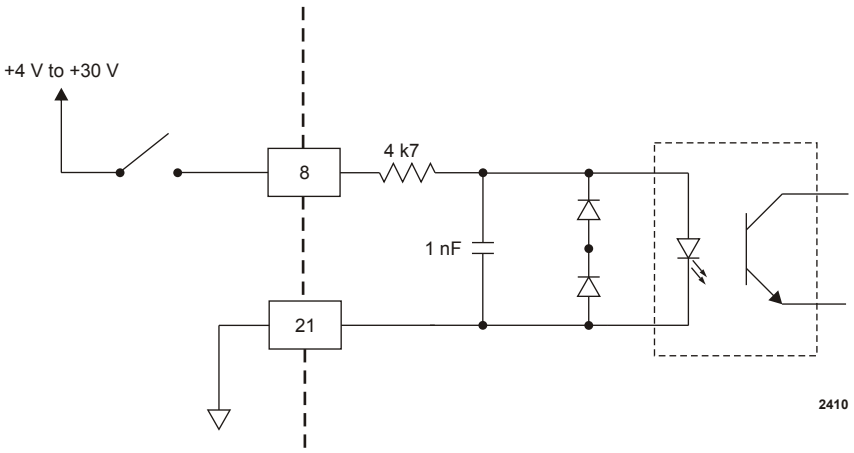


Figure 4-10. RF FORWARD/LOAD REGULATION signal wiring (pins 8 and 21)

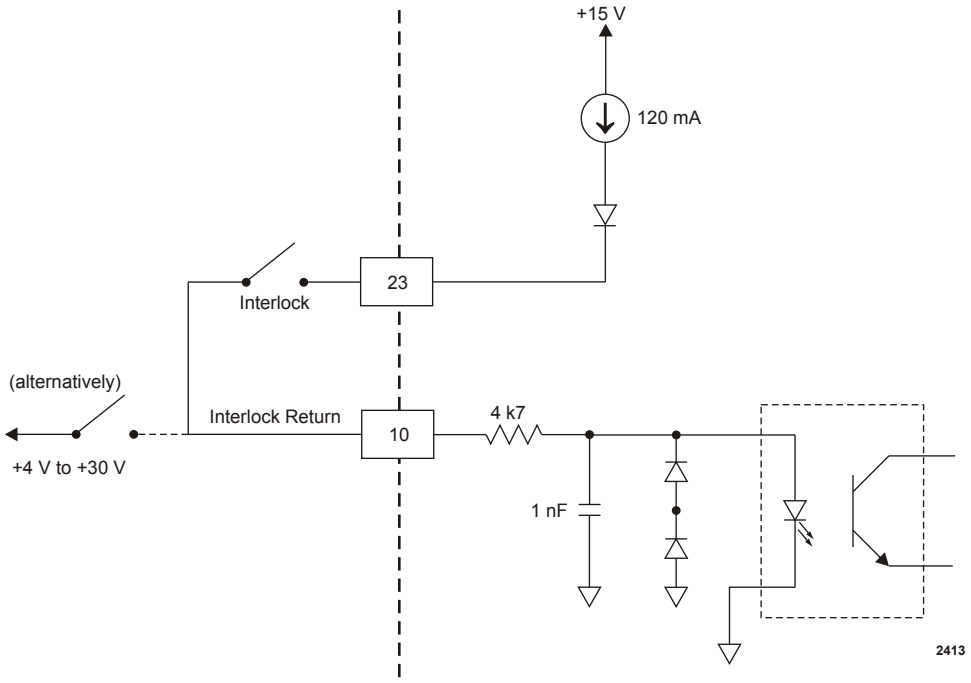


Figure 4-11. INTERLOCK LOOP signal wiring (pins 10 and 23)

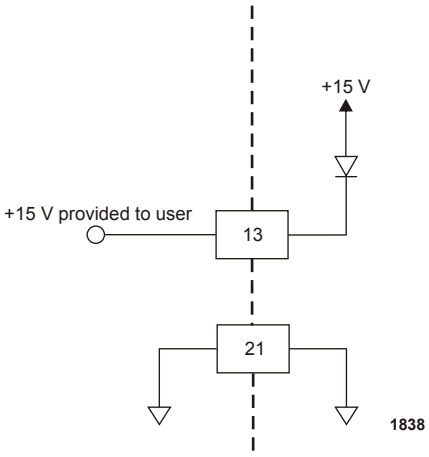


Figure 4-12. +15 VOLT DC signal wiring (pins 13 and 21)

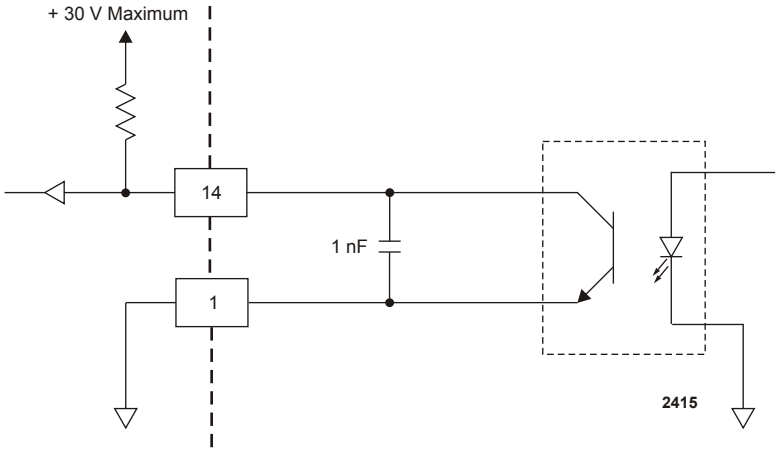


Figure 4-13. SET POINT STATUS signal wiring (pins 14 and 1)

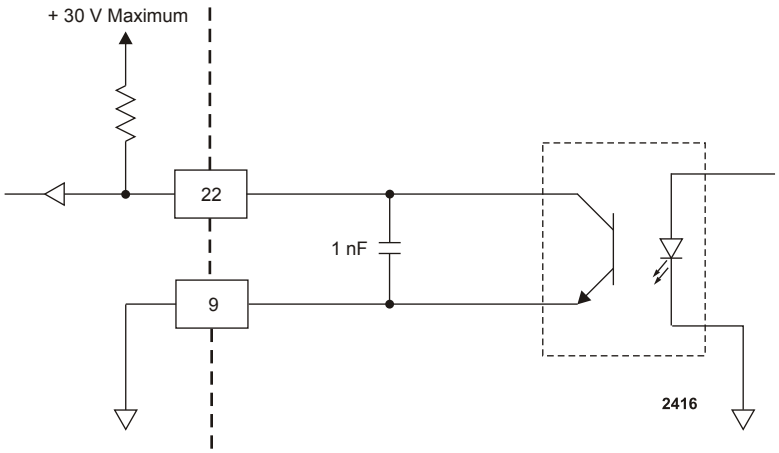


Figure 4-14. OVERTEMPERATURE signal wiring (pins 22 and 9)

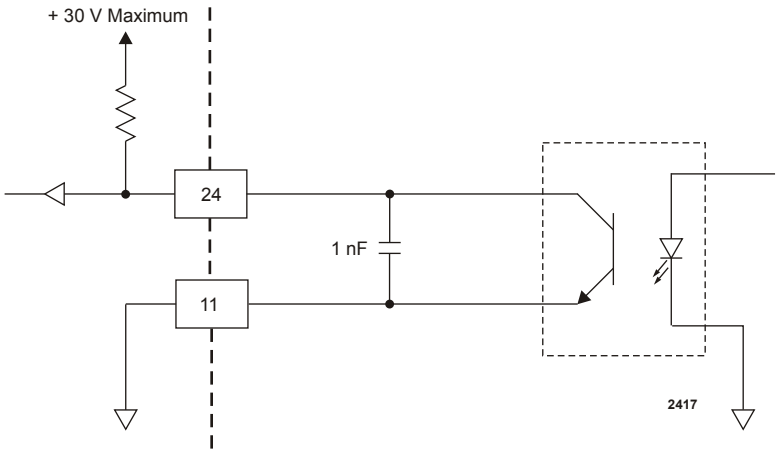


Figure 4-15. INTERLOCK SATISFIED signal wiring (pins 24 and 11)

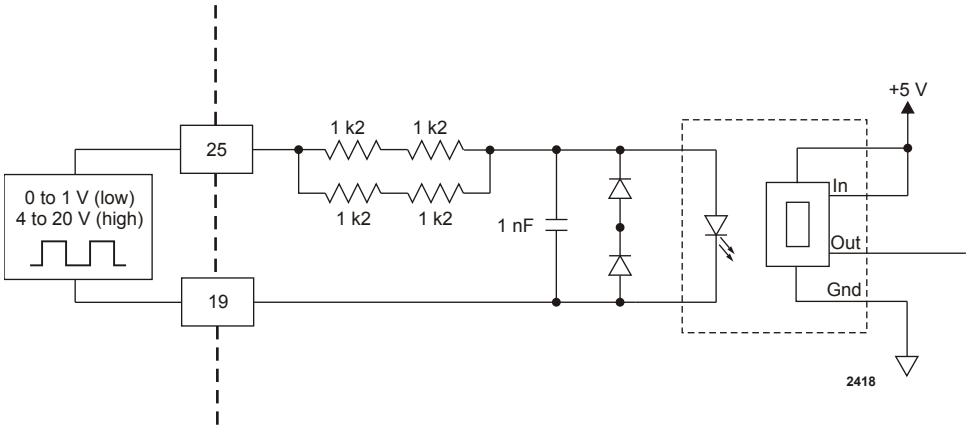


Figure 4-16. BLANKING/PULSING signal wiring (pins 25 and 19)

15-Pin User Port

USER PORT CONNECTOR

The **User Port** uses a 15-pin, shielded, male, subminiature-D connector that connects the generator with an external remote control unit.

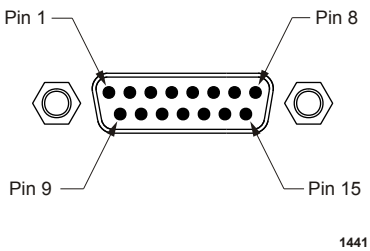


*Figure 4-17. **User Port** connector, 15 Pin*

SATISFYING MINIMAL REQUIREMENTS FOR THE 15-PIN USER PORT

Each Cesar generator with a 15-pin **User Port** also has an **Interlock** interface that allows you to integrate any Cesar generator into a system interlock loop that interrupts delivered RF power.

WARNING:

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

Even if you do not connect the Cesar generator into a larger system interlock loop, you must make the proper connections for the unit to enable RF power.

The Cesar generator may be shipped with an interlock jumper plug that provides a connection between the interlock pins (pins 1 and 2). You can use this jumper plug to satisfy the interlock and enable operation in situations where you do not intend to connect the remaining pins on this port.

Important

Using the interlock jumper plug disables the interlock function

Important

Interlock does not switch the generator on/off. If an interlock is not satisfied, the Cesar generator will issue an interlock error. Interlock errors must be resolved, so you must switch RF off (via the **User Port** or host port) or resolve the error (via the front panel) before you can switch on RF power again.

When the interlock is opened and then closed again, you must resolve the interlock error before using the generator again. To resolve the error with the **User Port**, you must switch RF power from on to off. For this reason, never physically connect the *RF POWER ON* pin with *INTERLOCK*. If you do so you many not be able to switch on the generator.

Interlock Interface Connector

The **Interlock** interface is a 9-pin connector.

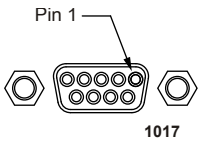


Figure 4-18. Interlock interface connector

Interlock Interface Pin Descriptions

Pins not described in the table are reserved.

Pin	Name	Reference pin	Signal type	Level	Description
1	*INTERLOCK INPUT (+)*	3	Input (floating)	5 V to 24 V	Contact closure to pin 2 via an external interlock loop. You may also provide a 5 VDC to 24 VDC signal referenced to pin 3 to satisfy the interlock
2	*INTERLOCK OUTPUT*	3	Output (floating)	15 V	Contact closure to pin 1 via the user's external interlock loop. This voltage output is floating and has no reference to ground.
3	*INTERLOCK RETURN (-)*		floating	0 V	This is the return pin for an external interlock signal. This pin must be used as return for the external interlock voltage, because the interlock input (pin 1) is floating and has no reference to ground.
4					Connect to the shield of the external interlock cable.

15-PIN USER PORT CABLING REQUIREMENTS

The cable used to connect the generator's **User Port** to the system controller must be a shielded, 15-wire I/O cable. Shielded twisted-pair wiring may be used but is not mandatory. Signal losses should be minimized by keeping the cable length as short as possible. The maximum recommended cable length between the generator and the controller is 10 meters (33´). To minimize interference from adjacent electrical equipment, the EMI shield in the cable must be terminated to the metal shells of the cable's connectors. Additionally, the chassis of the generator must be tied to a local earth ground through an adequately sized copper grounding strap. Unless otherwise specified, all analog signals are 0 V to 10 V while all digital signals are 5 V or $V_{Interface}$.

ACTIVATING THE 15-PIN USER PORT

The Cesar generator can run in front panel control mode, **User Port** remote control mode, or host port remote control mode. You can activate the **User Port** remote control mode using either of the following methods:

- The front panel
- Host port command **14**

If **User Port** remote control is activated, it remains active even if the generator is switched off and on. You can deactivate **User Port** remote control via either the front panel or host port command **14**.

WARNING:

RISK OF DEATH OR BODILY INJURY. The Cesar unit will deliver RF power immediately at system power up when all of the following conditions are met: User port is activated; pin 10 (*RF POWER ON*) of the User port is activated; and pin 1 (*INTERLOCK INPUT*) of the Interlock interface is activated.

RESOLVING ERROR DISPLAYS WHEN USING THE 15-PIN USER PORT

If the Cesar generator encounters an error while being operated via the **User Port**, the generator displays the error message on the front panel display and turns off RF power. The Cesar generator continues to show the error message on the front panel until both of the following conditions are met:

- The error condition is gone
- The RF on signal is deactivated

Once the above two conditions are met, the error message is deleted and the Cesar generator shows the normal display.

15-PIN USER PORT PIN DESCRIPTIONS AND WIRING DIAGRAMS

This table provides the connector pin descriptions for the 15-pin **User Port**. For a description of the signal types, see “**User Port** Signal Specifications” on page 4-7

*Table 4-5. 15-Pin **User Port** Pin Descriptions*

Signal Pin	Return Pin	Name	Signal Type	Description
1	8	*OPERATING MODE A*	Digital input	Connecting pin 1 and pin 2 to a high or low level allows you to set the regulation mode as indicated in Table 4-6 on page 4-23. A high level switches to remote control.
2	8	*OPERATING MODE B*	Digital input	Connecting pin 1 and pin 2 to a high or low level allows you to set the regulation mode as indicated in Table 4-6 on page 4-23. A high level switches to remote control.
3	8	*READY STATUS*	Digital output	This signal indicates that the generator is ready for operation.
4	8	*ERROR*	Digital output	This signal indicates an error such as overload due to temperature, mismatch, or an open interlock loop.
5	8	*MAXIMUM RF POWER LEVEL REACHED*	Digital output	This error message indicates that more RF power is demanded than available by the RF generator. This error may occur in the following situations: • In DC Bias regulation mode, the RF power necessary for the desired DC Bias voltage may be higher than the generator is able to deliver. • In real power regulation mode, the forward power necessary may be higher than the generator is able to deliver. • The external pulsing frequency exceeds the limit. (See the specifications.)
6	8	*RF ON*	Digital output	This signal indicates that more than 1% of the nominal power is present at the RF output.

*Table 4-5. 15-Pin **User Port** Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
7	8	*INTERFACE VOLTAGE*	Digital input	If no voltage is applied to pin 7, 5 V is the standard level for digital inputs and outputs. If you want any other level, an external voltage must be applied to pin 7 and will be used as supply voltage for the digital outputs at pin 3, 4, 5, and 6. The voltage range is 5 V to 24 V, with a maximum current of 300 mA, depending on the load at the outputs.
8		*GROUND*		Reference pin.
9	8	*BLANKING/ PULSE MODE*	TTL Input	Pulse signal input. A TTL square wave input that allows RF power blanking. Use this input if the internal pulsing capabilities do not meet your requirements. When external pulsing is not used, this input may be set up to switch between continuous wave operation and internal pulsing. This alternate function is enabled by changing the unit setting (**Device Configuration Settings** from the front panel)
10	8	*RF POWER ON*	Digital input	This signal allows you to enable or disable RF power. ☞ **Important** Before the generator can deliver power, the interlock must be satisfied.
11	8	*DC BIAS SET POINT*	Analog input	This signal provides a linearly scaled setting to the DC bias voltage. The default range is 0 V to 10 V, but you can change this range. 0 V to 10 V = 0 V to maximum DC bias (4000 V default maximum value).
12	8	*RF POWER SET POINT*	Analog input	This signal provides a linearly scaled setting to the RF forward power. The default range is 0 V to 10 V, but you can change this range. For example, 5 V = 50% of the nominal generator power; 10 V = 100%.

*Table 4-5. 15-Pin **User Port** Pin Descriptions (Continued)*

Signal Pin	Return Pin	Name	Signal Type	Description
13	8	*TEST VOLTAGE FOR FORWARD POWER*	Analog output	This signal provides a linearly scaled readback of RF forward power as measured at the generator output. The default range is 0 V to 10 V, but you can change this range. 0 V to 10 V = 0 W to maximum output power.
14	8	*TEST VOLTAGE FOR REFLECTED POWER*	Analog output	This signal provides a linearly scaled setting to reflected power as measured at the generator output. The default range is 0 V to 10 V, but you can change this range. For example, 5 V = 50% of the nominal generator power; 10 V = 100%.
15	8	*TEST VOLTAGE FOR DC SELF BIAS*	Analog output	This signal provides a linearly scaled setting to DC self bias voltage as measured at the matching network. The default range is 0 V to 10 V, but you can change this range. For example, 5 V = 50% of the nominal DC bias (4 kV); 10 V = 100%.

*Table 4-6. Setting regulation mode with 15-pin **User Port** pins 1 and 2*

Operating Mode A (Pin 1)	Operating Mode B (Pin 2)	Control Setting	Description
Low	Low	Local	No remote control function
Low	High	Remote	RF forward power
High	Low	Remote	DC Bias regulation
High	High	Remote	Real power

Wiring Diagrams for the 15-Pin User Port

The diagrams in this section provide wiring information to connect to the 15-pin **User Port**.

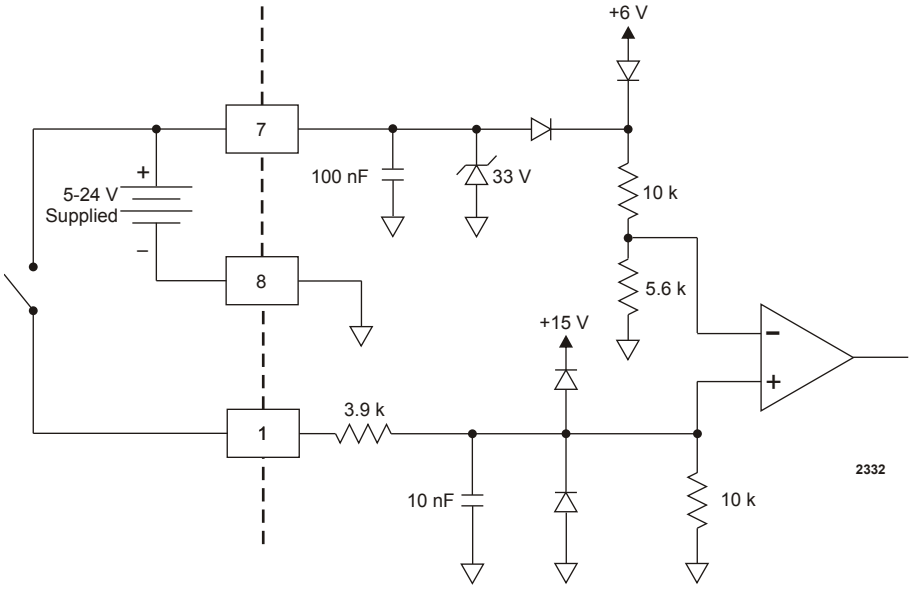


Figure 4-19. OPERATING MODE A wiring diagram (pins 1 and 8)

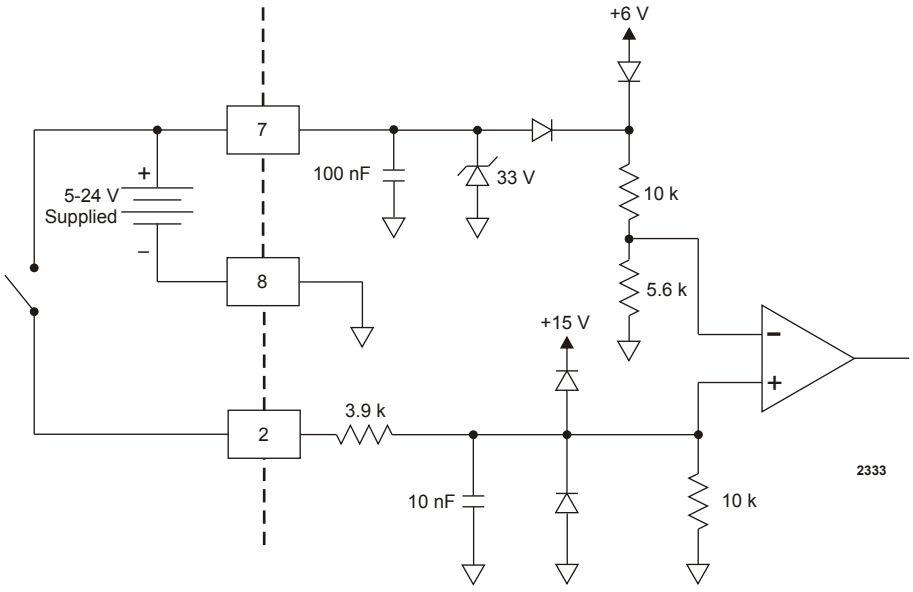


Figure 4-20. OPEATING MODE B wiring diagram (pins 2 and 8)

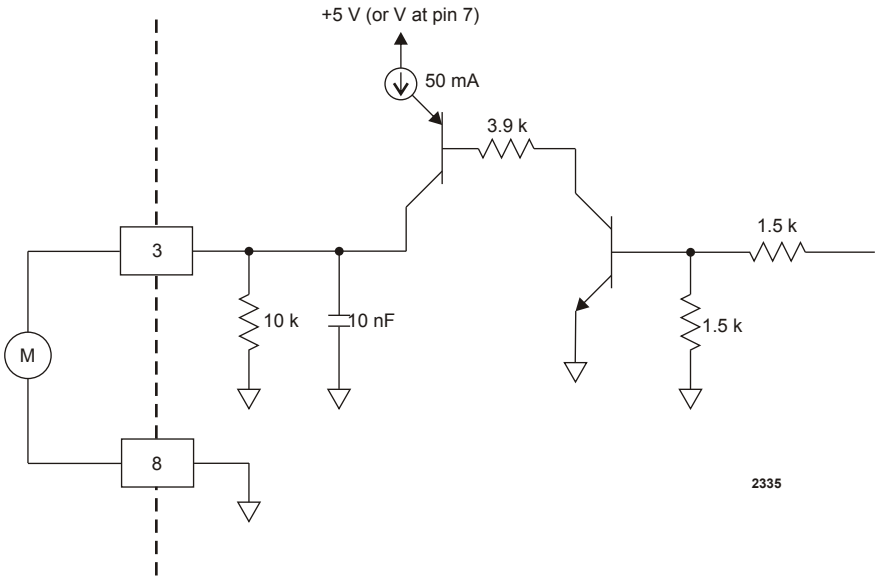


Figure 4-21. READY STATUS wiring diagram (pins 3 and 8)

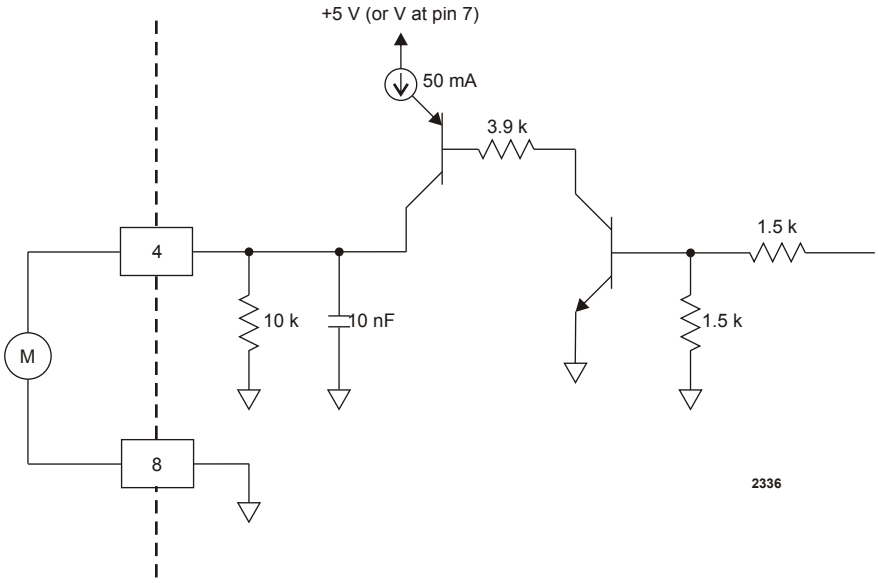


Figure 4-22. ERROR wiring diagram (pins 4 and 8)

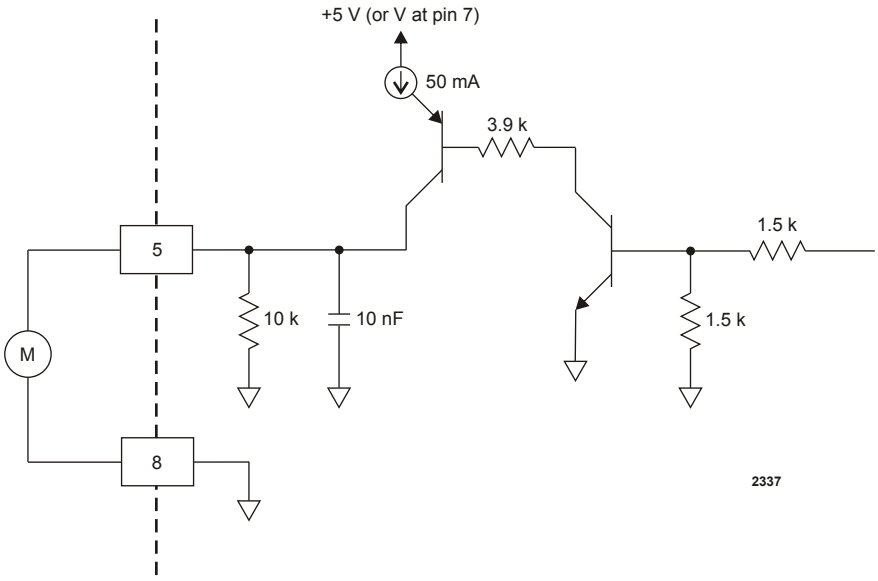


Figure 4-23. MAXIMUM POWER LEVEL REACHED wiring diagram (pins 5 and 8)

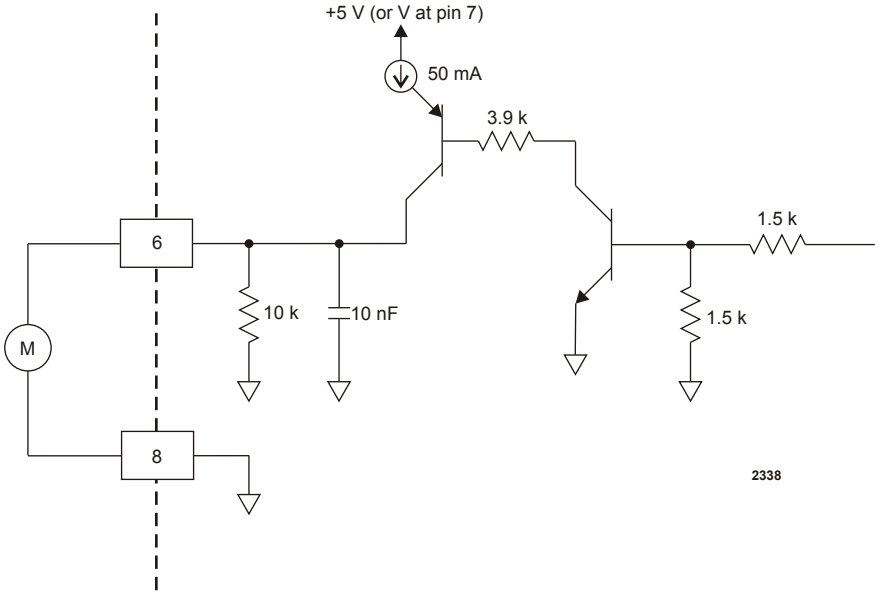


Figure 4-24. RF ON wiring diagram (pins 6 and 8)

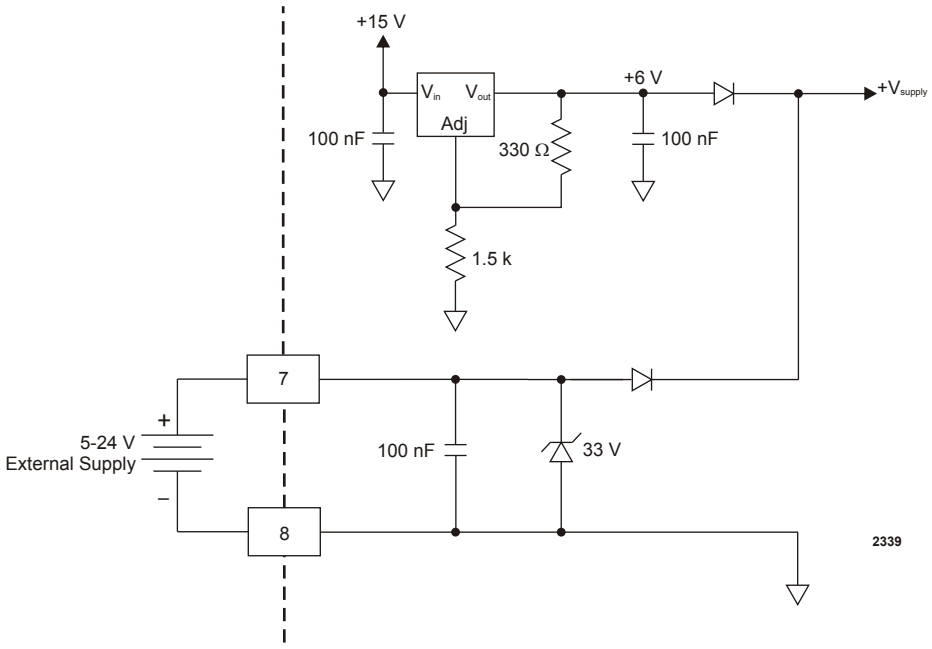


Figure 4-25. INTERFACE VOLTAGE wiring diagram (pins 7 and 8)

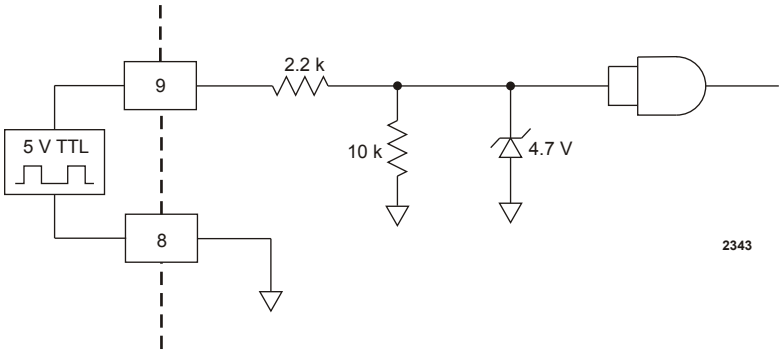


Figure 4-26. BLANKING/PULSING MODE wiring diagram (pins 9 and 8)

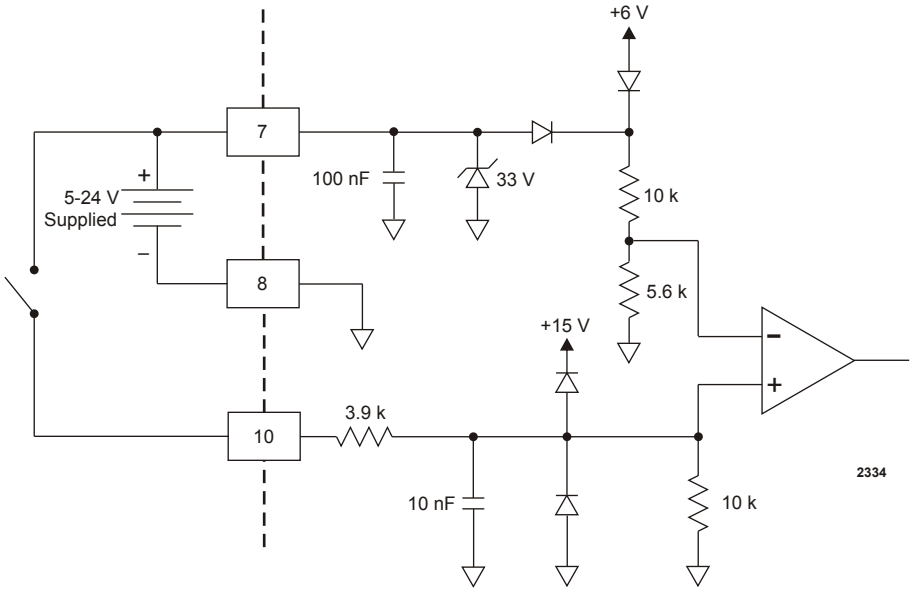


Figure 4-27. RF POWER ON wiring diagram (pins 10 and 8)

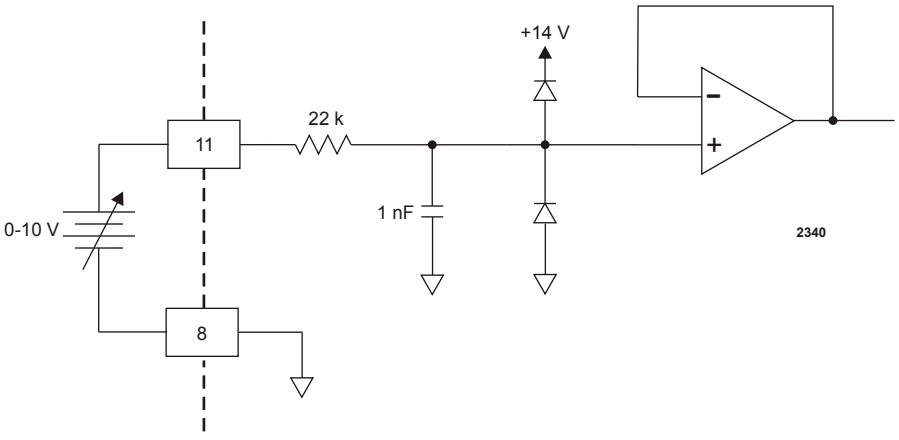


Figure 4-28. DC BIAS SET POINT wiring diagram (pins 11 and 8)

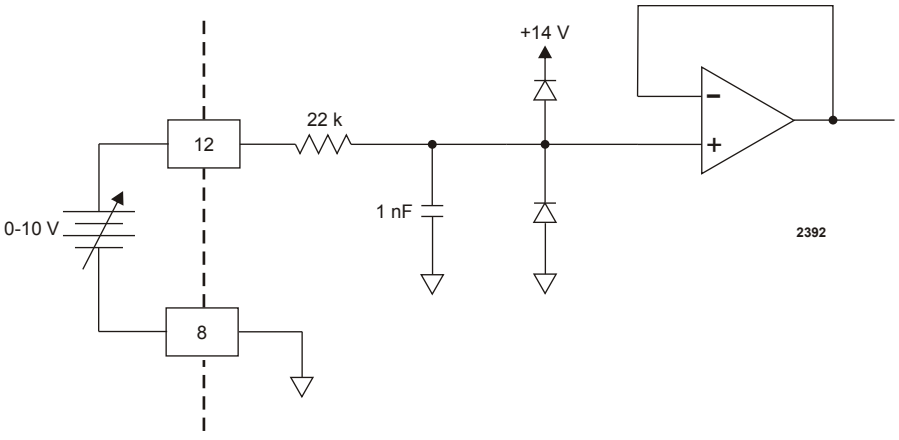


Figure 4-29. RF POWER SET POINT wiring diagram (pins 12 and 8)

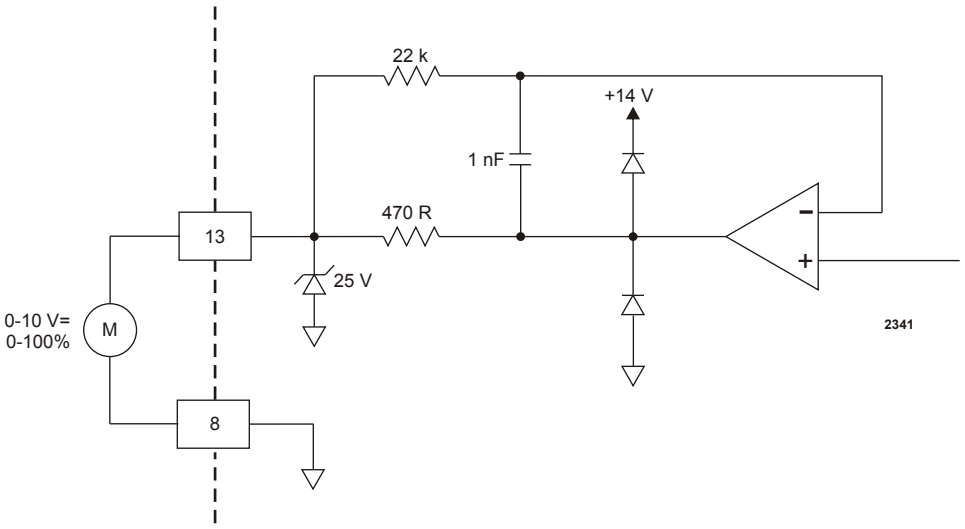


Figure 4-30. TEST VOLTAGE FOWARD POWER wiring diagram (pins 13 and 8)

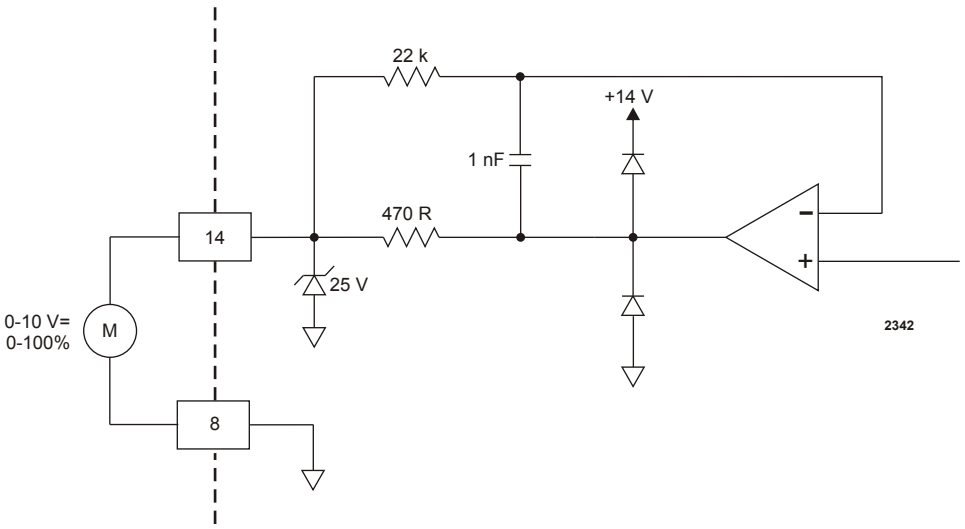


Figure 4-31. TEST VOLTAGE REFLECTED POWER wiring diagram (pins 14 and 8)

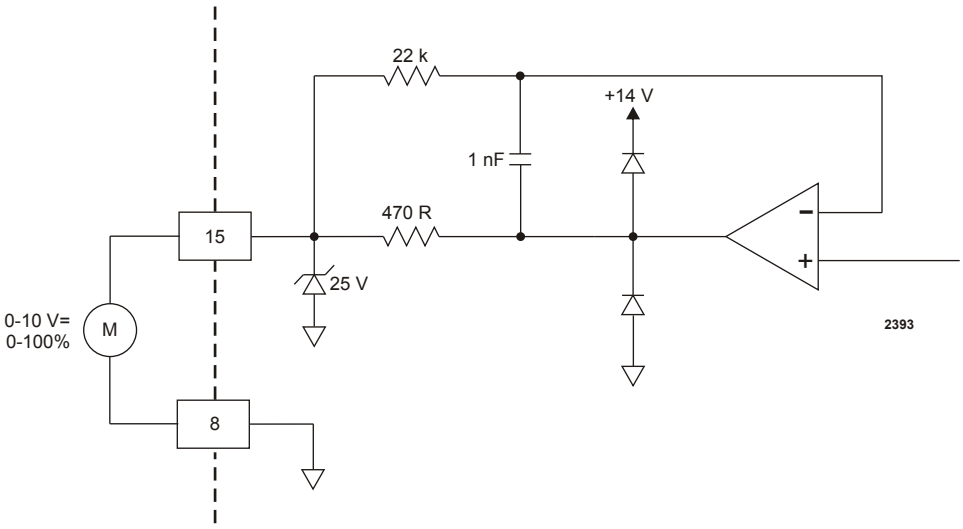


Figure 4-32. TEST VOLTAGE FOR DC BIAS wiring diagram (pins 15 and 8)

CESAR GENERATOR HOST PORT

The Cesar generator has three communications (host port) interface options that allow the generator to interface with a host computer:

- **RS-232** With AE Bus
- **PROFIBUS**
- **Ethernet** (Modbus/TCP)

To determine which host port option you have, refer to the labels on your unit.

The host port commands are very similar for all interfaces. All host port commands are listed and described in the host port commands table.

Related Links

- "RS-232 Interface" on page 4-30
- "PROFIBUS Interface" on page 4-36
- "Ethernet Interface" on page 4-43
- "AE Bus Commands" on page 4-49

RS-232 Interface

The Cesar unit provides a serial communications interface through the **RS-232** port. This interface allows the Cesar unit to interface with a host computer using the AE Bus protocol.

The **RS-232** AE Bus host port interface uses an RS-232 signal format and AE Bus communication protocol.

RS-232 CONNECTOR

The serial **RS-232** port connector is a 9-pin, female, shielded, subminiature-D connector for interfacing with a host computer.

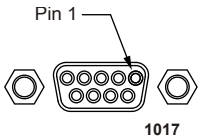


Figure 4-33. RS-232 port connector

RS-232 PORT PIN DESCRIPTIONS

Table 4-7. RS-232 port pin descriptions

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

* Do not connect pins marked *RESERVED*. Do not ground this factory reserved pin. Grounding this pin disrupts the operation of the unit.

AE BUS TRANSMISSION PARAMETERS

The communications capability of the **RS-232** port is limited to the following parameters:

- RS-232 protocol
- Baud rates, selected on the front panel:
  - 9600
  - 19,200
  - 38,400
  - 57,600

  - 115,200
- Cesar unit address is always 1.
- Odd parity
- One start bit, eight data bits, one stop bit
- Low-order bytes transmitted before high-order bytes (little endian)

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

The Cesar unit sends data through pin 2 (*TX RS232)*. This pin must be connected to the receive pin (*RX RS232*) on the host computer's serial connector. The receive pin is normally pin 2 for a standard, 9-pin serial port and normally pin 3 for a standard, 25-pin 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 Cesar unit. The AE Bus message packet combines a set quantity of bits and bytes in such a way that groups of information can be sent over communications lines at one time. Five types of information (fields) make up a communications message packet.

- Header (address and the length of Data field)
- Command Number
- Optional Length byte
- Data
- Checksum

Figure 4-34 shows the organization of these fields in the AE Bus message packet. The subsequent paragraphs describe each field in detail.

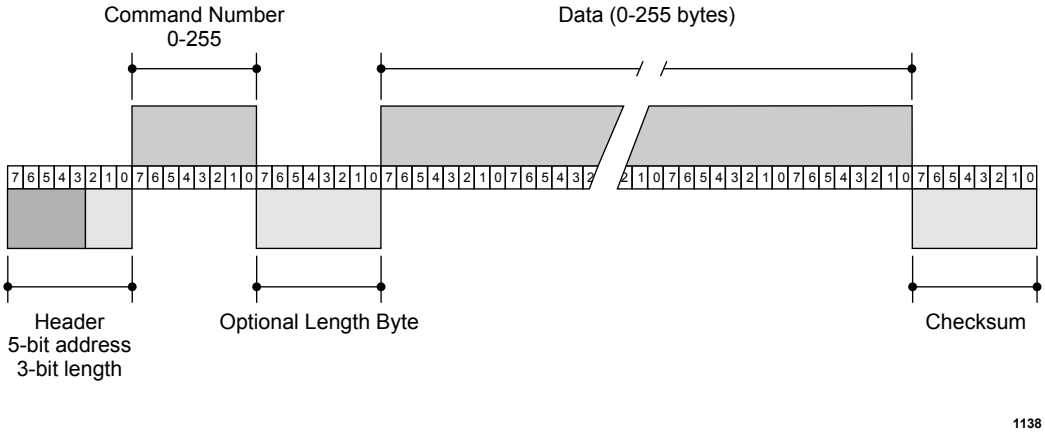


Figure 4-34. *Graphic representation of a message packet*

AE Bus Header Byte

The first byte in each packet contains two pieces of information: five bits contain the packet address, and three bits contain the data byte count. If the message packet originates with the host computer, the address specifies the packet destination (to the Cesar unit, for example). If the packet is going to the host, the address specifies the packet origin (from the Cesar unit). 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, which the Cesar unit does not support.

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

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

AE Bus Command Number Byte

This one-byte field contains an 8-bit value from 0 to 255 (00h to ffh) representing the command number. If the message packet originates with the host computer, this value specifies the purpose of the message packet. If the message originates with the Cesar unit, the value specifies the command to which it is responding.

AE Bus Optional Length Byte

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

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

AE Bus Data Bytes

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

If the value specified in the length bits (bits 0, 1, and 2) of the Header field is 0 to 6, the Cesar unit expects zero to six data bytes. However, if the value in the Header field is 7 (07h), the Cesar unit looks for the Optional Length byte after the Command field and reads this value to calculate the data byte count.

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

For example, a command with 7 data bytes that included one 8-bit value, one 16-bit value, and one 32-bit value, would be sent as shown in Table 4-8.

Table 4-8. AE Bus byte structure

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

AE Bus Checksum Byte

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

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

CREATING AN IDEAL COMMUNICATIONS TRANSACTION

Figure 4-35 illustrates the steps in an ideal communications transaction between a host computer and the Cesar unit.

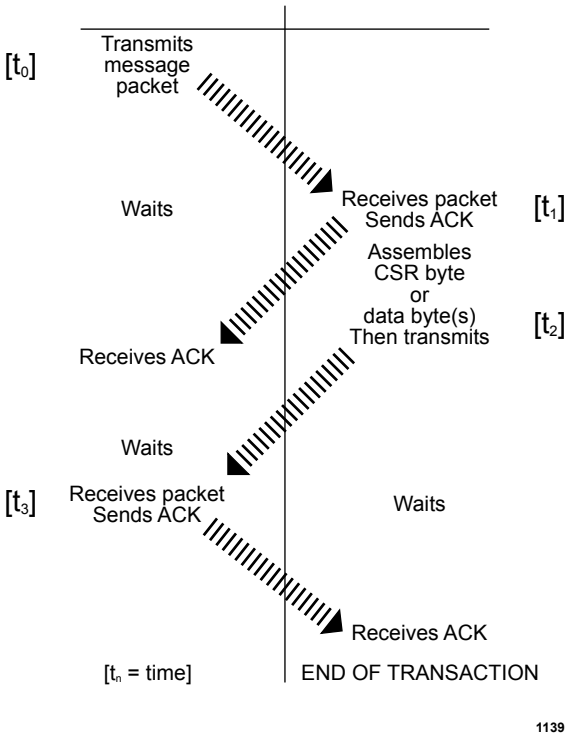


Figure 4-35. AE Bus communications transaction

T_0: Host Transmits Message Packet

The host computer sends a message packet to the Cesar unit. The packet contains one of the following:

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

T_1: Unit Verifies Host Transmission Packet

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

- If the address does not match, the Cesar unit does not respond to the host computer; the Cesar unit resets and resumes waiting for a message addressed to it. If the address matches but the exclusive-or (XOR) sum of the bytes in the packet (including the checksum) is not zero, the Cesar unit sends a negative acknowledgment (NAK), hexadecimal 15h, to the host computer.
- If the address matches and the message is intact, the Cesar unit sends an acknowledgment (ACK), hexadecimal 06h, to the host computer.

If the Cesar unit receives a request for data or status information, it gathers and sends the requested information. Otherwise, it evaluates the incoming command and sends

a message packet that contains a one-byte data value (CSR code) to the host. The power supply sends CSR code 0 when it has accepted the command.

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

T_2: Unit Transmits Response to Host

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

T_3: Host Acknowledges Unit Response

If the Cesar unit receives an ACK from the host computer, it returns to the normal waiting state. If the Cesar unit receives a NAK from the host computer, the unit retransmits the response packet. The Cesar unit continues to retransmit in response to NAK transmissions until the host computer stops the cycle. If the Cesar unit receives no response within 100 ms, it assumes an ACK and returns to the waiting state.

AE Bus Communications Transaction Example

Figure 4-36 illustrates the steps in an example communications transaction between a host computer and the Cesar unit.

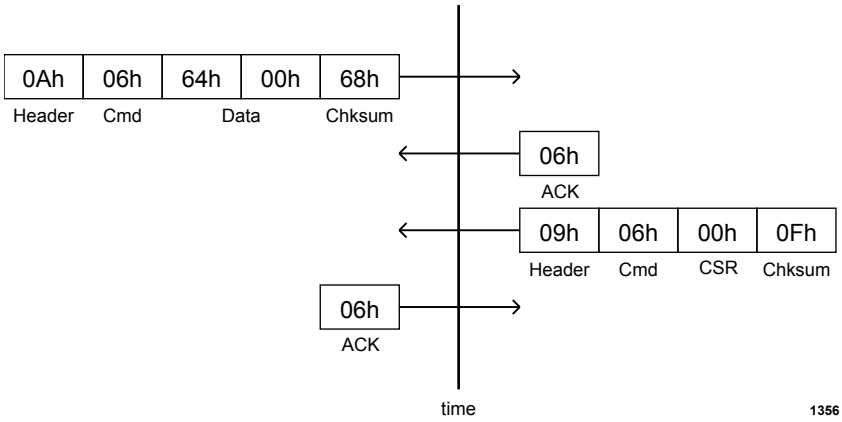


Figure 4-36. *Communications transaction example*

PROFIBUS Interface

The Cesar unit provides a serial communications interface through the **PROFIBUS** (Process Field Bus) port. This interface allows the Cesar unit to interface with a PROFIBUS Master, which resides in a programmable logic controller (PLC).

PROFIBUS CONNECTOR

The serial **PROFIBUS** port connector is a 9-pin, female, shielded, subminiature-D connector, two status LEDs, and two rotary address switches located beside the connector. You can use the **PROFIBUS** host port to interface with a host computer.

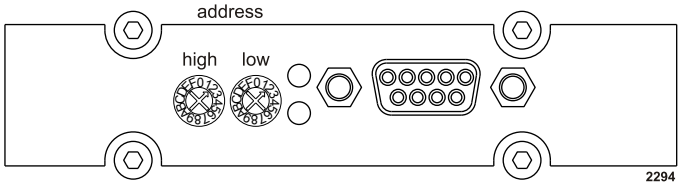


*Figure 4-37. **PROFIBUS** port connector*

PROFIBUS PORT PIN AND SIGNAL DESCRIPTIONS

*Table 4-9. **PROFIBUS** port pin and signal descriptions*

Signal Pin	Return Pin	Pin Name	Signal Type	Description
1	n/a	Unassigned	n/a	n/a
2	n/a	Unassigned	n/a	n/a
3	n/a	I/O port	Digital I/O	Differential I/O
4	n/a	Unassigned	n/a	n/a
5	n/a	Return	n/a	Isolated PROFIBUS return
6	5	+5 V	+5 VDC	Isolated PROFIBUS supply voltage
7	n/a	Unassigned	n/a	n/a
8	n/a	I/O port	Digital I/O	Differential I/O
9	n/a	Unassigned	n/a	n/a

PROFIBUS CABLING AND TERMINATION

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

Table 4-10. Baud rate and cable lengths

Baud Rate	Length
1.5 M	200 meters

Table 4-10. Baud rate and cable lengths (Continued)

Baud Rate	Length
12 M	100 meters

Terminate each segment at both ends, and power the termination at all times. If a segment has more than 31 devices, then you must use a repeater. The termination resistors should be on the connector housing of the PROFIBUS cable (not included). Ensure that you follow proper termination procedures if your generator is the last slave on the PROFIBUS cable.

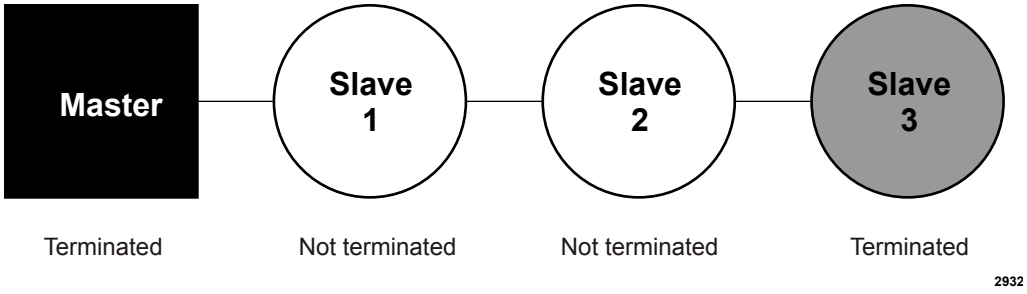


Figure 4-38. Example of a segment

AE PROFIBUS PROTOCOL

The **PROFIBUS** port provides an interface that lets you communicate with the Cesar unit from a PROFIBUS Master. AE manufactures a PROFIBUS interface compliant 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 PROFIBUS interface.

☞ **Important**

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

PROFIBUS GSD Files

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

The GSD file for your unit's PROFIBUS is available from Advanced Energy. For general PROFIBUS information and specific information about GSD files, visit the following Web site:

http://www.profibus.com

Setting the Unit PROFIBUS Network Address

The **PROFIBUS** address for your unit is set at the factory. To change the **PROFIBUS** address, use the rotary dials on the rear panel to set the new address (using hexadecimal code). You can set an address between 1 and 125.

☞ **Important**
You cannot change the unit address from the PROFIBUS Master.

PROFIBUS Master Reset Command

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

Baud Rate

The auto-baud feature of AE's **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 Status LEDs

The **PROFIBUS** LEDs (light-emitting diodes) on the rear panel consist of two status LEDs to indicate whether the **PROFIBUS** system is operating properly

Table 4-11. PROFIBUS status LEDs

Unit Status	Red LED	Green LED
PROFIBUS system is off or unavailable	on	on
PROFIBUS cable is connected, but master is not active and/or master did not initialize slave	blinking	on
Incorrect GSD file	blinking	on
Incorrect **PROFIBUS** slave address	blinking	on
PROFIBUS module or generator are configured incorrectly (internal error)	off	on
PROFIBUS cable connected, master is active, ID of device is correct, GSD file is correct, there is communication	off	blinking fast

Watch Dog Timer

As a safety feature, the PROFIBUS maintains a watch dog timer that shuts off the Cesar unit output and shows an error (PROFIBUS WATCHDOG EXPIRED) if the PROFIBUS master stops communicating. The watch dog timer maintains a value for time (between 10 ms and 10 minutes) that the Cesar unit 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 unit's microprocessor uses the numbers you enter to octet 2 and 3 of 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. The values for octet 2 and 3 must not equal or be zero.

You can disable the watch dog timer through the PROFIBUS master.

PROFIBUS-Specific Errors

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

PROFIBUS Data Consistency

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

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

You can create a work around to this problem with a command sequence that ensures the data for a command will not be changed before the next download packet is received. Here is an example procedure:

1. Send the null command (command 0). The Cesar 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.

See your PLC documentation for additional information.

Transmission Rates and The Handshake Feature

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

In response to this issue, AE has developed a handshake feature, which echoes back the last sent command in byte 13 of the upload packet. This feature allows you to send a command and wait for verification that the command was accepted before sending the next command. Using the handshake feature has the following benefits:

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

☞ **Important**
You can choose not to use the handshake feature, but if you do so, do not send commands 0 through 127 to the Cesar generator at a rate faster than one command per 80 milliseconds.

PROFIBUS COMMAND STRUCTURE

The number command-based AE PROFIBUS protocol is designed to take advantage of the high transmission rates provided by the PROFIBUS standard. The download packet (outbytes) and the upload packet (inbytes) as well as the AE PROFIBUS "handshake" feature are described in the sections that follow.

PROFIBUS Download Packet

The download packet for **PROFIBUS** contains four bytes.

*Table 4-12. Configuration of **PROFIBUS** download packet bytes*

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

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

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

PROFIBUS Upload Packet

During every **PROFIBUS** data exchange, the Cesar unit supplies a 14-byte upload packet. This table defines the bytes contained in the upload packet.

Byte	Description
0	Status flags—first byte
1	Status flags—second byte
2	Delivered power low
3	Delivered power high
4	Forward power low
5	Forward power high
6	Reflected power low
7	Reflected power high
8	Data byte (LSB)
9	Data byte
10	Data byte
11	Data byte
12	Data byte (MSB)
13	Command number (echo of command sent)

PROFIBUS Upload Packet Data Bytes 0 and 1

Bytes 0 and 1 of the upload packet contain information (in the form of status bit flags) about the status of the Cesar unit:

Table 4-13. PROFIBUS upload packet status bit flags

Byte	Description
Byte 0—first status byte	Bit 8 = Control mode (with bit 9) Bit 9 = Control mode (00 = **User**, 10 = **PROFIBUS**) Bit 10 = Set point status OK Bit 11 = Reserved Bit 12 = End of Target Life (EOTL) Bit 13 = Active toggle bit Bit 14 = Reserved Bit 15 = Reserved

Table 4-13. PROFIBUS upload packet status bit flags (Continued)

Byte	Description
Byte 1—second status byte	Bit 0 = Reserved Bit 1 = Overtemperature condition Bit 2 = Interlock mechanism open Bit 3 = Reserved Bit 4 = Reserved Bit 5 = Reserved Bit 6 = Reserved Bit 7 = Output is on

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

PROFIBUS Upload Packet Data Bytes 8 through 13

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

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

Ethernet Interface

The Cesar unit provides an Ethernet communications interface that allows the unit to communicate with a host computer. The interface consists of an RJ-45 port (labeled **Ethernet** on your unit) and the AE TCP protocol, which uses function code (FC) 23. FC23 is used to map AE Bus commands from the Cesar to the Modbus/TCP packet.

ETHERNET CONNECTOR AND INDICATORS

You can control the Cesar unit through a network using an Ethernet Modbus/TCP connection.

☞ **Important**

The Cesar unit supports a Modbus/TCP connection to port 502. For more information about the Modbus/TCP protocol, visit the Modbus Users Web Site at: www.modbus.org.

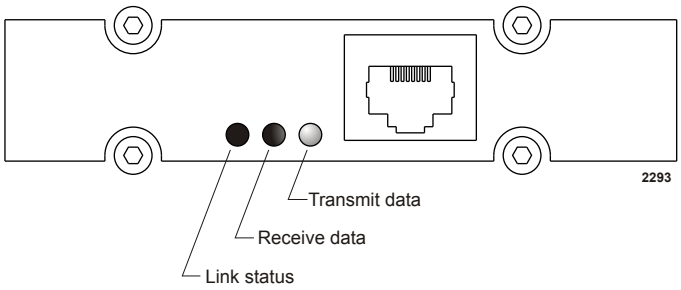


Figure 4-39. Ethernet connector and indicators

The three LEDs next to the Ethernet connector communicate when the unit is transmitting data and if the Ethernet link has been established:

- Link status
  - Green = OK
  - Dark = No connection
- Receive data
  - Red = Active
  - Dark = Not active
- Transmit data
  - Red = Active
  - Dark = Not active

UNDERSTANDING AE TCP COMMANDS AND REGISTER TYPES (FC23)

The AE TCP protocol wraps host port commands into TCP packets. The unit acts as a server while the host or tool program communicating with the unit acts as a client. The unit listens for requests for TCP connections on registered port 502. Port 502 is assigned to Modbus/TCP protocol. The unit can support up to six simultaneous TCP connections.

One of the Modbus/TCP frame formats, class 2 function code 23 (FC23), wraps host port commands into Modbus/TCP packets. FC23 functions according to the Modbus/TCP standard (go to http://www.modbus.org for more information). You can use FC23 to run all common commands.

Establishing a Connection

To establish a TCP connection, the host or tool program (client) connects to TCP port 502. If the number of already established connections exceeds the predefined limit for the given equipment, the connection is rejected.

Once the connection is established, the client may perform multiple transactions consisting of the following two steps:

1. The client sends a request containing a host port command to be executed by the unit (server).
2. The server executes the host port command and returns a packet containing the unit's reply to the command (CSR or data).

☞ **Important**
For optimum performance, keep the TCP connection open (and remaining open) during continuous operation. Opening and closing a connection for each command transaction will result in poor communication performance.

Data Encoding

The Cesar unit uses little endian (least significant byte first) architecture.

In FC23, the portion of the packet containing the command bytes is little endian. These bytes are ordered exactly as described for AE host port commands.

Multiple clients may send configuration information simultaneously. All configuration commands in the Cesar are atomic, which prevents erasing problems, however, one client may overwrite another's configuration information.

USING MODBUS/TCP FC23

FC23 allows you to send any Cesar AE Bus command through the Modbus/TCP interface, providing complete control of the system in a way that directly corresponds to the AE Bus.

To accommodate this use of AE Bus commands, the Cesar unit uses some special values in the FC23 packet.

☞ **Important**
Errors associated with the commands are reported as single byte CSRs contained in the returned data bytes.

FC23 Send Packet

Table 4-14. Packet format for FC23 send

Byte Numbers	Send Value	Purpose
0 and 1	Transaction ID	Not used (value is copied into reply)
2 and 3	Protocol ID	0
4 and 5	Number of bytes following	Count of bytes in packet (starting with byte 6)
6	Unit ID	Ignored
7	Function code	23 = 0x17

Table 4-14. Packet format for FC23 send (Continued)

Byte Numbers	Send Value	Purpose
8 and 9	Reference number for read	0xFFFF ☞ **Important** This value is necessary to denote the special use of FC23 (mapping to AE Bus commands).
10 and 11	Word count	Not used
12 and 13	Reference number for write	0xFFFF ☞ **Important** This value is necessary to denote the special use of FC23 (mapping to AE Bus commands).
14 and 15	Word count for write	Not used
16	Byte count for write	Not used
17	AE Bus command number	AE Bus command number
18	Number of data bytes in AE Bus write packet	Total number of data bytes in the packet ☞ **Important** In AE TCP, the AE Bus packet does not use the header and checksum bytes. For a description of the AE Bus packet, see the AE Bus protocol.. For information on the number of data bytes in a command, see the AE host command set.
19 and up	AE Bus data bytes	Data bytes contained in the AE Bus packet For information on the number of data bytes in a command, see the AE host command set. Modbus word swapping does not affect the order of these bytes. These bytes should be ordered according to the AE Bus command format (least significant bytes first).

FC23 Response Packet

Table 4-15. Packet format for FC23 response

Byte Numbers	Send Value	Purpose
0 and 1	Transaction ID	Not used (value is copied from send packet)

Table 4-15. Packet format for FC23 response (Continued)

Byte Numbers	Send Value	Purpose
2 and 3	Protocol ID	0
4 and 5	Number of bytes following	Count of bytes in packet in Modbus big endian order (starting with byte 6) • Byte 4 = most significant byte • Byte 5 = least significant byte
6	Unit ID	Copied from send packet.
7	Function code	23 = 0x17
8	Byte counter	Not used
9	AE Bus command number	AE Bus command number
10	Number of bytes in AE Bus response packet	Total number of data bytes in the AE Bus packet ☞ **Important** In AE TCP, the AE Bus packet does not use the header and checksum bytes. For a description of the AE Bus packet, see the AE Bus protocol. For information on the number of data bytes in a command, see the AE host command set.
11 and up	AE Bus data bytes	Data bytes or CSR information contained in the AE Bus packet For information on the number of data bytes in a command, see the AE host command set. Modbus word swapping does not affect the order of these bytes. These bytes should be ordered according to the AE Bus command format (least significant bytes first).

FC23 Exception Error Packet

The Cesar unit may reply to Modbus/TCP commands with an exception error packet if something goes wrong in the communication.

Table 4-16. Packet format for FC23 exception error

Byte Numbers	Purpose	Response Value
0 and 1	Transaction ID	Not used (value is copied from send packet)
2 and 3	Protocol ID	0

Table 4-16. Packet format for FC23 exception error (Continued)

Byte Numbers	Purpose	Response Value
4 and 5	Number of bytes to follow	Count of bytes in packet (starting with byte 6)
6	Unit ID	AE Bus address
7	Function code + 0x80	151 = 0x97
8	Exception code	01 = Illegal function

FC23 Example

This example uses AE Bus command 168 to read back power, voltage, and current from the unit using the AE TCP connection.

Table 4-17. Packet format for command 168 send

Byte Numbers	Send Value	Purpose
0 and 1	0x00, 0x00	Transaction ID (any value)
2 and 3	0x00, 0x00	Protocol ID
4 and 5	0x00, 0x0D	Number of bytes to follow (count of bytes in packet starting with byte 6)
6	0x00	Unit ID
7	0x17	Function code [23=(0x17)]
8 and 9	0xFF, 0xFF	Reference number for read = 0xFFFF ☞ **Important** This value is necessary to denote the special use of FC23 (mapping to AE Bus commands).
10 and 11	0x00, 0x00	Word count (Not used = 0)
12 and 13	0xFF, 0xFF	Reference number for write = 0xFFFF *Note:* This value is necessary to denote the special use of FC23 (mapping to AE Bus commands).
14 and 15	0x00, 0x00	Word count for write (Not used = 0)
16	0x00	Byte count for write (Not used = 0)
17	0xA8	AE Bus command number = 168

Table 4-17. Packet format for command 168 send (Continued)

Byte Numbers	Send Value	Purpose
18	0x00	Number of bytes in AE Bus command write packet = 0 ☞ **Important** End of packet—no data bytes exist in this command.

This example illustrates the response packet for command 168.

Table 4-18. Packet format for command 168 response

Byte Numbers	Send Value	Purpose
0 and 1	0x00, 0x00	Transaction ID (any value)
2 and 3	0x00, 0x00	Protocol ID
4 and 5	0x00, 0x0E	Number of bytes to follow (count of bytes in packet starting with byte 6)
6	0x00	Unit ID
7	0x17	Function code [23=(0x17)]
8	0x00	Byte counter (any value)
9	0xA8	AE Bus command = 168
10	0x06	Number of response data bytes for AE Bus command
11 and 12	0xD1, 0x07	Power = 2000
13 and 14	0x84, 0x01	Voltage = 388
15 and 16	0x04, 0x02	Current = 516 (5.16 A)

AE Bus Commands

The following sections describe the command status response (CSR) codes returned by the Cesar unit in response to an AE Bus command, as well as the complete set of AE Bus commands. You can use these commands with one or more of the following interfaces (depending on your unit's configuration):

- AE Bus (serial)
- PROFIBUS
- Ethernet

ACTIVATING HOST PORT REMOTE CONTROL (AE BUS COMMAND 14)

By default, when you switch on the Cesar generator it is in front panel control mode. To use the host port commands, the unit must be in host port remote control mode. Once activated, the unit will remain in host port remote control mode until deactivated by AE Bus command **14** or until the Cesar generator is switched off. To specify the correct remote control settings and filters, you may need to send command **14** multiple times. Table 4-19 describes the behavior for each command **14** value.

To Activate Host Port Remote Control

1. Ensure the Cesar generator is switched on, but RF is off. By default, all control is from the front panel.
2. If desired and if you will be specifying host port or **User Port** remote control, use the front panel to specify remote control overrides.
3. Send AE Bus command **14** with a value of 2, 4, or 6 to set the control domain.
4. If desired, you can also send command **14** to change the front panel behavior. To specify the correct remote control settings and filters, you may need to send command **14** multiple times.
   - Send a value of 11, 12, or 13 to disable front panel functionality (soft keys, knob, **Matching** keys, **RF On/Off** keys). You can later send a value of 10 to re-enable normal behavior.
   - Send a value of 22 or 23 to disable portions of the display functionality. You can later send a value of 20 to re-enable normal behavior.
   - If you have switched to 1x mode (command 11, 12, or 13), first send a value of 10 to reset before sending values 22 or 23.

*Table 4-19. AE Bus command **14** remote control settings, resets, and overrides*

Command 14 value	Description	
2	Host Port	Normal behavior: • Host port and **User Port**: If you did not specify remote control overrides, then you have no button or soft key functionality on the front panel, but you have full display functionality (for example, the display key works and values are displayed). • All domains (host port, **User Port**, and front panel): If you specified remote control overrides, then those overrides determine the behavior of the knob, the **RF On/Off** keys, and **Matching** keys).
4	User Port	
6	Front panel	
10	Resets front panel control to normal behavior. Use this to reset remote control after sending values 11, 12, or 13. Normal behavior is the behavior defined by Command **14** (value of 2, 4, or 6) plus remote control overrides. Commands **11**, **12**, and **13** act as additional filters for restricting the front panel buttons and knobs. The unit continues to show values on the display.	
11	Disable front panel **Program** and **Presets** soft keys. Exceptions: None (Remote control overrides set from the front panel do not affect the **Program** and **Presets** soft keys)	
12	Set front panel to remote operation, where all soft and regular keys are disabled, except the **Display** soft key: • Disable front panel **Program** and **Presets** soft keys. • No change of remote mode by front panel. • Disable **RF On** and **RF Off** keys, set point (knob), and **Matching** keys (unless there is a local override). Exceptions: Remote control overrides set from the front panel.	
13	All soft and regular keys (and all menus) are disabled, including the **Display** soft key. Exceptions: Remote control overrides set from the front panel.	
20	Resets front panel display to the normal behavior. Use this to reset remote control after sending values 22 or 23. Normal behavior is the behavior defined by command **14** (value of 2, 4, or 6) plus remote control overrides. Values 20, 22, and 23 control the front panel display; values 22 and 23 also disable the front panel keys and knob.	

Table 4-19. AE Bus command 14 remote control settings, resets, and overrides (Continued)

Command 14 value	Description
22	All front panel display values are turned off except `Ready`, `Active`, or `Error`. All front panel overrides are disabled. Exceptions: none.
23	All front panel display values are disabled. All front panel overrides are disabled. Exceptions: none.

AE BUS COMMAND STATUS RESPONSE (CSR) CODES

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

Table 4-20. AE Bus command status response (CSR) codes

Code	Meaning
0	Command accepted
The following CSR codes are sent in response to a command that was not accepted and provide an indication of why the command was not accepted	
1	Control code is incorrect
2	Output is on (change not allowed)
4	Data is out of range
7	Active fault(s) exist
9	Data byte count is incorrect
19	Recipe is active (change not allowed)
50	The frequency is out of range
51	The duty cycle is out of range
53	The device controlled by the command is not detected
99	Command not accepted (there is no such command)

AE BUS PORT COMMAND SET

The Cesar unit communication interfaces use two types of AE Bus commands:

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

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

Most AE Bus commands are the same for all of the available interfaces. Differences are noted where they exist.

Your unit may not have all features listed here. If you issue a command for a feature that your unit does not have, the unit returns CSR **99**, Command not accepted.

Table 4-21. AE Bus Commands

Command	Description	Data Bytes Sent	Data Bytes Returned
0 **null** This command is for PROFIBUS only.	This command is always accepted but is ignored.	0	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
1 **Turn output off**	Turns off RF output. This command shuts the RF output off immediately if ramping in not enabled. Otherwise it starts the RF output off ramp. If issued while on or off ramping is in progress, the RF output is shut off immediately. If issued while a power ramping recipe is in progress, the RF output is shut off immediately and the recipe is suspended. A subsequent command **2 turn output on** will resume the recipe execution. See "Controlling RF On With AE Bus Commands" on page 4-85 for a discussion of the methods to control RF on and off. All latched faults are cleared in the fault status register. It does not clear any faults that are currently active. This command is accepted regardless of control mode. Read back with command **162**.	0	1 (CSR only)
2 **turn output on**	Turns on RF output. Turns on the RF output if there are no active or latched faults. This command is accepted only when host port control mode is active. It is not accepted when a power ramping recipe is being programmed (commands **19**, **21**, **22** and **23**). If the recipe is already programmed, then this command executes the recipe. See "Controlling RF On With AE Bus Commands" on page 4-85 for a discussion of the methods to control RF on and off. Read back with command **162**.	0	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
3 **set regulation mode**	Sets the regulation mode. The regulation mode can be changed between forward, real, and DC Bias regulation modes while the RF output is on. This command is accepted only when host port control mode is active. It is not accepted when a power ramping recipe is being or has been programmed (commands **19**, **21**, **22** and **23**) or is running. Send one data byte, indicating the desired regulation mode: • 6 = Forward power regulation • 7 = Real power regulation (sometimes called load power regulation or delivered power regulation) • 8 = DC Bias regulation (sometimes called external power regulation) See also commands **4**, **8**, **9**, and **10**. Read back with command **154**.	1	1 (CSR only)
4 **set forward power limit**	Limits the forward power in DC Bias regulation mode (set with command **3**) by specifying the maximum forward power that can be delivered. The forward power limit is accepted in all regulation modes but is only applied while in DC bias regulation mode. This command is accepted only when host port control mode is active. It is not accepted when a power ramping recipe is being programmed (commands **19**, **21**, **22** and **23**) or is running. Send two data bytes, least significant byte first, representing the maximum forward power in watts. • Accepts a value of 5% to 100% of maximum power Read back with command **169**.	2	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
5 **set reflected power limit**	Sets the maximum reflected power. The reflected power limit is in effect for all regulation modes. The reflected power limit can be changed while the RF output is on. This command is accepted only when host port control mode is active. Send two data bytes, least significant byte first, representing the reflected power limit as a percentage of maximum power. • Accepts a value of 1 watt through the maximum reflected power (see electrical specifications table). The maximum value is also limited by cable attenuation factors settings that are negative. The cable attenuation factor is changeable through a front panel menu setting. Read back with command **170**.	2	1 (CSR only)
8 **set power set point**	Sets the output set point level for the selected regulation mode (set with command **3**). This command is accepted only when host port control mode is active. It is not accepted when a power ramping recipe has been programmed (commands **19**, **21**, **22** and **23**) or is running. Send two data bytes, least significant byte first, representing the set point level in watts or volts: • Watts, if in forward or real power regulation modes. Accepts a value of 0 to the unit's maximum RF output power or the user power limit. • Volts, if in DC Bias regulation mode. Accepts a value of 0 to maximum external feedback value. Read back with command **164**.	2	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
9 **set maximum external feedback**	Sets the maximum external feedback value in volts. It is only used when operating in DC Bias regulation mode. This command is accepted only when host port control mode is active. Send three data bytes, least significant byte first. • Bytes 0 and 1 = Maximum external feedback in V. Accepts a value in the range of 100 to a factory set maximum, typically 4000. • Byte 2 is only for compatibility and is ignored There is no read back command for the current setting.	3	1 (CSR only)
10 **set RF on time limit**	This command sets the maximum RF on time in seconds. When the time since an RF on command exceeds the configured limit without an RF off command, RF is switched off and the error **E52 RF on time limit** is issued. This command is accepted only when host port control mode is active. Send 2 data bytes, least significant byte first: • Acceptable values are for the time limit are 0 – 3600 seconds. A value of 0 deactivates this function. Read back with command **243**.	2	1 (CSR only)
11 **select active target**	Select one of four target lifetime counters to activate. These counters integrate power and time while the RF output is on. When sending commands through a **PROFIBUS** interface, use this command first to select the target, then use command **12** to specify the target life. This command is accepted only when host port control mode is active. Send one data byte. • Accepts a value of 0 to 4. If 0 is selected, then no target life timer will count. Read back with command **156**.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
12 **set target life** AE Bus and Ethernet version. See next row for Profibus version of command	Sets the target life in hundredths of kilowatt hours for one of four targets. The selected target lifetime counter is also reset to zero. When an enabled target lifetime counter exceeds its target life a warning status bit will be set. This command is accepted only when host port control mode is active. Send five data bytes, least significant byte first. • Byte 0 = The target number. Acceptable values are 1 to 4. • Bytes 1 through 4 = The target life in hundredths of kWh (for example, 100 = 1 kWh). Acceptable values are 1 to 2160000. Read back with command **157**.	5	1 (CSR only)
12 **set target life** Profibus version. See previous row for AE Bus/ Ethernet version of command	Sets the target life, in hundredths of kilowatt hours, of the currently active target (see command **11**). The selected target lifetime counter is also reset to zero. When an enabled target lifetime counter exceeds its target life a warning status bit will be set. This command is accepted only when host port control mode is active. Send three data bytes, least significant byte first. • Bytes 0 to 2 = The target life in hundredths of kWh (for example, 100 = 1 kWh). Acceptable values are 1 to 2160000. Read back with command **157**.	3	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
13 **set match network control**	Sets the tuner control if the Cesar generator is connected to a VarioMatch or Navio matching network through the **Matching** interface. Sets the match network control mode if a match network is connected and powered on. Tune mode **Automatic with initialization** uses the last commanded capacitor position as an initial preset position when RF power is commanded off. It returns a CSR of **53** if a match network is not connected or not powered on. The match network must be connected through the **Matching** interface connector, and must be either a VarioMatch, Navio, or other match network that is electrically and functionally compatible. This command is accepted only when host port control mode is active. Send one data byte: • 0 = Manual • 1 = Automatic • 2 = Automatic with initialization Read back with command **163**.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
14 **select active control mode**	Sets the generator's active control mode. This command is accepted in host port, **User Port**, and front panel control modes. Send one data byte: • 2 = Host port (serial) control • 4 = **User Port** (analog) control • 6 = Front panel (local) control Changing between control modes 2, 4, and 6 while the RF output is on will force the RF output off before changing the mode. Valid modes that affect front panel operational control are: • 10 = Reset front panel display and control to normal operation if in modes 11, 12, or 13 • 11 = Disable front panel program menu and presets • 12 = Disable all front panel functions except the **Display** soft key • 13 = Disable all front panel functions Valid modes that affect front panel display content are: • 20 = Reset front panel display to normal operation if in modes 22 or 23 • 22 = Set front panel display to show only `Ready`, `Active`, or `Error` • 23 = Turn off front panel display (shows … in display lower right corner) For additional information on how to use command **14**, see "Activating Host Port Remote Control (AE Bus Command **14**)" on page 4-50. Read back with command **155**.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
19 **set number of recipe steps**	Sets the number of recipe steps when creating a power ramping recipe. It is the first in a sequence of commands used to program a recipe. The initial set point that precedes step 1 is always 0. The final set point that follows the last step is always 0. Each recipe step consists of three components, which can be set in any order: • A set point (use command **21**) • A ramp time—applies to the set point change in a recipe step (use command **22**) • A run time—applies after the set point is reached and the next recipe step (use command **23**) The full sequence of steps to set up a recipe: 1. Send command **19** to specify the number of steps. 2. For each step, set up recipe parameters with commands **21**, **22**, and **23**. Once all recipe parameters are programmed, recipe construction is complete and the RF output may be turned on. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send one data byte, representing the desired number of recipe steps: • Accepts a value of 0 through 2 • 0 disables power ramping and RF-On ramping functions. See "Controlling RF On With AE Bus Commands" on page 4-85 for a discussion of the three methods to control RF on. There is no read back command for the current setting.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
21 **recipe step/ ramp time**	Sets the ramp time for a given recipe step. You must first set the number of recipe steps with command **19**. See command **19** for a discussion of recipes and their construction. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send three data bytes, least significant byte first: • Byte 1 = Recipe step number (1 to 2) • Bytes 2 and 3 = Ramp time value in tenths of a second. Send a value from 0 to 36000 (36000 = one hour) Read back with command **191**.	3	1 (CSR only)
22 **recipe step/set point**	Sets the set point for a given recipe step. You must first set the number of recipe steps with command **19**. See command **19** for a discussion of recipes and their construction. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send three data bytes, least significant byte first. • Byte 1 = Recipe step number (1 to 2) • Bytes 2 and 3, least significant byte first = Set point value in watts or volts: ◦ Watts, if in forward or delivered power regulation modes. Accepts a value of 0 to the unit's maximum RF output power or the user power limit. ◦ Volts, if in external (DC Bias) regulation mode. Accepts a value of 0 to maximum external feedback value. Read back with command **188**.	3	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
23 **set recipe step/ run time**	Sets the run time for a specified recipe step. You must first set the number of recipe steps with command **19**. See command **19** for a discussion of recipes and their construction. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send three data bytes, least significant byte first. • Byte 1 = Recipe step number (1 to 2) • Bytes 2 and 3 = Run time in tenths of a second. Send a value from 0 to 36000 (36000 = one hour) Read back with command **188**.	3	1 (CSR only)
24 **save presets**	Saves the current settings of the generator (everything except device configuration, arc information, and target life settings) to EEPROM as a numbered preset. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send 1 data byte: • Acceptable values for the preset number are 1 to 5.	1	1 (CSR only)
25 **restore presets**	Restores the numbered preset to the current operational state of the generator. This command is accepted only when host port control mode is active. It is not accepted when the RF output is turned on. Send 1 data byte: • Acceptable values for the preset number are 1 to 5.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
27 **set pulsing configuration**	Controls the pulsing configuration. The pulsing mode may be changed while the RF output is turned on. Mode 1 selects the internal pulse function established by commands **93** and **96**. Modes 2 through 5 utilize the **User Port** blanking/pulsing input to control the pulsing function. Modes 4 and 5 gate the internally generated pulse function established by commands **93** and **96**. This command is accepted only when host port control mode is active. Send one data byte to set the pulsing mode. • 0 = Pulsing off • 1 = Internal pulsing • 2 = External pulsing (Hi = RF on; Low = RF off) • 3 = External pulsing inverted (Hi = RF off; Low = RF on) • 4 = Gated internal pulsing (Hi = CW; Low = Pulse) • 5 = Gated internal pulsing inverted (Hi = Pulse; Low = CW) Read back with command **177**.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
29 **set remote control override**	Sets the front panel and **User Port** override controls. Each bit of the mask enables partial front panel or **User Port** control of that function. This command is accepted only when host port control mode is active. The remote control override can be changed while the RF output is turned on. Send one data byte to define overrides: • Bit 0 = Enable front panel RF on/off buttons • Bit 1 = Enable front panel Rotating knob • Bit 2 = Enable front panel **Matching** keys • Bit 3 = Enable setting RF on/off from the **User Port** • Bit 4 = Enable setting RF power set point from the **User Port** To set remote control overrides, use the values in Table 4-22 on page 4-86. For a description of how the overrides interact, see "Setting and Disabling Remote Control Override" on page 5-36. There is no read back command for this setting.	1	1 (CSR only)
30 **set user port scaling**	Sets **User Port** (analog) voltage scaling. This command is accepted only when host port control mode is active. Send one data byte: • The value specified is divided internally by 2 giving 0.5 volt granularity. • Acceptable values for the **User Port** scaling parameter are 4 to 40 (2 to 20 V). Read back with command **158**.	1	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
31 **set RF-on/off ramping rise time**	Sets ramping rise time. Setting the ramp rise time to zero turns off the ramping function and subsequent command **151 report RF-on ramping parameters** will return 0 for both rise and fall times. The ramp rise time can be set while the RF output is on, however the ramp rise time is not allowed to change during a ramp (rise or fall) that is currently in progress. This command is accepted only when host port control mode is active. Send two data bytes, least significant byte first: • Ramp rise time in tenths of seconds. • Acceptable values for the ramp rise time parameter are 0 to 2400 tenths of seconds (4 minutes). See "Controlling RF On With AE Bus Commands" on page 4-85 for a discussion of the three methods to control RF on. Read back with command **151**.	2	1 (CSR only)
32 **set RF-on/off ramping fall time**	Sets ramping fall time. Setting the ramp fall time to zero turns off the entire ramping function and subsequent command **151 report RF-on/off ramping parameters** will return 0 for both rise and fall times. The ramp fall time can be set while the RF output is on, however the ramp fall time is not allowed to change during a ramp (rise or fall) that is currently in progress. This command is accepted only when host port control mode is active. Send two data bytes, least significant byte first: • Ramp fall time in tenths of seconds. • Acceptable values for the ramp fall time parameter are 0 to 2400 tenths of seconds (4 minutes). See "Controlling RF On With AE Bus Commands" on page 4-85 for a discussion of the three methods to control RF on. Read back with command **151**.	2	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
33 **set reflected power parameters**	Sets reflected power limit parameters. The reflected power limit parameters can be changed while the RF output is on. This command is accepted only when host port control mode is active. Send three data bytes, least significant byte first. • Byte 1 = The number of seconds (after reaching the limit set by bytes 2 and 3) until RF is turned off. ◦ Accepts a value of 0 s to 200 s • Bytes 2 and 3 = Power limit trigger in W. ◦ Acceptable values are 1 to the lesser of the value set by command **5 set reflected power limit** or the product of the unit's maximum RF output power and the reflected power factor, both of which are set at the factory. Setting the time limit and power limit trigger value to 0 disables this function. Read back with command **152**.	3	1 (CSR only)
36 **set arc suppression parameters**	Sets arc suppression parameters. For each parameter you want to set, send this command with the parameter selection and appropriate value. This command is accepted only when host port control mode is active. If pulsing is enabled (see command **27 set pulsing configuration**), then arc management is disabled and this command is ignored. • Byte 0 (8-bit value) = arc suppression parameter selection ◦ 0 = Arc suppression time This is the amount of time in µs that the RF output is turned off when an arc is first detected. If the arc is not quenched on the first attempt, the suppression time is doubled on each subsequent attempt until the arc is extinguished, or the maximum number of attempts has been reached.	3	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Valid values = 5 µs to 500 µs. 0 disables the arc suppression, but leaves the arc detection enabled. Default = 20 µs ◦ 1 = Initial delay time This parameter specifies the amount of time in ms that must elapse before enabling the arc suppression after RF power is first turned on. The arc counter is also disabled during this time. Valid values = 10 ms to 5000 ms. Default = 20 ms ◦ 2 = Set point delay time Arc suppression is temporarily disabled any time a new set point is received that results in a greater than 2% difference from the previous set point. This parameter specifies the amount of time in ms that must elapse before re-enabling the arc suppression after a significant set point change. The arc counter is also disabled during this time. Valid values = 10 ms to 5000 ms. Default = 20 ms ◦ 3 = Number of attempts. The number of times arc suppression will attempt to quench an arc before terminating the arc suppression. If the maximum number of attempts is reached, arc suppression will become disabled and the RF output will be set to the off state. When the RF output is turned off, the arc suppression fault (**E18 Arc suppression fault**) is issued to indicate the reason for turning off. Valid values = 0 to 100 attempts. 0 = infinite attempts. Default = 10 ◦ 9 = Clear arc counter		

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	This parameter clears the arc counter to zero and can be issued at any time. The arc counter is automatically cleared when a turn RF output on command is received. There is no parameter value to send. • Bytes 1 and 2 (16-bit value) = Arc suppression parameter value (LSB first). Read back with command **199**.		
69 **set serial port baud rate** This command is for AE Bus only. Do not use with PROFIBUS and Ethernet.	Sets the serial port baud rate. This command is accepted only when host port control mode is active. Send three data bytes • Byte 1 is only for compatibility and is ignored • Bytes 2 and 3 set the baud rate (send least significant byte first). Valid baud rates are: ◦ 9600 ◦ 19200 ◦ 38400 ◦ 57600 ◦ 115,200 (for 115200, send 0) Read back with command **212**.	3	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
84 **set arc suppression potentiometer sensitivity values**	Sets the arc suppression potentiometer sensitivity values. This command is accepted only when host port control mode is active. • Byte 0 (8-bit value) = Offset. Range is 0 through 255. This value is added to the base calibration value for each channel. If the sum exceeds 255, the result is truncated to 255. Default = 0. • Byte 1 (8-bit value) = potentiometer device number ◦ 4 = Device 1 (digital potentiometer 1) ◦ 5 = Device 2 (digital potentiometer 2) • Byte 2 = potentiometer channels ◦ When byte 1 = 4 (Device 1): ▪ 0 = potentiometer channel 0 (upper limit offset) ▪ 1 = potentiometer channel 1 (upper limit gain) ▪ 2 = potentiometer channel 2 (lower limit offset) ▪ 3 = potentiometer channel 3 (lower limit gain) ◦ When byte 1 = 5 (Device 2): ▪ 0 = potentiometer channel 0 (reserved) No other values are valid.	3	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
93 **set pulsing frequency**	Sets the RF pulsing frequency. Any combination of pulsing frequency and duty cycle that results in an RF output on time of less than 16 µs is invalid and will return a CSR error code. See command **96** for a discussion of frequency and duty cycle combinations. This command is accepted only when host port control mode is active. Send four data bytes, least significant byte first, representing the pulsing frequency in Hz. • Accepts a value from 1 Hz to the maximum RF pulse frequency in Hz. For the range, see the RF pulse frequency specification in the Specification chapter. For backward compatibility and for PROFIBUS, this command accepts 3 data bytes and it sets the fourth byte to zero. Read back with command **193**.	3 or 4	1 (CSR only)
96 **set pulsing duty cycle**	Sets the RF pulsing duty ON time in increments of 1%. This command is accepted only when host port control mode is active. Send two data bytes: • 1 to 99 (in percent), which represents the RF output ON time. The minimum duty cycle for a given pulsing frequency can be determined by the expression: `MinimumDuty = (PulseDelay + 3.6) * PulseFrequency * 0.000001` (where *PulseDelay* is factory configured). Any combination of pulsing frequency and duty cycle that results in an RF output on time of less than 16 µs is invalid and will return a CSR error code. Read back with command **196**.	2	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
111 **initialize capacitors**	Moves load and tune capacitors of a connected VarioMatch or Navio matching network to the factory set minimum position. This command will not work with other matching networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector. The command returns a CSR of **53** if a match network is not connected or not powered on. This command is accepted only when host port control mode is active. Send the command with no data bytes.	0	1 (CSR only)
112 **move load capacitor position**	Moves the load capacitor motor of a connected VarioMatch or Navio matching network to the specified percentage position. This command will not work with other matching networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector. The command returns a CSR of **53** if a match network is not connected or not powered on. This command is accepted only when host port control mode is active. Send two data bytes (LSB first) to specify the load position in tenths of a %. • Acceptable values for the load position must be within the factory set range set (typically 40 – 960). Read back with command **175**.	2	1 (CSR only)
119 **explicit PROFIBUS fault clear** This command is for PROFIBUS only. Do not use with AE Bus and Ethernet.	Clears **PROFIBUS** fault and error code register. Send one data byte.	0	1 (CSR only)

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
122 **move tune cap position**	Moves the tune capacitor motor of a connected VarioMatch or Navio matching network to a specified percentage position. This command will not work with other matching networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector. The command returns a CSR of **53** if a match network is not connected or not powered on. This command is accepted only when host port control mode is active. Send two data bytes (LSB first) to move the series motor to its new position. • Tune position in tenths of a %. Acceptable values are the range set at the factory (typically 40 to 960) Read back with command **175**.	2	1 (CSR only)
128 **report power supply type**	Reports the generator type; returns 5 ASCII characters (for example, `CESAR`).	0	5
129 **report model number**	Reports the model number of the generator. The returning packet contains 5 ASCII characters. The model number indicates the RF frequency and the output capacity.	0	5
130 **report software part number**	This command returns a non-terminated ASCII string that represents the specified AE software part number. The returning packet contains 5 ASCII characters.(for example, C3STD). Use this command in conjunction with command **198** to fully identify the software in the unit.	0	5

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
131 **report match network motor movement**	Reports the VarioMatch or Navio match network motor movement when the generator is connected to the match network through the **Matching** interface. This command will not work with other matching networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector. Returns one data byte indicating motor movement status: • 0 = Match network's motors stopped • 1 = Match network's motors running	0	1
151 **report RF-on/ off ramping parameters**	Report RF on and off ramping rise and fall times. Returns four data bytes, least significant byte first: • Bytes 0 and 1 = ramp up time in tenths of a second • Bytes 2 and 3 = ramp down time in tenths of a second If either ramp rise time (command **31**) or ramp fall time (command **32**) are set to 0, then this command will return 0 for both rise and fall times. Set with commands **31** and **32**.	0	4
152 **report reflected power parameters**	Reports reflected power limit parameters. Returns three data bytes, least significant byte first: • Byte 0 = Time limit in seconds until RF is turned off • Bytes 1 and 2 = Power limit trigger Set with command **33**. See command **33** for a discussion of these values.	0	3

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
154 **report regulation mode**	Reports the active regulation mode of the unit. Returns one data byte representing the regulation mode: • 6 = Forward power ($P_{forward}$) • 7 = Load power (P_{real}) • 8 = External power (DC Bias) Set with command **3**.	0	1
155 **report active control mode**	Reports the current control mode of the unit. Returns one data byte representing the control mode: • 2 = Host port (serial) • 4 = **User Port** (analog) • 6 = Front panel (local control) Set control mode with command **14**.	0	1
156 **report active target**	Reports the number of the active target lifetime counter. Returns one data byte indicating the active target selected. Set with command **11**.	0	1
157 **report target life**	Reports the amount of life remaining in the target you specify. Send one data byte, representing the desired target number (1 to 4). Returns 4 data bytes indicating the target life in hundredths of kilowatt hours (for example, 100 = 1 kWh). Set with command **12**.	1	4
158 **report User Port scaling**	Reports **User Port** (analog) voltage scaling. Returns 1 data byte: • Byte 0 = **User Port** scaling in volts Set with command **30**.	0	1
162 **report process status**	Reports process status. When fault present status bits are set, one or more active or latched faults currently exist within the unit. To get a list of active faults, send command **223 report fault status register**. The controller returns the packet described as below.	0	4

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Byte 0 (bit flags): • 0 = Reserved • 1 = Unassigned • 2 = Recipe run is active • 3 = Reserved • 4 = Reserved • 5 = Output power (0 = Off, 1 = On) • 6 = RF on requested (0 = Off, 1 = On) • 7 = Set point tolerance ◦ 0 = Within tolerance (RF is on and there is no overload condition) ◦ 1 = Out of tolerance (any type of overload is active or if RF is off) Byte 1 (bit flags): • 0 = End of target life • 1 and 2 = Reserved • 3 = Overtemperature fault in power amplifier (PA) or switch mode power supply (SMPS) • 4 and 5 = Reserved • 6 = Unassigned • 7 = Interlock (0 = interlock closed, 1 = interlock open) Byte 2 = Bits 0 through 7, reserved. Byte 4 (bit flags): • 0 = DC current limit warning • 1 = Reserved • 2 = PROFIBUS error • 3 and 4 = Reserved • 5 = Fault present (0 = no faults, 1 = faults exist) • 6 = Reserved		

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	• 7 = CEX is locked (0 = CEX is unlocked, 1 = CEX is locked)		
163 **report match network control mode**	Reports match network control mode when the generator is connected to a VarioMatch or Navio match network through the **Matching** interface. This command will not work with other match networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector. If a match network is not connected or powered on, this command reports the last successful control mode set. Returns one data byte: • 0 = Manual control • 1 = Automatic control • 2 = Automatic with initialization Set with command **13**.	0	1
164 **report set point and regulation mode**	Reports the set point value in W when operating in power regulation modes or in V when operating in external (DC Bias) regulation mode. The command also returns the active regulation mode. See commands **8** and **3** for a discussion of these values. Returns three data bytes: • Bytes 0 and 1 = Set point value in W or V • Byte 2 = Regulation mode: ◦ 6 = Forward power ($P_{forward}$) ◦ 7 = Load power (P_{real}) ◦ 8 = External power (DC Bias)	0	3
165 **report forward power**	Reports the current forward power. The controller returns two data bytes representing the forward power in W (LSB first).	0	2
166 **report reflected power**	Reports the current reflected power level. The controller returns two data bytes representing the reflected power in W (LSB first).	0	2

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
167 **report delivered power**	Reports current delivered power. The controller returns two data bytes representing the delivered power in W (LSB first).	0	2
168 **report external feedback (DC Bias)**	This command reports the current external feedback value as measured at the DC Bias input on the user card or the DC Bias as measured through an attached match network. The controller returns two data bytes representing the external feedback in V (LSB first).	0	2
169 **report forward power limit**	Reports forward power limit. The controller returns two data bytes representing the user forward power limit in W. Set with command **4**.	0	2
170 **report reflected power limit**	Reports reflected power limit. The controller returns two data bytes representing the reflected power limit in W. Set with command **5**.	0	2
175 **report capacitor positions**	Reports current load and tune capacitor positions. This command returns valid data only if a match networks connected and turned on. Returns four data bytes, least significant byte first: • Bytes 0 and 1 = current load position in tenths of a % (0 to 1000) • Bytes 2 and 3 = current series position in tenths of a % (0 to 1000) Set with commands **112** and **122** or by using the automatic tune process.	0	4

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
177 **report pulsing configuration**	Reports pulsing configuration settings. Returns one data byte. • 0 = Pulsing off • 1 = Internal pulsing • 2 = External pulsing (Hi = RF on; Low = RF off) • 3 = External pulsing inverted (Hi = RF off; Low = RF on) • 4 = Gated internal pulsing (Hi = CW; Low = Pulse) • 5 = Gated internal pulsing inverted (Hi = Pulse; Low = CW) Set with command **27**.	0	1
188 **report recipe step, set point, and run time**	Reports the set point and run time for the selected recipe step. Send one byte to select the desired recipe step. Returns four data bytes, least significant byte first: • Bytes 0 and 1 = Recipe step set point in W • Bytes 2 and 3 = Recipe step run time in tenths of seconds Set with commands **22** and **23**.	1	4
191 **report recipe step / ramp time**	Reports the ramp time for the selected recipe step. Send one byte to select the desired recipe step. Returns two data bytes, least significant byte first: • Bytes 0 and 1 = Recipe step ramp time in tenths of seconds Set with command **21**.	1	4
193 **report pulsing frequency**	Reports the RF pulsing frequency. Returns four data bytes, least significant byte first, representing the pulse frequency in Hz. Set with command **93**.	0	4

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
196 **report pulsing duty cycle**	Reports RF pulsing duty cycle in percent of on-time per cycle. The controller returns two data bytes, least significant byte first, representing the duty cycle in the percent of on-time per cycle. Set with command **96**.	0	2
198 **report software revision level**	Reports the revision level of the software. Returns 4 data bytes, least significant byte first, representing the software revision as an ASCII string. The format is *mmnn*, where *mm* is the major revision number and *nn* is the minor revision number (for example, software revision 1.22 would return 0122) Use in conjunction with command **130** to obtain the version/revision of the software.	0	4
199 **report arc events and potentiometer sensitivity**	Reports values for the selected arc data or potentiometer sensitivity value. Send 1 data byte (8-bit value) indicating the desired arc suppression parameter. The parameters that are stored in non-volatile memory (NV) are indicated below. • Byte 0: ◦ 1 = Arc events per run ◦ 2 = Arc events per second ◦ 3 = Arc suppression time (NV) ◦ 4 = Reserved ◦ 5 = Reserved ◦ 6 = Digital potentiometer 1 sensitivities values (NV) ◦ 7 = Digital potentiometer 2 sensitivity values (NV) ◦ 8 = Initial delay time in ms (NV) ◦ 9 = Set point delay time in ms (NV) ◦ 10 = Number of attempts before failing (NV)	1	4

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	Returns 4 data bytes, least significant byte first. The interpretation of the data returned depends on the value sent in byte 0: • Arc events per run (send value = 1): ◦ Bytes 0 through 3 (32-bit value) = The number of arc events during the current RF ON cycle. An RF On command resets the arc counter to zero (0). • Arc events per second (send value = 2): ◦ Bytes 0 through 3 (32-bit value) = The number of arc arcs that have occurred in the previous full second of operation. • Arc suppression time (send value = 3): ◦ Bytes 0 through 3 (32-bit value) = The amount of time in µs the RF output is turned off when an arc is first detected. See command **36** for a discussion of this value. • Digital potentiometer 1 sensitivity values (send value = 6): ◦ Byte 0 (8-bit value) = Potentiometer Channel 0 (upper limit offset) ◦ Byte 1 (8-bit value) = Potentiometer Channel 1 (upper limit gain) ◦ Byte 2 (8-bit value) = Potentiometer Channel 2 (lower limit offset) ◦ Byte 3 (8-bit value) = Potentiometer Channel 3 (lower limit gain) The offset and gain values control the sensitivity of the arc detection circuit. These values are set using command **84** or the diagnostic tool. • Digital potentiometer 2 sensitivity values (send value = 7): ◦ Byte 0 (8-bit value) = upper limit offset ◦ Byte 1 (8-bit value) = (reserved)		

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
	◦ Byte 2 (8-bit value) = (reserved) ◦ Byte 3 (8-bit value) = (reserved) • Initial delay time (ssend value = 8): ◦ Bytes 0 through 3 (32-bit value) = The initial delay time in ms. This is the amount of time in ms that must elapse before enabling the arc suppression after RF power is first turned on. See command **36** for a discussion of this value. • Set point delay (send value = 9): ◦ Bytes 0 through 3 (32-bit value) = The set point delay time in ms. The arc algorithm is temporarily disabled any time a new set point is received which results in a greater than 2% difference from the previous set point. See command **36** for a discussion of this value. • Number of attempts (send value = 10): ◦ Bytes 0 through 3 (32-bit value) = The number of times the arc suppression will attempt to quench an arc before terminating the arc suppression. See command **36** for a discussion of this value. Set these values with commands **36** and **84**.		
205 **report unit run time**	Reports the total time in seconds that the generator was producing output power. This number is incremented each second while RF power is turned on. The controller returns four data bytes, least significant byte first, representing unit run time.	0	4

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
212 **report serial port address and baud rate** This command is for AE Bus only. Do not use with PROFIBUS and Ethernet.	Returns the serial port address and baud rate. Returns three data bytes: • Byte 0 = AE bus address (always 1) • Bytes 1 and 2 = Baud rate ◦ 9600 ◦ 19,200 ◦ 38,400 ◦ 57,600 ◦ 115,200 (for 115200, the return value is 0) Set with command **69**.	0	3

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
223 **report fault status register**	Reports the current fault status register value. Sending command **1** will clear this register. but will not clear any faults that are currently active. The following fault status bits are reported: • Byte 0: ◦ 0 = Interlock loop open ◦ 1 = SMPS temperature too high ◦ 2 = RF generator temperature too high ◦ 3 = Chill plate humidity too high ◦ 4 = RF power section failure ◦ 5 = A/D-Conversion failure ◦ 6 = Reserved ◦ 7 = Reserved • Byte 1: ◦ 0 = Arc suppression fault ◦ 1 = External pulse too short ◦ 2 = RF on time exceeded ◦ 3 through 5 = Reserved ◦ 6 = Software error (invalid switch case value) ◦ 7 = Reserved • Bytes 2 and 3: All bits are unassigned.	0	4
230 **report condensation sensor data**	Returns sensor data: • Bytes 0 and 1 = Reserved • Bytes 2 and 3 = Condensation sensor data, which is a humidity reading in analog to digital converter (ADC) counts.	0	4
231 **report unit serial number**	The controller returns four data bytes representing the unit's serial number (LSB first). Bytes 0 through 3 = Unsigned long integer	0	3

Table 4-21. AE Bus Commands (Continued)

Command	Description	Data Bytes Sent	Data Bytes Returned
243 **report RF on time limit**	Reports the RF on time limit. Returns two data bytes, least significant byte first. This value is in seconds and ranges from 0 to 3600. A value of zero indicates the function is disabled. Set with command **10**.	0	2

Controlling RF On With AE Bus Commands

There are three methods to control RF on with AE Bus commands:

- No recipe control: Commands **1** and **2**. These commands turn RF on and off if you do not have a recipe defined. If you have a recipe defined, see the description below.
- Power ramping recipe: Commands **19**, **21**, **23**, **23**
- RF-on slew rate ramping: Commands **31**, **32**

The behavior of commands **1** and **2** depends on which recipe is active:

- No recipe active: Turns RF on or off immediately.
- Power ramping recipe:
  - Command **2**: Executes the recipe.
  - Command **1**: If issued while a power ramping recipe is in progress, the RF output is shut off immediately and the recipe is suspended. A subsequent command **2 turn output on** command will resume the recipe execution.
- RF-on/off slew rate ramping:
  - Command **2**: Executes the recipe.
  - Command **1**: If issued when no recipe is in progress, this start the RF output off ramp. If issued while RF-on/off slew rate ramping is in progress, the RF output is shut off immediately.

Power ramping and RF-on slew rate ramping methods are mutually exclusive. If you program a power ramping recipe, then RF-on slew rate is disabled. If you set RF-on slew rate, then power ramping is disabled. If either power ramping or RF-on slew rate is enabled, and you send command **19**, **31**, or **32** with a value of 0, then both are disabled.

Remote Control Override Settings (Command 29)

Table 4-22. Remote control override settings (command 29)

Value	RF on/off			RF power set point			Matching	
	Remote	RF on/ off keys	User Port	Remote	Rot knob	User Port	Remote	Matchin g keys
0	x			x			x	
1		x		x			x	
2	x				x		x	
3		x			x		x	
4	x			x				x
5		x		x				x
6	x				x			x
7		x			x			x
8			x	x			x	
10			x		x		x	
12			x	x				x
14			x		x			x
16	x					x	x	
17		x				x	x	
20	x					x		x
21		x				x		x
24			x			x	x	
28			x			x		x

Installation, Setup, and Operation

PREPARING TO INSTALL THE UNIT

Spacing Requirements

The Cesar generator is designed for 19″ racks but may be used alternatively as a desktop model. Regardless, you must ensure proper air flow:

- 6 cm (2.4″) required on the left and right sides for airflow
- 10.16 cm (4″) required at rear for cable connections

Additional space for connectors and cabling can be necessary. Also, allow adequate space for anyone who may need to access the front and rear panels.

DANGER:

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

Dimensional Drawings

The following figure shows Cesar unit dimensions. Your unit may look slightly different from the drawing.

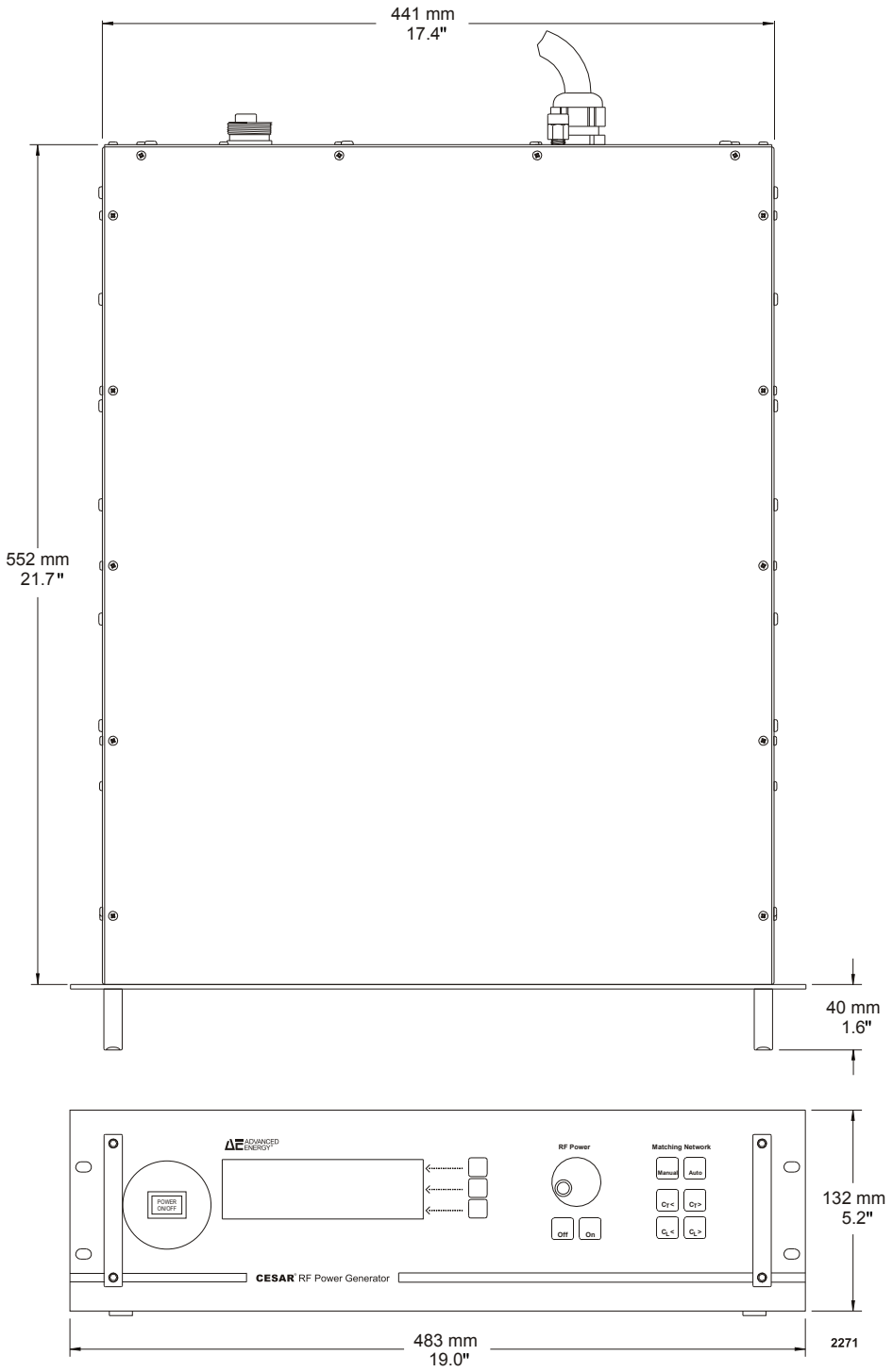


Figure 5-1. Cesar unit dimensions

The following rear panel drawing is representative. The actual rear panel of your unit may have a slightly different configuration than what is shown in the drawing.

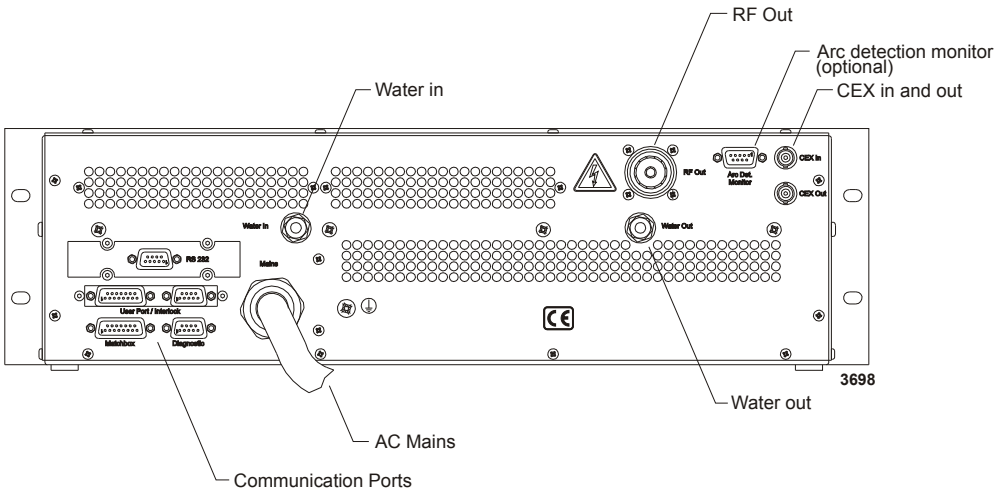


Figure 5-2. Cesar rear view

Installation Requirements

Install this unit according to the following requirements.

DANGER:

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

WARNING:

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.

CAUTION:

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

Tools Required for Installation

AE supplies the following equipment:

- The Cesar generator

- An AC Mains cable (depending on your unit, this may not be included with the product)

For successful installation, you will need to supply the following additional equipment:

- 19″ rack or stable mounting surface
- 4 mounting screws (if you are rack-mounting the unit) and an appropriate screwdriver
- A match network (if you are using the generator with a match network). The Cesar generator is compatible with a VarioMatch, Navio, or a match network with the same control functions and electronic topology.
- Water in and out hose and/or connectors
- Cables
  - Grounding cable
  - Shielded coaxial cable for RF output
  - All communication interface cables for the interfaces available on the unit
  - Interlock interface cable
  - CEX in and out cables (if you are using CEX circuitry)
  - RC control cable (if you are connecting a match network)

Unpacking the Unit

☞ **Important**

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

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

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

LIFTING THE UNIT

⚠ **CAUTION:**

The modules are heavy. Use two people to lift the module.

To Lift the Unit:

- Lift the unit by holding on to the two handles on the front of the unit while also supporting the rear of the unit.

INSTALLING THE UNIT

Mounting

The Cesar generator is designed to be built into 19″ racks. However, the unit's compact outline dimensions also allow you to use the generator as a single desktop model.

TO MOUNT THE CESAR GENERATOR:

1. Select a position that ensures proper and unlimited airflow from both sides of the generator to the rear panel:
   - 6 cm (2.4″) required on the left and right sides for airflow
   - 10.16 cm (4″) required at rear for cable connections

   CAUTION:
   Never integrate the Cesar unit into a 19″ rack or any other outer cabinet in a way that may either reduce or interrupt a proper airstream.
2. Ensure you can meet all water cooling requirements.
3. Secure the unit in place using the four front-panel mounting holes and four screws.

Grounding

WARNING:
Do not attempt to turn on power until the chassis of the unit is tied to a local earth ground through a copper grounding strap that is sized in accordance with applicable requirements.

- Connect the ground terminal at the rear panel of the generator with the nearest PE ground (usually the 19″ rack).

  Use a proper grounding cable that meets your national standards and has a cross-sectional area of at least 4 mm^2. Proper operation requires that you use a central, common ground for the generator, matching network, and load.

Connecting Cooling Water

WARNING:

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.

The Cesar generator water cooling system does not include water solenoid, water flow meter, or humidity sensor. You must take external measures to protect the unit and the environment.

The **Water In** and **Water Out** connectors are located on the rear panel of the generator, and are one of the following:

- Stainless steel hose connectors. They include sleeve nuts for plastic hoses with 8 mm ID (inner diameter) and 10 mm OD (outer diameter). On request, 3/8″ adapter fittings (3/8″ BSP thread) can be mounted.

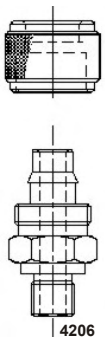


Figure 5-3. Water fitting for plastic hose with 8 mm ID and 10 mm OD

- Stainless steel RECTUS™ quick-connect hose connectors.

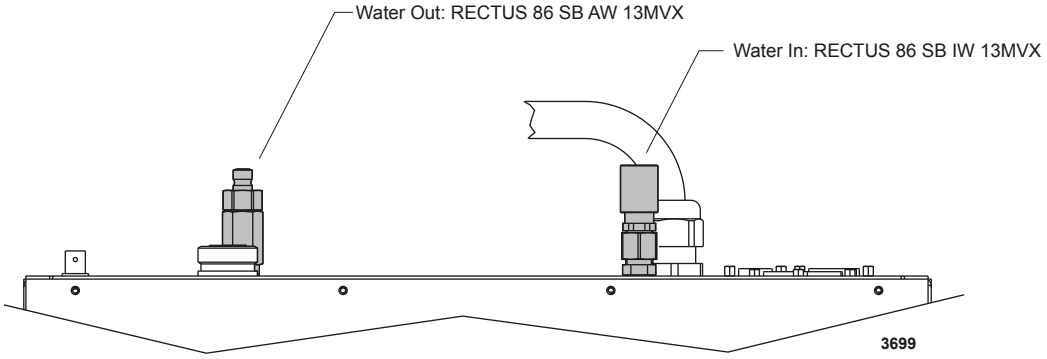


Figure 5-4. Water connector for RECTUS quick-connect fitting

TO CONNECT COOLING WATER:

1. Install a source of water to the **Water In** connector.
2. Install a source of water out to the **Water Out** connector.
3. Ensure that the water flow and pressure meet the cooling specifications.
4. Leak test the connections.

Connecting Output Power

WARNING:

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

DANGER:

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

The following figure provides a basic example drawing of an RF output connector. For all options of RF output connectors, the center pin provides the RF output connection, while the outer cable provides a ground connection.

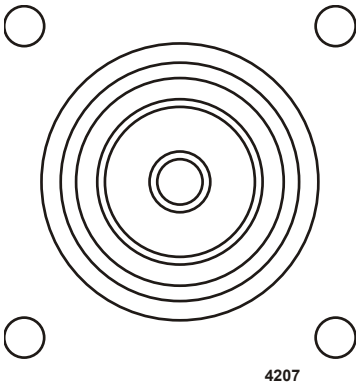


Figure 5-5. RF Output connector—7/16

TO CONNECT RF OUTPUT POWER

1. Connect one end of a shielded coaxial cable of 50 Ω impedance to the **RF Out** connector.

   For information on optimum cable length, contact AE Global Services.

2. Connect the other end of the RF cable to the input of the load or match network.

   The match network connector is labeled:

- **RF Generator** on the VarioMatch match network
- **Analog I/O** on the Navio match network

Connecting Communication Interfaces

The communication interfaces that you use will depend on how you want to communicate with the Cesar generator and which interface options you have. The unit provides several communication interface options that allow you to control the unit remotely:

- **User Port**: 25-pin or 15-pin
- Host port: **PROFIBUS**, **Ethernet**, or **RS-232**

Note: Even if you are not using the **User Port** for communication, some **User Port** circuits must be satisfied to operate the Cesar generator.

TO CONNECT THE COMMUNICATION INTERFACES

Make each interface connection. For specific information on the interface connections, including pin descriptions and communication protocols, see the communication sections in the user manual.

Connecting the Generator to a System Interlock Loop

For the Cesar generator to operate, you must satisfy the interlock requirements. How to satisfy the interlock depends on the type of user port you have.

SATISFYING THE INTERLOCK WITH A 25-PIN USER PORT

If you have a 25-pin **User Port**, must satisfy the **User Port** *INTERLOCK LOOP* signal to operate the generator. For information on the interlock interface, including pin descriptions, see the user port section in the user manual.

SATISFYING THE INTERLOCK WITH A 15-PIN USER PORT

Units with a 15-pin **User Port** also have an **Interlock** interface that allows you to connect the generator into a larger system interlock loop. For specific information on the **Interlock** interface, including pin descriptions, see the user port section in the user manual.

To connect the system interlock, connect the 9-pin **Interlock** connector to the associated socket at the rear panel.

Related Links

- “Satisfying Minimal Requirements for the 25-pin User Port” on page 4-5
- “Satisfying Minimal Requirements for the 15-pin User Port” on page 4-18

Connecting a VarioMatch or Navio Match Network (Optional)

If you want the Cesar generator to control a match network and/or to read the DC self-bias voltage, you must connect a matching unit. The generator is compatible with the VarioMatch match network, Navio match network, and other match networks with the same control functions and electronic topology.

> **CAUTION:**
> Improper connection of any existing external matching units to the Cesar unit could result in product or property damage.

TO CONNECT TO A MATCH NETWORK

1. Connect one end of a control interface cable to the generator's **Matching** interface.
2. Connect the other end of the cable to the match network's interface (labeled **Interface** on the VarioMatch match network, labeled **Analog I/O** on the Navio match network).

Connecting an Arc Detection Monitor (Optional)

If you want to use an oscilloscope to help determine how to set the arc suppression parameters, use the **Arc Det. Monitor** interface.

TO CONNECT AN ARC DETECTION MONITOR

1. Connect one end of the cable to the Cesar generator's **Arc Det. Monitor** interface.
2. Connect the other end of the cable to the oscilloscope.

Connecting Common Exciter (CEX) Circuitry (Optional)

Each Cesar generator provides two type BNC, female CEX connectors: **CEX In** and **CEX Out**. These connectors are located on the generator rear panel.

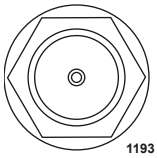


Figure 5-6. CEX Connector

The common exciter routes the RF clock signals among the various parts of the RF module, allowing you to lock the outputs of two or more Cesar generators. Locking

the generators together causes the generators to run at the same frequency and with a fixed phase relationship between their outputs. Therefore, multiple Cesar generators can be coupled into the same plasma.

☞ **Important**
In this type of operation, slight differences in output frequency or in the phase of the RF energy can create variations in frequency that may have adverse affects.

When a generator receives CEX input within the required specifications, it automatically frequency-locks to that signal.

TO MAKE THE CEX CONNECTIONS

- Connect the CEX output of the master generator or a common waveform generator to the CEX input of up to three slave units by using T-connectors for more than one slave.

☞ **Important**
The phase relationship between the RF power is affected by the length of the cable used to connect the units. The use of a defined CEX interconnect cable results in minimal phase shift. You can also use commercially available phase shifters in the interconnect path to provide additional control of phase shift.

Connecting AC Input (Mains) Power

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

⚠ **DANGER:**
Never connect the generator to the mains while the cabinet is open.

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

The Cesar generator's AC input (Mains) has an open mains cable that is permanently attached to the generator.

☞ **Important**
Not all models have a circuit breaker. If this device does not have a circuit breaker; you must install and operate it with a circuit breaker switch on the AC input. The circuit breaker switch must be easily accessible and near the device. The circuit breaker must be marked as the disconnecting device for the equipment.

TO CONNECT THE AC INPUT POWER

- Connect the Cesar generator to the power mains by connecting the AC Mains cord with your input power source.

☞ **Important**
The On/Off power switch does not completely disconnect the **Mains**.

☞ **Important**
You must install an external switch to completely disconnect **Mains**.

Connecting and Setting **Ethernet** (Modbus/TCP) Communication

Your Cesar generator may include an **Ethernet** port, which allows you to create a Modbus/TCP network connection to the unit.

This section provides information on connecting **Ethernet** communication and setting the IP configuration for your unit, which will allow you to connect to the unit through your network.

TO CONNECT FOR ETHERNET COMMUNICATION

- To connect for Ethernet communication, connect the Cesar generator **Ethernet** port to a network connection using a standard, straight-through network cable. The generator does not include this cable.

SETTING THE IP CONFIGURATION FOR ETHERNET COMMUNICATION

Your Cesar generator is shipped with the following default IP configuration:

- IP address: 192.168.111.111
- Netmask address: 255.255.255.0
- Gateway address: not set

Before using the system, you must reset the IP configuration to settings appropriate for your network.

Selecting an Appropriate IP Configuration

Selecting an appropriate IP configuration for your network can be difficult. Setting an address that already exists may cause serious network problems. Consult your network administrator for appropriate IP configuration settings.

Once you have identified an appropriate IP address, you can use the `ping` command in the Windows Command Prompt to make sure that the network address is not currently in use. If the address is free at the moment you send the `ping` command, the result will be `Request timed out.` For more information on using the `ping` command and the Command Prompt, see the Windows Help, available under the Windows **Start** button.

Changing the IP Configuration

The Cesar generator is designed for use in a BootP environment (that is, a BootP server is running on the LAN), which will automatically set the unit IP configuration. However, you can also reset the IP configuration settings in a non-BootP environment. The following procedures provide instructions for both situations.

To Change the IP Configuration With BootP

1. Configure your BootP server to recognize the Cesar generator MAC address (located on a sticker on the back of the unit, close to the **Ethernet** connector).
2. In the BootP server configuration, set an IP address for the generator that is appropriate for your network, and assign the MAC address of the generator to this IP address. Consult your network administrator to identify appropriate IP address settings.
3. Connect the generator to the network (this network should be routed to the BootP server) using a standard, straight-through network cable.
4. Power the generator on. In approximately 30 seconds, the generator will be visible to the BootP server and consequently your network (at the address specified in step 2).

To Change the IP Configuration Without BootP

If you are using the Modbus Cesar generator in a non-BootP environment, you need to change the IP configuration through the BootP server utility that is available from AE. For more information on using this software, see the online help system available when you launch the software.

FIRST TIME OPERATION

Before proceeding with first time operation, be sure you have satisfied the installation requirements and completed the installation procedures.

There are several ways in which you can operate Cesar generator. Refer to the section that describes how you intend to operate the generator:

Operating the Cesar Generator for the First Time With the User Port

There are two **User Port** options:

- 15-pin **User Port**
- 25-pin **User Port**

This section describes operating procedures for both **User Port** options.

TO OPERATE THE CESAR GENERATOR FOR THE FIRST TIME WITH THE 25-PIN USER PORT

1. If the generator is not connected to a system interlock loop, verify that there is external contact closure between **User Port** pins 10 and 23 (*INTERLOCK LOOP*).
2. Apply water and ensure the water is flowing at or above the specified minimum value.
3. Power on the system by pushing the front panel **POWER ON/OFF** button. The button will light when the unit is turned on.

   Some units will have an on/off switch instead of a button. Depending on the unit, turn the switch as follows:

   - Turn the front panel on/off switch clockwise until it points to 1.
   - Turn the front panel on/off switch clockwise until it is vertical.

   The initial front panel screen will display the Cesar generator model name, the operating frequency, the maximum RF power, and the software version. After five seconds, the display will change to a standard operation screen.
4. Listen to ensure the fans are rotating.
5. There are two ways to specify user port control:

   - On the front panel, set the **Control by** setting to **User Port**.
   - Set the host control mode by sending host port **active control mode** command **14**: 4 = User port control.

6. Verify that you have selected the desired power regulation. Use the following **User Port** pins:
   - Use pin 6 for RF forward power/ DC Bias regulation
   - Use pin 8 for RF forward/load power regulation
7. Apply the appropriate voltage to pin 5 (*SET POINT*).
8. Apply the appropriate voltage to pin 4 (*RF PWR ON*).
9. Check the load. If your load is a plasma:
   - Is the plasma lit? If not, you may have a faulty connector or too little input power (see the troubleshooting section).
   - Is the plasma stable (that is, is the plasma producing a constant glow)? If not, see the troubleshooting section
10. If you have a matching network connected and you are using automatic tune control:
    - Did the capacitors begin to move? If not, see the troubleshooting section.
11. Vary the chamber conditions according to your process requirements, and verify that the Cesar generator can cover the required load impedance range.

Congratulations, you have successfully installed and operated the Cesar generator.

TO OPERATE THE CESAR GENERATOR FOR THE FIRST TIME WITH THE 15-PIN USER PORT

1. If the generator is not connected to a system interlock loop, verify that there is external contact closure between **User Port** pins 1 and 2 *(INTERLOCK*).
2. Apply water and ensure the water is flowing at or above the specified minimum value.
3. Power on the system by pushing the front panel **POWER ON/OFF** button. The button will light when the unit is turned on.

   Some units will have an on/off switch instead of a button. Depending on the unit, turn the switch as follows:
   - Turn the front panel on/off switch clockwise until it points to 1.
   - Turn the front panel on/off switch clockwise until it is vertical.

   The initial front panel screen will display the Cesar generator model name, the operating frequency, the maximum RF power, and the software version. After five seconds, the display will change to a standard operation screen.
4. Listen to ensure the fans are rotating.
5. There are three ways to specify **User Port** control:
   - On the front panel, set the **Control by** setting to **User Port**.

- Set the host control mode by sending host port **active control mode** command **14**: 4 = **User Port** control.
- Set the operation mode. By activating one of these modes the generator automatically switches to **User Port** control.

6. Verify that you have selected the desired power regulation mode (**User Port** pins 1 and 2).
7. Apply the appropriate voltage to **User Port** pin 12 (*RF POWER SET POINT*).
8. Apply the appropriate voltage to **User Port** pin 10 (*RF PWR ON*).
9. Check the load. If your load is a plasma:
   - Is the plasma lit? If not, you may have a faulty connector or too little input power (see the troubleshooting section).
   - Is the plasma stable (that is, is the plasma producing a constant glow)? If not, see the troubleshooting section
10. If you have a matching network connected and you are using automatic tune control:
    - Did the capacitors begin to move? If not, see the troubleshooting section.
11. Vary the chamber conditions according to your process requirements, and verify that the Cesar generator can cover the required load impedance range.

Congratulations, you have successfully installed and operated the Cesar generator.

Operating the Cesar Generator for the First Time With the Host Port

There are three host port options: **Ethernet**, **RS-232**, and **PROFIBUS**. This section describes operating procedures for all host port options.

TO OPERATE THE CESAR GENERATOR FOR THE FIRST TIME WITH THE HOST PORT

1. If the generator is not connected to a system interlock loop, verify that the user port interlock signal is satisfied:
   - If you have a 25-pin **User Port**, verify that there is external contact closure between **User Port** pins 10 and 23 (*INTERLOCK LOOP*).
   - If you have a 15-pin **User Port**, verify that there is external contact closure between **Interlock** pins 1 and 2 (*INTERLOCK INPUT* and *INTERLOCK OUTPUT*).
2. Apply water and ensure the water is flowing at or above the specified minimum value.
3. Power on the system by pushing the front panel **POWER ON/OFF** button. The button will light when the unit is turned on.

Some units will have an on/off switch instead of a button. Depending on the unit, turn the switch as follows:

- Turn the front panel on/off switch clockwise until it points to 1.
- Turn the front panel on/off switch clockwise until it is vertical.

The initial front panel screen will display the Cesar generator model name, the operating frequency, the maximum RF power, and the software version. After five seconds, the display will change to a standard operation screen.

4. Listen to ensure the fans are rotating.
5. Set the host control mode by sending host port **active control mode** command **14**: 2 = User port control.
6. Select the desired power regulation mode by sending host port **regulation mode** command **3**.
   - 6 = Forward power ($P_{forward}$) regulation
   - 7 = Load power (P_{real}) regulation
   - 8 = External power (DC Bias) regulation

   ☞ **Important**
   You cannot change power regulation mode while RF power is on.
7. Send host port **set point** command **8** to set the setpoint.
8. Send host port **RF on** command **2** to turn on RF power.
9. Check the load. If your load is a plasma:
   - Is the plasma lit? If not, you may have a faulty connector or too little input power (see the troubleshooting section).
   - Is the plasma stable (that is, is the plasma producing a constant glow)? If not, see the troubleshooting section
10. If you have a matching network connected and you are using automatic tune control:
    - Did the capacitors begin to move? If not, see the troubleshooting section.
11. Vary the chamber conditions according to your process requirements, and verify that the Cesar generator can cover the required load impedance range.

Congratulations, you have successfully installed and operated the Cesar generator.

Operating the Cesar Generator for the First Time With the Front Panel

You can operate the Cesar generator using either full front panel control or the host port with partial front panel control (remote control override). This section describes full front panel control operation.

TO OPERATE THE CESAR GENERATOR FOR THE FIRST TIME WITH THE FRONT PANEL

1. Ensure that the user port interlock signal is satisfied.
   - If you have a 25-pin **User Port**, verify that there is external contact closure between **User Port** pins 10 and 23 (*INTERLOCK LOOP*).
   - If you have a 15-pin **User Port**, verify that there is external contact closure between **Interlock** pins 1 and 2 (*INTERLOCK INPUT* and *INTERLOCK OUTPUT*).
2. Apply water and ensure the water is flowing at or above the specified minimum value.
3. Power on the system by pushing the front panel **POWER ON/OFF** button. The button will light when the unit is turned on.

   Some units will have an on/off switch instead of a button. Depending on the unit, turn the switch as follows:
   - Turn the front panel on/off switch clockwise until it points to 1.
   - Turn the front panel on/off switch clockwise until it is vertical.

   The initial front panel screen will display the Cesar generator model name, the operating frequency, the maximum RF power, and the software version. After five seconds, the display will change to a standard operation screen.
4. Listen to ensure the fans are rotating.
5. Press the **RF Power On** key on the front panel.
6. Use the **RF Power** knob to increase the RF power to a desired level.
7. Check the load. If your load is a plasma:
   - Is the plasma lit? If not, you may have a faulty connector or too little input power (see the troubleshooting section).
   - Is the plasma stable (that is, is the plasma producing a constant glow)? If not, see the troubleshooting section
8. If you have a matching network connected and you are using automatic tune control:
   - Did the capacitors begin to move? If not, see the troubleshooting section.
9. Vary the chamber conditions according to your process requirements, and verify that the Cesar generator can cover the required load impedance range.

Congratulations, you have successfully installed and operated the Cesar generator.

Related Links

• “Setting and Disabling Remote Control Override” on page 5-36

CESAR GENERATOR FRONT PANEL

You can monitor and change the Cesar generator settings using either the front panel or through the host port. Figure 5-7 illustrates the front panel control elements. This shows an example display; the information, units, and values on your unit may vary.

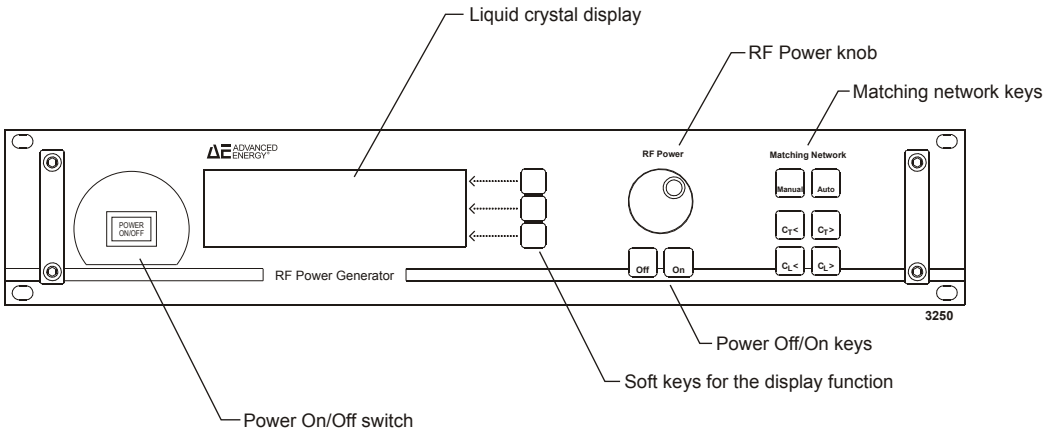


Figure 5-7. Front panel

Related Links

- "Front Panel Control Elements" on page 5-18
- "Using the Front Panel Program Menu" on page 5-20
- "Viewing Measurements in the Display" on page 5-23
- "Viewing and Using the Front Panel when in Remote Control Mode" on page 5-25
- "Setting and Using Preset Generator Settings for Different Applications" on page 5-43

Front Panel Control Elements

Control	General Description
POWER ON/OFF switch or push-button	Located on the left-hand side of the front panel, **POWER ON/OFF** allows you to turn the Cesar generator on and off from AC Mains. ☞ **Important** The **POWER ON/OFF** switch does not completely disconnect the Mains. You must install an external switch to completely disconnect Mains. For units with the push-button: • Push the button once to turn on power. The push button lights when the unit is turned on. • Push the button again to turn off power. For units with a switch: • To power on the generator, turn the switch clockwise to a vertical position or to 1, depending on your unit. • To power off the generator, turn the switch counter-clockwise to a horizontal position or 0, depending on your unit.
LCD graphic display	The liquid crystal display (LCD) allows you to read all operating conditions and power values.
Soft key functions	The **Program** and **Preset** soft keys, located on the right side of the LCD, allow you to make changes in the program menu and set presets. To view current settings, use the **Display** soft key. Continue pressing this soft key to cycle through many of the unit's settings.
RF Power On/Off keys	The **RF Power On/Off** keys turn RF power off or on. • To turn off RF power, press the left **Off** key. • To turn on RF power, press the right **On** key.
RF Power knob	The **RF Power** knob allows you to control RF power in forward power and load power regulation mode or DC bias in the external regulation mode. This knob is also used to select various values in the **Program** menu. • To increase a value, rotate the **RF Power** knob clockwise. • To decrease a value, rotate the **RF Power** knob counter-clockwise.

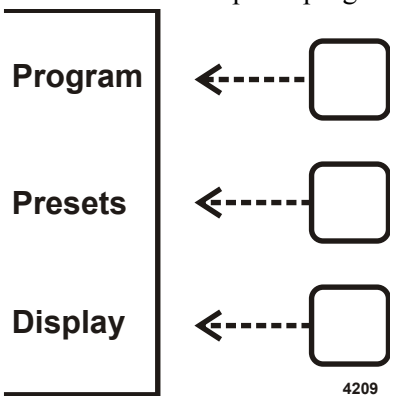
Control	General Description
Match network control of VarioMatch and Navio match networks	**Matching Network** control buttons allow you to control operation of a VarioMatch or Navio match network that is connected to the **Matching** interface on the generator. The matching control consists of four keys that change capacitor position. ☞ **Important** These control keys work only with VarioMatch and Navio match networks that are connected to the **Matching** interface of the generator. These keys can not be used to control any other match network unless it is electrically and functionally compatible and is connected through the **Matching** interface connector.

Using the Front Panel Program Menu

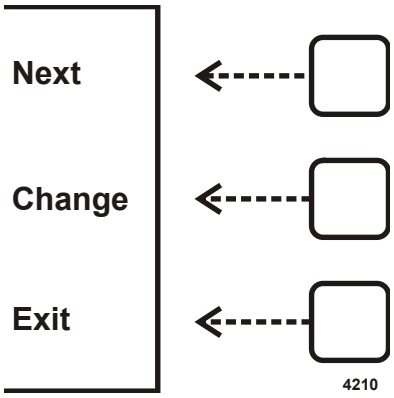
The Cesar generator features an operating menu that offers several enhanced functions. You can manually set these functions to meet your specific process needs, and you can store up to ten presets for ten different applications.

ACCESSING THE PROGRAM MENU

To access the front panel program menu, press the **Program** soft key.



The LCD graphic display will change to display the program menu structure consisting of the **Next**, **Change**, and **Exit** soft keys.



- Press **Next** to cycle through the menu until you reach a desired function.

  You can only move forward through the program menu. To return to a previous function displayed on the menu screen, you must press **Next** repeatedly until you again reach the desired function.
- Press **Change** to view the submenu for any particular function, and follow the submenu prompts.
- Press **Exit** to exit the program menu, to quit a menu, or to execute or store the programmed settings.

ENTERING VALUES IN THE PROGRAM MENU

You may change a variety of parameters in the program menu by using a combination of the soft keys and the **RF Power** knob. Use the soft keys to make menu selections, and use the **RF Power** knob to set specific values. Then press the appropriate soft key to save that value.

You can only move forward through the program menu. To return to a previous function displayed on the menu screen, you must press **Next** repeatedly until you again reach the desired function.

FRONT PANEL PROGRAM MENU TREE

The following figures illustrate the various menus and submenus available in the front panel program menu.

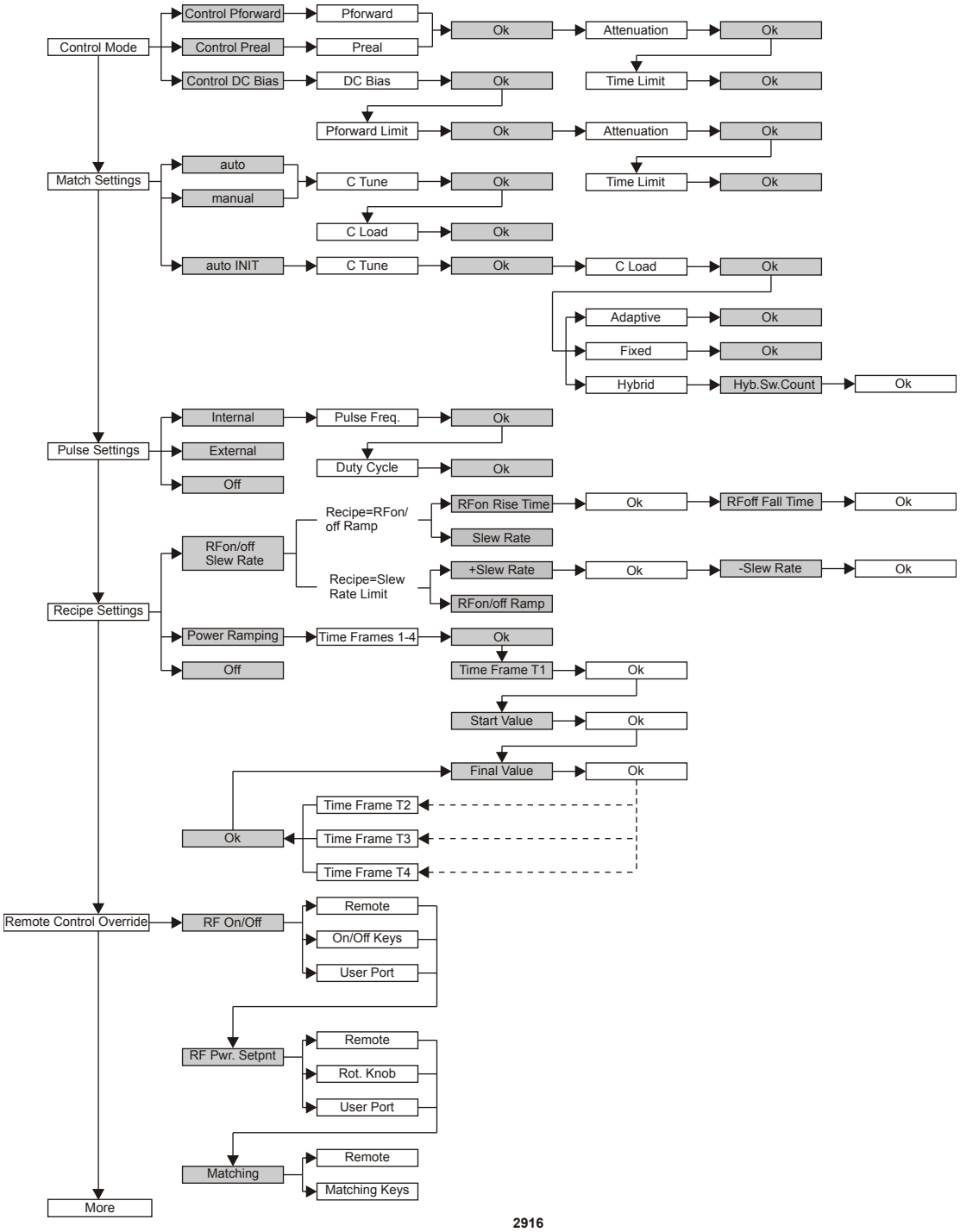


Figure 5-8. *Front panel program menu tree*

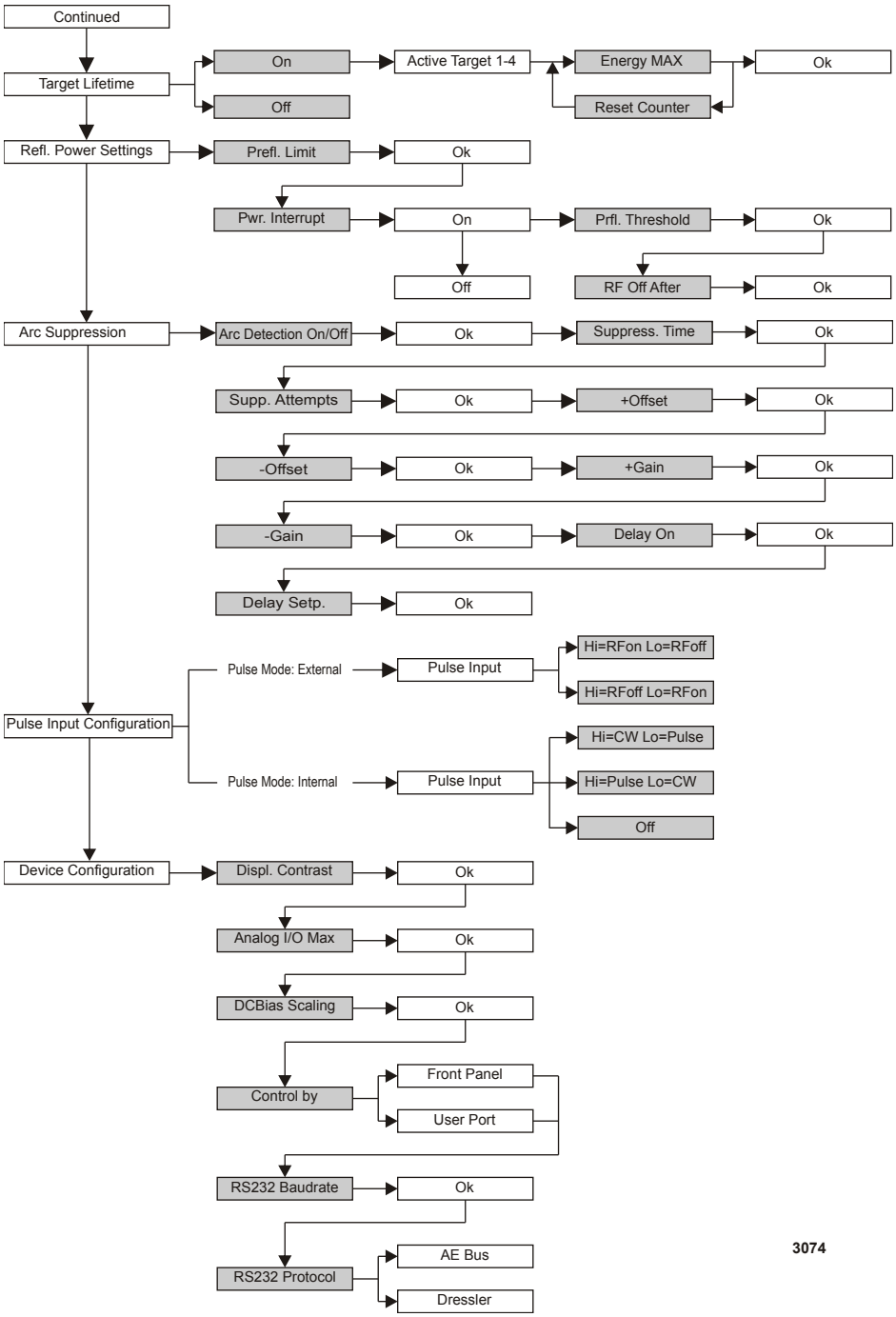


Figure 5-9. *Front panel program menu tree (continued)*

Viewing Measurements in the Display

To view current measurements, use the **Display** soft key. When you switch on the generator, the **Display** field is empty. Each time you press the **Display** soft key a different measurement appears. Continue pressing this soft key to cycle through the measurements.

Display units	Measurement
W_f	Forward RF output power
W_{real}	Real RF output power
V_{Bias}	DC bias voltage
xxxx # Arcs	Displayed only if arc detection is enabled. The number of arcs detected outside the specified limits. This counter is reset each time RF is turned on. Arcs within the RF on or setpoint delay time are not counted.

If you specified a cable attenuation value, see "Using the Cable Attenuation Feature" on page 5-54 for a description of the values displayed on the front panel.

If the front panel displays `Error E xxx`, you have an error condition. See the Troubleshooting section of the user manual.

REMOTE CONTROL OPERATION

By default, when you switch on the Cesar generator it is in front panel control mode. You can also operate the generator in remote control mode via either the host port or the **User Port**.

- Front panel control

  This is the default control mode.

- Host port remote control

  To use the host port commands, the unit must be in host port remote control mode. Once activated, the unit will remain in host port remote control mode until deactivated by command **14** or until the generator is switched off.

- **User Port** remote control

  You can activate **User Port** remote control mode via either the front panel or via host port command **14**. Once activated, the unit will remain in **User Port** remote control mode even if the generator is switched off and on. You can deactivate **User Port** remote control via either the front panel or host port command **14**.

Additionally, you can specify overrides to the remote control modes (see "Setting and Disabling Remote Control Override" on page 5-36).

Viewing and Using the Front Panel when in Remote Control Mode

When the Cesar generator is under remote control, the front panel displays which remote control mode is active on the right-hand side of the display, near the soft keys. During remote control no program or preset functions are available. The **Display** soft key remains active.

You can determine the remote control mode status by looking at the front panel display:

- If the **Exit** soft key is active, then the remote mode was activated by the program menu, and you can exit by using the **Exit** soft key.
- `Full` or `Part` indicates whether the generator is fully or only partially under remote control
- `UserPort` or `HostPort` indicates the remote control mode.

Table 5-1 shows the possible items you will see on the right-hand side of the display, depending on which remote control mode you are currently in.

***Table 5-1.** Remote control mode displayed on the front panel*

When you see this:	This is the current state:

`Exit`
`Full`
`UserPort`
`Remote`
`Control`
	The generator is in user port mode. The **User Port** was activated by the program menu. Pressing the **Exit** soft key will exit this mode and return to front panel operation. No local (front panel) overrides remain active.

`Exit`
`Part`
`UserPort`
`Remote`
`Control`
	The generator is in user port mode. The **User Port** was activated by program menu. `Part` indicates that some remote control override is active. Pressing the **Exit** soft key will exit this mode and return to front panel operation. All local (front panel) overrides remain active.

`Full`
`UserPort`
`Remote`
`Control`
	The generator is in user port mode. The **User Port** was activated by the 15-pin **User Port** or by the host port. You can exit this mode using only the same method used to activate it. No local (front panel) overrides remain active.

`Part`
`UserPort`
`Remote`
`Control`
	The generator is in user port mode. The **User Port** was activated by the 15-pin **User Port** or by the host port. `Part` indicates that some remote control override is active. You can exit this mode using only the same method used to activate it. All local (front panel) overrides remain active.

`Full`
`HostPort`
`Remote`
`Control`
	The generator is in host port mode. You can activate host port mode only via the host port. You can deactivate the host port either via the host port or by switching the generator off and on. All local (front panel) overrides remain active.

Table 5-1. Remote control mode displayed on the front panel (Continued)

When you see this:	This is the current state:
`Part HostPort Remote Control`	The generator is in host port mode. `Part` indicates that some remote control override is active. You can activate host port mode only via the host port. You can deactivate the host port either via the host port or by switching the generator off and on. All local (front panel) overrides remain active.

RF Control and Resetting Errors

The RF on/off can be controlled by the **User Port**, host port, or front panel, depending on which remote and local control settings are enabled.

☞ **Important**
If your device specifies a minimal set point, RF will be switched off when it goes below the set point.

To reset error messages, use Table 5-2 to determine which interface you can use. The interface you can use depends on a combination of the interface that is in control (front panel, **User Port**, or host port) and the interface that has the control of RF on/off. To reset errors:

- Front Panel

  When the error is fixed and you are allowed to reset the error, the bottom soft key will display **Quit**. Press **Quit** to reset the error. If **Quit** is not displayed, the error is still active and can not be reset.

- **User Port**

  Error messages are reset automatically as soon as both the error is fixed and the RF on signal is not active. When RF on is then reactivated, the unit is ready.

- Host Port

  Once the error is fixed, error messages are reset automatically every time a new command is received. The reset is done before the command is executed.

Table 5-2. RF on/off control

Interface in control	Interface with RF control		
	RF on/off by Front Panel	RF on/off by User Port	RF on/off by Host Port
Front Panel	Front Panel	Front Panel and **User Port**	–
User Port	**User Port** and Front Panel	**User Port**	–

Table 5-2. RF on/off control (Continued)

Interface in control	Interface with RF control		
	RF on/off by Front Panel	RF on/off by User Port	RF on/off by Host Port
Host Port	Host Port and Front Panel	Host Port and **User Port**	Host Port

NORMAL OPERATION

The following sections provide information on basic operating procedures and settings for normal operation. Each section describes how to perform the function using the front panel. Some sections also describe how to perform the function through the host port.

Setting Regulation Mode

The Cesar generator is designed to regulate power into a broad range of output impedances. The unit can operate in the following:

- Forward power regulation ($P_{forward}$)

  In forward power regulation mode, the generator regulates RF power with constant forward power.

- Real power regulation (sometimes called load or delivered power regulation) (P_{real})

  In real power regulation mode, the generator regulates RF power with constant load (real) power. Real power = Forward power – Reflected power.

- DC Bias regulation (sometimes called external power regulation)

  In DC bias regulation mode, the generator regulates RF power at a constant DC self bias voltage in the chamber. The RF output power can be limited to protect your plasma chamber against high RF power. For example, this limitation is useful if there is no self bias voltage at the beginning of the process.

The regulation mode setting is retained in nonvolatile memory.

In all regulation modes, you can set a cable attenuation variable. This feature allows the Cesar generator to compensate for losses of the cable between the generator and the load. You set this value as a percent; it is displayed as both percent and dB.

DETERMINING THE REGULATION MODE SETTING

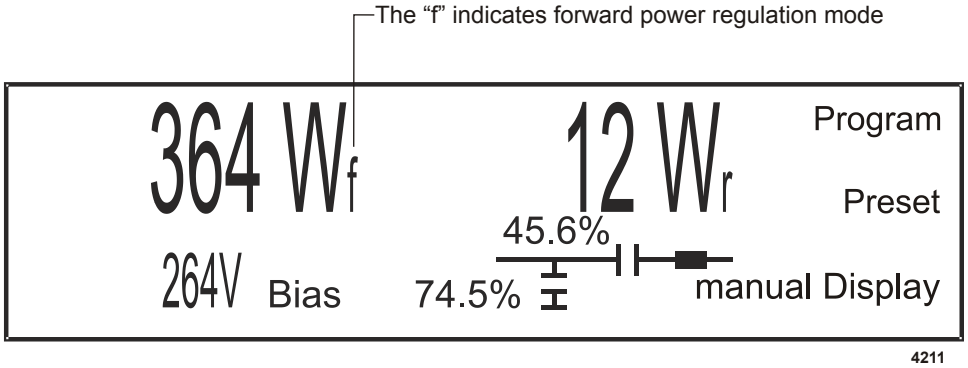
You can determine the regulation mode using either the host port or the front panel.

- Front panel

  A description of the regulation mode setting will appear on the display, next to either the power value in watts or the DC bias value in volts:

  - **f** indicates forward power regulation
  - **real** indicates real power regulation
  - **bias** indicates DC bias regulation

  For example, forward power regulation is selected in the following illustration.



- Host port

  If you are using the **RS-232** port, the **PROFIBUS** port, or the **Ethernet** port to control and monitor the generator, send command **154**. The controller will return one byte representing the regulation mode.

TO SET REGULATION MODE

This section explains how to select the regulation mode using the **User Port**, the host port, or the front panel. If you want to specify cable attenuation, you must use the front panel procedure.

To set regulation mode using the **User Port** or the host port:

- **User Port**

  One of the following:

  - Use pin 2 on the 15-pin **User Port**
  - Use pin 8 on the 25-pin **User Port**

- Host port

  If you are using the **RS-232** port, the **PROFIBUS** port, or the **Ethernet** port to control and monitor the generator, set and configure regulation with commands **3**, **4**, **8**, **9**, and **10**..

To Set Regulation Mode Using the Front Panel

1. Press the **Program** soft key.

2. Press **Next** until you see **Control Mode** on the display.
3. Press **Change**.
4. Select the soft key for the desired regulation mode:
   - **Control Pforward**
   - **Control Preal**
   - **Control DC Bias**
5. If you selected **Control DC Bias**:
   a. Using the **RF Power** knob, set a DC Bias value between 0 V and 4000 V. Then press **Ok** to continue.

      Press the **Increm Auto** soft key to toggle between dynamic increments (Auto) and several fixed increments.

      4000 V is the default value. To change the default settings, see "Changing the Device Configuration Settings" on page 5-41.

   b. Using a combination of the **Increm Auto** soft key and the **RF Power** knob, set the forward power maximum value (in W) between 5% and 100% of the maximum output power for your unit. Then press **Ok** to continue.
6. If you selected **Control Pforward** or **Control Preal**: Using the **RF Power** knob, select the desired power set point (`Pforward` or `Preal` on the front panel) between 0 W and the maximum output power for your unit. Then press **Ok** to continue.

   Press the **Increm Auto** soft key to toggle between dynamic increments (Auto) and several fixed increments.
7. Using the **RF Power** knob, select the desired cable attenuation value between -10% and +50%. The default is 0% (no cable attenuation). Then press **Ok** to continue.
8. Using the **RF Power** knob, set the desired RF on time limit between 1 second and 3600 seconds (`Off` deactivates this feature). Then press **Ok** to continue.

   You will see the selected values on the display.
9. If the values you see on the display are correct, press the **Exit** soft key. If the values are incorrect, press **Change**.
10. To start using the regulation mode information, press the **Execute** soft key. To cancel, press **Abort**.

Setting the Pulse Function

The Cesar generator's pulse function allows you to switch on the RF power (at a given set point) and switch it off with the pulse frequency. You can select between:

- Internal pulsing

Internal pulsing modifies the pulse repetition frequency (PRF). The waveform is always a rectangle; the power is given by the set point. The internal pulse generator is configurable, based on your unit's pulse frequencies and on duty cycles between 0.1% and 99%. You cannot send a duty cycle of 0.1% to 1% via the **User Port**; this range is available only on certain units, and only via the front panel.

- External pulsing

  The pulsing of the generator will work according to the gating pulse signal applied to the analog **User Port**. The pulse-gating signal must be of a 5 V TTL/CMOS level.

SELECTING INTERNAL OR EXTERNAL PULSING

This section explains how to select internal or external pulsing using the host port or the front panel.

To select and configure internal or external pulsing using the host port (**RS-232** port, **PROFIBUS** port, or **Ethernet** port). use host port commands **27**, **93**, and **96**.

To Select Internal or External Pulsing Using the Front Panel

1. Press the **Program** soft key.
2. Press **Next** until you see **Pulse Settings** on the display.
3. Press **Change**.
4. Press **Internal** for internal pulsing. Press **External** for external pulsing.
5. For internal pulsing:
   a. Select the desired **Pulse Freq.** value using a combination of the **Increm Auto** soft key and the **RF Power** knob. See the product specification for the RF pulse frequency range.
   b. Press **Ok** to confirm.
   c. Select a duty cycle value between 0.1% to 99% using the **RF Power** knob. Steps below 1% are in increments of 0.1, steps between 1% and 99% are in increments of 1. The exact duty cycle range depends on the unit.

      The duty cycle is a function of the pulse repetition frequency (PRF), and the wide range of 0.1% to 99% only exists at low pulse frequencies. The higher the PRF, the lower the possible duty cycle range
6. Press **Ok** to confirm.
7. Press the **Exit** soft key.
8. Press the **Execute** soft key.

The operating screen will change to display the pulsing status:

- Internal pulse: the front panel displays the frequency and duty cycle.

- External pulse: if there is no pulse signal at the **User Port**, the front panel displays **External pulse (off)**.

CHANGING THE PULSE INPUT CONFIGURATION SETTINGS

The configuration settings allow you to program the “polarity” of the Cesar generator's pulse input function. You can change the pulse input configuration settings using the front panel.

Before changing the pulse input configuration settings, you must first turn on the pulsing function.

To Change the Pulse Input Configuration Settings

1. Press the **Program** soft key.
2. Press **Next** until you see **Pulse Input Configuration** on the display.
3. Press **Change**.
4. Select the desired “polarity” of the pulse input:
   a. If the pulse function is set to external pulsing, choose either:
      - `Hi=RFon`
        `Low=RFoff`

        This setting enables standard external pulsing.
      - `Hi=RFoff`
        `Low=RFon`

        This setting enables inverse external pulsing.

   b. If the pulse function is set to internal pulsing, choose from:
      - `Hi=CW`
        `Low=Pulse`

        This setting switches between internal pulsing and continuous power with the pulse input at a high state.
      - `Hi=Pulse`
        `Low=CW`

        This setting switches between internal pulsing and continuous power with the pulse input at a low state.
      - `Off`

        This setting disables the pulse input. Normal internal pulsing is used.
5. Press the **Exit** soft key.
6. Press the **Execute** soft key.

TO TURN OFF PULSING

1. Press the **Program** soft key.

2. Press **Next** until you see **Pulse Settings** on the display.
3. Press **Off** to turn off the pulsing feature.
4. Press the **Exit** soft key.
5. Press the **Execute** soft key.

Creating Recipes (RF on/off, Slew Rate, Power Ramping)

This feature enables you to create a power profile that may consist of up to four time frames. You can choose to program one of the following recipe settings using the Cesar generator front panel: **RF on/off Ramp**, **Slew Rate**, and **Power Ramping**.

Related Links

- "Recipe Settings Operating Screen" on page 5-35
- "Creating an RF On/Off Ramp Recipe" on page 5-32
- "Creating a Slew Rate Recipe" on page 5-33
- "Creating a Power Ramp Recipe" on page 5-34
- "To Turn Off the Recipe Settings Feature" on page 5-35

CREATING AN RF ON/OFF RAMP RECIPE

This feature allows gradual, well-controlled development of the rising and falling edge of the RF power envelope when swathing RF on and off, which differs significantly from common RF power functionality with its fast and uncontrolled rise time. You can program your "critical plasma system" to strike smoothly with a well-controlled rising edge of the RF power.

You can create an RF on/off ramp recipe using either the host port or the front panel. To create the recipe with the host port (**RS-232**, **PROFIBUS**, or **Ethernet**), use commands **31** and **32**.

To Create an RF On/Off Ramp Recipe Using the Front Panel

1. Press the **Program** soft key.
2. Press **Next** until you see **Recipe Settings** on the display.
3. Press **Change**.
4. Press **RF on/off SlewRate**.
5. If **Recipe = Slew Rate Limit**, then you must first select **RF on/off Ramp**.
6. Set the **RF Rise Time** between 0.1 s and 60 s using a combination of the **Increm Auto** soft key and the **RF Power** knob.
7. Press **Ok** to confirm.
8. Set the **RF Fall Time** between 0.1 s and 60 s using a combination of the **Increm Auto** soft key and the **RF Power** knob.
9. Press **Ok** to confirm.

CREATING A SLEW RATE RECIPE

This feature allows gradual, well-controlled development of the rising and falling edge of the RF power envelope when changing the set point. Unlike “RF on/off ramp”, slew rate is always active when RF is on. This feature works with all control modes.

Setting the slew rate limits RF power rise/fall to the programmed slew rate:

$$\frac{Power_{nominal}}{time}$$

4235

- $Power_{nominal}$: The nominal power output of your Cesar generator
- *time*: The user-specified time, in seconds, to reach nominal power. Specify time as follows:
  - +Slew Rate (rising edge): Specify the time for a power change from 0 Watts to the nominal power output of your device. The generator calculates a slew rate from this time.
  - -Slew Rate (falling edge): Specify the time for a power change from the nominal power output of your device to 0 Watts. The generator calculates a slew rate from this time.

Example: Assume the +Slew Rate is set to 8.2 and the nominal power output is 600 W. If you switch RF on with a set point of 0 Watts, then change the set point to 600 Watts, the generator will increase the output to 600 Watts in 8.2 seconds.

$$\frac{600W}{8.2s} = 73.12\ \frac{W}{s}$$

4230

You can create a slew rate recipe using the front panel. This is not supported with other interfaces.

To Create a Slew Rate Recipe Using the Front Panel

1. Press the **Program** soft key.
2. Press **Next** until you see **Recipe Settings** on the display.
3. Press **Change**.
4. Press **RF on/off Slew Rate**.
5. If Recipe = RF on/off Ramp, then you must first select **Slew Rate**.
6. Set the +Slew Rate by selecting a time (in minutes:seconds) using a combination of the **Increm Auto** soft key and the **RF Power** knob. The generator will set the +Slew Rate based on the time (in seconds) you enter and the nominal output of your generator.
7. Press **Ok** to confirm.
8. Set the -Slew Rate by selecting a time (in minutes:seconds) using a combination of the **Increm Auto** soft key and the **RF Power** knob. The

generator will set the -Slew Rate based on the time (in seconds) you enter and the nominal output of your generator.

9. Press **Ok** to confirm.

CREATING A POWER RAMP RECIPE

Power ramping allows you to determine the shape of a power ramp within a specified time frame. There are four programmable time frames.

You can create a power ramp recipe using either the host port or the front panel. To create the recipe with the host port (**RS-232**, **PROFIBUS**, or **Ethernet**), use commands **19**, **21**, **22**, and **23**.

To Create the Power Ramping Recipe Using the Front Panel

1. Press the **Program** soft key.
2. Press **Next** until you see **Recipe Settings** on the display.
3. Press **Change**.
4. Press **Power Ramping**.
   a. Select the number of time frames (1 to 4) you want to use in your recipe using the **RF Power** knob.
   b. Press **Ok** to confirm.
   c. Set a time for T1 (the recipe's first power ramp) between 0.1 s and 60 minutes using a combination of the **Increm Auto** soft key and the **RF Power** knob.
   d. Press **Ok** to confirm.
   e. Set a **Start Power** value for T1 between 0 W and your unit's maximum output power using a combination of the **Increm Auto** soft key and the **RF Power** knob.
   f. Set a Final Power value for T1 between 0 W and your unit's maximum output power using a combination of the **Increm Auto** soft key and the **RF Power** knob.
   g. Press **Ok** to confirm.
   h. Set a time for T2 (the recipe's second power ramp) between 0.1 s and 60 minutes using a combination of the **Increm Auto** soft key and the **RF Power** knob.
   i. Press **Ok** to confirm.
   j. The **Start Power** value will display as the final value of T1. Set a **Final Value** for T2 between 0 W and your unit's maximum output power using a combination of the **Increm Auto** soft key and the **RF Power** knob.
   k. Repeat the last three steps to set time frames for T3 and T4 (the recipe's third and fourth power ramps).

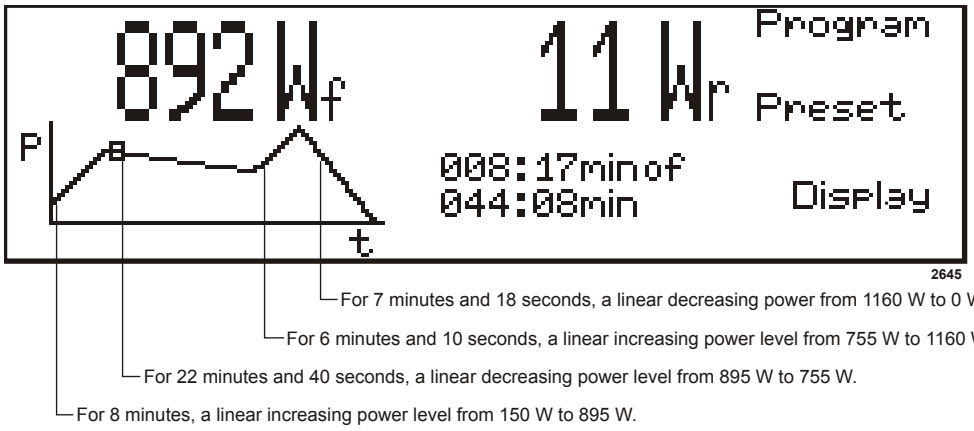
5. Press **Ok** to confirm.
6. Press the **Exit** soft key.
7. Press the **Execute** soft key.

TO TURN OFF THE RECIPE SETTINGS FEATURE

1. Press the **Program** soft key.
2. Press **Next** until you see **Recipe Settings** on the display.
3. Press **Change**.
4. Press **Off** to turn off the feature.
5. Press the **Exit** soft key.
6. Press the **Execute** soft key.

RECIPE SETTINGS OPERATING SCREEN

When you have a recipe enabled, the operating screen will change to display the current recipe status. See the following illustration for an example.



The **Recipe Settings** operating screen displays the actual position on the ramp by a moving cursor point, in addition to the start and total running time.

If RF power is turned off during the **Recipe Settings** function, by hand, or error, then the time stops. You may then:

- Press **Quit** to stop.
- Press **Restart** to start from the beginning.
- Press **Continue last val** to continue at the same position you stopped at before.

Setting and Disabling Remote Control Override

Remote Control Override allows you operate the Cesar generator using a combination of front panel control (local) and analog or digital (remote) control. You may control the generator remotely yet retain the following front panel (local) functions:

- **RF Power** knob
- **RF Power Off/On** keys
- **Matching** controls

Normally, when using remote control, all front panel controls are disabled. When you override remote control, you override only the controls selected.

SELECTING REMOTE CONTROL OVERRIDE

If you are using the host port (**RS-232** port, **PROFIBUS** port, or **Ethernet** port) to control and monitor the Cesar generator send command **29**.

To Select Remote Control Override

1. Press the **Program** soft key.
2. Press **Next** until you see **Remote Control Override** on the display.
3. Press **Change**.
4. Select the control source for turning on or off the RF output (**RF On/Off**):
   - To control RF on/off remotely, press **Remote**. This allows you to control RF on/off using only the selected remote control (front panel, **User Port**, or host port).
   - To control RF on/off with the front panel controls, press **On/Off Keys**. With this setting, if your remote control is currently through a host port (**RS-232** port, **Profibus** port, or **Ethernet** port), then you can control RF on/off using either the host port or the front panel.
   - To control RF on/off with the **User Port**, press **User Port**. This allows you to control RF on/off using only the user port. All other functions remain under the selected remote control.
5. Select the control source for setting the RF power set point (**RF Pwr.Setpnt**):
   - To select/change the set point remotely, press **Remote**. This allows you to control RF power set point using only the selected remote control (front panel, **User Port**, or host port).
   - To select/change the set point with the front panel, press **Rot. Knob**. With this setting, if your remote control is currently through a host port (**RS-232**, **Profibus**, or **Ethernet**), then you can control RF power set point using either the host port or the front panel.

- To select/change the set point with the **User Port**, press **User Port**. This allows you to control RF power set point using only the **User Port**. All other functions remain under the selected remote control.

6. Select the control source for setting the matching values (**Matching**):
   - To set matching values remotely, press **Remote**. This allows you to set matching values using only the selected remote control.
   - To set matching values with the front panel, press **Matching Keys**. This allows you to set matching values using only the front panel controls.
7. Press the **Exit** soft key.
8. Press the **Execute** soft key.

DISABLING REMOTE CONTROL OVERRIDE

When you disable **Remote Control Override** control, the generator will default to remote control if it is connected to an analog **User Port**; otherwise, if there is no analog **User Port** present, it will default to front panel (local) control.

To Disable Remote Control Override

1. Press the **Program** soft key.
2. Press **Next** until you see **Remote Control Override** on the display.
3. Press **Change**.
4. Select **Remote** for each of the options.
5. Press the **Exit** soft key.
6. Press the **Execute** soft key.

Setting and Turning Off the Target Lifetime Feature

In the **Target Lifetime** menu, you may program up to four target lifetime settings to integrate power and time. The Cesar generator will display a warning when the meter reading reaches the value of **Energy MAX**.

SETTING TARGET LIFETIME PARAMETERS

If you are using the host port (**RS-232** port, **PROFIBUS** port, or **Ethernet** port) to control and monitor the Cesar generator, use commands **11** and **12**.

To Set a Target Lifetime

1. Press the **Program** soft key.
2. Press **Next** until you see **Target Lifetime** on the display.
3. Press **Change**.

4. Press **On** to activate the lifetime counter.
5. Select an **Active Target** (1 to 4) using the **RF** knob.
6. Select the **Energy MAX** (between 0.01 kWh and 21600 kWh) using a combination of the **Increm Auto** soft key and the **RF Power** knob.
7. Press **Ok** to confirm.
8. Press the **Exit** soft key.
9. Press the **Execute** soft key.

☞ **Important**
Although the energy usage is correct internally, the parameters displayed do not refresh automatically; they are refreshed each time you re-enter this display.

TO TURN OFF THE TARGET LIFETIME FEATURE

1. Press the **Program** soft key.
2. Press **Next** until you see **Target Lifetime** on the display.
3. Press **Change**.
4. Press **Off**.
5. Press the **Exit** soft key.
6. Press the **Execute** soft key.

RESETTING A TARGET LIFETIME

☞ **Important**
Reset starts the counter to zero.

To Reset a Target Lifetime

1. Press the **Program** soft key.
2. Press **Next** until you see **Target Lifetime** on the display.
3. Press **Change**.
4. When **Active Target** appears, press **On**.
5. When **Energy MAX** appears, press **Ok**.
6. Press **Reset** to reset the lifetime counter.
7. Press **Ok** when the reset message appears.
8. Press **Ok** to confirm.
9. Press the **Exit** soft key.
10. Press the **Execute** soft key.

Changing Reflected Power Settings

The Cesar generator can tolerate continuous reflected power; however, it also allows you to set a value at which the forward power turn off when the reflected power reaches a certain limit for a specified period of time. The **Refl. Power Settings** menu allows you to create a reaction profile to shut off RF power when the reflected power reaches this limit.

☞ **Important**

The maximum reflected power displayed in this menu is scaled with the cable attenuation. If you set an attenuation variable other than 0%, see "Using the Cable Attenuation Feature" on page 5-54 for a description.

If you are using the host port (**RS-232**, **PROFIBUS**, or **Ethernet**) to control and monitor the Cesar generator, set the reflected power parameter using command **33**.

TO CHANGE REFLECTED POWER SETTINGS

1. Press the **Program** soft key.
2. Press **Next** until you see **Refl. Power Settings** on the display.
3. Press **Change**.
4. Set a **Prefl. Limit** between 20 W and your unit's maximum output power using the **RF Power** knob.
5. Press **Ok**.
6. If you want the generator to shut off when it reaches a threshold for a specified period of time (**Pwr. Interrupt**), press **On**. Otherwise, press **Off**. If you select **On**:
   a. Set the desired **Prefl. Threshold** value (between 12 W and a value less than **Prefl. Limit**) using the **RF Power** knob.
   b. Set the desired **RF Off After** value (between 1 µs and 3 m 20 s) using the **RF Power** knob.
   c. Press **Ok** to confirm.
7. Press the **Exit** soft key.
8. Press the **Execute** soft key.

Setting Arc Suppression Parameters

The Cesar generator monitors power reflected from the load. A certain amount of reflected power is normal; however, reflected power resulting from arcs in the load can cause damage in the load. Use the arc suppression parameters to specify the acceptable limits of reflected power. For an explanation of arc handling in the Cesar generator, see "The Arc Handling System" on page 5-49.

TO SET ARC SUPPRESSION PARAMETERS

1. Press the **Program** soft key.
2. Press **Next** until you see **Arc Suppression** on the display.
3. Press **Change**.
4. Set **Arc Detection** to On/Off to enable or disable arc detection in the generator.

   Default is Off. If arc detection is off, suppression is also off. If arc detection is On, you can turn arc suppression on by setting the next parameter (**Suppress. Time**) between 5 µs and 500 µs.
5. Press **Ok**.
6. Set the **Suppress. Time** between 5 µs and 500 µs using the **RF Power** knob.

   The suppression time is the time (in µs) that RF output is turned off when an arc is first detected. This time will double each time another arc is detected, up to the specified **Supp. Attempts**. Setting this to 0 turns off arc suppression.
7. Press **Ok** to confirm.
8. Set the **Supp. Attempts** between 0 and 100 using the **RF Power** knob.

   This value tells the generator the maximum number of times to turn off RF (suppress arcs) before turning off RF with an error condition. 0 = infinite number of tries.
9. Press **Ok** to confirm.
10. Set **+Offset** between 0 and 255 using the **RF Power** knob.

    +Offset sets the o_1 potentiometer sensitivity value. Default=0.

    This value, and the values for the next 3 parameters, is described in "The Arc Handling System" on page 5-49.
11. Press **Ok** to confirm.
12. Set **-Offset** between 0 and 255 using the **RF Power** knob.

    -Offset sets the o_2 potentiometer sensitivity value. Default=0.
13. Press **Ok** to confirm.
14. Set **+Gain** between 0 and 255 using the **RF Power** knob.

    +Gain sets the k_1 potentiometer sensitivity value. Default=0.
15. Press **Ok** to confirm.
16. Set **-Gain** between 0 and 255 using the **RF Power** knob.

    -Gain sets the k_2 potentiometer sensitivity value. Default=0.
17. Press **Ok** to confirm.
18. Set the **Delay on** between 10 ms to 5000 ms using the **RF Power** knob.

Delay on is the amount of time (in ms) that arc suppression is disabled when RF is first turned on. Arc counting is also disabled during this time. Default=20 ms.

19. Press **Ok** to confirm.
20. Set the **Delay setp.** between 10 ms to 5000 ms using the **RF Power** knob.

    Delay setp. is the amount of time (in ms) that arc suppression is disabled when the generator setpoint is changed. Arc counting is also disabled during this time. Default=20 ms.
21. Press **Ok** to confirm.
22. Press the **Exit** soft key.
23. Press the **Execute** soft key.

Changing the Device Configuration Settings

☞ **Important**
All selections in **Device Configuration Settings** are written directly to memory. Even if you press **Exit**, then **Escape**, the values you have selected are stored into memory.

The **Device Configuration** feature allows you to change the factory default settings and customize the Cesar generator to meet your specific needs. You can change the following parameters:

- Display contrast

  Display contrast allows you to adjust the contrast (brightness) of the LCD graphic display.

- Analog I/O MAX

  The analog interface level is factory set to the most common level range of 0 V to 10 V. However, you may reprogram this value by changing the maximum voltage of possible analog interface levels from 2 V to 20 V. The resulting range would be 0 V to (new maximum voltage), for example, 0 V to 20 V. These levels apply to all analog inputs and outputs on the **User Port**.

  However, the inputs and outputs are physically limited to a 10 V maximum. When using values over 10 V, you must limit your maximum set points and monitoring signals on the **User Port**.

  For example: If you set Analog I/O MAX to 20 V, you can then specify a set point of only 50% of the nominal output power (20 V = 100%, 10 V = 50%). Likewise, you limit the analog outputs to 10 V, even if the $P_{forward}$ is 100% of the nominal output power (100%=20 V, but limited to 10 V).

  An Analog I/O MAX over 10 V can be useful when used with cable attenuation (see "Using the Cable Attenuation Feature" on page 5-54). For example: If your Cesar generator has a maximum output of 1000 W, and you set cable attenuation to 50%, the output will display as 500 W. This means that if Analog

I/O Max = 10 V, then $P_{forward}$ would be 5 V. If this value should instead be 10 V, you can change the I/O Max to 20 V. This means there is set point of only 500 W maximum, but the generator will still output 1000 W (500 W set point with 50% cable attenuation).

> **CAUTION:**
> **All interface inputs and outputs are limited to a 10 V maximum. If you use values above 10 V, the maximum values you can measure at the User Port are still 10 V. Values over 10 V are for use only in combination with cable attenuation.**

- DC Bias Scaling

  You may set the maximum DC bias in volts from 0 V to 4000 V (in increments of 1, 10, 100, 10000, and Auto). 4000 V is the default value.

- Control by

  This feature lets you choose between front panel and **User Port** control. If you select **User Port**, you may exit this mode using the **Exit** soft key. This mode is stored even if you switch the unit off and on again. After switching off and on again, you are still able to exit using the **Exit** soft key.

  You can also operate in host port remote control (see host port command **14**).

  See "Remote Control Operation" on page 5-24 for a description of front panel, **User Port**, and host port remote control modes.

- RS-232 baud rate

  If your Cesar generator has an **RS-232** port, this function allows you to select the desired baud rate: 9600, 19200, 38400, 56000, or 115200.

- RS-232 protocol

  If your Cesar generator has an **RS-232** port, the **RS-232** protocol is factory-set to **AE Bus**, and most Cesar generators will use the default **AE Bus** protocol. However, a previous protocol (**Dressler**) is available for compatibility.

TO CHANGE THE DEFAULT DEVICE CONFIGURATION SETTINGS

1. Press the **Program** soft key.
2. Press **Next** until you see **Device Configuration** on the display.
3. Press **Change**.
4. Select the desired **Displ. Contrast** value using the **RF Power** knob.
5. Press **Ok** to confirm.
6. Press the desired **Analog I/O MAX** level using the **RF Power** knob.

You may select a maximum value between 2 V and 20 V using a combination of the **Increm Auto** soft key and the **RF Power** knob.

> **CAUTION:**
>
> All interface inputs and outputs are limited to a 10 V maximum. If you use values above 10 V, the maximum values you can measure at the User Port are still 10 V. Values over 10 V are for use only in combination with cable attenuation.

7. Press **Ok** to confirm.
8. Select the desired **DC Bias Scaling** using the **RF Power** knob. .

   You may select values between 0 V and 4000 V using a combination of the **Increm Auto** soft key and the **RF Power** knob
9. Press **Ok** to confirm.
10. Press the desired **Control by** setting:
    - **Front Panel** defaults to front panel control.
    - **User Port** defaults to user port control.
11. If your unit has an **RS-232** port, select the desired **RS232 Baud Rate** value using the **RF Power** knob.
12. Press **Ok** to confirm.
13. If your unit has an **RS-232** port, select the desired **RS232 Protocol**.
    - **AE Bus** is the standard protocol for Cesar generators.
    - **Dressler** is available for compatibility only.
14. Press **Ok** to confirm.
15. Press the **Exit** soft key.
16. Press the **Execute** soft key.

Setting and Using Preset Generator Settings for Different Applications

You can set the various front panel functions to meet your specific process needs, and you can store up to five presets (1 through 5) for five different applications. The presets store all settings in the program menu except pulse input configuration and device configuration. Preset 0 is reserved for factory settings and can be accessed read-only.

TO STORE A PRESET

1. Set all of the desired parameters using the front panel program menu.

2. After you have made the appropriate program menu selections, you will have the option to **Execute**, **Store Preset**, or **Quit**.
3. Press **Store Preset**. The settings for this particular preset will flash on the front panel.

TO ERASE A PRESET

1. Go to the preset number you wish to erase. (When you select a number, the settings for each particular preset will flash on the front panel).
2. Press **Quit**.

TO USE A PRESET

1. Go the preset you wish to select. (When you select a number, the settings for each particular preset will flash on the front panel).
2. Press **Execute**.

CONTROLLING A VARIOMATCH OR NAVIO MATCH NETWORK ATTACHED TO THE GENERATOR

If the Cesar generator is attached to a VarioMatch or Navio match network, you can control the match network manually or automatically.

☞ **Important**
The controls described here work only with a VarioMatch or Navio match network that is connected to the **Matching** interface of the generator. This function can not be used to control any other match networks unless they are electrically and functionally compatible and are connected through the **Matching** interface connector.

You may choose between:

- Manual tune

  In manual tune control, you manually set the tune and load capacitor positions of the match network. The automatic tuning feature is disabled.

- Automatic tune

  In automatic tune control, you set the tuning capacitor presets. The match network uses these presets to automatically adjust the capacitor positions and minimize reflected power. See "Setting Tune Control" on page 5-45 for additional information.

Determining the Current Match Network Tune Setting

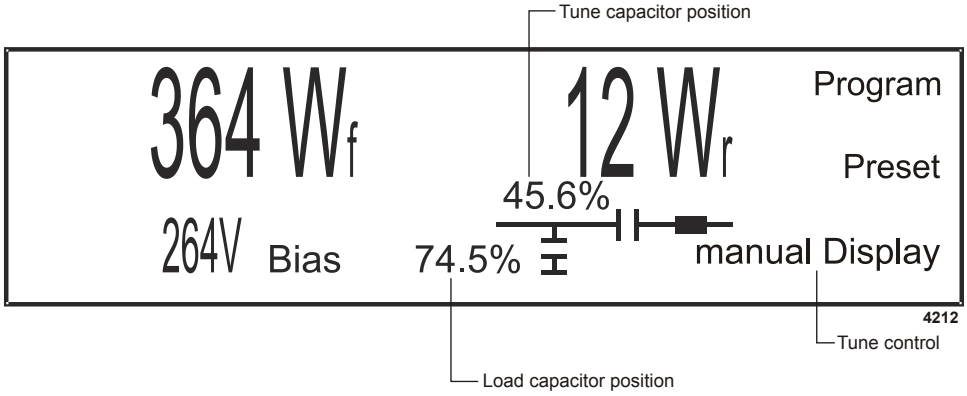
The following procedures explain how to determine if the match network is set to manual tune or automatic tune control.

If you are using the host port (**RS-232**, **PROFIBUS**, or **Ethernet**) to control and monitor the Cesar generator, use host port command **163**. You can also determine the capacitor limits and positions with host port commands **174** and **175**.

If a tune setting is active, a description will appear in the lower right-hand corner of the display:

- `auto` indicates automatic tune control
- `manual` indicates manual tune control
- `auto/I` indicates automatic tune control with presets

For example, manual tune control is selected in the following illustration.



Setting Tune Control

You can set the match tune control mode to one of the following:

- Automatic tune control

  AE recommends automatic tune control for standard match network operation. When a match network is attached and automatic tuning is set, the match network automatically adjusts the capacitor positions to minimize reflected power. The Cesar generator can set the match network to preset positions to find the optimum capacitor positions and ensure the shortest possible plasma ignition time. You can program the preset positions using either the front panel display or commands from the host port.

- Manual tune control

  In manual tune control, the automatic tuning feature is disabled and capacitor position is controlled only through the generator front panel.

- Automatic tune control, with a preset. With this selection, the C Tune and C Load positions are used both as an initial position and also as a preset.

To select the match tune mode using the host port (**RS-232**, **PROFIBUS**, or **Ethernet**), use host port command **13**. To set the load capacitor position, use command **112**. To set the tune capacitor position for automatic mode, use command **122**.

To select the match tune mode using the **Matching Network** keys:

- Press **Manual** to select manual tune mode.
- Press **Auto** to select automatic tune mode.
- Press **Auto** again to select automatic tune mode with presets.

TO SELECT THE TUNE MODE AND SET THE INITIAL C TUNE AND C LOAD POSITIONS

1. Press the **Program** soft key.
2. Press **Next** until you see **Match Settings** on the display.
3. Press **Change**.
4. Select the tune mode:
   - **auto**—Automatic tune mode
   - **manual**—Manual tune mode
   - **auto INIT**—Automatic tune mode with a preset.
5. Select the initial **C Tune** position using the **RF Power** knob. You may select values between 4% and 96%. Press **Ok** to confirm.
6. Select the initial **C Load** position using the **RF Power** knob. You may select values between 4% and 96%. Press **Ok** to confirm.
7. If you selected **auto INIT** control, (available with firmware release 1.21 and later), you need to select the positioning algorithm:
   - **Adaptive**—Default. Uses the positioning algorithm from a previous firmware release (release 1.20). AE recommends that you use this algorithm. If you encounter positioning problems, then switch to the hybrid algorithm.
   - **Fixed**—Uses the positioning algorithm from previous firmware release (releases 1.19 and earlier). Included for backwards compatibility.
   - **Hybrid**—Available in firmware release 1.21 and later. Uses a combination of adaptive and fixed algorithms. If you chose this type, you will also set the number of positioning failures allowed (**Hyb. Sw. Count**) using the **RF Power** knob.

     With the hybrid algorithm, positioning starts with the adaptive algorithm. If the match fails to reach the requested position in the number of failures you specified in **Hyb. Sw. Count**, then it will change to use the fixed algorithm.

   Press **Ok** to confirm.
8. Press the **Exit** soft key.

9. Press the **Execute** soft key.

The capacitors will move to the programmed positions, and the associated position values will begin to flash on the display, indicating that the capacitors are moving.

See also "Determining Automatic Tuning Presets" on page 5-47.

Determining Automatic Tuning Presets

The automatic tuning preset values establish the initial positions for both the tune (**C Tune**) and load (**C Load**) capacitors before RF power turns on. This feature is useful for different process recipes. You can change the preset values to meet your specific process needs. Appropriate preset values vary widely from application to application, depending on operating variables such as the type of application gas, the amount of pressure in the chamber, and the configuration of the chamber.

TO DETERMINE APPROPRIATE PRESET POSITIONS

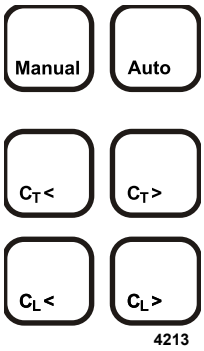
1. In an experimental chamber, turn on RF power at the expected power level.
2. Allow the Cesar generator to tune in manual tune control.
   - If the plasma ignites, use the **Matching** controls on the front panel to adjust the tuning parameters only slightly and find the optimum positions.
   - If the plasma fails to ignite, experiment to find a position where the plasma will ignite; then make small adjustments from that point to find the optimum positions.

Adjusting the Capacitors When in Manual Tune

When a VarioMatch or Navio match network is connected to the **Matching** interface of the Cesar generator and set to manual tune, you can adjust the tune and load positions using the following **Matching** control keys on the front panel.

These control keys work only with a VarioMatch or Navio match network that is connected to the **Matching** interface of the generator. You can use these keys to control another match network only if it is electrically and functionally compatible and is connected through the **Matching** interface connector.

If you want to use the host port for primary generator control, yet retain VarioMatch or Navio match network control on the front panel, you must set the generator to **Remote Control Override** (see "Remote Control Operation" on page 5-24).



On the front panel, there are keys for **Manual** and for **Auto**. If you are in front panel mode (or you have set the remote control override to front panel) you can use these keys to switch between manual and auto mode.

To adjust the tune and load capacitors:

- First, ensure that unit is set to manual tune control. The word `manual` should show on the display.
- Use the four capacitor keys on the generator front panel to adjust the tune and load capacitor positions (see Table 5-3). When you press one of these keys, the associated variable capacitor will turn in the chosen direction. The actual capacitor position will flash on the front panel display.
- The capacitor keys are functional only in manual mode.

☞ **Important**

Improper use of this feature may cause the VarioMatch or Navio match network to search but fail to tune or to exhibit modulated power delivery. These conditions are characterized by nonstable plasma glow or flickering plasma. See the troubleshooting section for more detailed information.

Table 5-3. Adjusting VarioMatch match network capacitors

Capacitor Key	Description
C_T<	This key moves the variable tune capacitor in a counter-clockwise direction and decreases the value of the tune capacitor.
C_T>	This key moves the variable tune capacitor in a clockwise direction and increases the value of the tune capacitor.
C_L<	This key moves the load capacitor in a counter-clockwise direction and decreases the value of the load capacitor.
C_L>	This key moves the load capacitor in a clockwise direction and increases the value of the load capacitor.

THE ARC HANDLING SYSTEM

Some Cesar generator units have an arc handling system. This system is responsible for detecting and suppressing arcs.

Understanding Arc Handling

There are two parts of the arc handling system, arc detection and arc suppression:

- Arc detection

  The Cesar generator detects rapid changes in the reflected power as measured at **RF Out** on the generator. An arc is detected when the reflected power goes outside the limits that you specify. You set these limits in the generator via the front panel or host port.

- Arc suppression

  The Cesar generator temporarily turns off RF power when it detects an arc.

When the generator encounters a possible arc, it handles the event using several parameters, including:

- System-defined parameters: settle time and observation time
- User-defined parameters: suppression time and suppression attempts

Figure 5-10 shows a block diagram of the arc handling system. The reflected power is filtered by both a slow and a fast filter. The output of the slow filter tracks slow changes in reflected power. Adding an offset (o_1) and a fraction (k_1) of the forward power to the output of the slow filter creates an upper limit. Subtracting an offset (o_2) and a fraction (k_2) of the forward power creates a lower limit. If the output of the fast filter either exceeds the upper limit or drops below the lower limit, an arc is detected.

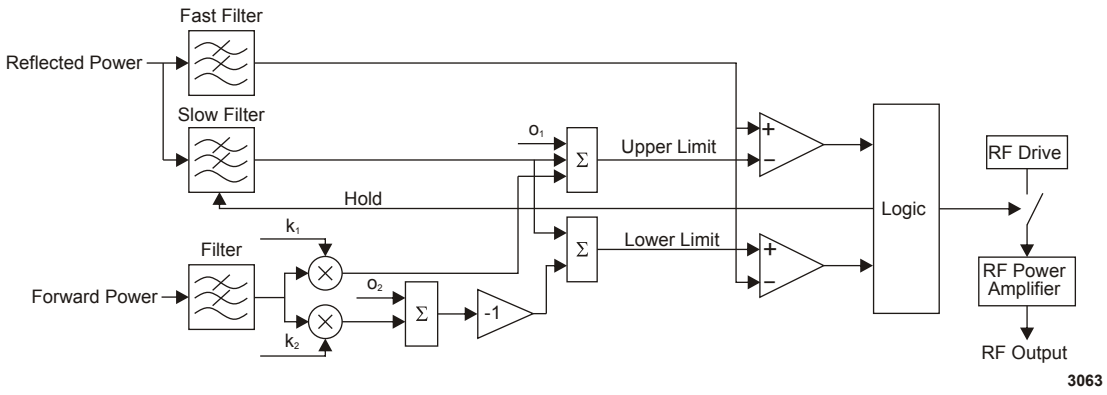


Figure 5-10. *Block diagram of the arc handling system*

As soon as an arc is detected, the output of the slow filter is frozen. The output of the slow filter thus maintains the reflected power level at the start of the arc, and since it

is too slow to react to the arc, this is essentially the condition present before the arc started.

In response to the first arc, RF is turned off for a user-specified period of time (suppression time). Then RF is turned on again for the fixed settle time (40 µs) to allow the plasma to settle down. In this 40 µs timeframe, RF is on but arc detection is off.

If reflected power is still outside the limits at the end of the settle time, RF is switched off again immediately. RF then stays off for double the specified suppression time. If reflected power is within the limits after the settle time, the system starts an additional observation time (also 40 µs). If an arc occurs again in this timeframe RF is switched off immediately and RF stays off for double the specified suppression time. This arc in the observation time is not counted as a new arc.

This process repeats until either the arc has been quenched or a user-defined suppression attempts value has been reached. Each time, the suppression time is doubled from the previous suppression time.

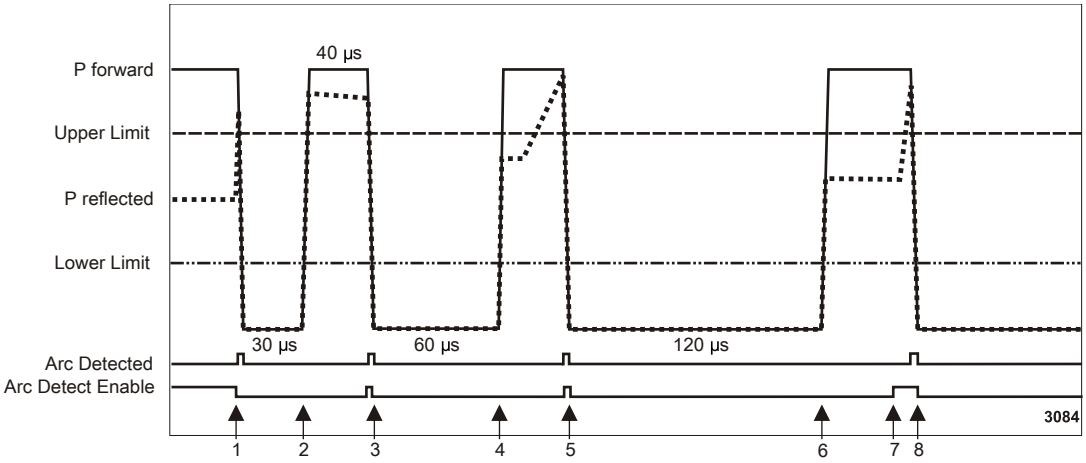
If the suppression attempts value is reached, the generator turns off with an error condition to protect processing equipment.

EXAMPLES

In these examples, assume the parameters are set to:

- Arc detect: on
- Suppression time: 30 µs
- Suppression attempts: 3

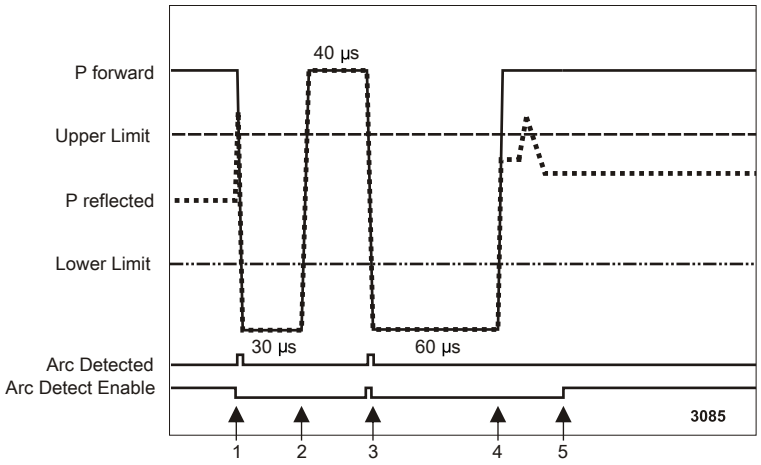
In the first example, arc detection is turned off with an error condition because the arc handling system suppresses the same arc the maximum number of times.



1. An arc is detected so RF is turned off for 30 µs (suppression time) and arc detection is disabled. The arc counter is increased by 1.
2. RF is turned on; Arc detection remains disabled for 40 µs (settle time) to allow the plasma to settle.

3. Arc detection is enabled; An arc is detected within the next 40 µs (observation time), so RF is turned off for 60 µs (double the previous suppression time) and arc detection is disabled. The arc counter is not increased because this is considered part of the same arc.
4. RF is turned on; Arc detection remains disabled for 40 µs to allow the plasma to settle.
5. Arc detection is enabled; An arc is detected within the next 40 µs, so RF is turned off for 120 µs (double the previous suppression time) and arc detection is disabled. The arc counter is not increased because this is considered part of the same arc.
6. RF is turned on, Arc detection remains disabled for 40 µs to allow the plasma to settle.
7. Arc detection is enabled.
8. An arc is detected within the next 40 µs (observation time) so RF is turned off with an error condition (suppression attempts = 3, and this is the 3rd attempt).

In the second example, the arc is suppressed after the second attempt, so RF and arc detection remain on.



1. An arc is detected so RF turned off for 30 µs (suppression time) and arc detection is disabled. The arc counter is increased by 1.
2. RF is turned on; Arc detection remains disabled for 40 µs (settle time) to allow the plasma to settle.
3. Arc detection is enabled; An arc is detected within the next 40 µs (observation time), so RF turned off for 60 µs (double the previous suppression time) and arc detection is disabled. The arc counter is not increased because this is considered part of the same arc.
4. RF is turned on; Arc detection remains disabled for 40 µs to allow the plasma to settle.
5. Arc detection is enabled; No arc is detected within the next 40 µs, so RF remains on and the arc detect counter is reset.

Setting Up The Arc Handling System

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

The actual values that the potentiometers are set to is the sum of these factory-set base sensitivity values and user-defined sensitivity values. Setting the potentiometer values this way helps ensure that different units behave the same if given the same user-defined sensitivity values.

To set sensitivity values, you will set the arc detection parameters from either the front panel or the user port:

- Using the front panel: See "Setting Arc Suppression Parameters".
- Using the host port (**RS-232** port, **PROFIBUS** port, or **Ethernet** port): use commands **36**, **84**, and **199**.

Use Table 5-4 to map parameters to parts of the arc handling block diagram in "Understanding Arc Handling".

***Table 5-4.** Mapping of arc detection parameters to the offsets and multipliers*

Description	Block Diagram Annotation	Front Panel Parameter	Device/ Potentiometer Allocation in AE Bus/ Profibus
Upper limit offset	o_1	+ Offset	Device 1, Potentiometer 0
Upper limit gain	k_1	+ Gain	Device 1, Potentiometer 1
Lower limit offset	o_2	- Offset	Device 1, Potentiometer 2
Lower limit gain	k_2	- Gain	Device 1, Potentiometer 3

The goal of setting sensitivity values is to set them so that the normal reflected power is always within the upper and lower limits; only the spikes (arcs) are outside the limits. The sensitivity values set in the factory should be close to the values that you would typically use. However, you may need to optimize the sensitivity values for your system.

The general process to optimize sensitivity values is to set o_1 and o_2 (with $k_1$and k_2 set to 0) such that the false detection rate is minimized using a low power process, and then check the performance at a higher power process. If more false alarms are generated with the high power process, you can increase $k_1$and k_2 to decrease the

sensitivity at high power. This way the sensitivity tracks the process power and a wider range of process powers can be maintained.

You set the sensitivity values using either the host port (commands **36**, **84**, and **199**) or the front panel. You can connect your Cesar generator to an oscilloscope via the **Arc Det. Monitor** connector so that you can see the following:

- Arc Detect signal (digital)
- Reflected power
- Forward power
- Upper limit bandwidth
- Lower limit bandwidth

If you use an oscilloscope, connect it to the generator using the **Arc Det. Monitor** pinout description.

Whether or not you use an oscilloscope to monitor the values, the procedure to determine sensitivity values is the same.

TO DETERMINE SENSITIVITY VALUES

1. At low power, increase the upper bandwidth by changing the upper limit via **+Offset** on the front panel or host port from zero until you no longer have false arcs. Leave all other parameters alone (**-Offset**=0, **±Gain**=0)
2. If you are still getting false arcs, then increase the lower bandwidth by changing the lower limit via **-Offset** on the front panel or host port from zero until you no longer have false arcs.
3. Decrease the upper bandwidth by changing the upper limit via **+Offset** on the front panel or the host port until you no longer have false arcs.
4. Repeat steps 1 to 3 to fine-tune the upper and lower bandwidth.
5. Check the performance at high power. If you have no false arcs then the parameters are set correctly.
6. If you are getting false arcs at high power, then adjust the **+/- Gain**. These values increase the limit when the power is increased.

TO DETERMINE RF ON AND SET POINT CHANGE TIME

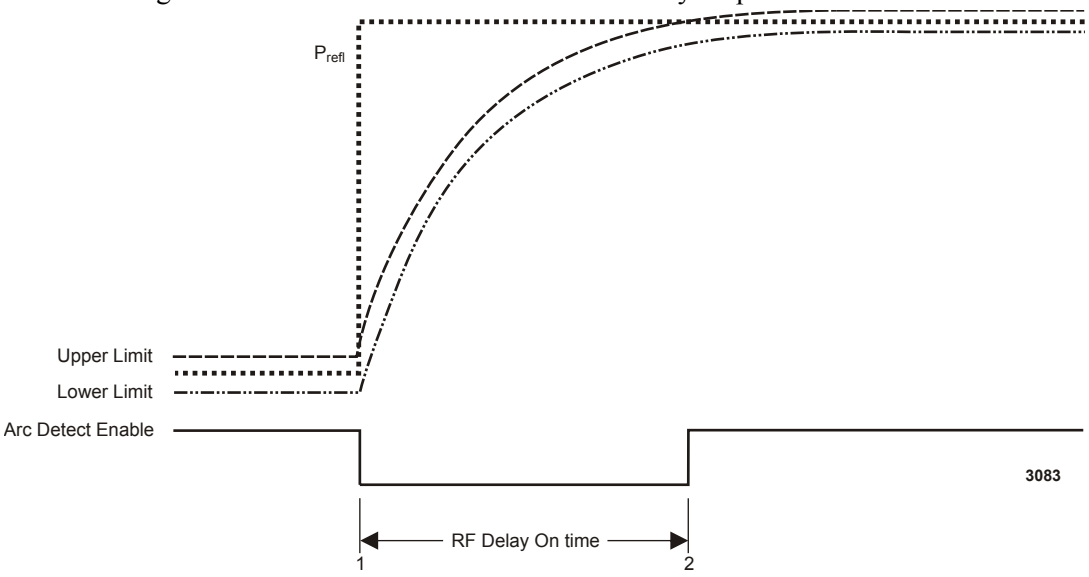
Arc detection is switched off automatically when either of the following changes:

- Set point change
- RF switched on

You want the upper and lower limits to detect all arcs, but there must be some time for the limits to settle around normal RF power before turning on arc detection. You will need to set RF delay on time and delay setpoint time such that no false arcs are

detected prior to the limits settling, and yet arc detection is on as soon as arcs can accurately be detected.

The following illustration shows where to set the RF delay on parameter.



1. When forward power is turned on, arc detection is turned off for the specified RF delay on time.
2. Once RF delay on time is reached, arc detection is enabled.

The arc handling system uses the delay set point value when the set point changes, in a manner similar to the way it uses RF delay on. Set the delay set point so that when the set point changes, arc detection is not enabled until RF has time to settle.

USING THE CABLE ATTENUATION FEATURE

Attenuation is the last item when setting regulation mode from the front panel, after adjusting the power (forward or real mode) or $P_{forward}$ limit (DC Bias mode).

Use this feature if you want to know both the forward power going into the load (instead of the power going out of the generator) and the reflected power at the load (instead of the reflected power at the generator). The difference in power at the generator and the load is caused by the losses of the cable connecting both (cable attenuation).

Cable Attenuation Description

You can adjust the cable attenuation between -10% (-0.45 dB) and +50% (+3.01 dB). Only positive values make sense to compensate cable losses. Negative values are implemented to be able to balance different measurement equipment.

To use the cable attenuation feature, you need to know the exact loss of your RF cable. When you supply an accurate cable attenuation value, the internal calculation will, in effect, move the measurement point from the generator RF output port to the front of the load. The Cesar generator will now display the values at this virtual measurement point and also provide the recalculated values to all interfaces (for example, **User Port** or **RS-232**).

If you use this feature:

- The Cesar generator will no longer display the measured values at the generator output but the recalculated values. All power limits you can adjust (for example, **Pforward** or **Preflected** in DC bias mode) are now related to the virtual measurement at the load.
  - **Pforward** displays the value: $P_{forward(Load)}$ (the calculated value accounting for attenuation)
  - **Preflected** displays the value: $P_{reflected(Load)}$ (the calculated value accounting for attenuation)
- This function affects the monitor outputs of the interfaces (**User Port** and **RS-232**) as well as the front panel display. These outputs are linked to the displayed value of **Pforward** and **Preflected**.

When you set the attenuation to 0% (the default), the front panel displays the standard measurement.

If you change the RF cable to one with different attenuation, you do not need to change your power presets. You need to adjust only the attenuation value for the new cable.

Figure 5-11 and Figure 5-12 illustrate the $P_{forward}$ and $P_{reflected}$ values. The calculations are described in "Forward Power Calculation" and "Reflected Power Calculation".

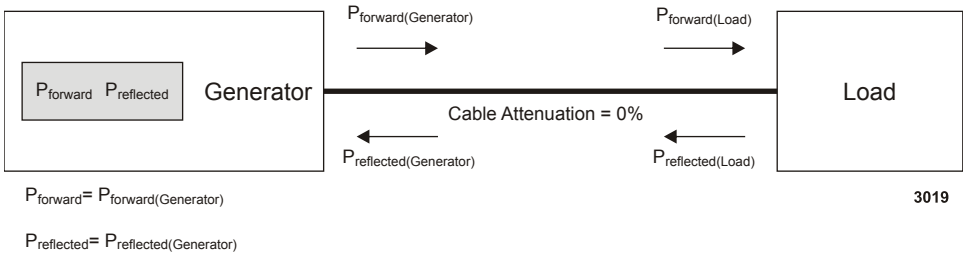


Figure 5-11. Generator with no cable attenuation

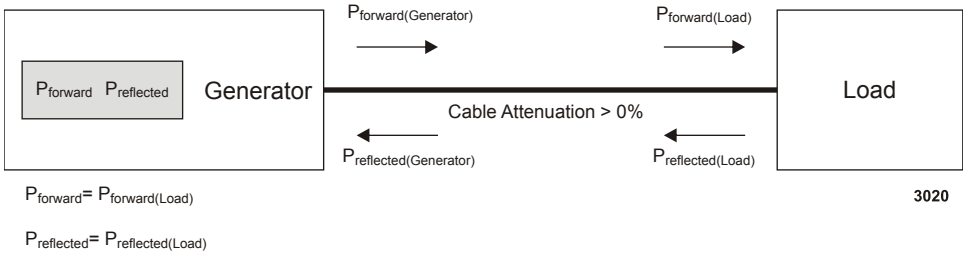


Figure 5-12. Generator with cable attenuation

FORWARD POWER CALCULATION

The power $P_{forward(Generator)}$ is the power coming out of the generator ($P_{forward(Generator)}$ is equal to $P_{forward}$ at *Attenuation*=0%). At the end of the cable the power $P_{forward(Load)}$ is going into the load.

$$P_{forward(Load)} = P_{forward(Generator)} \; x \; (1 - Attenuation)$$

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REFLECTED POWER CALCULATION

If the load is mismatched, there is $P_{reflected(Load)}$ coming back from the load. This power is damped also by the cable on its way back to the generator and it reaches the generator as $P_{reflected(Generator)}$ ($P_{reflected(Generator)}$ is equal to $P_{reflected}$ at *Attenuation*=0%).

$$P_{reflected(Load)} = \frac{P_{reflected(Generator)}}{(1 - Attenuation)}$$

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$P_{forward(Generator)}$ and $P_{reflected(Generator)}$ are the actual values measured by the generator. $P_{forward(Load)}$ and $P_{reflected(Load)}$ are the virtual values that are calculated when you set the attenuation variable.

Cable Attenuation and Reflected Power Settings

The maximum reflected power is scaled with the cable attenuation (attenuation is specified as %). When cable attenuation is set, the **Prefl. Limit** and **Prefl. Threshold** values shown in the **Refl. Power Settings** menu are adjusted for attenuation. This means you can use the cable attenuation feature without changing all your limits.

- **Prefl. Limit** (displayed) = **Prefl. Limit** (set) / (1-**Attenuation**)
- **Prefl. Threshold** (displayed) = **Prefl. Threshold** (set) / (1-**Attenuation**)

For example, if the **Prefl. Limit** is set to 200 W, and if **Attenuation** is changed from 0% to 50% then the displayed value is changed from 200 W to 400 W (200 W / 50% = 400 W).

Example: Assume you use a 100 m cable with a loss of 3 dB (=50%) and the generator delivers 1000 W at the output. Then the power at the load would be 500 W (1000 W * (1-50%)), If 400 W is reflected back, the reflected power measured at the generator would be 200 W (400 W * (1-50%)).

By setting cable attenuation, the Cesar generator will display the condition at the load. In this example, the generator will display 500 W output power, although 1000 W are leaving the generator. The generator will display 400 W reflected power, although only 200 W are going back into the generator.

CONNECTING TO AN ETHERNET-ENABLED UNIT WITH A WEB BROWSER

Your Cesar generator may include an **Ethernet** port, which allows you to create a Modbus/TCP network connection between the unit and your local area network (LAN). This section provides information on connecting to an **Ethernet**-enabled unit with a web browser.

To Connect to an Ethernet-enabled Cesar Generator With a Web Browser

1. Open a standard Web browser program.
2. Type the Cesar generator's IP address into the Web browser **Address** field.

If you have trouble connecting, use the information in "Connecting and Setting **Ethernet** (Modbus/TCP) Communication" on page 5-11 to ensure that:

- The generator is connected to the network through the **Ethernet** port
- The generator is receiving proper input power
- You are typing in the correct IP address
- The BootP server found the Cesar generator's MAC address (if you are using a BootP server to change the IP address)

If you continue to have trouble, refer to the troubleshooting section of the online help for the BootP utility software that came with the unit (on a CD-ROM) or contact AE Global Services.

Troubleshooting and Global Services

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

BEFORE CONTACTING AE GLOBAL SERVICES

DANGER:

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

WARNING:

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.

Checks With Power Off

1. Ensure that the power to the unit is off.
2. Check for visible damage to the unit, cables, and connectors.
3. Ensure that all unit connectors are installed correctly and fastened tightly.
4. Check to determine whether any system-related circuit breakers have been tripped.
5. Verify that the input power to the unit meets specifications.
6. Ensure ground connections are adequate and secure.

Checks With Power On

- Check the unit's input and remote power connections to ensure the proper power is being supplied to the unit.

Troubleshooting Checklists

GENERAL TROUBLESHOOTING

Use the following procedure to troubleshoot general problems.

1. Did you install the generator according to the installation instructions in this manual?
   - If yes, go to the next step.
   - If no, reinstall the generator.
2. Is the mains voltage within specifications?
   - If yes, go to the next step.
   - If unsure or no, see "Incorrect Input Voltage" on page 6-5.
3. Is the interlock satisfied?
   - If yes, go to the next step.
   - If unsure or no, see "Interlock Not Satisfied" on page 6-3.
4. Is the front panel display (LCD) lit?
   - If yes, go to the next step.
   - If no, see "Front Panel Display (LCD) Not Lit" on page 6-4.
5. Check the front panel display for any fault (EXX) or warning (WXX) messages.
   - If there is no warning or error message on the display, go to the next step.
   - If there is an error or warning message on the display, see "Troubleshooting Using Error Codes" on page 6-6.
6. Does the generator communicate with the host computer?
   - If yes, go to the next step.
   - If no, see "Communication Problems" on page 6-4.
7. For any other general problems, contact AE Global Services.

MATCHING NETWORK TROUBLESHOOTING

Use the following procedure to troubleshoot potential problems with the matching network.

1. Did you install the matching network according to the instructions in the manual?
   - If yes, go to the next step.
   - If unsure or no, check installation or reinstall according to the manual that came with the matching network.
2. Did you verify that the impedance range of the matching network is appropriate to the load?
   - If yes, go to the next step.
   - If unsure or no, see "Improper Impedance Range" on page 6-5.
3. Did you properly establish the RF connections between the generator and the matching network as well as between the matching network and the load?
   - If yes, go to the next step.
   - If unsure or no, see "Improper RF Connection or Cabling" on page 6-5.
4. Did you establish proper common grounding for the generator, matching network, and load?
   - If yes, go to the next step.
   - If unsure or no, see "Improper Grounding" on page 6-6.
5. Did you establish the correct interface connection for remote control of the matching network?
   - If yes, but you are still having trouble, check that both units are correctly powered up (AC Mains) and check the cable and connectors for damage.
   - If unsure or no, see the installation section of the match network manual and see "Improper **Matching** Interface Connection" on page 6-6.
6. If these steps have not resolved the problem, contact AE Global Services.

Interlock Not Satisfied

You must satisfy the interlock connection, even if you do not connect the generator into a larger system interlock loop.

- To create hardware interlocks using the 25-pin **User Port**, use pins 10 and 23.
- If you have a 15-pin **User Port**, ensure external contact closure between the **Interlock** pins 1 and 2.

Related Links

- "Satisfying Minimal Requirements for the 25-pin User Port" on page 4-5
- "Satisfying Minimal Requirements for the 15-pin User Port" on page 4-18

Front Panel Display (LCD) Not Lit

The front panel display should operate as soon as the front panel **On/Off** switch is turned on.

1. Verify that the front panel **On/Off** switch is on.
2. Verify that the input line voltage is within specifications.

Communication Problems

Several factors can cause communication problems:

- Poor grounding

  Ensure that the communication cable shield is properly grounded. Ensure that the generator and the matching network are properly grounded according to the installation instructions for both the generator and the matching network.

- Improper cabling

  Ensure that each of the communication cables matches the specifications for the communication interface.

- Incorrect baud rate (RS-232 port only)

  Ensure that the baud rate used by the host computer and the baud rate set in the generator are the same.

- Incorrect or corrupt data packet

  Verify that the data packet has been set up correctly.

- Commands transferring too fast

  Ensure the commands are sent to the generator at a rate less than 1 command every 50 milliseconds (20 commands per second) if you are not using the recommended handshaking protocol.

Capacitor Failure

The generator is compatible with a VarioMatch, Navio, or other matching network with the same control functions and electronic topology. Several factors could cause the matching network capacitors to fail:

- No or incorrect power or input voltage
- The unit set for incorrect tuning control

- Incorrect parameters set for the unit

Incorrect Input Voltage

Ensure that the input voltage to the unit is within specifications.

Ensure that the input connector is connected to the correct pins.

Improper Impedance Range

A variety of problems can occur if the specifications of the connected matching network do not correspond to basic application parameters such as impedance, current, voltage, phase angle, forward power, and reflected power. These problems can include:

- Difficulty igniting plasma
- Difficulty achieving expected minimum reflected power with manual or automatic tuning by the matching network
- Arcing inside the matching network

If the generator is connected to a VarioMatch matching network, you can change the impedance range of the matching network by changing the tap settings. For information on checking the VarioMatch impedance range and changing the tap settings, see the VarioMatch manual.

If the generator is connected to a Navio matching network, you can request a new coil kit. To do so, contact AE Global Services.

For any additional information or questions, contact AE Global Services.

Improper RF Connection or Cabling

Proper operation requires low impedance RF connections between the generator, match network, and load. In most situations, coaxial cable of an appropriate diameter is sufficient for the RF connections. Additionally, make the following checks:

- Verify that there contacts are not loose or corroded.
- If you are working with an installation that requires low impedances and higher currents, try metal strap or stripline connections.
- Consider the surface area and surface structure of conducting elements (cables, vacuum feedthroughs, and electrodes) to ensure that all elements are appropriate for the low penetration depth of RF currents.
- Minimize the cable length between the match and load to minimize power losses. With some applications, you may also need to optimize the cable length between the generator and the match to achieve a stable plasma that doesn’t flicker or flash

For more information on optimizing cable length, see the matching network manual. For questions about proper cable selection, contact AE Global Services for the cable selection guide.

Improper Grounding

Proper operation requires that you use a central, common ground for the generator, matching network, and load. Ensure that you have appropriate grounding for all elements of the system.

Improper Matching Interface Connection

Cesar generators, VarioMatch match networks, and Navio match networks are equipped with compatible **Matching** connectors. You can use this connection to control the match network through the generator front panel. To troubleshoot this connection:

- Verify that you are using the correct cable.
- Check whether you can send basic commands to the match network from the generator, such as switching between automatic and manual tuning modes or moving the capacitors in manual mode.

Refer to the match network manual for additional troubleshooting suggestions

If none of these procedures resolves the problem, contact AE Global Services.

Improper Tuning Adjustment

AE ships VarioMatch and Navio units with standard tuning settings, which are appropriate for most applications. In rare cases, the tuning parameters may need to be adjusted for special applications. For information on adjusting these tuning parameters, contact AE Global Services.

TROUBLESHOOTING USING ERROR CODES

Fault and Warning Types and Clearing Faults

The generator responds to many error and warning conditions. Errors and warnings display on the front panel. Errors are also reported through command **223** on the RS-232 port. Errors and warnings appear as follows:

- Errors: EXX, followed by the message text.

- Warnings: WXX, followed by the message text.
- Communication Warnings: WXX or CSRXX, followed by the message text.

While troubleshooting and solving problems with the generator, you may need to turn off AC Mains or open the cabinet. Some of the documented procedures are for trained personnel only. Use appropriate precautions and safety procedures.

WARNING:

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

DANGER:

The Cesar on/off power switch does not completely disconnect the Mains. You must have an external switch installed to completely disconnect the Mains.

WARNING:

Internal capacitors may take up to five minutes to discharge to a safe level after input power has been removed. Wait before removing covers.

DANGER:

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

Error Code Descriptions and Resolutions

Error conditions always turn output off. If multiple error conditions exist, the unit displays all errors. When operating in front panel control mode, you need to reset the unit after the condition that caused the error has been resolved. Once the condition is resolved, the front panel displays a **Quit** soft key, which you press to reset the unit.

The **Quit** soft key will not display until the error condition is resolved. (In remote control mode, the unit automatically resets after the condition that caused the error is resolved.)

The following table lists the error messages that may occur on the generator, describes each error message, and explains how to resolve the error. If the information in this table does not resolve the problem, contact AE Global Services.

Use the following table to understand error codes and actions you can take if you encounter one or more of them.

Table 6-1. Error codes

Error Code	Description and Resolution
E01 **Interlock loop open**	Open interlock loop. Causes: Switch opened, interlock loop not connected to the **User Port**. Solution: Close interlock loop by making the proper connections to satisfy the interlock.
E10 **SMPS temperature too high**	Switch mode power supply temperature is too high. Cause: Cooling water temperature too high/water flow too low. Solution: Let generator cool down, improve cooling Ensure proper airflow: • Check to see that the air flow is unobstructed and below the specified input temperature. • Listen to ensure that the fan is operating properly. Ensure proper water flow: 1. Wait for the unit to cool. 2. Ensure the water temperature, flow rate, and pressure are within specification. 3. Check the water lines to ensure that they are unobstructed.
E11 **RF generator temperature too high**	RF power section (chill plate) temperature too high. Cause: Cooling water temperature too high/water flow too low. Solution: Let generator cool down, improve cooling Ensure proper airflow: • Check to see that the air flow is unobstructed and below the specified input temperature. • Listen to ensure that the fan is operating properly. Ensure proper water flow: 1. Wait for the unit to cool. 2. Ensure the water temperature, flow rate, and pressure are within specification. 3. Check the water lines to ensure that they are unobstructed.

Table 6-1. Error codes (Continued)

Error Code	Description and Resolution
E18 **Arc suppression fault**	Arc could not be quenched. The arc suppression logic was not able to successfully quench an arc in the specified maximum number of attempts. That is, after re-enabling RF after the last attempt the arc was still active; therefore, RF is turned off. When this error occurs, the xxxx # Arcs is displayed on the front panel. Cause: Arc suppression parameters not set correctly. Solution: • Increase the number of attempts. • Increase the initial suppression time. • Increase the bandwidth • Increase initial delay or set point change delay. Cause: Plasma chamber dirty or defective. Solution: • Check the load (for example, the plasma chamber) for the cause of the arc. • Clean plasma chamber.
E52 **RF on time limit**	The time since an RF on command was issued exceeds the configured limit without an RF off command. RF is switched off. Cause: RF was on longer than the configured time limit allowed. Solution: Change the RF on time limit. Change the recipe settings.
E61 **External pulse too short**	Either the external pulse frequency or duty cycle measured by the FPGA were found to be out of range. The generator has turned off to protect itself from damage. Causes: Either the pulse repetition frequency is too high or the duty cycle is too low for the actual pulse repetition frequency. Solution: Either reduce the pulse frequency to be within limits or increase the duty cycle.
E90 **A/D-Conversion failure**	Software/controller fault: A/D-conversion synchronization loss. Causes: EMC-problem. Solution: Switch generator off and on again, ensure installation and operating environment comply with EMC requirements (see the installation instructions). If problem persists contact AE Global Services.

Table 6-1. Error codes (Continued)

Error Code	Description and Resolution
E91 **DDS VCO communication failure**	Software/controller fault: Internal communication fault. Cause: EMC problem. Controller cannot communicate with DDS. Solution: Switch generator off and on again, ensure installation and operating environment comply with EMC requirements (see the installation instructions). If problem persists contact AE Global Services.
E97 **Invalid EEPROM contents - Can not initialize device, please call service**	Controller fault: Parameter data is corrupt (checksum error or invalid data). Cause: EMC problem. Solution: Switch generator off and on again. If problem persists contact AE Global Services.
E98 **Invalid calibration data - Can not initialize device, please call service**	Controller fault: Calibration data is corrupt (checksum error or invalid data). Cause: EMC problem. Solution: Switch generator off and on again. If problem persists contact AE Global Services.
E99 **Reset during initialization - Can not initialize device, please call service**	Power was interrupted during initialization Cause: Power was interrupted (switched on and off too fast) during initialization. The controller may be defective. Solution: Switch generator off and on again. If error persists contact AE Global Services.
E901 **Software: unexpected default case**	Software fault. Cause: Firmware problem. Solution: Contact AE Global Services to receive a firmware update. Please report the software version, the complete error message, and the circumstances under which the error occurred.

Warning Message Descriptions and Resolutions

Warning conditions do not shut output power off, and the warning message is cleared when the condition that caused the warning condition is gone. The front panel displays only one warning message at a time. Overload warnings indicate that an operating limit has been exceeded, and the unit has reduced output power to remain within the allowable range. On the front panel, overload messages end with an exclamation point.

☞ **Important**

When an overload warning is active, the unit is not meeting set point.

Use the following table to understand warning messages and actions you can take if you encounter one or more of them.

Table 6-2. Warning messages

Warning Message	Description and Resolution
W10 **Power at limit!**	The voltage or the current has exceeded the limit of the internal SMPS. The unit has reduced output to remain within the limits. Output is not at set point. Cause: VSWR is too high. Solution: Reduce VSWR.
W11 **Pforw. maximum reached!**	The forward power needed to reach the real power set point is higher than the maximum forward power. The forward power is limited to the maximum forward power and so the unit has reduced forward power output to remain within the limits. Output is not at set point. Cause: VSWR is too high. Solution: Reduce VSWR.
W12 **Prefl. at limit!**	The reflected power has exceeded the maximum reflected power. The unit has reduced forward power output to remain within the limits. Output is not at set point. Cause: VSWR is too high. Solution: Reduce VSWR.
W13 **Pforw. at limit!**	This warning occurs in external (DC bias) regulation mode when the forward power required to reach the DC bias set point is higher than the user-set limit. The unit has reduced forward power to remain within the limits. Output is not at set point. Cause: The plasma did not ignite. Solutions: • Increase the forward power limit. You can set this limit through the host port or the front panel. • Change plasma conditions.
W30 **RF will switch OFF in X s**	The generator allows you to interrupt power if the reflected power exceeds a specified threshold for a specified period of time. This message occurs when the actual reflected power is above the threshold for power interruption. RF will switch off after the specified period of time. To avoid this situation, check your load or change the reflected power settings.
W41 **Frequency at limit!**	In frequency shift tuning (FST), the output frequency has reached its upper or lower limit. Therefore, the phase controller is not working at set point. Cause: VSWR is too high. Solution: Reduce VSWR.

Table 6-2. Warning messages (Continued)

Warning Message	Description and Resolution
W50 **Target lifetime has expired**	The target lifetime counter has reached the user-set target life limit. This warning does not affect the operation of the unit. Cause: Target has reached calculated lifetime. Solution: Change target or reset target lifetime counter. You can change these settings through the host port or the front panel.

Communication Warning Descriptions and Resolutions

Communication warning messages are displayed for five seconds on the front panel if a communication problem occurs. They have no influence on the behavior of the generator. They are informational messages which help to detect and solve communication problems.

Use the following table to understand communication warning messages that may occur on the prod-name generator, describes each message, and explains how to resolve the associated problem.

Table 6-3. Communication warning messages

Warning Message	Description and Resolution
W101 **Host timeout**	Timeout occurred on the host port—the generator was waiting for an answer but didn't receive one in time. Cause: EMC problem, transmission. Solution: Check cabling and transmission. Cause: Protocol violation. Solution: Check protocol implementation.
W102 **Host handshake fault**	The generator received a NAK from the host when waiting for an acknowledge. Cause: EMC problem, transmission. Solution: Check cabling and transmission, reduce baud rate.
W103 **Host checksum fault**	The generator received a packet from the host with a checksum error and responded with a NAK. Cause: EMC problem, transmission. Solution: Check cabling and transmission, reduce baud rate.
CSR 1 **Wrong control mode**	The generator responded to a host port command with a command status response (CSR) code of 1. Cause: The command is allowed only in host port control mode. Solution: Set generator to host port control mode with command **14**.

Table 6-3. Communication warning messages (Continued)

Warning Message	Description and Resolution
CSR 2 **RF on**	The generator responded to a host port command with a command status response (CSR) code of 2. Cause: The command is allowed only when RF is off. Solution: Switch RF off with command **1**.
CSR 4 **Data out of range**	The generator responded to a host port command with a command status response (CSR) code of 4. Cause: The data from the host was out of the allowed range for this command/generator. Solution: Resend data within the allowed range.
CSR 7 **Fault(s) active**	The generator responded to a host port command with a command status response (CSR) code of 7. Cause: The command is not allowed while a fault is active. Solution: Eliminate the cause of the fault.
CSR 9 **Wrong data byte count**	The generator responded to a host port command with a command status response (CSR) code of 9. Cause: The number of host port data bytes does not match the expected number for this command. Solution: Check the AE Bus commands description for correct data byte count.
CSR 19 **Recipe active**	The generator responded to a host port command with a command status response (CSR) code of 19. Cause: The command is not allowed while a recipe is active. Solution: Switch RF off and stop recipe with command **1**.
CSR 50 **Frequency out of range**	The generator responded to a host port command with a command status response (CSR) code of 50. Cause: The command tried to set a duty cycle that is out of the allowed range for the currently set pulse frequency. Solution: Reduce pulse frequency with command **93** prior to setting the duty cycle. See unit specifications for allowed combinations of pulse frequency and duty cycle.
CSR 51 **Duty cycle out of range**	The generator responded to a host port command with a command status response (CSR) code of 51. Cause: The command tried to set a pulse frequency that is out of the allowed range for the currently set duty cycle. Solution: Increase duty cycle with command **96** prior to setting the pulse frequency. See unit specifications for allowed combinations of pulse frequency and duty cycle.

Table 6-3. Communication warning messages (Continued)

Warning Message	Description and Resolution
CSR 53 **No device**	The generator responded to a host port command with a command status response (CSR) code of 53. Cause: The command controls a device that is not installed or connected to the generator (for example, arc handling or matching network). Solution: Check the device or connections.
CSR 99 **Command not implemented**	The generator responded to a host port command with a command status response (CSR) code of 99. Cause: The command is not implemented in this generator/firmware. Solution: See the AE Bus commands description for a listing of the supported commands.

AE GLOBAL SERVICES

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

Table 6-4. AE Global Services 24 X 7 contact information

Office	Contact
AE, World Headquarters 1625 Sharp Point Drive Fort Collins, CO 80525 USA ☞ **Important** For returns and repairs, please call Global Services to get the correct shipping address.	Phone (24 hrs/day, 7 days/week): 800.446.9167 or 970.221.0108 Fax (M–F, 7:00 am – 5:30 pm MST): 970.407.5981 Email: (We will respond to email by the next business day.) technical.support@aei.com For Sekidenko thermal product support, contact by email: thermalapplications@aei.com

Table 6-4. AE Global Services 24 X 7 contact information (Continued)

Office	Contact
If you would prefer to contact a local or regional sales or service office, visit the Advanced Energy web site for current contact information (click on Sales and Support): • http://www.advanced-energy.com	

RETURNING UNITS FOR REPAIR

Before returning any product for repair and/or adjustment, first follow all troubleshooting procedures. After following troubleshooting procedures, if your unit is unable to resume normal operation, contact AE Global Services and discuss the problem with a representative. Be prepared to give them the model number and serial number of the unit as well as the reason for the proposed return. This consultation call will allow Global Services to determine if the unit must actually be returned for the problem to be corrected. Such technical consultation is always available at no charge.

DECOMMISSIONING THE UNIT

When it becomes necessary to decommission the unit, use the following guidelines:

- Chamber residue and electronic components: discard in accordance with local safety/environmental regulations
- Aluminum parts, steel parts, and copper wiring: recycle
- Plastics: recycle or discard in accordance with local safety/environmental regulations

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