

Series 2268

850-Watt Programmable DC Power Supplies

Reference Manual

2268S-901-01 Rev. A / January 2015



2268S-901-01

A Greater Measure of Confidence



Series 2268
850 Watt DC Power Supplies
Reference Manual

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with nonhazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read and follow all installation, operation, and maintenance information carefully before using the product. Refer to the user documentation for complete product specifications.

If the product is used in a manner not specified, the protection provided by the product warranty may be impaired.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating properly, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the user documentation. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, perform safe installations, and repair products. Only properly trained service personnel may perform installation and service procedures.

Keithley Instruments products are designed for use with electrical signals that are measurement, control, and data I/O connections, with low transient overvoltages, and must not be directly connected to mains voltage or to voltage sources with high transient overvoltages. Measurement Category II (as referenced in IEC 60664) connections require protection for high transient overvoltages often associated with local AC mains connections. Certain Keithley measuring instruments may be connected to mains. These instruments will be marked as category II or higher.

Unless explicitly allowed in the specifications, operating manual, and instrument labels, do not connect any instrument to mains.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30 V RMS, 42.4 V peak, or 60 VDC are present. A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.

Operators of this product must be protected from electric shock at all times. The responsible body must ensure that operators are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product operators in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 V, no conductive part of the circuit may be exposed.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance-limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, ensure that the line cord is connected to a properly-grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

When installing equipment where access to the main power cord is restricted, such as rack mounting, a separate main input power disconnect device must be provided in close proximity to the equipment and within easy reach of the operator.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.


For safety, instruments and accessories must be used in accordance with the operating instructions. If the instruments or accessories are used in a manner not specified in the operating instructions, the protection provided by the equipment may be impaired.


Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with the same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as protective earth (safety ground) connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.


If a  screw is present, connect it to protective earth (safety ground) using the wire recommended in the user documentation.

The  symbol on an instrument means caution, risk of danger. The user must refer to the operating instructions located in the user documentation in all cases where the symbol is marked on the instrument.

The  symbol on an instrument means caution, risk of electric shock. Use standard safety precautions to avoid personal contact with these voltages.

The  symbol on an instrument shows that the surface may be hot. Avoid personal contact to prevent burns.

The  symbol indicates a connection terminal to the equipment frame.

If this  symbol is on a product, it indicates that mercury is present in the display lamp. Please note that the lamp must be properly disposed of according to federal, state, and local laws.

The **WARNING** heading in the user documentation explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in the user documentation explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits — including the power transformer, test leads, and input jacks — must be purchased from Keithley Instruments. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. Other components that are not safety-related may be purchased from other suppliers as long as they are equivalent to the original component (note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water-based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., a data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

Safety precaution revision as of January 2013.

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Introduction

In this section:

This section describes the features of the 2268 Series 850 Watt Power Supply.

WELCOME

Thank you for choosing a Keithley Instruments product. The Series 2268 850-Watt DC power supply is designed for use in the laboratory and for test applications. It also has excellent regulation and low output voltage ripple. The digital displays provide accurate readings of voltage and current and also provide for easy, precise setting of output values using digital entry of current and voltage values. Output voltage can be set from the front panel, using a remote analog voltage or resistance, or over any of the digital interfaces: LAN, USB, GPIB, or RS-485. Voltage and current analog outputs are also available for remote monitoring and analog control.

EXTENDED WARRANTY

Additional years of warranty coverage are available on many products. These valuable contracts protect you from unbudgeted service expenses and provide additional years of protection at a fraction of the price of a repair. Extended warranties are available on new and existing products. Contact your local Keithley Instruments representative for details.

CONTACT INFORMATION

If you have any questions after you review the information in this documentation, please contact your local Keithley Instruments office, sales partner, or distributor, or call Keithley Instruments corporate headquarters (toll-free inside the U.S. and Canada only) at 1-800-935-5595, or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the Keithley Instruments website (<http://www.keithley.com>).

FEATURES AND OPTIONS

The Series 2268 Programmable DC Power Supply provides stable, variable output voltage and current for a broad range of development and system requirements. The power supplies have a high power density, numerous industry standard interfaces, and a number of excellent features:

- RS-232, RS-485, GPIB, Ethernet (ENET), analog programming (APG), and USB built-in ports
- Seamless switching between front panel and any digital interface (RS-232, RS-485, USB, GPIB or ENET)
- Simultaneous digital displays for both voltage and current
- Front panel control by rotary Adjust/Enter knob, permitting high resolution output setting
- Active Power Factor Correction (PFC) reduces input current and input current harmonics
- Automatic crossover system allowing the power supply to switch between Constant Current, Constant Voltage and Constant Power operating modes
- Parallel or series connection among multiple units to produce greater diversity or to use in higher power applications
- Short-circuit protection of DC outputs, providing greater operating safety
- Built-in APG and ISOL interface to provide a galvanically isolated analog voltage control of the output, master/slave output tracking, and remote Enable/Disable for safety and precision
- Remote output voltage sensing to automatically compensate for cable losses.
- Software calibrated
- Three user setting memory locations

UNPACKING AND INSPECTING

Inspect for Damage

Upon receiving the Model 2268, carefully unpack the unit, and inspect for any obvious signs of physical damage that might have occurred during shipment. Notify the shipping agent of any damage immediately.

Shipment Contents

The following items are included with every Series 2268 order:

- Series 2268 power supply
- Series 2268 product information CD-ROM
- AC line power cord
- Series 2268 additional accessories, as ordered

SERIES 2268 850-WATT MODELS

| Model | Output Voltage | Output Current |
|--------------|----------------|----------------|
| 2268-20-42 | 0-20 V | 0-42 A |
| 2268-40-21 | 0-40 V | 0-21 A |
| 2268-60-14 | 0-60 V | 0-14 A |
| 2268-80-10.5 | 0-80 V | 0-10.5 A |
| 2268-100-8.5 | 0-100 V | 0-8.5 A |
| 2268-150-5.6 | 0-150 V | 0-5.6 A |

RACK MOUNT KIT OPTIONS

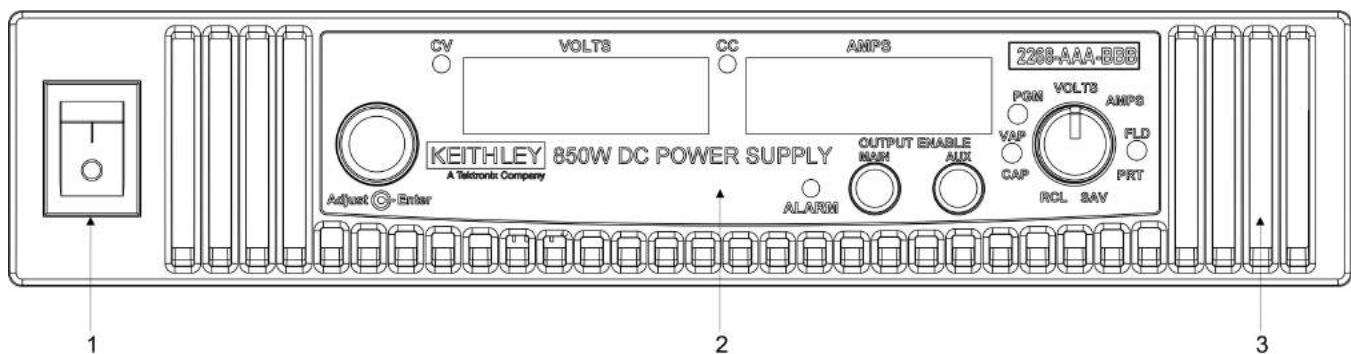
Rack-mount kits are available for the Series 2268 instruments. The table below shows the available models. Complete details and installation instructions are included in the document that ships with each rack-mount kit.

Important: We recommend that you provide additional rear support to the Series 2268 when mounting it in a rack.

| Number of Units | Model Number |
|-----------------|--------------|
| Single | 2268-RMK-1 |
| Dual | 2268-RMK-2 |

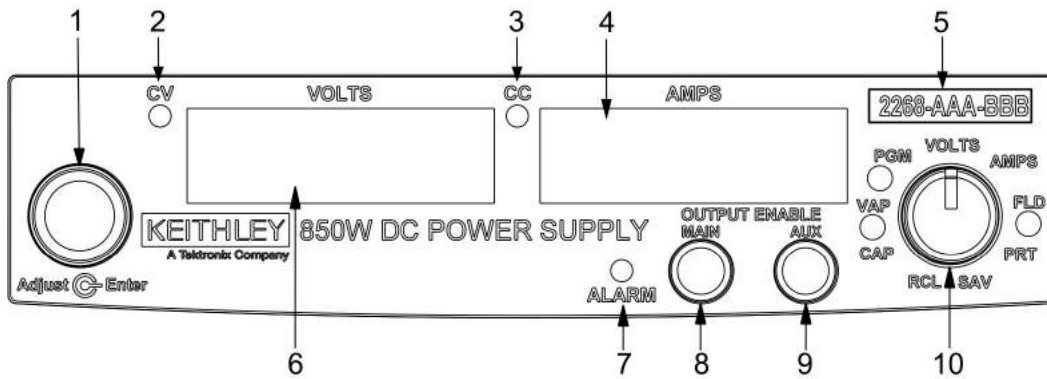
FRONT PANEL FAMILIARIZATION

Figure 1: Series 2268 850-Watt Front Panel



| Item | Description |
|------|----------------------------------|
| 1 | Front panel power switch |
| 2 | Front panel display see Figure 2 |
| 3 | Air intake vents |

Figure 2: Series 2268 850-Watt Front Panel Display and Controls



| Item | Description |
|------|---|
| 1 | Rotary Adjust/Enter control |
| 2 | Constant Voltage (CV) Mode LED (green) |
| 3 | Constant Current (CC) Mode LED (green) |
| 4 | Output Current Display |
| 5 | Model Identification Label |
| 6 | Output Voltage Display |
| 7 | Alarm Indicator LED (red) |
| 8 | OUTPUT ENABLE Main button |
| 9 | OUTPUT ENABLE Aux button |
| 10 | 9-Position Mode Control (For detailed information, see "Configuring Settings from the Front Panel" on page 30). |

REAR PANEL FAMILIARIZATION

Figure 3: Series 2268 850-Watt, 20 V to 40 V Rear Panel

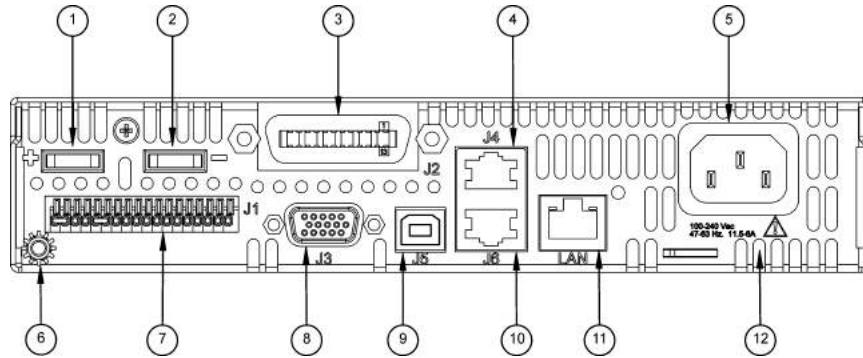
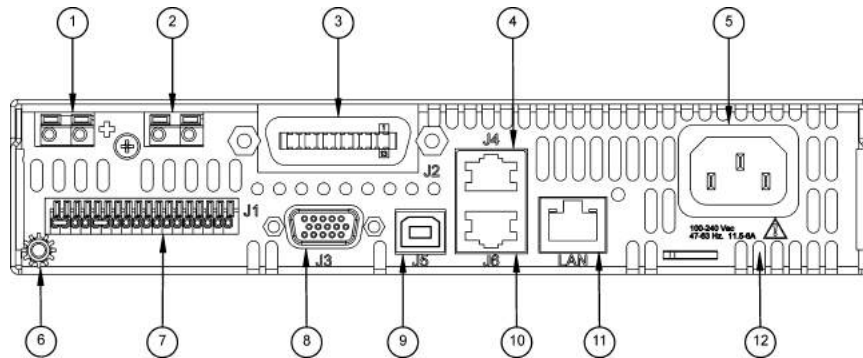


Figure 4: Series 2268 850-Watt, 60 V to 150 V Rear Panel



| Item | Description |
|-------------|---|
| 1 | 20 V– 40 V Models: DC Output Terminal Positive (6.5 mm hole diameter) 60 V–150 V Models: DC Output Connectors Positive |
| 2 | 20 V– 40 V Models: DC Output Terminal Negative (6.5 mm hole diameter) 60 V–150 V Models: DC Output Connectors Negative |
| 3 (J2) | Ethernet (ENET) or GPIB Connector |
| 4 (J4) | RS-232/RS-485 Connector In Port |
| 5 | AC Input Connector (IEC Type) |
| 6 | Chassis Ground Stud |
| 7 (J1) | Analog Programming (APG) Connector. For pin information, see page 74. |
| 8 (J3) | AUX Output and Isolated Analog Programming (ISOL) Connector. For pin information, see page 87. |
| 9 (J5) | USB Connector |
| 10 (J6) | RS-485 Connector Multichannel Port |
| 11 | Ethernet/LAN Connector |
| 12 | Fan Exhaust Vents |

Installation

In this section:

This section provides information and procedures for inspecting, installing, and testing the power supply.

BASIC SETUP PROCEDURE

Below is a summary of the basic setup procedure with references to the relevant sections in this section. Refer to this table if you are unfamiliar with the installation requirements for the power supply. Complete each step in the sequence given.

| Step | Description | Action | Reference |
|------|--------------------------------------|--|---|
| 1 | Inspect | Inspect the power supply. | "Step 1: Inspecting and Cleaning" on page 18. |
| 2 | Install | Install the power supply (benchtop or rack mount). Ensure adequate ventilation. | "Step 2: Location and Mounting" on page 19. |
| 3 | Connect Input Power | Connect AC input power. | "Step 3: Connecting AC Input Power" on page 20. |
| 4 | Select Wires | Select wires that are correctly rated for the maximum DC output current. | "Step 4: Selecting Load Wires" on page 21. |
| 5 | Test | Perform functional tests for voltage mode operation, current mode operation, and front panel controls. | "Step 5: Performing Functional Tests" on page 23. |
| 6 | Connect Loads | Connect the load wires to the DC output. | "Step 6: Connecting Loads" on page 25. |
| 7 | Connect Remote Sensing (if required) | Connect remote sensing connectors on power supply to load. | "Step 7: Connecting Remote Sensing" on page 28. |

STEP 1: INSPECTING AND CLEANING

Initial Inspection

When you first receive your unit, perform a physical check:

1. Inspect the unit for any scratches and cracks, broken switches, connectors or displays.
2. Ensure that the packing box contains a power cord.
3. If you see external damage or suspect internal damage, contact the carrier immediately.

Periodic Cleaning

The power supply only requires periodic cleaning, not routine servicing. Whenever a unit is removed from operation, clean the metal surfaces with naphtha or an equivalent solvent, and clean the front panel with a weak solution of soap and water. Use low-pressure compressed air to blow dust from components on the printed circuit boards.

STEP 2: LOCATION AND MOUNTING

The power supply may be rack-mounted or used in benchtop applications.

Rack Mounting

Keithley offers a Single and a Dual Rack Kit (2268-RMK-1 and 2268-RMK-2). See "Rack Mount Kit Options" on page 13 for information about available rack mount kits. To purchase a rack mount kit, contact your local Keithley Instruments office, sales partner, or distributor, or call Keithley Instruments corporate headquarters (toll-free inside the U.S. and Canada only) at 1-800-935-5595, or from outside the U.S. at +1-440-248-0400. For worldwide contact numbers, visit the Keithley Instruments website (<http://www.keithley.com>).

Ventilation

Whether operating the power supply in a rack or on a bench, allow air to reach the ventilation inlets on the front and rear of the unit for cooling. The direction of airflow is from the front of the unit to the back of the unit. Ventilation space is not required at the top, bottom or sides of the power supply.

STEP 3: CONNECTING AC INPUT POWER



WARNING: Shock hazard

Disconnect AC power from the unit before removing the cover. Even with the front panel power switch in the Off position, live line voltages are exposed when the cover is removed. Repairs must be made by an Authorized Service Center.



WARNING: Shock hazard

There is a potential shock hazard if the power supply chassis and cover are not connected to an electrical ground via the safety ground in the AC input connector. Ensure that the power supply is connected to a grounded AC outlet with the recommended AC input cord configured for the available line voltage as described in this section.



WARNING: Shock hazard

The AC input cord is the disconnect device for the power supply. The plug must be a non-locking plug which is readily identifiable by and accessible to the operator. The input cord must be no longer than 9.84 feet (3 m).

AC Input Connector

The AC input connector is a standard IEC 16 A 250 V male connector located on the rear panel of the power supply. The AC input cord provided is rated for 30 A, 300 V.

STEP 4: SELECTING LOAD WIRES

This section provides recommendations for selecting minimum load wire sizes.

Load Wiring

To select the wiring for connecting the load to the power supply, consider the following factors:

- Insulation rating of the wire. Current carrying capacity of the wire.
- Maximum load wiring length for operation with remote sense lines.
- Electrical noise and impedance effects of the load lines.

Insulation Rating

Use load wiring with a minimum insulation rating equivalent to the maximum output voltage of the power supply.

Current Carrying Capacity

The load wiring must have a current carrying capacity greater than the output rating of the power supply to ensure that the load wiring will not be damaged if the load is shorted. The table that follows shows the maximum current rating for various gauges of wire rated for 105 °C operation, based on a maximum current density of 450 A/cm².

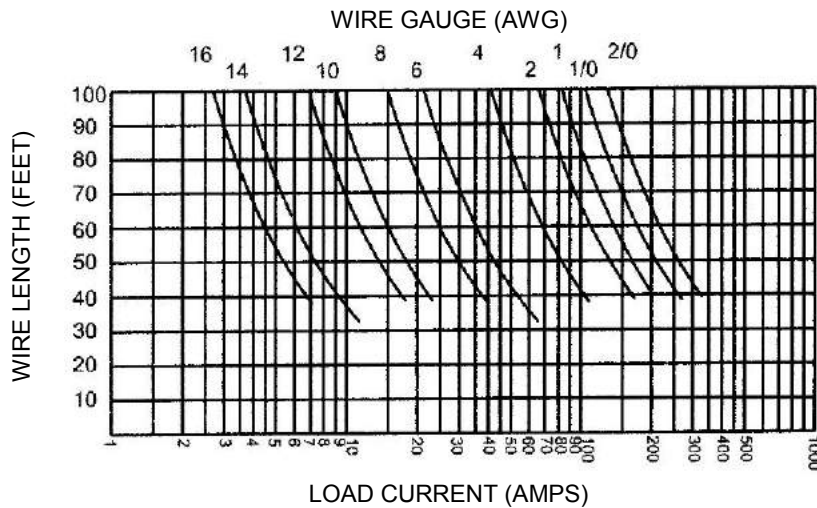
Operating at the maximum current rating shown in the table below results in an approximately 30 °C temperature rise for an appropriately-sized load wire operating in free air. Where load wiring must operate in areas with elevated ambient temperatures or bundles with other wiring, use larger gauges or wiring rated for higher temperatures.

Current Carrying Capacity for Load Wiring

| Wire Size (AWG) | Maximum Current (Amps) | Wire Size (AWG) | Maximum Current (Amps) |
|-----------------|------------------------|-----------------|------------------------|
| 20 | 2.5 | 6 | 61 |
| 18 | 4 | 4 | 97 |
| 16 | 6 | 2 | 155 |
| 14 | 10 | 1 | 192 |
| 12 | 16 | 1/0 | 247 |
| 10 | 21 | 2/0 | 303 |
| 8 | 36 | n/a | n/a |

Maximum Load Wiring Length For Operation With Sense Lines

Figure 5: Maximum Load Wire Length for 1 V Line Drop



Noise and Impedance Effects

To minimize noise pickup or radiation, use shielded twisted pair wiring of the shortest possible length for load sense wires. Connect the shield to the power supply chassis. Where shielding is impossible or impractical, simply twisting the wires together will offer some noise immunity.

STEP 5: PERFORMING FUNCTIONAL TESTS

The functional test procedures include:

- Power-on and front panel functional checks
- Voltage mode operation and current mode operation checks.

For information on local operation, see the section on “Local Operation” on page 30 for adjusting front panel controls and settings.

Powering the Power Supply On/Off

To power on the power supply:

1. Ensure that the front panel power switch is in the Off position.
2. Ensure that the AC line voltage is within operating range.
3. Connect the line cord to a grounded AC outlet.
4. Turn the front panel power switch to the On position.

After a short power-on delay, **8888 8888** illuminates on the output voltage and current displays, followed by **PSU On**.

After approximately 1 second, the display returns to normal status.

To power off the power supply:

- ◆ Turn the front panel power switch to the Off position.

AC FAIL will blink on the display. The ALARM LED illuminates. After a short delay, all lights on the display will not be illuminated.

Voltage and Current Mode Operation Checks

To perform the voltage and current mode operation checks:

1. Ensure that the front panel power switch is in the On position and the output is disconnected.
2. If the OUTPUT ENABLE Main button is illuminated, press the button to turn off the output.
3. To check voltage mode operation, turn the 9-position mode control to the VOLTS position.

The voltage set point will blink dimming and then return to full brightness. For more information, see the section on “Local Operation” starting on page 30.

4. Adjust the voltage to 5 V.
5. To check current mode operation, turn the 9-position mode control to AMPS position.

Verify that the current set point is blinking in the output current display.

6. Adjust the current to 1 A.
7. Press the OUTPUT ENABLE Main button to turn On.
8. Turn the front panel power switch to the Off position.
9. Turn the front panel power switch to the On position.
10. Connect a short circuit across the output terminals. Use leads of sufficient current carrying capacity. (See “Step 4: Selecting Load Wires” on page 21.)
11. Press the OUTPUT ENABLE Main button to enable the output. The button will be illuminated when the output is enabled.

CC Mode LED illuminates and the voltage and current are displayed. CC Mode LED illuminates and the preset load current is displayed.

12. Turn the front panel power switch to the Off position.

STEP 6: CONNECTING LOADS

This section describes how to connect loads to the power supply for both single and multiple loads.



WARNING: Shock hazard

There is a shock hazard at the power supply output when operating at an output greater than 40 V. To protect personnel against accidental contact with hazardous voltages, ensure that the load and its connections have no accessible live parts.



CAUTION: Cable damage

When making connections to the output terminals, ensure terminals of opposite polarity do not touch. Load cables and sense wires should be provided with strain relief.

DC Output Connectors



WARNING: Shock hazard

Disconnect the AC input before making any connections. A shock hazard may be present at the output terminals. Allow 15 seconds after the AC power has been removed before making any connections.

20 V-40 V Models

The 20 V-40 V models are equipped with output terminals, as shown in Figure 3.

60 V-150 V Models

The 60 V-150 V models are equipped with output connectors, as shown in Figure 4. These models have output currents that may require users to use wire diameters that would not fit into a single output connector, so there are two output connectors in parallel to increase the potential current carrying capacity of load wiring.

Inductive Loads and Batteries



CAUTION

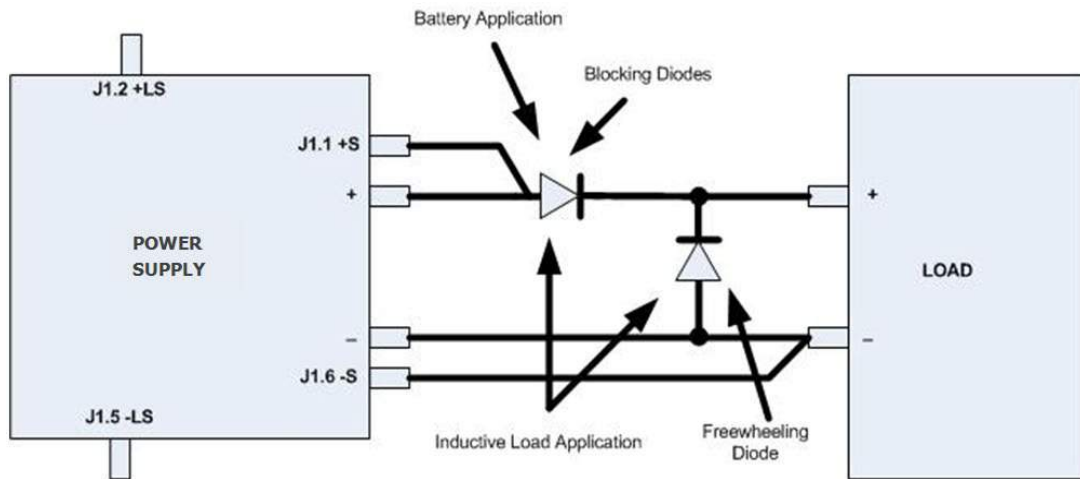
The power supply requires freewheeling and blocking diodes across the output while driving inductive loads or batteries to protect the power supply from damage caused by power being fed back into the supply and from high voltage transients.

Selecting Diodes

The diode must have a voltage rating at least 20% greater than the power supply's output voltage and have a current rating greater than or equal to the power supply's output rating. Connect the cathode to the positive output and the anode to the return.

Where positive load transients such as back EMF from a motor may occur, connect a Transient Voltage Suppressor (TVS) or a varistor across the output to protect the power supply. The breakdown voltage rating for the TVS or varistor must be approximately 10% higher than the rated supply output.

Figure 6: Diode Placement

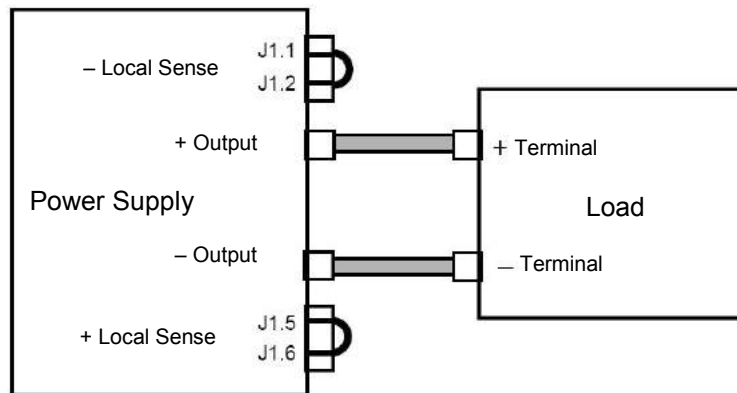


Connecting Single Loads

Figure 7 shows the recommended load connections for a single load which is sensing its voltage locally. Local sense lines shown are the default connections at the rear panel APG J1 connector. The load lines should use the largest gauge and shortest length of wire possible to ensure optimal performance.

You do not need remote sensing for basic operation of your power supply. However, if you wish to correct any small drops in your load lines, then use the remote sensing feature. See “Step 7: Connecting Remote Sensing” on page 28 for more information.

Figure 7: Connecting Single Loads



Connecting Multiple Loads

The proper connection of distributed loads is an important aspect of power supply use. The common method of connection is a radial load connection. Power is connected to each load individually from a single pair of terminals designated as the positive and negative distribution terminals. This pair of terminals may be the power supply output terminals, the load terminals, or a distinct set of terminals especially established for distribution use. In this scheme, there are no ground loops and the effect of one load upon another is minimized.

STEP 7: CONNECTING REMOTE SENSING



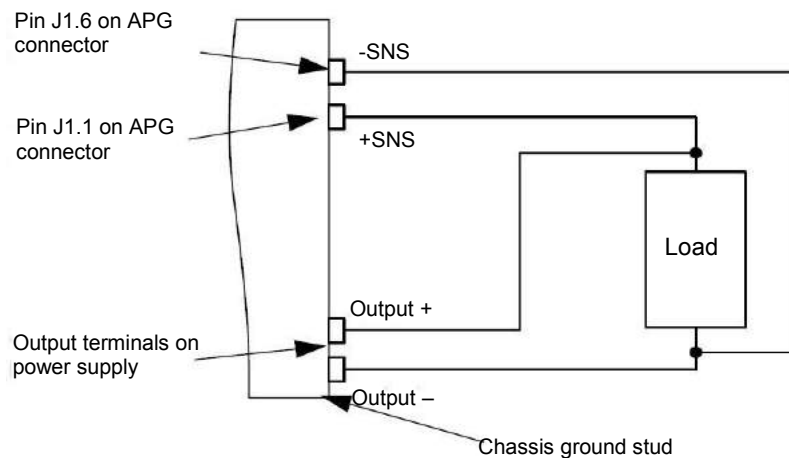
WARNING: Shock hazard

There is a potential shock hazard at the sense connectors when using a power supply at an output greater than 40 V. Select wiring with a minimum insulation rating equivalent to the maximum output voltage of the power supply for use as local sense jumpers or for remote sense wires. Ensure that connections at the load end are shielded to prevent contact with hazardous voltages.

Remote sensing permits you to shift the regulation point of the power supply from the output terminals to the load or other distribution terminals.

Use shielded twisted pair wiring of 20 to 26 AWG for best noise performance. Make sure that the shielded twisted pair wiring insulation is rated higher than the maximum output voltage of the power supply. If possible, one end of the shield of the sense lines should be attached to the chassis ground of the power supply.

Figure 8: Remote Sense Connection



To connect the remote sense wires:

1. Ensure that the front panel power switch is in the Off position.
2. Using a small flat blade screwdriver, remove the two sense jumpers from pins J1.1 and J1.2, and from pins J1.5 and J1.6 on the APG Connector.

3. Connect one end of the shield of the twisted pair wire to the chassis ground point on the power supply.
4. Connect the positive sense line (+SNS) from the positive regulation point as close as possible to the load terminals to pin J1-1.
5. Connect the negative sense line (-SNS) from the return of the load to pin J1-6.

To compensate for losses in power leads connected to the output, the power supply provides sense connections beside the output terminals. With remote sense leads in place, the power supply regulates to the displayed voltage at the point where the sense lines are connected to the output leads. With the sense lines disconnected, the power supply regulates the voltage at the output terminals.

**CAUTION: Equipment damage**

Do not operate the power supply with sense lines connected to the load without also connecting the load power leads to the output terminals.

**CAUTION: Reverse polarity**

Avoid reversing positive (+) and negative (-) sense connections. When using remote sense to compensate for load line losses, ensure that the positive sense line is connected to the positive load terminal and the negative sense line is connected to the negative load terminal. Do not reverse these connections or the power supply may be damaged.

Important: Long load leads with large capacitance at the load and remote sensing can cause voltage instability due to inductance of the load leads. Measures to reduce inductance and/or capacitance (raising resonant frequency) or using local sense can be beneficial in stabilizing the system.

Local Operation

In this section:

This section provides the procedures for local (front panel) operation such as:

- Configuring settings.
- Operating in constant voltage mode, constant current mode, and constant power mode).
- Using the protection features.
- Using multiple power supplies

INTRODUCTION

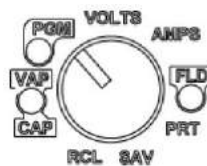
Once you have installed the power supply and connected both the AC input power and the load (covered in “Installation” on page 17), the power supply is ready for local operation. To turn the power supply on, see “Powering the Power Supply On/Off” on page 23.

CONFIGURING SETTINGS FROM THE FRONT PANEL

The 9-position mode control is used with the rotary Adjust/Enter control to configure settings in local operation. See Figure 2 for location of the front panel features.

Using the 9-position mode control, select one of nine modes: VOLTS, AMPS, FLD, PRT, SAV, RCL, CAP, and VAP. See Figure 9 below and the table that follows for detailed information on the nine modes.

Figure 9: 9-Position Mode Control



Using the Rotary Adjust/Enter Control

The rotary Adjust/Enter control is used to change settings and set the value selected. The front panel displays information on the output voltage and output current displays. Each display has a maximum of four characters that are made up of 7 segments.

Coarse and Fine Adjustment Modes

The coarse and fine adjustment modes are used for setting the voltage and current set points, OVP and UVP settings.

Coarse adjustment mode When using local operation to set the current and voltage set points, use the coarse adjustment mode (default) followed by the fine adjustment mode (described next). The coarse adjustment mode quickly adjusts the settings in large increments to reach the desired value.

Fine adjustment mode Pressing the rotary Adjust/Enter control to change the mode to fine adjustment mode, provides the ability to manipulate the last significant digit. Once the exact desired value for the setting has been selected, press the rotary Adjust/Enter control to commit the value to the unit.

| 9 Positions on the Mode Control Knob | Turning the rotary Adjust/Enter control lets you... | Pressing the rotary Adjust/Enter control lets you... |
|---|--|---|
| VOLTS (Voltage Programming) | Select the voltage set point in coarse or fine adjustment modes. See “Automatic Mode Crossover” on page 38. | Set the value selected and cycle to the next setting. |
| AMPS (Current Programming) | Select the current set point in coarse or fine adjustment modes. See “Constant Current (CC) Mode Operation” on page 38. | Set the value selected and cycle to the next setting. |
| FLD (Foldback) | Select Foldback option: CC, CV or none. See “Setting Foldback Mode” on page 49. | Set the value selected and cycle to the next setting. |
| PRT (Protection) | Select the OVP set point (see page 50). Select the UVP set point (see page 51.) Select OTP temperature and Shutdown (see page 52.) | Set the value selected and cycle to the next setting. |
| SAV (Save User Preset) | Select the user setting memory location. See “Saving User Setting Memory Locations” on page 59. | Save user setting memory values. |
| RCL (Recall User Preset) | Select the user setting memory location. See “Recalling User Setting Memory Locations” on page 60. | Load user setting memory values into the power supply. |
| CAP (Current Analog Programming) | Select the programming source and select the range. | Set the value selected and cycle to the next setting. |
| VAP (Voltage Analog Programming) | Select the programming source and select the range. | Set the value selected and cycle to the next setting. |
| PGM (Programming Options) | Select the remote interface to be used for control, local lockout or current sharing. | Select interface/Option and cycle to the next setting. |

NAVIGATING THE MENU SYSTEM

The menu system follows a select and set model with the exception of the VOLTS and AMPS modes. See “Setting VOLTS and AMPS Modes” next.

The general procedure for setting up the features in the select and set model is:

1. To select a mode, rotate the 9-position Mode control to the desired mode or press the rotary Adjust/Enter control once to activate the current selection on the mode control knob. See Figure 9.
2. To select the feature or setting, rotate the rotary Adjust/Enter control to scroll through the different available settings of that mode.

The settings appear on the output current display.

3. Press the rotary Adjust/Enter control to select the feature or setting.
4. Set each value using the rotary Adjust/Enter control. When the value has been selected, press the rotary Adjust/Enter control to commit the updated value. Additional values may become available, depending on the setting that is being configured.

Setting VOLTS and AMPS Modes

The only exceptions to the select and set model are the VOLTS and AMPS modes which do not allow the selection of tracking and select and set mode by turning the rotary Adjust/Enter control. In VOLTS and AMPS modes, the default entry mode setting is automatically selected as either voltage or current tracking, respectively.

Voltage and current values can be set in tracking mode or select and set mode using the rotary Adjust/Enter control:

- Tracking mode—the new values take effect as the rotary Adjust/Enter control is rotated.
- Select and set mode—the new values do not take effect until the rotary Adjust/Enter control is pressed. See “Normal Display Mode and Inactivity Timeout” on page 33.

To access the tracking mode for entering voltage and current:

1. Select the VOLTS or AMPS position on the 9-position mode control. If the set point is blinking, the unit is in coarse tracking mode.
 - When the VOLTS mode is selected, the voltage set point will blink in the output voltage display.
 - When the AMPS mode is selected, the current set point will blink in the output current display.
2. Use the rotary Adjust/Enter control to adjust the set point. Note that there is an activity time out (see “Normal Display Mode and Inactivity Timeout” on page 33).
The adjustments you make to the set point affect the opposing output value (voltage when in AMPS mode or current when in VOLTS mode), which will update in the non-blinking display.
3. Press the rotary Adjust/Enter control to enter fine adjust tracking mode.
The set point blinks faster when the unit is in fine adjust tracking mode.
4. Use the rotary Adjust/Enter control to fine tune the set point.
5. Once the set point has been selected, press the rotary Adjust/Enter control to exit tracking mode and return to normal display mode.

To access the select and set entry mode for the voltage and current set points:

1. Select VOLTS or AMPS position on the 9-position mode control.
2. Press the rotary Adjust/Enter control three times in succession to enter coarse Pre-Set Adjustment.
3. Press the rotary Adjust/Enter control one more time to enter fine Pre-Set Adjustment.
4. Press the rotary Adjust/Enter control once again to set the value.
The units can also timeout (adjustable) to exit the menu. Once Pre-Set Mode is entered, CrPU or FnPU will appear in the voltage display.

Normal Display Mode and Inactivity Timeout

Normal display mode appears on the output voltage and current displays when the configuration changes from the front panel have been completed or when the inactivity timeout occurs (default is 3 seconds). Normal display mode shows the output voltage and current values.

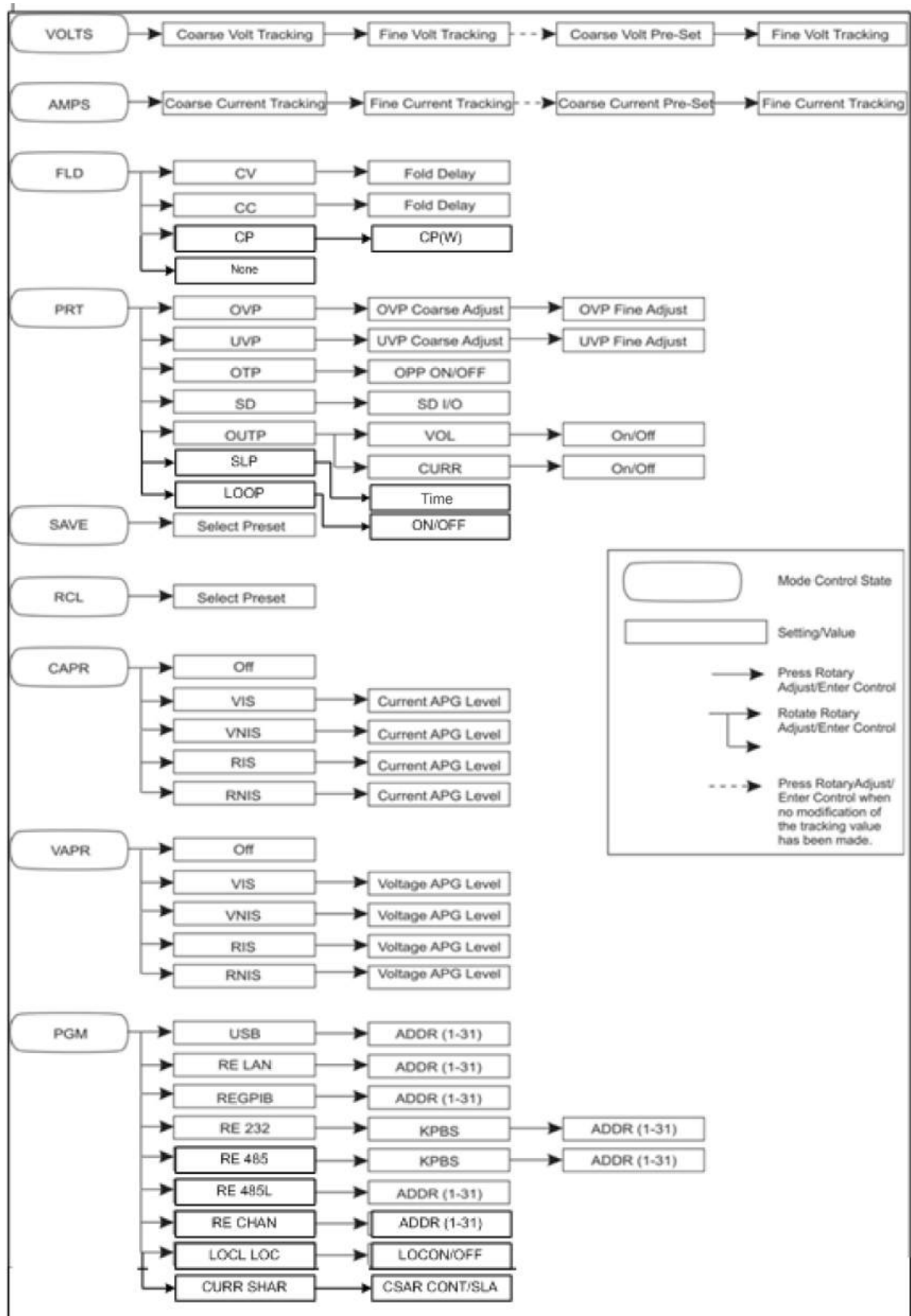
If a timeout occurs before the changes made to the value have been set, the changes will not be saved and you will have to re-enter the changes. The inactivity timeout is variable from 1 to 20 seconds and can only be changed using the SCPI command.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel> ]:FPANel[ : ]TIMEout
```

Important: Each user memory setting location stores the timeout so that beginning users and expert users are not required to use the same timeout

Figure 10: Front Panel Menu System



DISPLAY MESSAGES ON THE FRONT PANEL

The front panel displays on the power supply will use text as shown in the table that follows to indicate the status or mode.

| Display Text | Text Description |
|-----------------|----------------------------------|
| <i>0</i> | Negative Polarity |
| <i>232</i> | RS 232 |
| <i>485</i> | RS 485 |
| <i>485L</i> | RS 485L |
| <i>8888</i> | All segments On, Power Up |
| <i>1</i> | Positive Polarity |
| <i>AC</i> | Alternating Current |
| <i>Addr</i> | RS 485 Address |
| <i>AnPr</i> | Analog Programming |
| <i>AS</i> | Power On Autostart |
| <i>AuAS</i> | Auxiliary Autostart |
| <i>[APr</i> | Current Analog Programming |
| <i>[Lr</i> | Clear |
| <i>[C</i> | Constant Current |
| <i>[On]</i> | Controller |
| <i>[P</i> | Constant Power |
| <i>[U</i> | Constant Voltage |
| <i>[rPC</i> | Coarse Current Pre-set Mode |
| <i>[rPU</i> | Coarse Voltage Pre-set Mode |
| <i>[Shr</i> | Current Share (same as CUrrShAr) |
| <i>[Urr</i> | Current |
| <i>[UrrShAr</i> | Current Share (same as CShr) |
| <i>dELd</i> | Fold Delay |
| <i>donE</i> | Done |
| <i>Err</i> | Error (debug) |
| <i>FOLD</i> | Foldback |
| <i>FAI L</i> | Fail |
| <i>FAn</i> | Fan |
| <i>FLA</i> | Flash |
| <i>FnPC</i> | Fine Current Preset Mode |
| <i>FnPU</i> | Fine Voltage Preset Mode |
| <i>FLd</i> | Foldback |
| <i>HbPS</i> | Data rate (kbps) |
| <i>GPI b</i> | GPIB Interface |

| Display Text | Text Description |
|-------------------------|--|
| <i>I_n</i> | Interlock |
| <i>LAN</i> | ENET Interface |
| <i>LE C</i> | Current APG Level |
| <i>LE U</i> | Voltage APG Level |
| <i>Loc</i> | Lock |
| <i>LOCL</i> | Local |
| <i>LOOP</i> | Loop Protection |
| <i>OFF</i> | Off |
| <i>On</i> | On |
| <i>OUTP</i> | Output Protection |
| <i>OCP</i> | Over Current Protection |
| <i>OTP</i> | Over Temperature Protection |
| <i>OVP</i> | Over Voltage Protection |
| <i>UVPF</i> | Over Voltage Protection fine adjustment |
| <i>OUPC</i> | OVP Calibration |
| <i>POL</i> | Polarity |
| <i>PrD</i> | Protection mode |
| <i>PSU</i> | Power Supply Unit |
| <i>r I S</i> | Isolated Resistive Analog Programming |
| <i>rCL</i> | Recall Preset |
| <i>rE</i> | Remote Programming/Interface |
| <i>rnt S</i> | Non-Isolated Resistive Analog Programming |
| <i>C_{on}T</i> | Controller (current share controller) |
| <i>ShAR</i> | Share (current share) |
| <i>ChAR_n</i> | Multichannel Remote Interface |
| <i>S rS</i> | Soft reset |
| <i>SAUE</i> | Save Preset |
| <i>Sd</i> | Shutdown |
| <i>SLA</i> | Slave (current share slave) |
| <i>SLP</i> | Sleep Mode |
| <i>U I S</i> | Isolated Analog Voltage Programming |
| <i>Un I S</i> | Non-Isolated Analog Voltage Programming |
| <i>USB</i> | USB Interface |
| <i>UUP</i> | Under Voltage protection coarse adjustment |
| <i>UVPF</i> | Under Voltage protection fine adjustment |
| <i>VAP_r</i> | Voltage Analog Programming |
| <i>UOL</i> | Voltage |

A blinking numeric value is either a voltage or current set point in tracking mode. The display in which the set point appears, either output voltage or output current displays, indicating the type of set point: voltage or current.

STANDARD (LOCAL) OPERATION

The power supply can be controlled by two methods, either from the front panel or from any of the remote interfaces. Front panel control is referred to as local operation (default setting) while control via any of the remote interfaces is called remote operation. To set up the power supply for remote operation, see the section on “Remote Operation” starting on page 101. Once the remote connection has been established, the power supply can switch seamlessly between local operation and any digital interface (RS-232, RS-485, GPIB, USB and Ethernet).

Local lockout (page 61) is a feature that allows the front panel to be locked so that accidental button presses are ignored. This feature is often used to lock out the front panel while a user is controlling the power supply from a remote location.

The output of the power supply has three modes of operation: Constant Voltage, Constant Current, and Constant Power. All three of the operating modes are available regardless of which control method (local or remote) is used.

OPERATING MODES

The output mode in which the power supply operates at any given time depends on the following factors:

- Output voltage set point V_{SET}
- Output current set point I_{SET}
- Impedance of the attached load R_L

The three output modes of operation are Constant Voltage (CV) mode (see page 37), Constant Current (CC) mode (see page 38), and Constant Power (CP) mode (see page 38).

Output enabled When the output is turned on, both the voltage and current rise as quickly as possible to try and reach the set points (V_{SET} and I_{SET}) that were configured prior to enabling the output. Initially the unit will operate in CV mode, which is the default mode. As the voltage and current rise to meet the requirements of the load, the set point that is reached first (based on the R_L , either V_{SET} or I_{SET}) will determine which mode the power supply will remain in. The operating mode is indicated by either the CC mode LED or the CV mode LED, one of which will illuminate on the front panel.

Output disabled The mode of operation is not determined until the output is enabled. The CV and CC mode LEDs will not indicate the mode while the output is disabled.

Constant Voltage (CV) Mode Operation

If the output is enabled and the configured current set point is much higher than the requirements for the attached load, then the voltage will rise until it reaches the voltage set point. When the output voltage reaches the voltage set point, it stops rising. The unit will continue to operate in CV mode. The load current will still vary to meet any changes in required load current draw resulting from a change in the attached load.

Constant Current (CC) Mode Operation

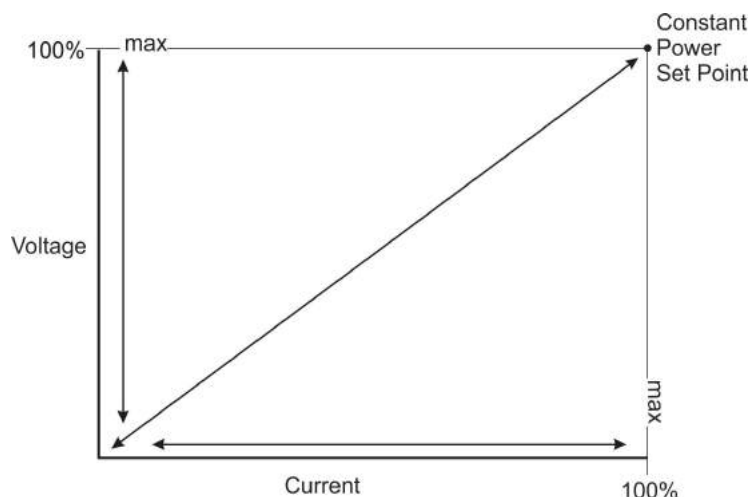
If the output is enabled, the voltage and current start to rise. At this time the unit is operating in CV mode (default operational mode). As the load current drawn reaches the value of the output current setting, the unit will switch to CC mode and not allow any additional current to be drawn above the value of I_{SET} . The unit is now operating in CC mode. The voltage will still vary to meet any changes in required output voltage resulting from a change in the attached load.

Constant Power (CP) Mode Operation

If the output is enabled, the voltage and current start to rise. The unit will continue to increase the current until one of the following occurs:

- The programmable power set point has been reached.
- The voltage set point has been reached, in which case the unit will regulate the voltage in order to maintain the voltage set point.
- The current set point has been reached, in which case the unit will regulate the current in order to maintain the current set point.

Figure 11: Voltage:Current:Constant Power Set Point



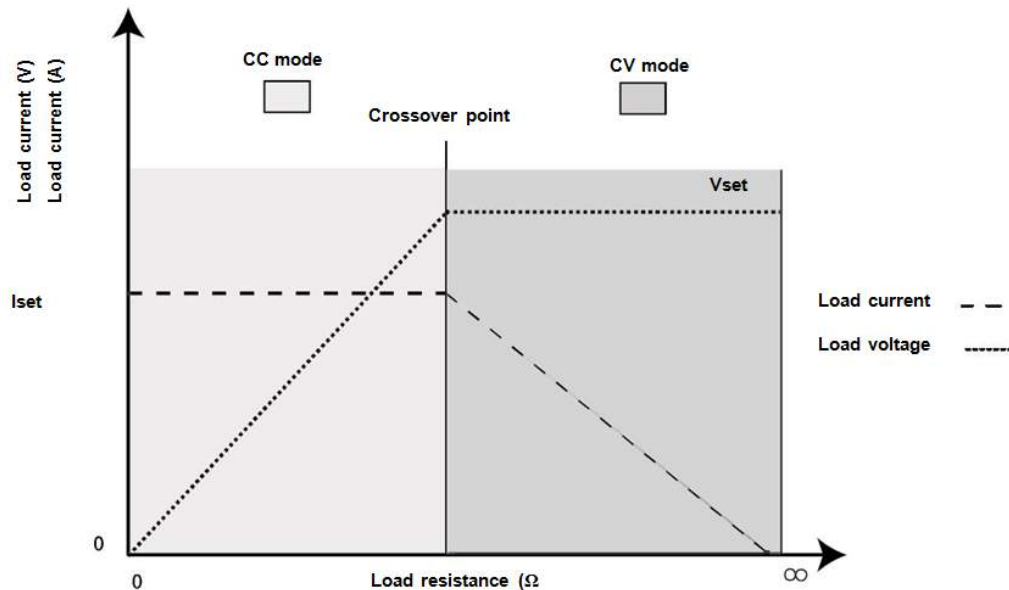
Automatic Mode Crossover

Mode crossover occurs when the unit makes the switch between operating modes. Crossover can occur from CV to CC or vice versa, depending on how the attached load resistance changes. Figure 12 shows the relationships between the variables.

For example, if the unit was initially operating in CV mode with the output voltage at the voltage set point and the load current below the I_{SET} and the attached load resistance began to decrease, the current would rise to meet this change in the load. The load current will increase in proportion to the decrease in the load resistance until the load current drawn reaches the current set point. At this point further decreases in load resistance (increased load current requirements) will cause the unit to cross over into CC mode where the output voltage will vary with changing load resistance and the load current will remain at the I_{SET} value.

The reverse operating mode change can also occur if the load resistance is increased to the point that the required load current drops below the I_{SET} value. At that point the power supply would crossover to CV mode and the load current would be free to vary as the load resistance changed.

Figure 12: Operating Modes



To set the voltage set point (VSET):

1. Turn the 9-position mode control to the VOLTS position or press the rotary Adjust/Enter control if the 9-position mode control is already at the VOLTS position.

The voltage set point is blinking in the output voltage display. The output current will be displayed in the output current display.

2. Set the desired voltage value using the rotary Adjust/Enter control.

Important: If you can't get the set point to the desired level, you may need to change the set points for OVP.

3. Press the rotary Adjust/Enter control to transition to Fine Adjust mode.

The set point will blink faster to indicate fine adjust tracking mode.

4. Set the desired voltage value using the rotary Adjust/Enter control.
5. Once the desired value has been set, press the rotary Adjust/Enter control to commit the setting.

Important: The control circuits have been designed to allow you to set the output voltage up to 105% over the model-rated maximum value. The power supply will operate within these extended ranges, but full performance to specification is not guaranteed.

Quick Tip: Remote operation uses these SCPI commands. See page 101.

The SCPI command (s) for these instructions are:

```
[[[:]SOURce[<channel>]]:VOLTage[:LEVel][[:IMMediate]]
[:AMPLitude]
```

Important: The maximum and minimum setting values of the output voltage are limited by the Over Voltage Protection and Under Voltage Protection settings.

To set the current set point (I_{SET})

1. Turn the 9-position mode control to the AMPS position or press the rotary Adjust/Enter control if the 9-position mode control is already at the AMPS position.

The voltage set point is blinking in the output voltage display. The output current will be displayed in the output current display.

2. Set the desired current value using the rotary Adjust/Enter control.
3. Press the rotary Adjust/Enter control to transition to Fine Adjust mode.
The set point blinks faster to indicate fine adjust tracking mode.
4. Set the desired current value using the rotary Adjust/Enter control.
5. Once the desired value has been set, press the rotary Adjust/Enter control to commit the setting.

Important: The control circuits have been designed so that output current can be set up to 105% over the model-rated maximum values. The power supply will operate within these extended ranges, but full performance to specification is not guaranteed.

The SCPI command (s) for these instructions are:

```
[[:]SOURCE[<channel>]]:CURRENT[:LEVEL][:IMMEDIATE] [:AMPLITUDE]
```

SHIPPED CONFIGURATION (LOCAL OPERATION)

The power supply is configured for local operation at the factory. See the table that follows for a summary of this configuration.

| Local Control Configuration | Additional References |
|--|---|
| Use the front panel controls to adjust the output voltage and current set point settings. | See section on “Local Operation” on page 30 for front panel operation. See section on, “Analog Programming & Isolated Analog Programming” on page 72 for analog programming procedures. |
| The OVP set point is adjusted at the front panel to 105% above the maximum rated output voltage. | See “Using Over Voltage Protection (OVP)” on page 50 for the adjustment procedure. |

ENABLING THE OUTPUT

Enabling the output on will also turn off the ALARM LED if the ALARM LED has been latched on due to an alarm triggering and automatically clearing. See “Alarms and Errors” on page 44.

To enable the output power:

- ◆ Press the OUTPUT ENABLE Main button on the front panel or enter the SCPI command.

The OUTPUT ENABLE Main button will illuminate.

To disable the output power:

- ◆ Press the OUTPUT ENABLE Main button when the OUTPUT ENABLE Main button is illuminated.

The output will be disabled and the LEDs will not be illuminated.

Important: The main output will not turn on if the shutdown function is activated. See “Using the External Shutdown Function” on page 53.

Quick Tip: Remote operation uses these commands. See page 101.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut [ <channel> ] [ : POWER ] [ : STATE ]
```

ENABLING THE AUXILIARY OUTPUT

To enable on the auxiliary output:

- ◆ Press the OUTPUT ENABLE Aux button on the front panel.

The OUTPUT ENABLE Aux button will illuminate.

Important: The auxiliary output will not be enabled if the external AUX_ON_OFF signal line is being used to disable the auxiliary outputs. See “AUX Output and Isolated Analog Programming (ISOL) Connector” on page 87.

To disable the auxiliary output:

- ◆ Press the OUTPUT ENABLE Aux button on the front panel again. The OUTPUT ENABLE Aux button will not be illuminated.

If the auxiliary output is activated, +5 V on J3.9 (+AUX1) and +15 V on J3.11 (AUX2) will be present with respect to Pin J3.2 or Pin J3.6 (COM ISOLATED). (See also “AUX Output and Isolated Analog Programming (ISOL) Connector” on page 87 for more details.)

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:AUXiliary[ :STATe ]
```

OUTPUT AUTO START MODE (AUTO RESTART)

The Auto Start mode establishes the state of the output of the power supply after recovery from a complete power cycle (all front panel LEDs are not illuminated).

If Auto Start mode is set to On, the power supply output will return to its previous value when the power supply is powered up again.

If Auto Start mode is set to Off, the power supply output will remain off after the power supply is powered up again.

To change the Auto Start mode:

1. Press and hold the OUTPUT ENABLE Main button for 1 second. *AS On* or *AS OFF* is displayed.
2. Switch the Auto Start mode.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut [ <channel> ] [ :POWer ] [ :STATe ] :PowerON [ :STATe ]
```

AUXILIARY AUTO START MODE

The Auxiliary Auto Start mode determines the state of the auxiliary output after a complete power cycle (all front panel LEDs are not illuminated). With Auxiliary Auto Start mode turned to On, the auxiliary output will be activated after the power supply is powered up again.

To define the Auxiliary Auto Start mode:

1. Press and hold the OUTPUT ENABLE Aux button for 1 second. *AURS On* or *AURS Off* is displayed.
2. To change to status to On or Off, press the OUTPUT ENABLE Aux button.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:AUXiliary:PowerON[ :STATe]
```

CONSTANT POWER MODE

In Constant Power Mode the power supply will continually adjust the current levels to maintain a constant power set point. This mode is intended primarily for loads with response time greater than approximately 100ms. In order to provide additional protection for the load, voltage and current limits may be set while in the constant power mode. If the unit cannot regulate to the Constant Power setting due to load conditions, it will regulate at either the voltage or the current limit depending on the load demand.

Example, CP Mode:

```
Constant Power set 500W
Voltage limit 61V
Current limit 20A
```

To activate Constant Power mode and set the value:

1. Turn the 9-position mode control to the FLD position or press the rotary Adjust/Enter control if the 9-position mode control is already at the FLD position.
2. Turn the rotary Adjust/Enter control until "CP" is displayed.
3. Press the rotary Adjust/Enter control.
4. Turn the Adjust/Enter control to the desired set point.
5. Press the rotary Adjust/Enter control.
6. Turn the Adjust/Enter control for fine adjustment.
7. Press the rotary Adjust/Enter control to commit the Constant Power operation.

To disable Constant Power operation:

1. Turn the 9-position mode control to the FLD position or press the rotary Adjust/Enter control if the 9-position mode control is already at the FLD position.
2. "FLD" is displayed on the output voltage display and the output current display shows the Constant Power mode "CP".

3. Turn the rotary Adjust/Enter control until “NONE” is displayed in the output current display.
4. Press the rotary Adjust/Enter control to commit the setting once the desired value has been set.
5. The green FLD LED will turn off and the display will return to the normal display mode.

The SCPI command (s) for these instructions are:

```
[ : ]SOURce[ <channel> ] : POWer : MODe [ : STATe ]
```

```
[ : ]SOURce[ <channel> ] : POWer : LEVEl
```

ALARMS AND ERRORS

Several conditions can cause alarms in the POWER SUPPLY. Some conditions are:

- From user configurable features.
- Controlled in hardware and will trigger regardless of configuration.

All alarms, with the exception of the Fan alarm, will result in the output of the power supply being disabled. The Fan alarm does not affect the output.

When an alarm is triggered, the appropriate alarm message will begin blinking on the display and the Alarm **LED** will be illuminated. It is possible that more than one alarm will trigger at the same time. When this occurs, the alarm with the highest precedence will blink on the display. The table that follows lists the precedence of alarms. If the alarm is cleared and the event which caused the alarm has not been corrected, then the alarm may trigger again immediately. Fix the reason for the alarm before you clear it.

| Alarm | Precedence | Output Latch | Maskable | Display |
|-------------------------------------|-------------|--------------|----------|-----------|
| AC Fail | 1 (Highest) | Yes | No | AC FA IL |
| Over Temperature Protection (OTP) | 2 | Yes | No | OTP |
| Fan | 4 | No | Yes | FAN PRO |
| Interlock | 6 | No | No | In Loc |
| Over Voltage Protection (OVP) | 7 | Always | No | OVP PRO |
| Over Current Protection (OCP) | 8 | Always | No | OCP PRO |
| Foldback | 9 | Yes | Yes | FLD PRO |
| External Shutdown | 10 | No | Yes | SD PDL |
| Under Voltage Protection (UVP) | 11 (Lowest) | No | Yes | UVP PRO |
| Current Loop Protection | 12 (Lowest) | | | Loop Pro |
| Flash Checksum Failure ¹ | N/A | N/A | N/A | FLA FAI L |

¹. The Flash Checksum Failure alarms are an exception as they can only occur during boot up or recalling a user setting slot. If a checksum error is detected when recalling a user slot, no modification of settings will occur, and an error will be pushed to the SCPI error queue. If a checksum occurs at boot-up, then this checksum error can be cleared by doing a soft reset or by power cycling the unit.

CLEARING ALARMS

Clearing Triggered and Manual Alarms

To clear a triggered alarm, use one of the following methods:

- Turn the power supply Off and then On.
- Press and hold the rotary Adjust/Enter control for 3 seconds.

To clear a manual alarm:

1. Press and hold the rotary Adjust/Enter control for 3 seconds.

The *ALr CLR* message will be displayed on the front panel for a few seconds.

Important: When an alarm is cleared by using this method, only the current highest precedence alarm is cleared. If another alarm has occurred, then this alarm will now become the highest precedence alarm and will begin blinking on the display.

2. Repeat the alarm clearing until you have cleared all alarms.

Clearing a Flash Failure Alarm

The Flash Failure alarm is the only exception for clearing alarms. If a flash failure occurs at boot time, it can only be cleared by a soft reset key combination press (see “Resetting the Power Supply” on page 62) or by power cycling the unit. If a checksum error is detected when recalling a user slot, no modification of settings will occur, and an error will be pushed to the SCPI error queue. The alarm will clear after a duration per the currently configured front panel timeout setting.

To clear a triggered alarm, use one of the following methods:

- Turn the power supply Off and then On.
- For failures that occur during a recall of user memory settings, wait the duration of the currently configured front panel timeout.
- Press and hold the reset key combination (Flash Fail ONLY). See “Resetting the Power Supply” on page 62.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:PROTection:CLEar
```

Clearing Automatic Alarms

Some alarms will clear automatically when the condition that caused the alarm is no longer present. When an alarm automatically clears, the output voltage and current displays will return to normal, but the ALARM LED will remain illuminated to indicate that an alarm has occurred. If an automatic alarm is triggered, the normal alarm clearing procedure still applies.

To clear the ALARM LED after an automatic alarm has cleared, use one of the following methods:

- Send the SCPI Clear Alarm command.
- Press the OUTPUT ENABLE Main button to reenable the output. The ALARM LED will no longer be illuminated.

For example, if one of the fans was temporarily blocked, causing a Fan alarm, then the blockage was cleared and the fans restarted, the alarm would clear. The output voltage and current displays would be in normal mode, but the ALARM LED would be illuminated. See “Front Panel Alarm LED” on page 46 for information on other events that affect the ALARM LED.

Alarms status is tracked in the SCPI status registers. For more details on how and where the alarms are tracked, see “Standard SCPI Register Structure” on page 134.

Front Panel Alarm LED

The Alarm LED will illuminate due to one or more of the following events occurring:

- OTP has been tripped.
- A fan has stopped.
- OVP has tripped.
- OCP has tripped.
- UVP has tripped
- Interlock is open circuit.
- AC power falls out of range.
- Foldback has tripped.
- Persistent storage checksum is wrong (Flash Fail alarm).
- Internal malfunction of power supply.
- Any alarm has tripped and been cleared automatically.

The alarm LED will remain illuminated until the alarm is manually cleared (see “Clearing Triggered and Manual Alarms” on page 45) or by turning the main output on if the alarm has automatically been cleared.

Alarm Masking

It is possible to completely disable some alarms through the use of the alarm mask. If an alarm is masked then this masking will prevent it from registering in the SCPI conditions registers as well as not triggering the alarm. The alarms that can be masked are identified in the table on page 44. Setting the bit position (1) of an alarm will result in the alarm being enabled. Clearing the bit position (0) of an alarm will result in the alarm being masked/disabled.

For Example:

If you wanted to enable the OTP, Foldback and UVP alarms, you would take the foldback value of 256 and the UVP value of 1024 to get a mask of 1280. This is the value you would send with the SCPI command.

Control of the alarm mask is only available using the SCPI command.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel> ]:PROTection:MASK
```

The mask command takes a single parameter made up of the sum of the values for the alarms that are to be masked. See the table that follows for the alarm values associated with each maskable alarm.

| Alarm | Bit Position | Value |
|-----------------------------------|--------------|-------|
| Over Temperature Protection (OTP) | 2 | 2 |
| Not used | 3 | 4 |
| Fan | 3 | 8 |
| Foldback | 8 | 256 |
| External Shutdown | 9 | 512 |
| Under Voltage Protection (UVP) | 10 | 1024 |

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel> ]:PROTection:MASK
```

Alarm Output Latching

When an alarm is triggered, the output will be disabled with the exception of the Fan alarm. When an alarm is cleared, the alarm output latch determines if the output should be re-enabled to the state before the alarm occurred or if the output should remain in the off state.

Where setting the bit position (1) of an alarm latch will result in output latching to the off state when the alarm is cleared and if cleared (0) output will be re-enabled to the state before the alarm triggered.

To define the values for the bit position you determine which alarms you want to latch. Read the value for this bit position from the table that follows and sum them together. The result is the alarm last mask, which you should send with the SCPI command.

For Example:

If you wanted to enable latching for OTP and Foldback you would take the OTP value of 2 and add it to the foldback value of 256 to get a mask of 258. This is the value you would send with the SCPI command.

The output latches are accessible through the SCPI command.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel> ]:PROTection:LATCh
```

The latch command take a single decimal parameter made up of the sum of the values for the alarms to determine if they are to be latched in the off state on clearing. See the following table for the values associated with each latchable alarm.

| Alarm | Bit Position | Value |
|-----------------------------------|--------------|-------|
| AC Fail | 0 | 1 |
| Over Temperature Protection (OTP) | 1 | 2 |
| Foldback | 8 | 256 |

SETTING FOLDBACK MODE

Foldback mode is used to disable the output when a transition is made between the operating modes. The power supply will turn off/disable the output and lock in foldback mode after a specified delay if the power supply transitions into CV mode or into CC mode, depending on the foldback mode settings. This feature is particularly useful for protecting current or voltage sensitive loads. Foldback can be set to trigger a switch when transitioning from CV to CC mode or from CC to CV mode.

To set the foldback protection and foldback delay time:

1. Turn the 9-position mode control to the FLD position or press the rotary Adjust/Enter control if the 9-position mode control is already at the FLD position.
2. Select the type of crossover that will cause foldback to trigger by using the rotary Adjust/Enter control.

If the mode selected is CC or CV mode, the foldback delay timer will start on a transition into the selected mode. If the mode selected is none, foldback is not enabled.

3. Press the rotary Adjust/Enter control when the desired mode has been selected.

The FLD LED will illuminate and *dELA* will be displayed in the output voltage display.

4. Adjust the desired delay time using the rotary Adjust/Enter control.

The range can be set from 0.50 seconds to a maximum of 50 seconds. The step size is in increments of 0.05 seconds when setting from 0.50 to 5 seconds and then in 1 second increments from 5 seconds to 50 seconds.

5. Once the desired foldback delay time has been selected, press the rotary Adjust/Enter control to commit the foldback delay setting.

To disable foldback protection:

1. Turn the 9-position mode control to the FLD position or press the rotary Adjust/Enter control if the control knob is already at the FLD position.
2. *FLD* is displayed on the output voltage display and the output current display shows the current foldback trigger mode.
3. Turn the rotary Adjust/Enter control until *none* is displayed in the output current display.
4. Press the rotary Adjust/Enter control to commit the setting once the desired value has been set.
5. The green FLD LED will turn off and the display will return to the normal display mode.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:PROTection:FOLDBack[ :MODE ]
```

```
[ : ]OUTPut[ <channel> ]:PROTection:FOLDBack:LATCh
```

Important: If you set foldback while the output is enabled and the trigger you select is the same as the current operating mode, the foldback timer will begin counting immediately after the delay time has been set.

RESETTING ACTIVATED FOLDBACK PROTECTION

To reset activated and latched foldback protection, press and hold the rotary Adjust/Enter control for approximately 3 seconds.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:PROTection:CLEar
```

USING OVER VOLTAGE PROTECTION (OVP)

The OVP circuit protects the load in the event of an analog programming error, an incorrect voltage control adjustment, or a power supply failure. The OVP circuit monitors the output voltage at the output of the power supply and will disable the output whenever a preset voltage set point is exceeded. You can set the preset voltage trip point by using the 9-position mode control on the front panel or via one of the remote programming interfaces.

To prevent accidental tripping of the OVP while setting up, the firmware will prevent the OVP set point from being less than 105% of the voltage set point when in local set point control mode. When the power supply is in VAP mode for defining voltage set point the set point limitation will be based on the VAP input signal level. The user should note it is possible to trip OVP in this mode if the OVP is configured when the analog programming source is off.

When the user attempts to configure an OVP setpoint that is less than 105% of the voltage set point via the front panel the set point will stop allowing the value to decrement. If the user attempts to configure an OVP set point that is less than 105% of the voltage set point via SCPI a -221, “settings conflict error” will be pushed onto the error queue.

Defining the OVP Set Point

To define the OVP set point:

1. Turn the power supply On.
Ensure the voltage is lower than the desired set point.
2. Set the output to the desired voltage.
OVP can be set without setting desired output voltage first.
3. Turn the 9-position mode control to the PRT position. Ππο OYΠ is displayed.
4. Press the rotary Adjust/Enter control.
5. Turn the rotary Adjust/Enter control to set the upper limit protection. See “Coarse and Fine Adjustment Modes” on page 31.

Important: The OVP range is variable from $V_{SET} +5\%$ to $V_{MAX} +25\%$.

6. Once the desired value has been set, press the rotary Adjust/Enter control to commit the setting.

The SCPI command (s) for these instructions are:

```
[ [ : ]SOURce[ <channel> ] ]:VOLTagE:PROTection[:OVERvoltage] [ :LEVel ]
```

If the output is between OVP_{set} and -5% , an OVP warning message is possible when in APG mode.

USING UNDER VOLTAGE PROTECTION (UVP)

Important: UVP will not be active for voltage set points that are less than 1% of model voltage.

The UVP prevents voltage settings below a set value. The UVP lets you create a voltage window of operation when used in conjunction with the OVP setting. The UVP range is variable from 0 V to $OVP_{SET} - 10\%$.

The UVP is a protection that becomes active after the output is enabled and a period of time has passed to allow the output to reach its set point value before the UVP protection begins monitoring. As with OVP if the voltage set point is determined by analog control (VAP) and the voltage strays to within 5% of the UVP set point then UVP Safe will trigger to warn the user that they are about to trigger the UVP alarm.

The period of time before the UVP monitoring is active after the output is enabled is determined by the rise-time delay for the model. Since the rise time is based on a purely resistive load the user should be aware that UVP triggering might be possible in capacitive or rectifier loads due to the rise time being longer. In these cases it is recommended that the user mask the UVP alarm until the rise time has elapsed and then unmask the alarm to allow UVP protection to be enabled during operation.

Defining the UVP Set Point

To define the UVP set point:

1. Turn the power supply On.
2. Set the output to the desired voltage.
3. Turn the 9-position mode control to the PRT position. *PrO OVP* is displayed.
4. Turn the rotary Adjust/Enter control until *PrO UVP* is displayed.
5. Press the rotary Adjust/Enter control to select the UVP for setting up.
6. Set up the lower limit protection using the rotary Adjust/Enter control.

Important: The UVP range is variable from 0 volts to $OVP_{SET} - 10\%$.

7. Once the desired value has been set, press the rotary Adjust/Enter control to commit the setting.

See “Coarse and Fine Adjustment Modes” on page 31.

The SCPI command (s) for these instructions are:

```
[[:]SOURce[<channel>]]:VOLTage:PROTection:UNDer[:LEVel]
```

OVER CURRENT PROTECTION (OCP)

The OCP alarm is a firmware alarm that is only configurable using the SCPI interface. The OCP triggers if the output current exceeds the OCP set point. Because the OCP alarm is a firmware based alarm it has a latency before detection of the condition can occur. The user should be aware of this latency and take this into consideration when relying on OCP to protect a sensitive load. The maximum period for detecting an OCP condition is 300 ms.

OCP is fixed at 110% of rated current.

USING OVER TEMPERATURE PROTECTION LOCK (OTP)

The OTP lock protects the power supply in the event of an over temperature alarm. This alarm could be caused by ventilation restriction or overheating due to fan failure.

Two modes are available:

- Auto recovery (OTP OFF) where the power supply turns on again after cooling down.
- Latch mode (OTP ON) where you will need to reset the unit by turning the front panel power switch to Off and then On again.

If the OTP is activated, the main output will turn off and *P_r 0 07P* (over temperature protection) will blink on the display. The OTP alarm is an alarm that will auto recover when the temperature falls back into normal bounds.

Defining the OTP Mode

To define the OTP lock:

1. Turn the 9-position mode control to the PRT position. PrO OUP is displayed.
2. Turn the rotary Adjust/Enter control until *P_r 0 07P* is displayed.
3. Press the rotary Adjust/Enter control to display *07P On or OFF*.
4. Turn the rotary Adjust/Enter control to change to On or Off.
5. Press the rotary Adjust/Enter control.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel (s)> ]:PROTection:LATCh
```

Resetting in Latch Mode

To reset the power supply if the OTP alarm is tripped and the OTP mode is set to On (latching enabled), press and hold the rotary Adjust/Enter control for approximately 3 seconds.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel (s)> ]:PROTection:CLEAr  
[ : ]SYSTem[ <channel (s)> ]:PROTection:LATCh
```

USING THE EXTERNAL SHUTDOWN FUNCTION

Use the external shutdown function to enable or disable the output of the power supply via a logic level signal. When the external shutdown is triggered, the power supply will display *SD POL* on the output voltage and current displays. The external shutdown is useful for making adjustments to either the load or the power supply without shutting off the power supply or for using the power supply as part of a larger test system in which digital or analog control is required.

Activating the External Shutdown Function

To activate the external shutdown function, use the AUX output supply provided on the Analog Programming Connector J3. This input has a user selectable polarity with logic low input from 0.0V to 1.2V and logic high from 2.0V to 15V. The control signal for this input must be capable of sinking 10mA minimum. This input is also compatible with the use of dry contacts, where a short is logic low and an open is logic high. The input lines of the shutdown circuit are fully optically isolated.

Once the External Shutdown has been triggered, the display will blink the *SD POL*.

Controlling the External Shutdown Function

The external shutdown circuit accepts a voltage or dry contact control (high or low logic level) to enable or disable the power supply output. Make connections for the signals at the AUX Output and Isolated Analog Programming Connector on the rear panel. (See “AUX Output and Isolated Analog Programming (ISOL) Connector” on page 87 for more information.)

To activate the shutdown function:

Connect the control signal source to the Shutdown pin (J3.12) on the Aux Output and Isolated Analog Programming Connector with the control circuit ground connected to Isolated Ground pin (J3.6).

The External Shutdown pin is pulled high internally (normally high). Therefore, if this feature is not used, the polarity should be set to 1 to avoid false triggering. (See “Defining the Polarity of the External Shutdown Signal” on page 54 for instructions.)

Defining the Polarity of the External Shutdown Signal

1. Turn the 9-position mode control to the PRT position or press the rotary Adjust/Enter control if the control knob is already at the PRT position.
Pr \square OVP is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control until Pr \square Sd is displayed.
3. Press the rotary Adjust/Enter control to display Sd \square (shutdown on logic 0) or Sd 1 (shutdown on logic 1).
4. Press the rotary Adjust/Enter control to commit the desired polarity setting.

For example: If you set the shutdown logic to 1 (Sd 1) and apply a logic high (greater than 1.2 Vdc) to pin J3.12 relative to pin J3.6 on the ISOL connector, the power supply will shut down. Conversely, if you set the shutdown logic to 0 (Sd \square), the power supply will only operate when you have a logic high (greater than 1.2 Vdc) to pin J3.2 relative to pin J3.6.

Important: There is an internal pullup resistor inside the shutdown circuit so the shutdown polarity should be set to 0 if it is not being used.

The SCPI command (s) for these instructions are:

```
[ : ]OUTPut[ <channel> ]:POLarity
```

LOOP PROTECTION

The Loop Protection feature can be used to enable or disable multiple units in daisy chain configuration through the AUX Output and Isolated Analog Programming Connector, J3. Up to four units (example, Units #1 through #4) can be configured in Loop Protection; if one of the units is experiencing a fault condition, other units in the same loop will disable their output simultaneously. This is achieved by connecting Unit #1's MAIN_PS_GOOD to Unit #2's SD (Shutdown Main O/P) and continues until Unit #4's MAIN_PS_GOOD is fed to Unit #1's SD (Shutdown Main O/P). Common applications include single master controlling multiple slave units as a system On/Off. In addition, any fault from either operating unit will cause the system to disable.

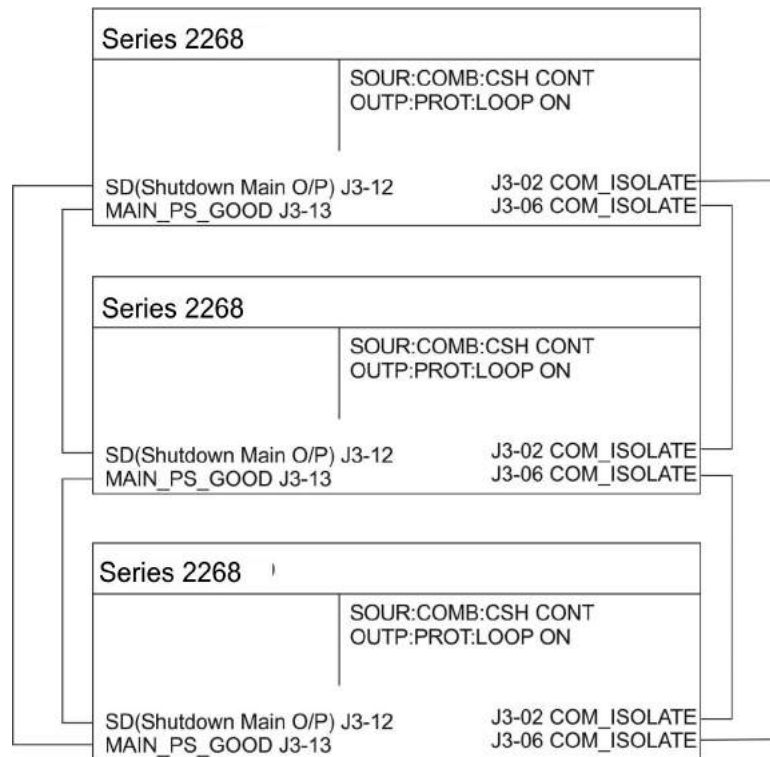
The Loop Protection can be enabled or disabled locally using the front panel 9-position mode control, or remotely using a SCPI command.

Important: While Loop Protection is enabled (ON), the external shutdown function will be automatically set to low active. When Loop Protection is disabled (OFF), the external shutdown function will be set to the user's last setting.

Setting up Loop Protection

To set up Loop Protection:

With the AC powered OFF, connect the first unit's pin J13.13 to the next unit's J 13.12 on the AUX Output and Isolated Analog Programming Connector. Do this for up to four units. An example of a 3-unit loop protection is illustrated as follows:

Figure 13: Loop Protection Setup**To enable or disable Loop Protection:**

1. Turn the 9-position mode control to the PRT position. PRO OVP is displayed.
2. Turn the rotary Adjust/Enter control until LOOP PRO is displayed.
3. Press the rotary Adjust control to display LOOP ON or OFF.
4. Press the rotary Adjust control to change the setting to ON or OFF.
5. Press the rotary Adjust control to accept the change.

The SCPI command (s) for these instructions are:

```
[:]OUTPut [<channel>]:PROTection:Loop[:STAtE]
```

INTERLOCK FUNCTION

The Interlock function can be used to wire an external shutoff switch that can be used to enable or disable the power supply output. When the switch is closed, the power supply will operate normally. If the switch is opened, the power supply will trigger the interlock alarm. The output will be disabled, the display will blink *Int LDC*, and the ALARM LED will illuminate. This alarm will automatically clear when the switch closes again, and the output will automatically be restored to its pre-alarm state (either enabled or disabled). The interlock function can only be enabled or disabled (defined) using a SCPI command (cannot be masked or latched through the alarm protection mechanisms.). Common applications include an emergency shutoff switch or a door switch.

Connect the switch between pins J3.14 and J3.15 on the AUX Output and Isolated Analog Programming Connector.

Defining the Interlock Mode

The Interlock mode is controlled via SCPI commands. There is no front panel access for enabling or disabling the Interlock functionality. See “Interlock Enable/Disable” on page 161.

The SCPI command for setting the Interlock mode to On or Off is:

```
[ : ]SENSE[ <channel> ]:PROTECTION:INTERlock[ :STATE ]
```

OUTPUT PROTECTION

The output voltage and the output current can be programmed (preset) to automatically start at zero Volts and zero Amps upon power-up and upon output enable. Also, each can be reprogrammed to disable the automatic reset to zero.

Programming Voltage Output Preset

To Enable/Disable automatic reset to 0 Volts:

1. Turn the rotary Adjust/Enter control to PRT and press.
2. Turn again until *PRT OUTF* is displayed.
3. Press to display *OUTP UOL*.
4. Turn to display *UOL ON* or *UOL OFF*.
5. Press to commit the selected setting.

Important: This single front panel operation affects both power on and output enable. However, when using SCPI, there is a separate command for each.

The SCPI command to query or enable/disable the 0 Voltage Output Preset at power-on is:

```
[ : ]SYSTEM[ <channel> ]:PON:VOLTage { ? | ON | OFF }
```

The SCPI command to query or enable/disable the 0 Voltage Output Preset upon output enable is:

```
[ : ]SYSTEM[ <channel> ]:PON:ENable:VOLTage { ? | ON | OFF }
```

Programming Current Output Preset

To Enable/Disable automatic reset to 0 Amps:

1. Turn the rotary Adjust/Enter control to PRT and press.
2. Turn again until *Prt 007P* is displayed.
3. Press to display *007P Curr.*
4. Turn to display *Curr On* or *Curr Off*.
5. Press to commit the selected setting.

Important: This single front panel operation affects both power on and output enable. However, when using SCPI, there is a separate command for each.

The SCPI command to query or enable/disable the 0 Current Output Preset at power-on is:

```
[ : ]SYSTem[ <channel> ] :PON:CURREnt { ? | ON | OFF }
```

The SCPI command to query or enable/disable the 0 Current Output Preset upon output enable is:

```
[ : ]SYSTem[ <channel> ] :PON:ENABle:CURREnt { ? | ON | OFF }
```

POWER ON STATUS SIGNAL

Power On Status signal indicates a fault condition in the power supply. Power On Status signal is a TTL output signal at Pin J2.13 with reference to COM ISOLATED (Pin J2.2 or Pin J2.6).

During normal operation, the Power On Status signal will be high. If the output is disabled for any reason, the Power On Status signal will go low.

The following conditions will set the Power On Status to a low level:

- AC fail
- Current Loop Protection
- Over Voltage Protection (OVP)
- Under Voltage Protection (UVP)
- Over Current Protection (OCP)
- Over Temperature Protection (OTP)
- Foldback Protection
- Interlock
- Output Off
- Shutdown activated (rear panel shutdown).
- Internal hardware malfunction Fan failure

HARDWARE MALFUNCTION ALARMS

The power supply will turn off the output. An error message will be displayed in the event that:

- OVP trips
- Voltage deviation in CV mode reaches more than $\pm 5\%$ from the set level.¹
- Current deviation in CC mode reaches more than $\pm 5\%$ from the set level.¹

1. These two forms of hardware malfunction are only monitored in the corresponding APG mode.

CURRENT CONFIGURATION MEMORY SETTINGS

The power supply will save the unit settings at the time of power down. These settings will be loaded when the power is restored to the unit or the power supply is powered up again. The table that follows lists the settings that are saved and recalled on a power cycle event.

| |
|--|
| Voltage Setpoint |
| Current Setpoint |
| Voltage Output Protection |
| Current Output Protection |
| Over Voltage Protection (OVP) |
| Under Voltage Protection (UVP) |
| Over Temperature Protection (OTP) |
| Autostart OUTPUT ENABLE Main |
| Autostart OUTPUT ENABLE Aux |
| Foldback Mode |
| Foldback Delay |
| Shutdown Logic |
| Voltage Analog Programming (VAP) Mode |
| Voltage Analog Programming (VAP) Level |
| Current Analog Programming (CAP) Mode |
| Current Analog Programming (CAP) Level |
| Remote Programming Interface |
| Local Lock |
| PSU (Power Supply) Address |
| Data Rate (BPS) |
| Alarm Latches |
| Front Panel Timeout |
| Constant Power Mode |
| Constant Power Level |
| Loop Protection Enable |
| Line Drop Mode Settings |

USER SETTING MEMORY LOCATIONS

There are three user setting memory locations available for storing frequently used configurations. These user setting memory locations help to facilitate multiple users of a Series 2268 power supply who have different setups or when multiple loads are used that have different requirements. The table that follows lists the values that are stored in each user setting memory location.

| |
|--|
| Voltage Setpoint |
| Current Setpoint |
| Voltage Output Protection |
| Current Output Protection |
| Over Voltage Protection (OVP) |
| Over Temperature Protection (OTP) |
| Autostart OUTPUT ENABLE Main |
| Autostart OUTPUT ENABLE Aux |
| Foldback Mode |
| Foldback Delay |
| Shutdown Logic |
| Voltage Analog Programming (VAP) Mode |
| Voltage Analog Programming (VAP) Level |
| Current Analog Programming (CAP) Mode |
| Current Analog Programming (CAP) Level |
| Current Sharing Mode |
| Alarm Latches |
| Front Panel Timeout |

Saving User Setting Memory Locations

To save user setting memory locations:

1. Turn the 9-position mode control to the SAV position.
SAVE is displayed on the output voltage display with a number indicating a preset position which is displayed on the output current display.
2. Turn the rotary Adjust/Enter control to select a preset position from 1 to 3.
3. Press the rotary Adjust/Enter control.
SAVE done is displayed on the output voltage display.
4. The setting has now been saved to the selected user setting memory location.

The SCPI command (s) for these instructions are:

```
*SAV <setting_location>
```

or

```
[ : ]SYSTem[ <channel> ]:SAVE <setting_location>
```

Recalling User Setting Memory Locations

This feature recalls settings that were previously saved.

To load user setting memory locations:

1. Turn the 9-position mode control to the RCL position.
`rCL` is displayed on the output voltage display with a number indicating a preset position on the output current display.
2. Turn the rotary Adjust/Enter control to select a preset position from 1 to 3.
3. Press the rotary Adjust/Enter control.
`rCL done` is displayed on the output voltage display.

The settings in the selected user setting memory locations have now been applied to the power supply.

The SCPI command (s) for these instructions are:

```
*RCL <setting_location>
```

or

```
[ : ]SYSTem[ <channel> ]:RECall <setting_location>
```

Three user setting memory locations are available and one user setting memory location is saved automatically before AC power shutdown. This user setting memory location will be loaded after AC power is restored.

LOCAL LOCKOUT

Local lockout is a feature that allows the front panel to be locked so that accidental button presses are ignored. This feature is often used to lockout the front panel when you are controlling the power supply from a remote location. When in local lockout mode, the front panel will display `LOC Loc` whenever a button is pressed or a knob is turned.

Enabling Local Lockout

To enable local lockout:

1. Turn the 9-position mode control to the PGM position or press the rotary Adjust/Enter control if the control knob is already at the PGM position.
The display will show `rE` in the output voltage display and the selected remote interface in the output current display.
2. Turn the rotary Adjust/Enter control until the display shows `LOC Loc`.
3. Press the rotary Adjust/Enter control.
4. Turn the rotary Adjust/Enter control until the display shows `LOC On`.
5. Press the rotary Adjust/Enter control. Local lockout has been enabled.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem:REMOte:STATe
```

Disabling Local Lockout

To disable local lockout:

1. Turn the 9-position mode control to the PGM position or press the rotary Adjust/Enter control if the control knob is already at the PGM position.
The display will show `rE` in the output voltage display and the selected remote interface in the output current display.
2. Turn the rotary Adjust/Enter control until the display shows `LOC OFF`.
3. Press the rotary Adjust/Enter control.
Local lockout will be disabled after power-cycling the power supply.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel(s)> ]:REMOte:STATe
```

RESETTING THE POWER SUPPLY

The reset is used to clear the parameters to the factory default values.

Soft Reset

The soft reset is used to set the parameters (see table below) to the default values, but it does not reset the calibration constants

To perform a soft reset:

1. Turn the power supply to Off then On.

When the unit is powering on, `8888 8888` is displayed on the output voltage and current displays.

2. Press the key combination of both OUTPUT ENABLE Main button and OUTPUT ENABLE Aux button and hold continuously for 3 seconds in order to execute.

If the flash fail alarm triggers, it is also possible to reset the power supply. The front panel should display `PSU 5 r5`.

3. Once a reset has been triggered, the output voltage display shows `PSU CLR` for 1 second.

The model number will be displayed for 1 second and then return to normal mode.

After executing a reset, the power supply's settings are restored to the default settings but retain the calibration data. Following lists the default settings.

| Parameter | Setting |
|----------------------------|------------------------------------|
| Address | 1 |
| Data rate (Kbps) | 9.6 |
| Communication mode | RS-232 |
| Vout setting | 0 V |
| Iout setting | 0 A |
| Output | Off |
| AUX Out | Off |
| Trigger | Off |
| Ext. On/Off Polarity | Negative |
| Auto start mode | Off |
| AUX Auto start mode | Off |
| OVP | Maximum |
| UVP | 0 V |
| Foldback trigger | None |
| Foldback delay | 0.5 s |
| Current Share Mode | Controller |
| Alarm Output Latches | 263 (0 x 107, all latches enabled) |
| Alarms Mask | 2047 (0 x 7FF, all enabled) |
| Interlock | Disabled |
| Voltage Analog Programming | Off |

| Parameter | Setting |
|----------------------------|---------|
| Voltage APG Scale | 10 V |
| Current Analog Programming | Off |
| Current APG Scale | 10 V |
| Voltage Output Protection | Off |
| Current Output Protection | Off |

USING MULTIPLE POWER SUPPLIES



WARNING: Shock hazard

There is a shock hazard at the load when using a power supply at an output of greater than 40V or a combined output of greater than 40V. To protect personnel against accidental contact with hazardous voltages created by a series connection, ensure that the load, including connections, has no live parts which are accessible. Also ensure that the insulation rating of the load wiring and circuitry is greater than or equal to the maximum *or combined* output voltage of the power supply.



CAUTION: Equipment damage

Do not connect power supplies from different manufacturers in parallel or in series.

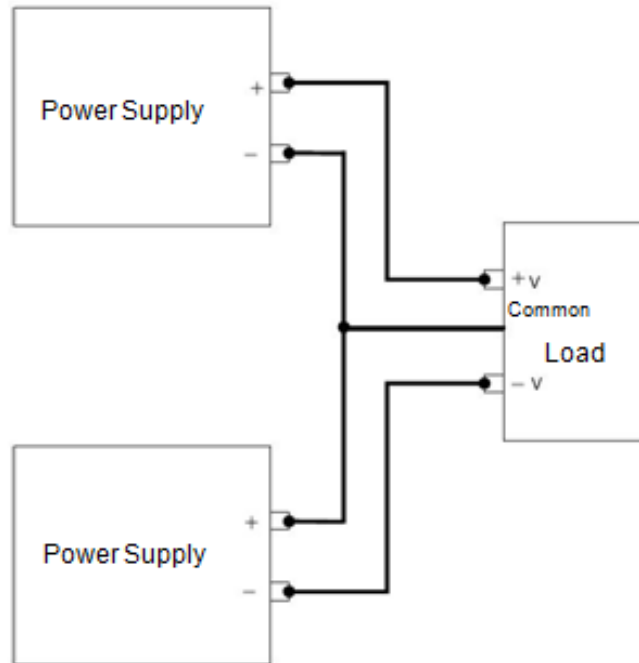


CAUTION: Equipment damage

The remote programming inputs are internally referenced to the power supply's negative output. Do not connect remote programming ground lines to the power supply's positive output.

You can operate power supplies of the same model with the outputs in series to obtain increased load voltage or with the outputs in parallel to obtain increased current, also called current sharing. Bipolar supply operation gives you two positive outputs, or a positive and a negative output. When using multiple supplies in series or parallel, they will not meet the single unit specifications in this Manual.

Figure 14: Bipolar Supply Operation



CONFIGURING MULTIPLE SUPPLIES FOR SERIES OPERATION

A maximum of two power supplies of the same rating can be connected in series to increase the output voltage.



CAUTION: Equipment damage

When two power supplies are connected in series, they should be programmed to the same output voltage to prevent damage to the lower voltage supply at short circuit condition.

Load Considerations



CAUTION: Equipment damage

Use properly rated diodes to protect the power supply from damage while driving inductive loads..

INDUCTIVE LOADS:

To prevent damage to the power supply from inductive kickback, connect a diode (rated at greater than the supply's output voltage and current) across the output. Connect the cathode to the positive output and the anode to return. Where positive load transients may occur, such as back EMF from a motor, a second diode in series with the output is recommended to protect the power supply.

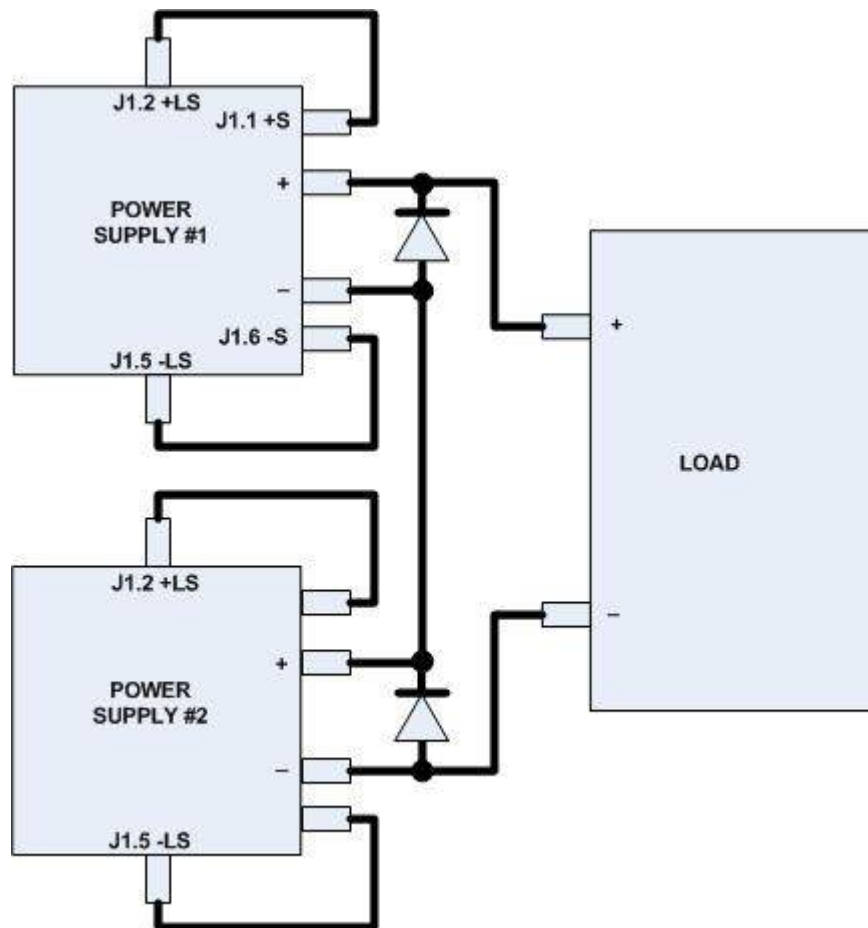
BLOCKING and FREE WHEELING DIODES:

The Peak Reverse Voltage ratings should be a minimum of 2-3 times the power supply maximum output voltage. The Continuous Forward Current rating should be a minimum of 1.5 times the power supply maximum output current. Heatsink may be required. There also may be a need for higher voltage rated parts, dependent on load circuit design and inductor values.

Connecting to the Load in Local Sensing Mode

Connect the negative (-) output terminal of one power supply to the positive (+) output terminal of the next power supply. See Figure 15 for a representation of series operation.

Figure 15: Series Operation



Connecting to the Load in Remote Sensing Mode

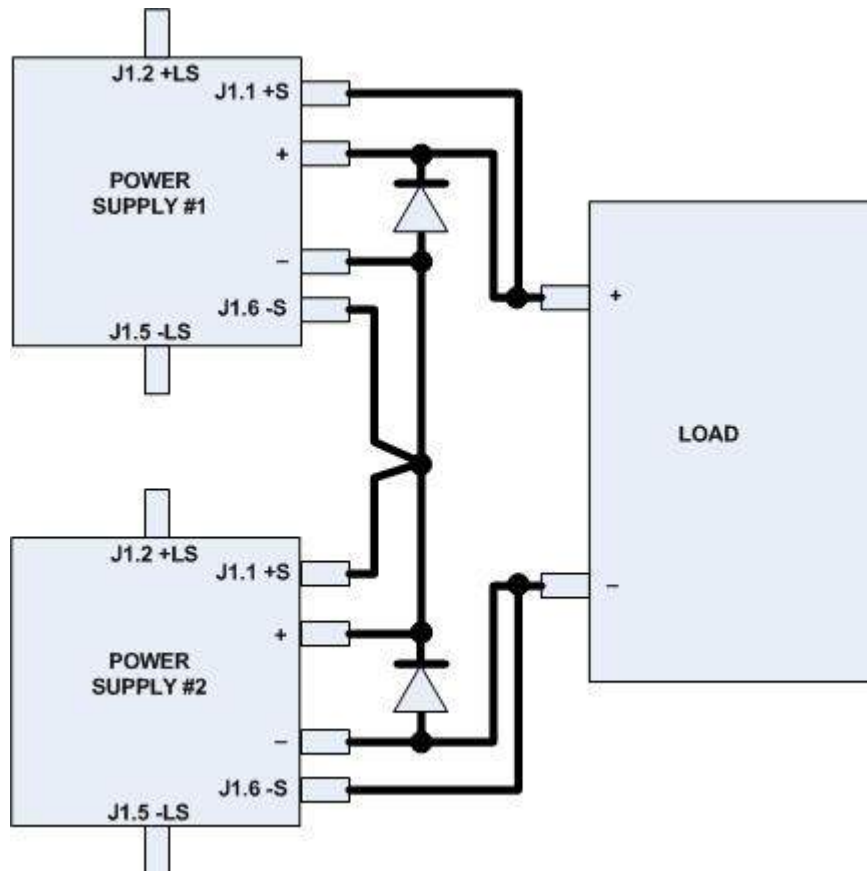
Connect the negative (-) output terminal of one power supply to the positive (+) output terminal of the next power supply. The more positive supply's positive sense line should connect to the positive terminal of the load (or distribution point). Its return sense line should connect to the connection between the two units at the same spot as the negative supply's positive sense line. The return sense line of the negative supply should be connected to the return of the load. See Figure 16.



CAUTION: Equipment damage

Do not connect sense lines through relays.

Figure 16: Load Connections in Remote Sensing Mode



CONFIGURING MULTIPLE SUPPLIES FOR CURRENT SHARING OPERATION (APG METHOD)

Up to four power supplies can be connected in parallel to increase the output current. One of the units will operate as the master unit and the remaining units will operate as slave units controlled by the master unit. The master unit uses the analog programming lines to set the output voltages and currents of the slave units to match its output.

In remote digital operation, only the master unit can be programmed remotely while the slave units that are connected remotely will only provide voltage, current and status readback information.

In APG current sharing topologies, only the master unit can be programmed using any of the input methods (front panel, remote digital, or analog programming control). The slave unit(s) voltage and current output(s) are determined by the master unit through the REF_I input to each slave unit. The readback using any of the monitoring methods (front panel display, user monitor lines or SCPI measure commands) of each unit (master or slave) will provide individual unit status, not system status.

Important: If current sharing is not being used, the unit must be configured as a controller. Failure to do so will result in unpredictable operation.

Setting up the Controller Unit

Set the output voltage of the master unit to the desired voltage. Program the current set point of the master unit to the desired load current set point divided by the number of parallel units. During operation, the master unit operates in Constant Voltage mode, regulating the load voltage at the programmed output voltage. Send the Current share SCPI command or use the following instructions to program front panel current share setup:

1. With the 9-position mode control at the PGM position, press the rotary Adjust/Enter control.
rE is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select [U-rShAr and press the Adjust/Enter control.
[Shr is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select [On] in the output current display.

4. Press the rotary Adjust/Enter control to commit the setting.

The SCPI command (s) for these instructions are:

```
[[:]SOURCE[<channel>]]:COMBine:CSHare[:MODE]
```

Setting up the Slave Units

The output voltage and current of the slave units should be programmed to maximum value. During parallel operation, the slave units operate as a controlled current source following the controller unit's output current.

All slave units must be configured with the SCPI command to enable current sharing, or use the following instructions to program front panel current share setup:

1. With the 9-position mode control at the PGM position, press the rotary Adjust/Enter control.
 rE is displayed on the output voltage display.
2. Turn the Adjust/Enter control to select “ $[U-rSHr]$ ” and press the Adjust/Enter control.
 $[Shr]$ is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select $5A$ in the output current display.
4. Press the rotary Adjust/Enter control to commit the setting.

The SCPI command (s) for these instructions are:

```
[[:]SOURCE[<channel>]]:COMBine:CSHare[:MODE]
```

Important: The slave unit discussed here is not the same as the remote interface slave described in section 5.

Setting Over Voltage Protection (OVP)

The master unit's OVP should be programmed to the desired OVP level. The OVP of the slave units should be programmed to a higher value than the master OVP. When the controller unit shuts down, it will program the outputs of the slave units to zero volts. If a slave unit shuts down, only that unit would shut down and the remaining slave units would supply all the load current if possible.

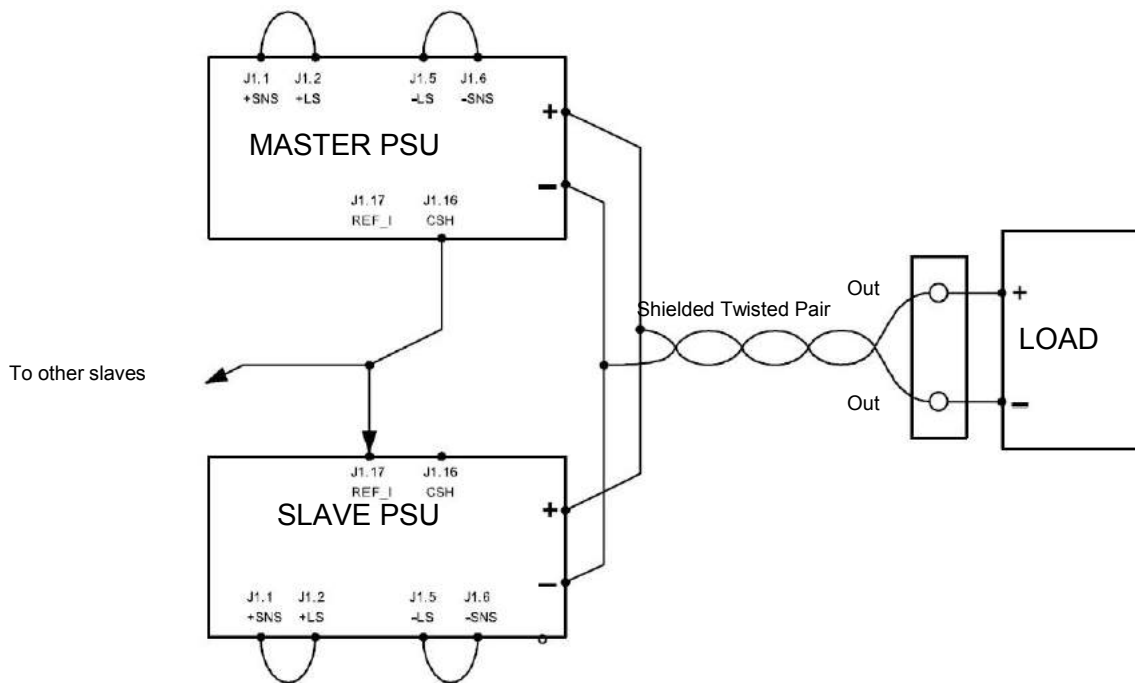
Setting Foldback Protection

Foldback protection is only available on the master units as the slaves operate in constant current mode. They should never crossover into constant voltage mode. If foldback is triggered on the master unit, when its output shuts down, it will program the slave unit's output to zero volts.

CONNECTING TO THE LOAD IN LOCAL SENSING MODE (PARALLEL CONTROL METHOD)

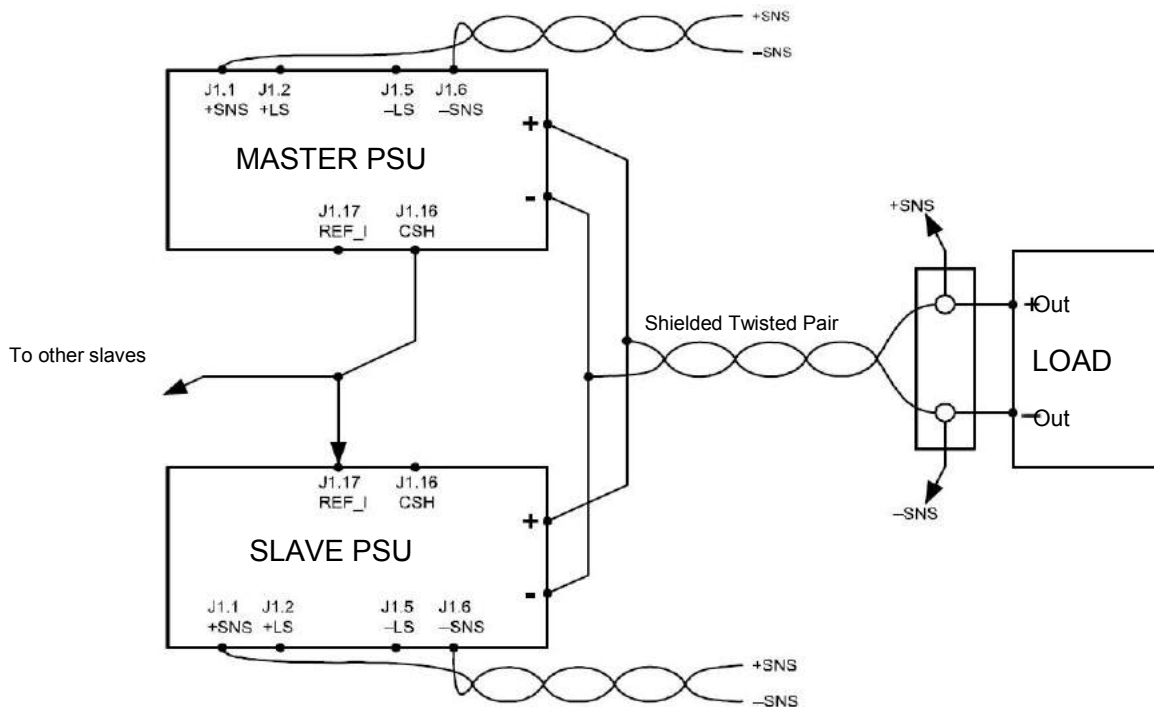
Connect the power supplies in parallel to obtain a single output supply with a higher output current set point. Set all of the outputs to the same voltage before connecting the positive (+) and negative (-) terminals in parallel. The total current available is the sum of the maximum currents of each power supply.

Figure 17: Load Connections in Local Sensing Mode



CONNECTING TO THE LOAD IN REMOTE SENSING MODE (PARALLEL CONTROL METHOD)

Figure 18: Load Connections in Remote Sensing Mode (Parallel Control Method)



POWER SAVING CONTROL (SLEEP MODE)

The Sleep Mode, supported by Series 2268 power supplies, is an effective way to reduce overall power consumption when the power supply is not in use for a specified period of time. If Sleep Mode is enabled, the power supply will revert to a low power consumption mode with the following characteristics:

- Display will be blank.
- The internal cooling fans will run at the lowest possible speed for whisper-quiet operation.
- Touching any button or one of the rotary knobs will immediately wake up the power supply to normal mode of operation.
- All settings will be preserved during sleep mode and the power supply will return to the previously set state when it wakes up.

The following conditions must be met in order for Sleep Mode to engage:

- The output of the power supply and auxiliary outputs must be off (standby).
- The Sleep Mode must be enabled (on).

To enable Sleep Mode:

Set a time delay for the duration of inactivity to elapse before entering Sleep Mode. This time (sleep hold-off delay) can be set from the Protection menu, under the SLP entry. The sleep hold off delay can be set from 1 to 9 hours.

To disable the Sleep Mode:

Set the sleep hold off delay value to zero (0). This is also the default state for the Sleep Mode feature. Thus, unless set from the front panel, Sleep Mode is off. Once enabled (set to a value from 1 to 9), it will be enabled. If the set time elapses without any activity on the power supply, it will enter Sleep Mode.

Note that after issuing a *RST command, the power supply will revert to factory default settings, which means Sleep Mode will be turned off.

To set up Sleep Mode:

1. Turn the 9-position Mode Control switch to the PRT (protect) position.
2. Turn the Rotary Adjust/Enter knob until the Output Current Display shows "SLP."
3. Press the Adjust/Enter button. The most recent setting for the Sleep Mode is displayed (a number from 1 to 9).
4. Turn the Rotary Adjust/Enter knob until the desired inactivity delay time is displayed.
5. Press the Adjust/Enter button.

Important: Sleep Mode is controlled only from the front panel.

Analog Programming & Isolated Analog Programming

In this section:

This section provides information and procedures for analog and isolated analog programming of the power supply.

INTRODUCTION

The rear panel connectors J1 and J3 provide an option to control and monitor the output of the power supply with analog signals. Connector J1 provides a non-isolated analog interface where all signals are referenced to the negative output terminal of the power supply. Connector J3 is an isolated interface and also provides an isolated auxiliary voltage output to aid analog programming.

ANALOG PROGRAMMING (APG) OF OUTPUT VOLTAGE AND OUTPUT CURRENT

Analog programming allows control of the power supply's output voltage, output current or both to be controlled from analog input sources. As the programming source is varied within the configured analog programming range (2-10 volts/k Ω max), the power supply's output varies proportionally over its output range. For example, if you set the programming scale to 10 V voltage source and apply 5 V to the programming pins, the power supply will be programmed to 50% of the output capability for your power supply.

While analog programming mode is configured, you will not be able to make adjustments to the set points from the front panel or through the remote interfaces.

The front panel will display AnPr in the output current display when the 9-position mode control is turned to VOLTS or AMPS positions for the parameter(s) that are configured to be controlled by analog programming. If an adjustment of a parameter controlled by APG is attempted using a SCPI command, a “-221 Settings Conflict” error will be pushed onto the error queue.

Using analog programming requires that you make connections to the Isolated Analog Programming Connector or Analog Programming Connector on the rear panel of the power supply.

REMOTE PROGRAMMING OPTIONS

Analog Monitor Signals

There are four monitor lines for analog programming the pin name and the related APG mode, which are listed in the table that follows. All of these lines are provided to give analog feedback. The output from these monitor lines is a value scaled to the Analog Programming level set for the corresponding analog programming type. For example, the voltage monitor and isolated voltage monitor lines are both scaled to the analog programming level that is set in the VAP mode.

| Related APG Mode | Reference Line Name | Connector |
|---|---------------------|-----------|
| Non-Isolated Voltage Analog Programming | VOL_MON | J1.13 |
| Isolated Voltage Analog Programming | IS_MON_VOL | J3.5 |
| Non-Isolated Current Analog Programming | CUR_MON | J1.14 |
| Isolated Current Analog Programming | IS_MON_CUR | J3.10 |

Important: Analog control monitor lines will reflect the output of the power supply even when the unit is not set to operate in analog programming mode.

Important: Isolated monitor lines are only valid when isolated analog programming modes are used for the respective voltage and current control. If local (front panel) control is used or non-isolated APG is used, these values will be inaccurate and should not be used for monitoring. Conversely, if isolated APG is used, the non-isolated monitor lines will be inaccurate.

Auxiliary Outputs

The auxiliary outputs are an additional isolated source. The auxiliary output has two outputs: +5 V output on J3.9 and a +15 V output on J3.11. The auxiliary output operates independently of the main output. It is enabled or disabled from the front panel by pressing the OUTPUT ENABLE Aux button. When the Aux output is enabled, the OUTPUT ENABLE Aux button is illuminated. Like the main output of the power supply, the Aux also has the ability to Autostart at power up. See “Output Auto Start Mode (Auto Restart)” on page 42 and “Auxiliary Auto Start Mode” on page 43 for details on controlling this feature.

The table that follows provides a summary of the options available for programming output voltage and current set point using an analog source.

| Control of... | Programming Scale ¹ | For more info... |
|-------------------|---------------------------------------|------------------|
| Output voltage | 2-10 V Voltage source (adjustable) | See page 77. |
| Current set point | 2-10 V Voltage source (adjustable) | See page 79. |
| Output voltage | 2-10 kΩ Resistive source (adjustable) | See page 82. |
| Current set point | 2-10 kΩ Resistive source (adjustable) | See page 84. |

1. The resolution can be adjusted in increments of 0.1 volts.

Analog Programming (APG) Connector J1

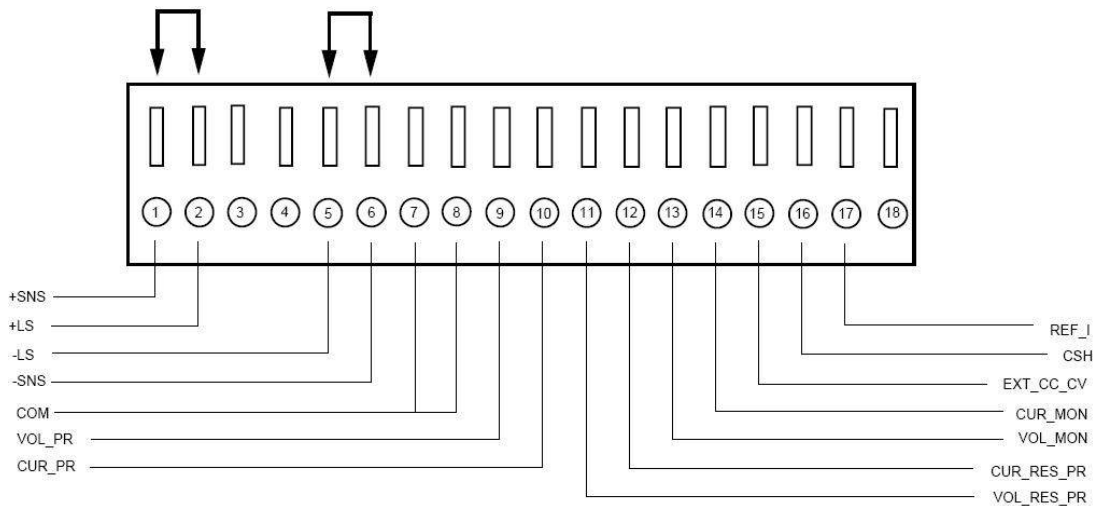
The APG connector is an 18-pin connector. See Figure 19.

The APG connector provides access to the following functions:

- Sense control
- Analog programming and monitoring.

Figure 19: APG Connector Terminals

(Pins 1 and 2 are jumpered; Pins 5 and 6 are jumpered).



| Pin | Reference | Function |
|-------|----------------------|--|
| J1.1 | +SNS Positive (+) | Sense } Local Sense } Jumper. Factory default condition. |
| J1.2 | +LS Positive (+) | |
| J1.3 | -NC | |
| J1.4 | -NC | |
| J1.5 | -LS Negative (-) | Local Sense } Sense } Jumper. Factory default condition. |
| J1.6 | -SNS Negative (-) | |
| J1.7 | COM Analog Common | Same as power supply negative sense (-SNS) |
| J1.8 | COM Analog Common | Same as power supply negative sense (-SNS) |
| J1.9 | VOL_PR | Analog Voltage Programming Input |
| J1.10 | CUR_PR | Analog Current Programming Input |
| J1.11 | VOL_RES_PR | Voltage Resistive Programming Input |
| J1.12 | CUR_RES_PR | Current Resistive Programming Input |
| J1.13 | VOL_MON ¹ | Voltage Monitor. The scale of this output is set by the APG voltage input range selected (see Important note at foot of this table). |
| J1.14 | CUR_MON ¹ | Current Monitor. The scale of this output is set by the APG current input range selected (see Important note at foot of this table). |

| Pin | Reference | Function |
|-------|-----------|--|
| J1.15 | EXT_CC_CV | External CC/CV. Indicates the state of the operate mode. When in CV mode, logic high is output and when in CC mode, logic low is output. Logic is TTL/CMOS compatible. |
| J1.16 | CSH | Current Share. Used to hook up units for current sharing. Output from master unit. Slave units should be left open. |
| J1.17 | REF_I | Current Reference Input. Slave input from current share output on the master unit. |
| J1.18 | NC | |

- ¹ Important: Non-isolated monitor lines are only valid in local control, digital remote and non-isolated analog programming modes for the respective voltage and current control. If isolated analog programming is used, the isolated monitor lines should be used as the non-isolated monitoring lines will not accurately reflect the output state of the power supply.

Making Control Connections



CAUTION: Equipment damage

Before making connections from external circuits to the Analog Programming Connector, turn the front panel power switch to Off and wait until the front panel displays are not illuminated.



CAUTION: Equipment damage

Program/monitor signal and return are internally connected to the power supply negative output (-S). Do not attempt to bias these away from that potential.

To connect the output wires to the APG and DC output connector:

1. Insert a 3/32 inch slot-head screwdriver into the orange-colored box of the connector until the end of the spring is reached.
2. Hold the connector open and insert the applicable output wire.
3. Remove the screwdriver.

Figure 20: Inserting Screwdriver into Spring Terminal Block

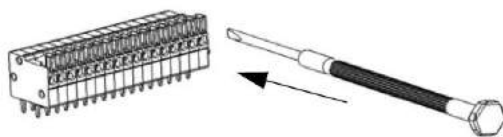
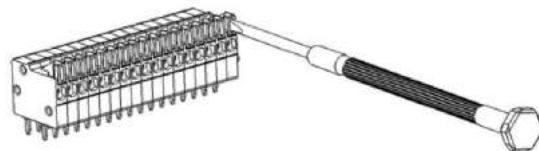


Figure 21: APG and DC Output Connector



Wiring



WARNING: Shock hazard

There is a potential shock hazard at the output when using a power supply with a rated output greater than 60 V. Use load wires that match the maximum voltage, current, and temperature ranges that you expect in your application. Type TEW wire with ratings of 105 °C and 600 V is suitable for use with all the Series 2268 power supplies.

For most connectors and jumpers, use any suitable wire such as 20 to 26 AWG stranded wire. For lowest noise performance, use shielded twisted pair wiring of 20 to 26 AWG of the shortest length possible. Ground the shield to pin J1.7 (analog common) on the Analog Programming Connector or to the chassis via one of the Analog Programming Connector screws.

ANALOG PROGRAMMING MODE

For more details about connections for your particular model, see “Rear Panel ” on page 15.



CAUTION: Equipment damage

The program/monitor signal and return are internally connected to the power supply's negative output. Do not attempt to bias these away from that potential. See “Making Control Connections” on page 75.

Analog Programming With External Voltage Source

Figure 22: Programming Output Voltage using an External Voltage Source

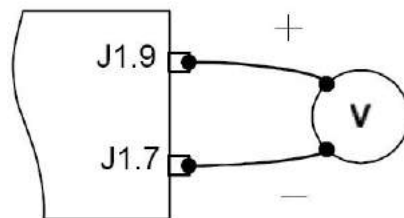
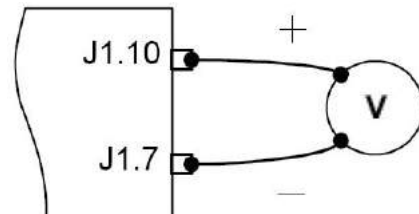


Figure 23: Programming Output Current using an External Voltage Source



Voltage-Controlled Voltage APG Setup

Activating APG Voltage Mode

To activate APG voltage mode using an external voltage source:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
VAPr is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select *Un 15* (voltage source from non-isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. *LE U* is displayed on the output voltage display.
4. Once the desired level has been selected, press the rotary Adjust/Enter control to commit the change.

The display will return to the normal display.

Deactivating APG Voltage Mode

To deactivate the APG voltage mode:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
2. *VAPr* is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select *none*.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for Analog Voltage Input Level

To query for analog voltage input level from non-isolated input:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
VAP is displayed on the output voltage display.
2. If the mode is currently *nonE* then select any other APG mode. If this step is done, be sure to restore the APG setting to *nonE* when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current APG mode.
3. Press the rotary Adjust/Enter control to select the APG mode.
 The output voltage display should read *LE U* and the output current display will display APG level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the APG mode was modified in step 2, execute the procedure to deactivate the APG voltage mode.

Quick Tip: Remote Operation uses these SCPI commands. See page 101.

The SCPI commands for these instructions are:

```
[ : ]SYSTem[ <channel>]:REMote:SOURce[ :VOLTage] <?|LOCAl
|AVOLTage|IAVOLTage|ARESistive|IAResistive>
[ : ]SYSTem[ <channel>]:COMMunicate:APROgram:LEVel[ :VOLTage] [ :ISOLated]
[ : ]MEASure[ <channel>][ :SCALAR]:APROgram[ :VOLTage][ :DC]?
```


Voltage-Controlled Current APG Setup

Activating APG Current Mode

To activate APG current mode using an external voltage source:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the mode control is already at the CAP position.
CAP is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select source UN IS (Voltage source from non-isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. LE is displayed on the output voltage display.
4. Select the input source level using the rotary Adjust/Enter control.
5. Once the desired level has been selected, press the rotary Adjust/ Enter control to commit the change.

The display will return to the normal display.

Deactivating APG Current Mode

To deactivate the APG current mode:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the mode control is already at the CAP position.
2. XAPI is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select NONE.
4. Press the rotary Adjust/Enter control to commit the change.

The display will return to the normal display.

Query for Analog Current Input Level

To query for analog current input level from non-isolated input:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the mode control is already at the CAP position.
[APR] is displayed on the output voltage display.
2. If the mode is currently nonE then select any other APG mode. If this step is done, be sure to restore the APG setting to nonE when the operation is complete. Otherwise, do not rotate the rotary Adjust/ Enter control to keep the current APG mode.
3. Press the rotary Adjust/Enter control to select the APG mode.
The output voltage display should read LE [and the output current display will display APG level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the APG mode was modified in step 2, execute the procedure to deactivate the APG voltage mode.

Quick Tip: Remote Operation uses these SCPI commands. See page 101.

The SCPI commands for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMOte:SOURce[ :VOLTagE ] <? | LOCa1
| AVOLtage | IAVoltage | ARESistive | IAREsistive>
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel:CURRent [ : ISOLated ]
[ : ]MEASure[ <channel> ] [ : SCALar ]:APROgram:CURRent [ : DC ]?
```

ANALOG PROGRAMMING WITH EXTERNAL RESISTOR

Figure 24: Programming Output Voltage using an External Resistor

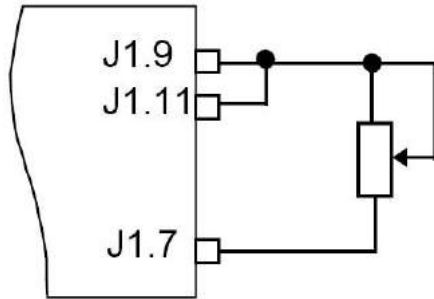
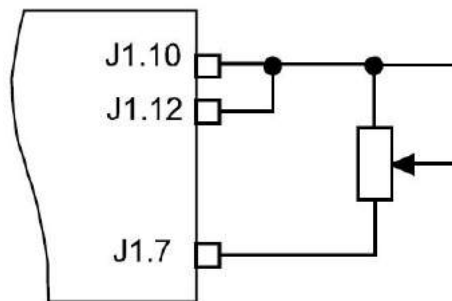


Figure 25: Programming Output Current using an External Resistor



APG Connector

Resistive-Controlled Voltage APG Setup

Activating APG Voltage Mode

To activate APG voltage mode using an external resistor:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position. VAP_R is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select $R_N I_5$ (resistor source from non-isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. $LE U$ is displayed on the output voltage display.
4. Select the input source level using the rotary Adjust/Enter control.
5. Once the desired level has been selected, press the rotary Adjust/Enter control to commit the change.

The display will return to the normal display.

Deactivating APG Voltage Mode

To deactivate the APG voltage mode:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
2. VAP_R is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select $NOPE$.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for Analog Voltage Input Level

To query for analog voltage input level from non-isolated input:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
VAPr is displayed on the output voltage display.
2. If the mode is currently *nonE* then select any other APG mode. If this step is done, be sure to restore the APG setting to *nonE* when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current APG mode.
3. Press the rotary Adjust/Enter control to select the APG mode.
 The output voltage display should read *LE U* and the output current display will display APG level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the APG mode was modified in step 2, execute the procedure to deactivate the APG voltage mode.

Quick Tip: Remote operation uses these SCPI commands. See page 101.

The SCPI commands for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce[ :VOLTage] <?|LOCAl
|AVOLTage|IAVoltage|ARESistive|IAResistive>
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel[ :VOLTage]
[ :ISOLated]
[ : ]MEASure[ <channel> ][:SCALAR]:APROgram[ :VOLTage][ :DC]?
```

Resistive-Controlled Current APG Setup

Activating APG Current Mode

To activate APG current mode using an external resistor source:

1. Turn the 9-position mode control to the CAP position to press the rotary Adjust/Enter control if the control knob is already at CAP position.
[RPr is displayed on the output voltage display.
2. Turn rotary Adjust/Enter control to select r n I5 (voltage source from non-isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. LE [is displayed on the output voltage display.
4. Once the desired level has been selected, press the rotary Adjust/Enter control to commit the change.

The display will return to the normal display.

Deactivating APG Current Mode

To deactivate the APG current mode:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the mode control is already at the CAP position.
2. [RPr is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select n n n E.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for Analog Current Input Level

To query for analog current input level from non-isolated input:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the mode control is already at the CAP position.
`[APR]` is displayed on the output voltage display.
2. If the mode is currently `nonE` then select any other APG mode. If this step is done, be sure to restore the APG setting to `nonE` when the operation is complete. Otherwise, do not rotate the rotary Adjust/ Enter control to keep the current APG mode.
3. Press the rotary Adjust/Enter control to select the APG mode.
 The output voltage display should read `LE [` and the output current display will display APG level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the APG mode was modified in step 2, execute the procedure to deactivate the APG voltage mode.

Quick Tip: Remote Operation uses these SCPI commands. See page 101.

The SCPI commands for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce:CURRent <? | LOCal
| AVOLtage | IAVoltage | ARESistive | IAREsistive>
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel:CURRent [ : ISOLated ]
[ : ]MEASure[ <channel> ] [ : SCALar ]:APROgram:CURRent [ : DC ]?
```

VOLTAGE AND CURRENT READBACK

Figure 26: Voltage Readback using APG Connector J1

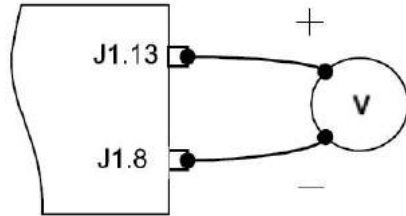
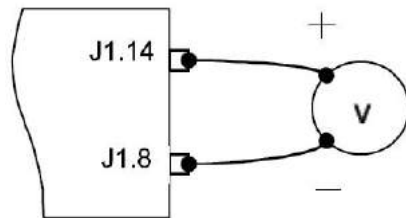


Figure 27: Current Readback using APG Connector J1



ISOLATED ANALOG PROGRAMMING MODE (ISOL)

See “Rear Panel Familiarization” on page 15 for more details about connections.

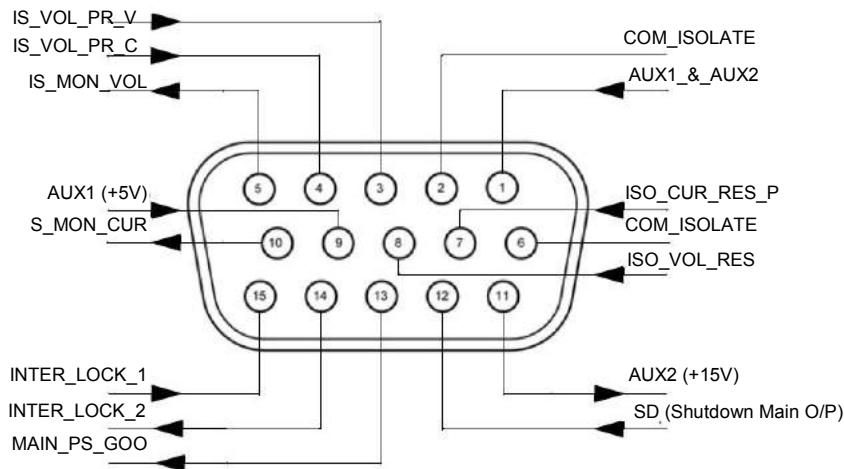
AUX Output and Isolated Analog Programming (ISOL) Connector

The AUX Output and Isolated Analog Programming (ISOL) Connector is a 15-pin female DSUB connector. See Figure 28. All pins on this connector are electrically isolated from the output of the power supply.

The AUX Output and ISOL Connector provide access to the following functions:

| Function | 850 W |
|----------------------------------|----------|
| Auxiliary +5 V and +15 V outputs | standard |
| OUTPUT ENABLE Aux | standard |
| Power On Status (output) | standard |
| SD—Shutdown (input) | standard |
| Interlock | standard |
| ISOL programming and monitoring | standard |

Figure 28: AUX Output and ISOL Connector Pinout



| Pin | Reference | Function |
|-------|-------------------------|--|
| J3.1 | AUX_ON_OFF | Auxiliary enable/disable |
| J3.2 | COM_ISOLATED | Isolated Common (Isolated from Main Output and Communication. Return wire for +5 V, +15 V Auxiliary Voltage. |
| J3.3 | IS_VOL_PR_VOL | Isolated Analog Voltage Programming Input |
| J3.4 | IS_VOL_PR_CUR | Isolated Analog Current Programming Input |
| J3.5 | IS_MON_VOL ¹ | Isolated Voltage Monitor. Scaled to the value of the Voltage Analog Programming Level. |
| J3.6 | COM_ISOLATED | Isolated Common (Isolated from Main Output and Communication. Return wire for control signals, monitoring and programming. |
| J3.7 | ISO_CUR_RES_PR | Isolated Current Resistive Programming |
| J3.8 | ISO_VOL_RES_PR | Isolated Voltage Resistive Programming |
| J3.9 | +AUX 1 ² | +5 V Isolated Output |
| J3.10 | IS_MON_CUR ¹ | Isolated Current Monitor. Scaled to the value of the Voltage Analog Programming Level. |
| J3.11 | +AUX 2 ² | +15 V Isolated Output |
| J3.12 | SD | Shutdown. Input to power supply to disable output. This input has user selectable negative logic operation via front panel or remote digital input/output. |
| J3.13 | PS_GOOD | PS_GOOD. Power supply output enabled. |
| J3.14 | INTER_LOCK 1 | Interlock. Dry contact type. Shorting pins J3.14 and J3.15 while the interlock functionality is enabled, will enable the output of the power supply. |
| J3.15 | INTER_LOCK 2 | Interlock |

1. Important: Isolated monitor lines are only valid when Isolated analog programming modes are used for the respective voltage and current control. If local control, digital control or non-isolated APG is used, the non-isolated monitor lines should be used as the isolated monitor lines will not accurately reflect the output state of the power supply.
2. Use unshielded cable up to 9.84 feet (3 m) length with high-density D-Sub type connector and a ferrite bead (Fair-Rite part number 0443164251).



CAUTION: Equipment damage

Do not drive or apply a voltage to pins J3.14 (Inter_Lock 1) or to pins J3.15 (Inter_Lock 2).

Making ISOL Control Connections



CAUTION: Equipment damage

Before making connections from external circuits to the Isolated Analog Programming Connector, turn the front panel power switch to off and wait until the front panel displays have gone out.

For most connectors and jumpers, use any suitable wire such as 22 AWG stranded wire. For lowest noise performance, use shielded twisted pair wiring of 22 AWG. Use the shortest leads possible. +5 V and +15 V Auxiliary Output reference to pin 2 and 6 (isolated common) on the ISOL Connector.

ISOL Programming With External Voltage Source

Figure 29: Programming Output Voltage using an Isolated External Voltage Source

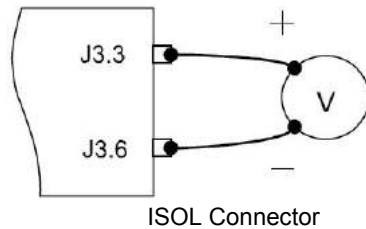
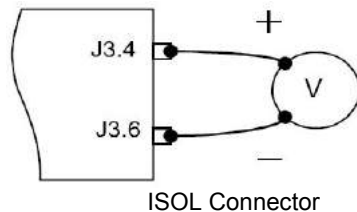


Figure 30: Programming Output Current using an Isolated External Voltage Source



Voltage-Controlled Voltage ISOL Setup

Activating ISOL Programming Voltage Mode

To activate ISOL programming voltage mode with an external voltage source:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
VAP is displayed on the output voltage display.
2. Turn rotary Adjust/Enter control to select *U I 5* (voltage source from isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. *LE U* is displayed on the output voltage display.
4. Select the input source level using the rotary Adjust/Enter control.
5. Once the desired level has been selected, press the rotary Adjust/ Enter control to commit the change.

The display will return to the normal display.

Deactivating ISOL Voltage Mode

To deactivate the ISOL voltage mode:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the mode control is already at the VAP position.
2. *VAP* is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select *none*.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for ISOL Voltage Input Level

To query for ISOL voltage input level from non-isolated input:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the control knob is already at the VAP position.
VAPr is displayed on the output voltage display.
2. If the mode is currently *nonE* then select any other ISOL mode. If this step is done, be sure to restore the ISOL setting to *nonE* when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current ISOL mode.
3. Press the rotary Adjust/Enter control to select the ISOL mode.
 The output voltage display should read *LE U* and the output current display will display ISOL level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the ISOL mode was modified in step 2, execute the procedure to deactivate the ISOL voltage mode.

Quick Tip: Remote Operation uses these SCPI commands. See page 101.

The SCPI command for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce[ :VOLTage]    <? | LOCAL
|AVOLTage|IAVoltage|ARESistive|IAResistive>

[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel [ :VOLTage][ :ISOLated]

[ : ]MEASure[ <channel> ][ :SCALAR]:APROgram[ :VOLTage] :ISOLated[ :DC]?
```

Voltage-Controlled Current ISOL Setup

Activating ISOL Programming Current Mode

1. Turn the 9-position mode control to the CAP position or press the rotary adjust/Enter control if the control knob is already at the CAP position.
CAP is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select $U I S$ (voltage source from isolated connector).
3. Press the rotary adjust/Enter control to commit the selected mode. $LE I$ is displayed on the output voltage display.
4. Select the input source level using the rotary adjust/Enter control.
5. Once the desired level has been selected, press the rotary adjust/ Enter control to commit the change.

The display will return to the normal display.

Deactivating ISOL Current Mode

To deactivate the ISOL current mode:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the control knob is already at the VAP position.
2. CAP is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select $none$.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for ISOL Current Input Level

To query for ISOL current input level from non-isolated input:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the control knob is already at the CAP position.
CAP is displayed on the output voltage display.
2. If the mode is currently nonE then select any other ISOL mode. If this step is done, be sure to restore the ISOL setting to nonE when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current ISOL mode.
3. Press the rotary adjust/Enter control to select the ISOL mode.
The output voltage display should read LE I and the output current display will display ISOL level.
4. Press the rotary adjust/Enter control to return to normal mode.
5. If the ISOL mode was modified in step 2, execute the procedure to deactivate the ISOL voltage mode.

Quick Tip: Remote operation uses these SCPI commands. See page 101.

The SCPI command for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce:CURRent: <? | LOCAL
| AVOLtage | IAVoltage | ARESistive | IAREsistive>
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel:CURRent [ : ISOLated ]
[ : ]MEASure[ <channel> ] [ : SCALar ]:APROgram:CURRent
: ISOLated [ : DC ]?
```

ANALOG PROGRAMMING WITH EXTERNAL RESISTOR

Figure 31: Programming Output Voltage using an Isolated External Resistor

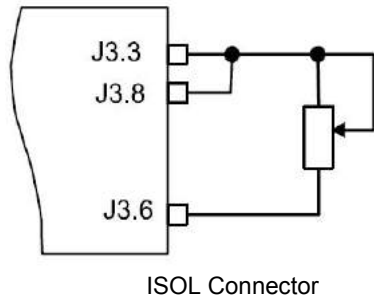
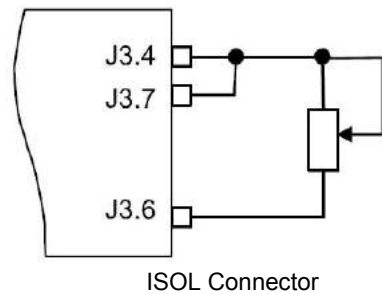


Figure 32: Programming Output Current using an Isolated External Resistor



Resistive-Controlled Voltage ISOL Setup

Activating ISOL Programming Voltage Mode

To activate ISOL programming voltage mode using an external resistor:

1. Turn the 9-position mode control to the VAP position or press the rotary adjust/Enter control if the control knob is already at the VAP position.
 U_{RPR} is displayed on the output voltage display.
2. Turn the rotary Adjust/Enter control to select r_{15} (resistor source from isolated connector).
3. Press the rotary adjust/Enter control to commit the selected mode. $LE U$ is displayed on the output voltage display.
4. Select the input source level using the rotary adjust/Enter control.
5. Once the desired level has been selected, press the rotary Adjust/ Enter control to commit the change.

The display will return to the normal display.

Deactivating ISOL Voltage Mode

To deactivate the ISOL voltage mode:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the control knob is already at the VAP position.
2. U_{RPR} is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select $none$.
4. Press the rotary adjust/Enter control to commit the change.

The display will return to the normal display.

Query for ISOL Voltage Input Level

To query for ISOL voltage input level from non-isolated input:

1. Turn the 9-position mode control to the VAP position or press the rotary Adjust/Enter control if the control knob is already at the VAP position.
VAP is displayed on the output voltage display.
2. If the mode is currently *nonE* then select any other ISOL mode. If this step is done, be sure to restore the ISOL setting to *nonE* when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current ISOL mode.
3. Press the rotary adjust/Enter control to select the ISOL mode.
 The output voltage display should read *LE U* and the output current display will display ISOL level.
4. Press the rotary adjust/Enter control to return to normal mode.
5. If the ISOL mode was modified in step 2, execute the procedure to deactivate the ISOL voltage mode.

Quick Tip: Remote Operation uses these SCPI commands. See page 101.

The SCPI command for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce[ :VOLTage]    <?|LOCal
|AVOLTage|IAVOLTage|ARESistive|IAResistive>

[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel [ :VOLTage][ :ISOLated]

[ : ]MEASure[ <channel> ][ :SCALar]:APROgram[ :VOLTage]
:ISOLated[ :DC]?
```

Resistive-Controlled Current ISOL Setup

Activating ISOL Resistive-Controlled Current Setup

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the control knob is already at the CAP position. CAP is displayed on the output voltage display.
2. Turn rotary Adjust/Enter control to select $r / 5$ (voltage source from isolated connector).
3. Press the rotary Adjust/Enter control to commit the selected mode. $LE \text{ } \square$ is displayed on the output voltage display.
4. Select the input source level using the rotary Adjust/Enter control.
5. Once the desired level has been selected, press the rotary Adjust/ Enter control to commit the change.

The display will return to the normal display.

Deactivating ISOL Current Mode

To deactivate the ISOL current mode:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the control knob is already at the CAP position.
2. CAP is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select $none$.
4. Press the rotary Adjust/Enter control to commit the change. The display will return to the normal display.

Query for ISOL Current Input Level

To query for ISOL current input level from non-isolated input:

1. Turn the 9-position mode control to the CAP position or press the rotary Adjust/Enter control if the control knob is already at the CAP position.
[RPr] is displayed on the output voltage display.
2. If the mode is currently nonE then select any other ISOL mode. If this step is done, be sure to restore the ISOL setting to nonE when the operation is complete. Otherwise, do not rotate the rotary Adjust/Enter control to keep the current ISOL mode.
3. Press the rotary Adjust/Enter control to select the ISOL mode.
The output voltage display should read LE [and the output current display will display ISOL level.
4. Press the rotary Adjust/Enter control to return to normal mode.
5. If the ISOL mode was modified in step 2, execute the procedure to deactivate the ISOL voltage mode.

Quick Tip: Remote operation uses these SCPI commands. See page 101.

The SCPI command for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce:CURRent <? | LOCal
| AVOLtage | IAVoltage | ARESistive | IAREsistive>
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel:CURRent [ : ISOLated ]
[ : ]MEASure[ <channel> ] [ : SCALar ]:APROgram:CURRent
: ISOLated [ : DC ]?
```

VOLTAGE AND CURRENT READBACK (ISOLATED)

Figure 33: Isolated Voltage Monitoring

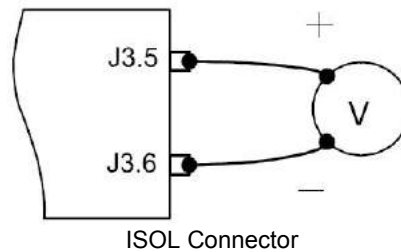
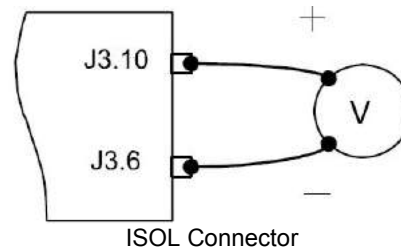


Figure 34: Isolated Current Monitoring



QUERY REMOTE CONTROL SOURCE STATE

Quick Tip: Remote operation uses these SCPI commands. See page 101.

The SCPI command for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMOte:SOURce[:VOLTage]?
```

```
[ : ]SYSTem[ <channel> ]:REMOte:SOURce:CURREnt?
```

Remote Operation

In this section:

This section describes the remote operation of the power supply via the communication ports.

INTRODUCTION

In addition to the front panel interface, the power supply can be remotely controlled through the various remote interfaces. The power supply implements the SCPI standard as its command line interface for remotely controlling the power supply. Additionally, a small subset of legacy commands has been provided for ease of use and backwards compatibility. All of the remote interfaces use the same command line interface.

Important: When using SCPI commands over a remote interface, wait at least 100 ms before sending another command. The preceding command must finish executing before another command is received to avoid input buffer overrun. Some commands take longer than 100 ms to execute; those commands are noted in this reference.

This section is divided into two parts:

- Hardware and Connection Setup provides information on how to setup a connection to the different remote interfaces available on the power supply. The remote interfaces covered include RS-232, RS-485, USB, and GPIB. Setting up LAN/Ethernet for remote operation starts on page 117.
- Command Line Interface and SCPI explains how to send commands to the power supply using the SCPI commands and the theory behind SCPI.

Important: Always start communication with the instrument by first sending the *ADR <address> command to select the unit you want to talk to - even if you are using only a single unit. If you do not do this, the instrument may not respond to commands.

HARDWARE AND CONNECTION SETUP

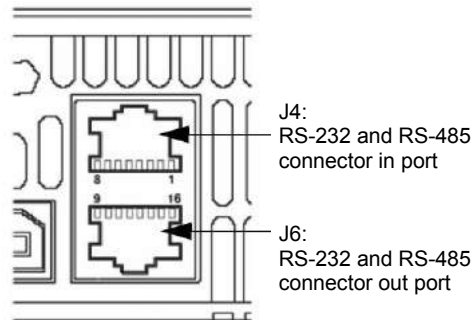
This section provides information on setting up the hardware and is organized into setup for each hardware type. Once the setup has been successfully completed, data can be sent to and responses received from the power supply. Select which hardware interface to use and follow the instructions and diagram for that hardware set up.

CONFIGURING REMOTE CONTROL USING RS-232

To configure remote control using RS-232:

1. Use the top J4 connector of the two 8-pin RJ-45 jacks, as shown in Figure 35, to connect to the RS-232 remote interface.
2. Connect from PC to power supply using a cable that meets the cabling specifications listed in the table that follows.

Figure 35: Remote Control Connectors



| Pin | Reference | Direction | Function |
|-------|-----------|-----------|---------------------|
| J4.1 | RX-232 | Input | RS-232 |
| J4.2 | TX-232 | Output | RS-232 |
| J4.3 | RXD+ | Input | RS-485 receiving |
| J4.4 | RXD- | Input | RS-485 receiving |
| J4.5 | TXD+ | Output | RS-485 transmitting |
| J4.6 | TXD- | Output | RS-485 transmitting |
| J4.7 | GND | – | Ground |
| J4.8 | NC | – | – |
| J6.9 | NC | – | – |
| J6.10 | NC | – | – |
| J6.11 | RXD+ | Input | RS-485 receiving |
| J6.12 | RXD- | Input | RS-485 receiving |
| J6.13 | TXD+ | Output | RS-485 transmitting |
| J6.14 | TXD- | Output | RS-485 transmitting |
| J6.15 | GND | – | Ground |
| J6.16 | NC | – | – |

RS-232 Communication Cable with RJ-45 to DB-9

Communication control cable with DB-9 connector (male) on the PC side and RJ-45 shielded connector on the power supply. The suggested cable length should be 9.84 feet (3 m).

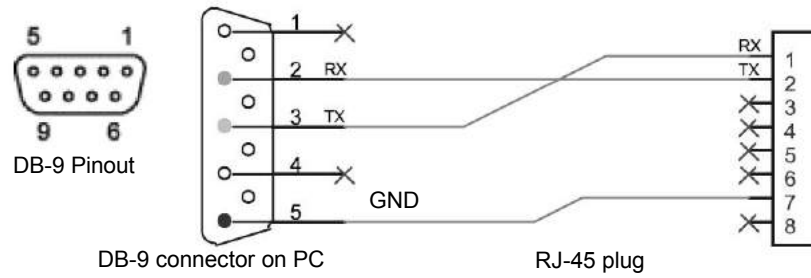
DB-9 Pinouts

| Pin | Name | Description | |
|------------|------|---------------|--------------|
| 1 | NC | No connection | |
| 2 | RX | Receive data | Twisted pair |
| 3 | TX | Transmit data | |
| 4 | NC | No connection | |
| 5 | GND | Ground | |
| 6, 7, 8, 9 | NC | No connection | |

RJ-45 Pinouts

| Pin | Name | Description | |
|------------|------|---------------|--------------|
| 1 | RX | Receive data | Twisted pair |
| 2 | TX | Transmit data | |
| 3, 4, 5, 6 | NC | No connection | |
| 7 | GND | Ground | |
| 8 | NC | No connection | |

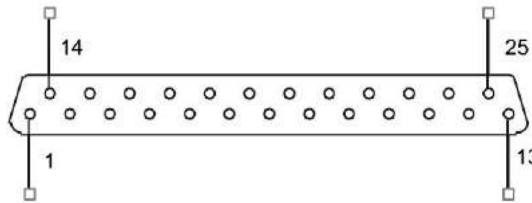
Figure 36: RS-232 Communication Cable with DB-9 Pinout



RS-232 Communication Cable with RJ-45 to DB-25

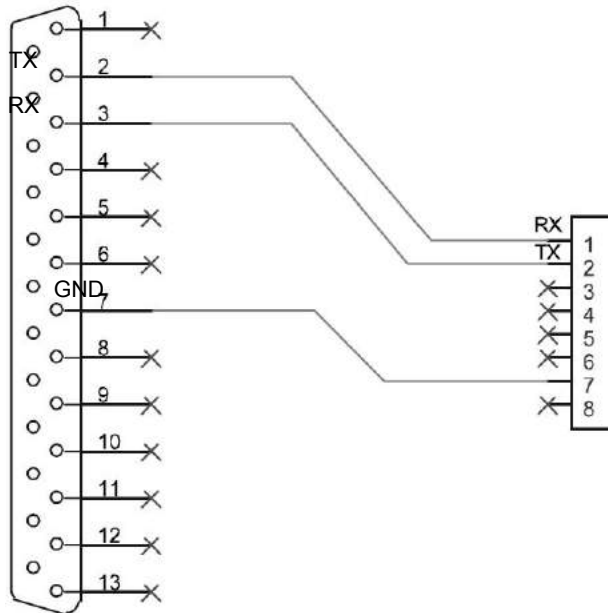
Communication control cable with DB-25 pinout (male) on the PC side and RJ-45 shielded connector on the power supply. The cable length should be 9.84 feet (3 m) or longer.

Figure 37: DB-25 Pinout



DB-25 Pinouts

| Pin | Name | Description |
|---------|------|---------------|
| 1 | NC | No connection |
| 2 | TX | Receive data |
| 3 | RX | Transmit data |
| 4, 5, 6 | NC | No connection |
| 7 | GND | Ground |
| 8, 9 | NC | No connection |

Figure 38: RS-232 Communication Cable with DB-25 Pinout

Completing the Setup

To complete the setup:

- ◆ Configure the power supply to use the 232 remote interface and set up the terminal that will be used on the connected PC.

See the sections entitled “Selecting the Appropriate Communication Port” on page 122 and “Terminal Configuration” on page 119 for more details.

CONFIGURING REMOTE CONTROL USING RS-485

RS-485 Communication Cable with RJ-45 to DB-9

Communication control cable with DB-9 pinout (female) on the PC side (see Figure 36) and RJ-45 shielded connector on the power supply.



CAUTION: Equipment damage

Figure 39 shows an example of wiring for NI RS485 communication cable with DB-9. Refer to the user manual of your communication card before wiring the cable.

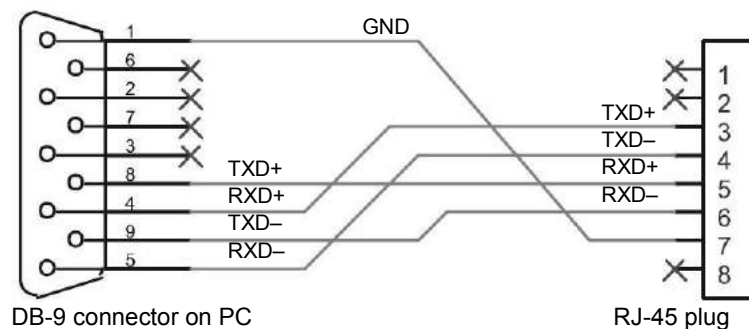
DB-9 Pinouts

| Pin | Name | Description | |
|------|------|---------------|--------------|
| 1 | GND | Ground | |
| 2, 3 | NC | No connection | |
| 4 | RXD+ | Receive data | Twisted pair |
| 5 | RXD- | Transmit data | |
| 6, 7 | NC | No connection | |
| 8 | TXD+ | Transmit data | Twisted pair |
| 9 | TXD- | Transmit data | |

RJ-45 Plug Pinouts

| Pin | Name | Description | |
|------|------|---------------|--------------|
| 1, 2 | NC | No connection | |
| 3 | TXD+ | Transmit data | Twisted pair |
| 4 | TXD- | Transmit data | |
| 5 | RXD+ | Receive data | Twisted pair |
| 6 | RXD- | Receive data | |
| 7 | GND | Ground | |
| 8 | NC | No connection | |

Figure 39: RS-485 Communication Cable with DB-9

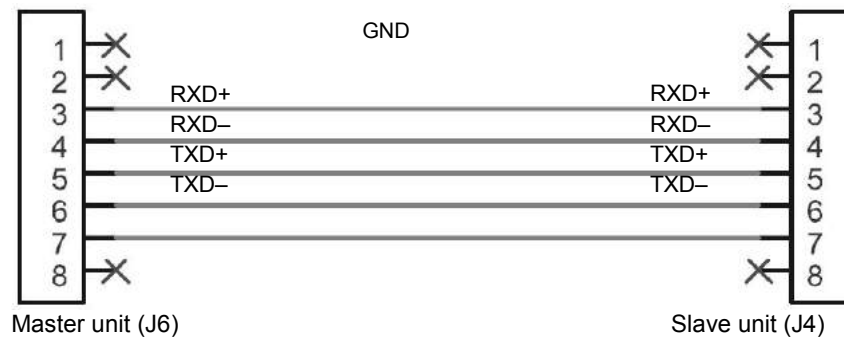


RS-485 Communication Cable with Two RJ-45s

Use the top connector of the two 8-pin RJ-45 jacks, as shown in Figure 40, to connect to the RS-485 remote interface. Communication cable with two RJ-45 shielded connectors connecting the master unit to the slave unit. The cable length should be 9.84 feet (3 m) or longer. The pinouts for the RJ-45 plug on the master unit are the same as described in the table that follows

| Pin | Name | Description |
|------|------|---------------|
| 1, 2 | NC | No connection |
| 3 | RXD+ | Receive data |
| 4 | RXD- | Receive data |
| 5 | TXD+ | Transmit data |
| 6 | TXD- | Transmit data |
| 7 | GND | Ground |
| 8 | NC | No connection |

Figure 40: RS-485 Communication Cable from Master to Slave Unit



Completing the Setup

To complete the setup:

- ◆ Configure the power supply to use the 485 remote interface and setup the terminal that will be used on the connected PC.

See sections entitled “Selecting the Appropriate Communication Port” on page 122 and “Terminal Configuration” on page 119 for more details.

CONFIGURING REMOTE CONTROL USING USB

The power supply can be controlled from a remote terminal using a USB interface. The standard USB connector is located on the rear panel. Use a standard USB shielded cable up to 9.84 feet (3 m) in length.

Setting Up the PC to Use the USB Connection

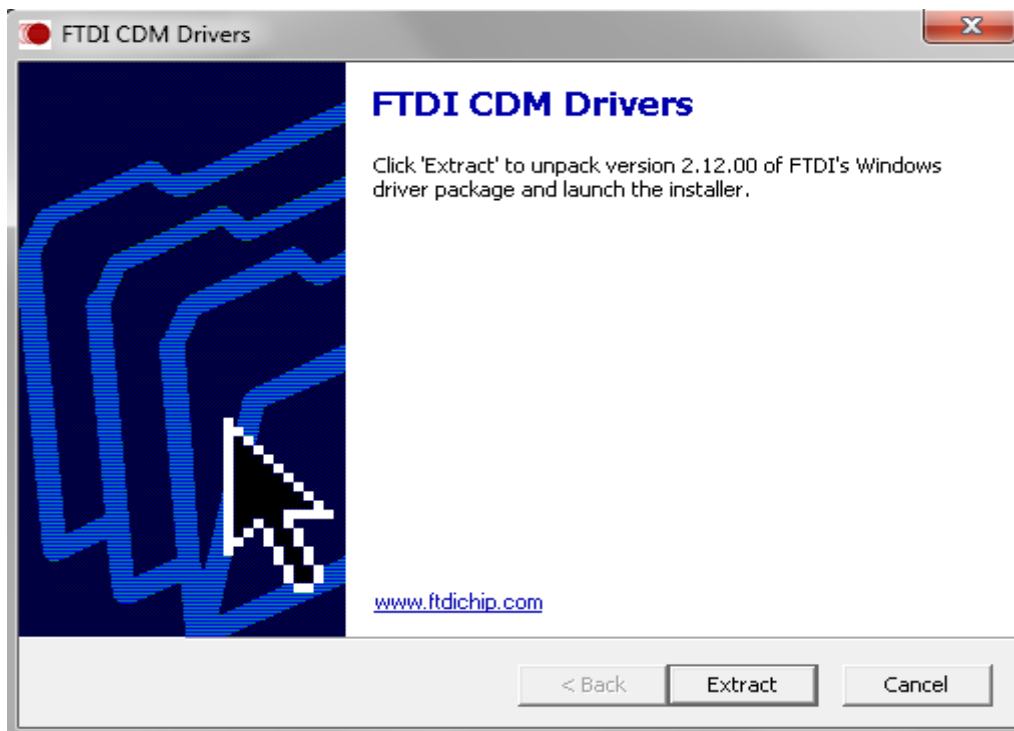
Installing USB to Serial Converter and Serial Port

To set up the USB connection, you'll need to download the latest driver from www.Keithley.com.

To download and install a virtual COM port (VCP) driver:

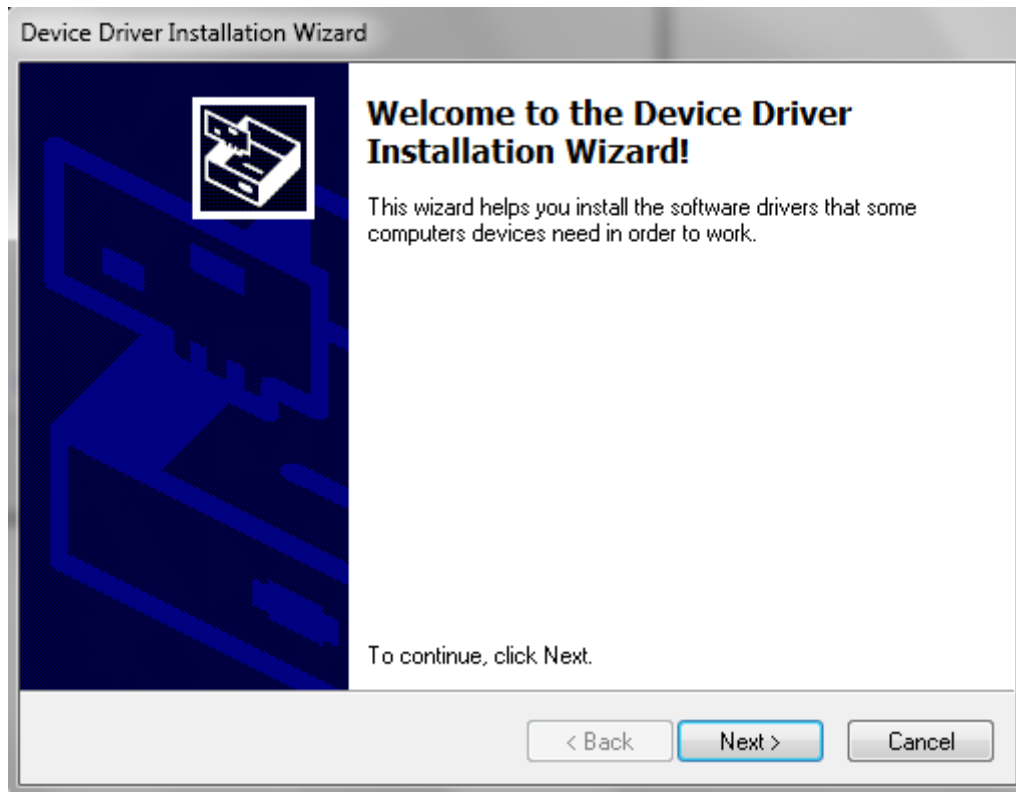
1. Go to www.keithley.com/support and enter your model number in the search box to find the driver you need to download.
2. Click the download link to download the driver.
3. Download the appropriate virtual COM port (VCP) drivers for your operating system (with enhanced BM series support).
4. Right-click the driver executable file and select Run as Administrator. The FTDI CDM Drivers window will launch.
5. Click Extract to extract the FTDI Windows driver package as shown in Figure 41.

Figure 41: FTDI Windows Driver Package Extraction



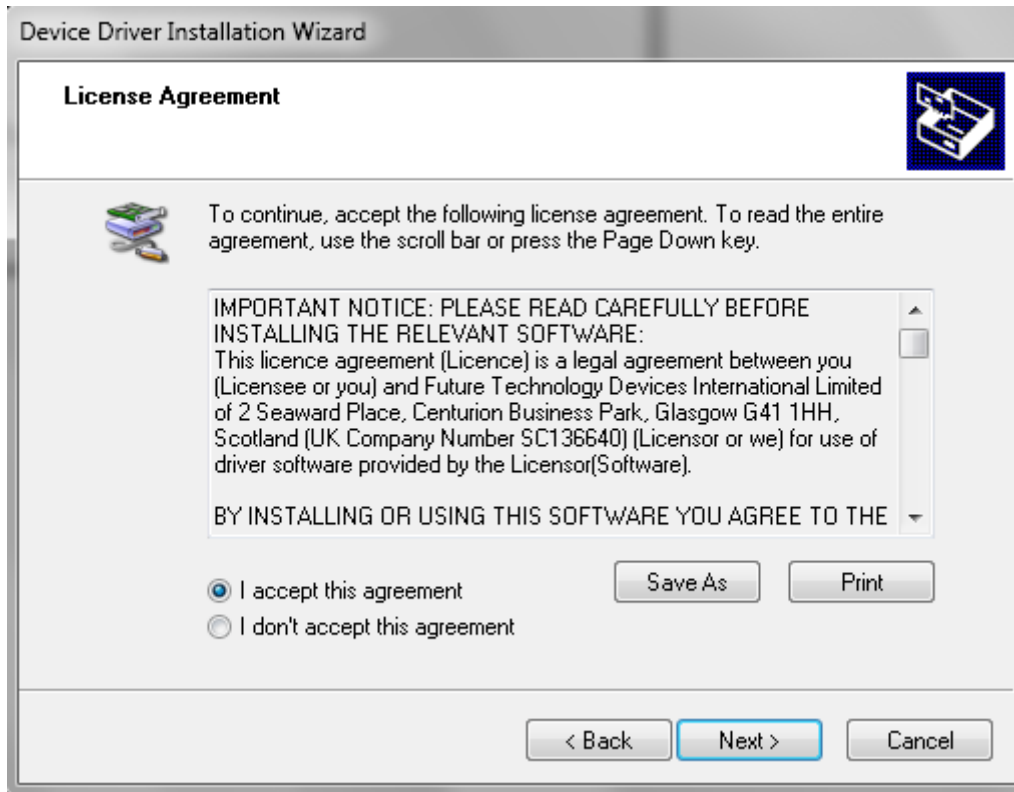
6. Launch the Device Driver Installation by clicking Next. See Figure 42.

Figure 42: Device Driver Installation Wizard



7. Click the radio button to indicate acceptance of agreement, (click Save As and or Print button(s) to maintain a copy of the agreement, if desired), and click Next to begin the installation. See Figure 43.

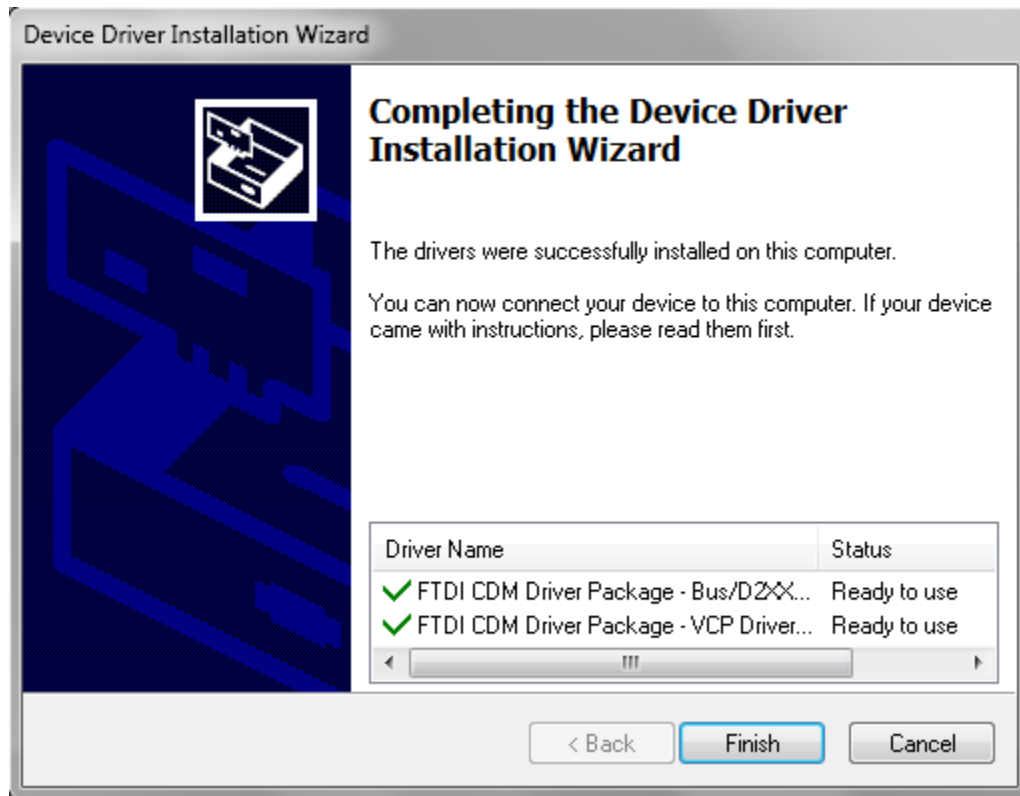
Figure 43: License Agreement



8. Click the radio button to indicate acceptance of agreement, (click Save As and or Print button(s) to maintain a copy of the agreement, if desired), and click Next to begin the installation.

9. To complete the installation, click Finish. See Figure 44.

Figure 44: Completing the Device Driver Installation Wizard



10. Once the installation is complete, connect your device to a spare USB port on your computer. Windows will automatically detect and finish the installation.

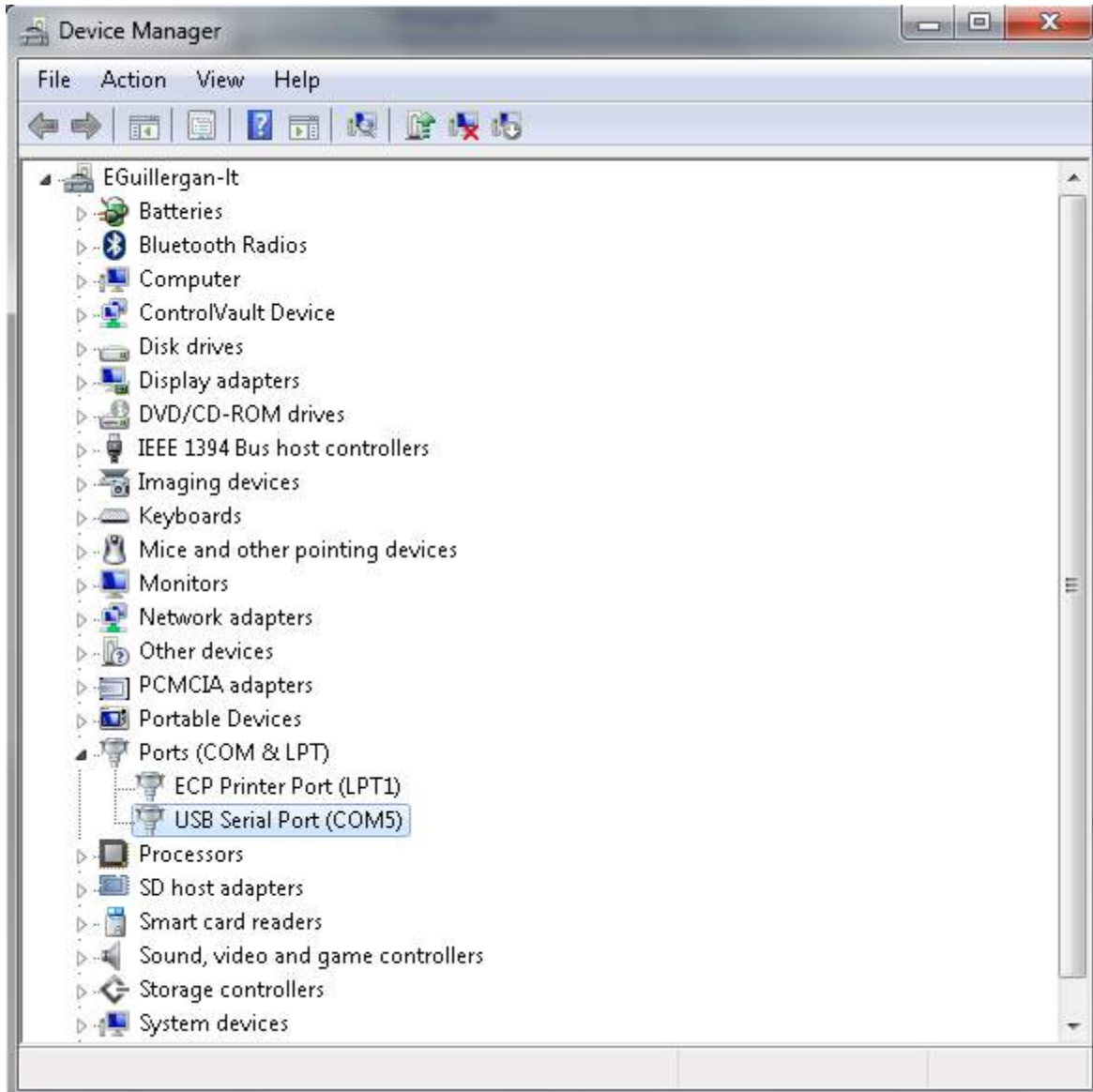
This completes the first part of the installation during which the USB to serial converter is installed. The second part involves the installation of a serial port, which should follow automatically once the converter installation is complete. Installation of the serial port does not require any user intervention.

Verifying Installation

Once the installation of the serial port has completed, verify that the installation has been successful by looking under Device Manager of the System Properties screen. The device should have installed as a USB Serial Port (COMx) attached to USB High Speed Serial Converter.

To verify that the device has been installed:

1. In Control Panel, go to System, click the Hardware tab and click on Device Manager. The Device Manager window displays. See Figure 45.

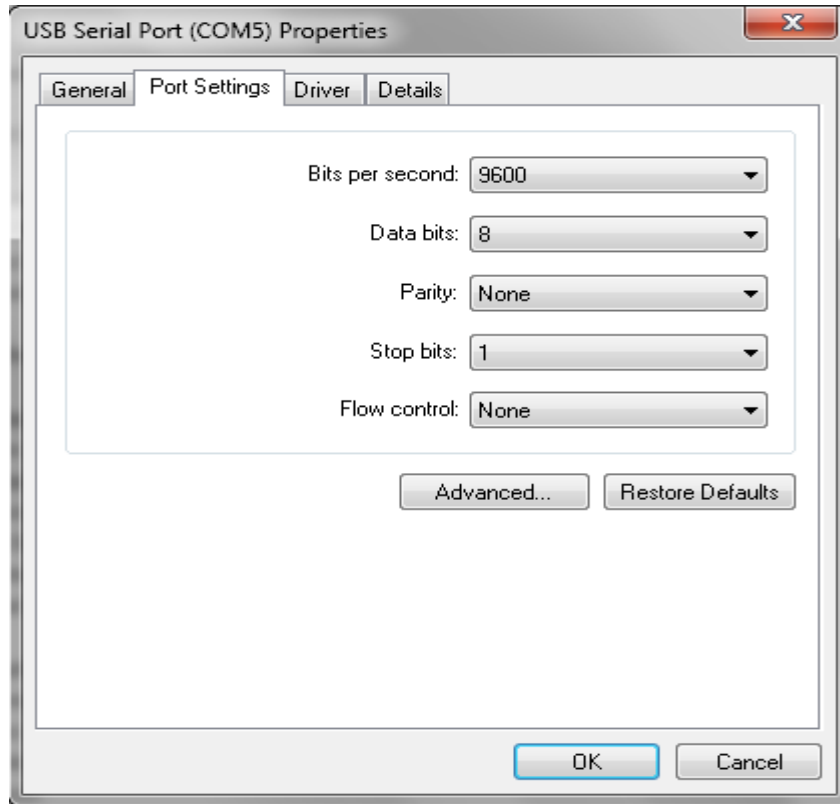
Figure 45: Device Manager

2. On the View menu, select Devices by Type.
3. To change the virtual COM port properties, select the USB Serial Port and then Click Properties.

This allows you to change serial port properties such as data rate (bps) and data bits. You are also able to change the COM port which is assigned to your device.

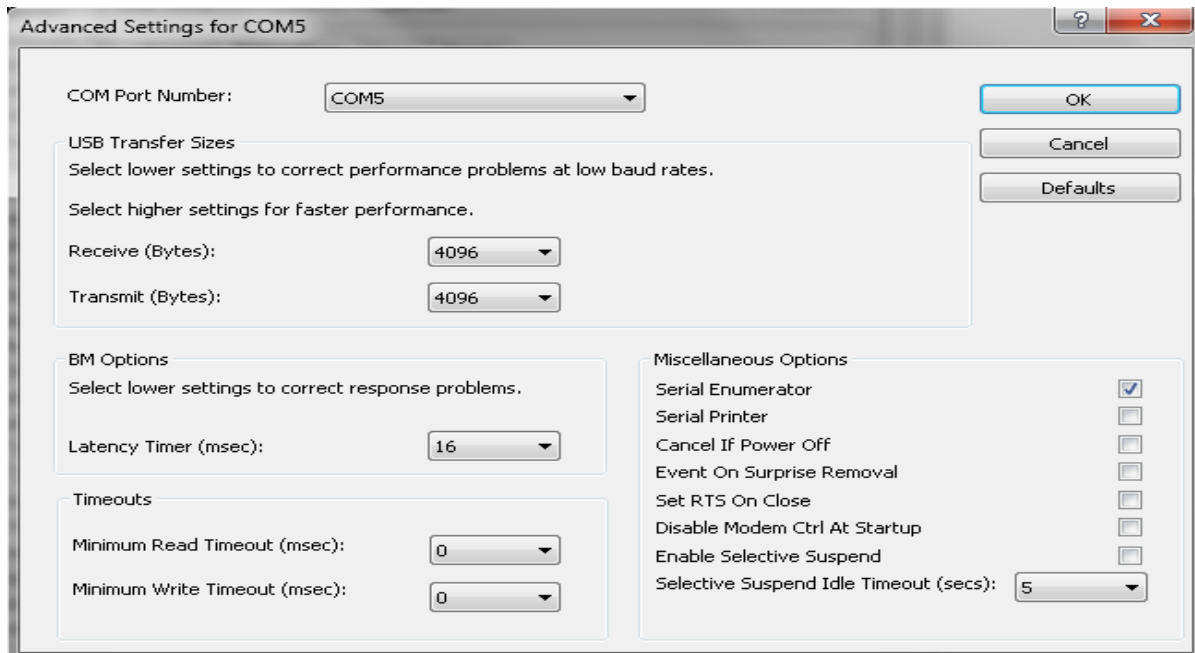
- Click the Port Settings tab, then click Advanced. See Figure 46.

Figure 46: Communications Port (COM5) Properties



- In the COM port list, scroll to the required COM port.

Figure 47: Advanced Settings for (COM5) Port



6. Click OK.

Ensure that you do not select a COM port which is already in use. This selection is particularly useful for programs, such as HyperTerminal, which only work with COM1 through to COM4.

Complete the Setup

To complete the setup:

- ◆ Configure the power supply to use the USB remote interface and set up the terminal that will be used on the connected PC.

See “Selecting the Appropriate Communication Port” on page 122 and “Terminal Configuration” on page 119 for more details.

CONFIGURING REMOTE CONTROL USING GPIB

The power supply can be programmed from a remote terminal using a General Purpose Interface Bus (GPIB) interface.

The GPIB interface is an 8-bit parallel data bus having a host of bus commands for synchronization and up to one megabyte data transfer rate. Use standard IEEE-486, 26 AWG GPIB cable up to 3 m length.

GPIB Pin Description

The GPIB port is a 21-pin, special GPIB female connector. The table that follows identifies the pin names and describes the pin functions.

| Pin # | Name | Function | Note |
|-------|------|--------------------|-----------|
| 1 | DIO1 | DIO1 | Data |
| 2 | DIO2 | DIO2 | Data |
| 3 | DIO3 | DIO3 | Data |
| 4 | DIO4 | DIO4 | Data |
| 5 | EOI | End of Identify | Control |
| 6 | DAV | Data Valid | Handshake |
| 7 | NRFD | Not Ready for Data | Handshake |
| 8 | NDAC | No Data Accepted | Handshake |
| 9 | IFC | Interface Clear | Control |
| 10 | SRQ | Service Request | Control |
| 11 | ATN | Attention | Control |
| 12 | - | Shield | Chassis |
| 13 | DIO5 | DIO5 | Data |
| 14 | DIO6 | DIO6 | Data |
| 15 | DIO7 | DIO7 | Data |
| 16 | DIO8 | DIO8 | Data |
| 17 | REN | Remote Enable | Control |
| 18 | - | DAV Return | Chassis |
| 19 | - | NRFD Return | Chassis |
| 20 | - | NDAC Return | Chassis |
| 21 | - | IFC Return | Chassis |

| | | | |
|----|---|---------------|---------|
| 22 | - | SRQ Return | Chassis |
| 23 | - | ATN Return | Chassis |
| 24 | - | Signal Ground | Chassis |

Communication with Your Device

This section provides information on selecting the GPIB interface as the communication port used on the power supply, and it also provides an example of how commands can be sent and received. The details of the IEEE 488.2 and SCPI status reporting register structures and a complete list of commands available can be found later in this section.

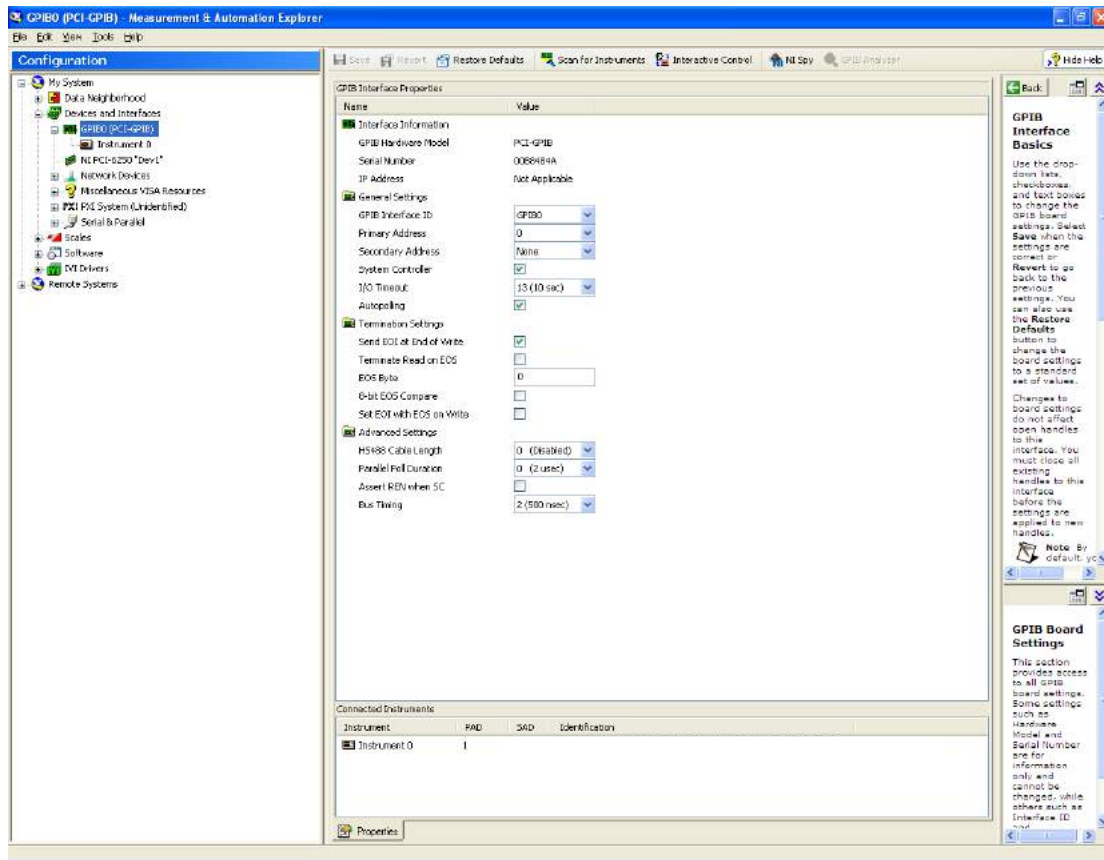
Selecting a Communication Port

To select the GPIB as the communication port:

1. Turn the 9-position Mode control to PGM.
rE is displayed in the output voltage display.
2. Turn the rotary Adjust/Enter control to select the GPIB communication port.
3. Press the rotary Adjust/Enter control.
Addr is displayed on the output voltage display.
4. Turn the rotary Adjust/Enter control to select the desired address between 1 to 30.
For the purpose of this example, 10 will be selected.
5. Press the rotary Adjust/Enter control to commit the new address.
6. Click Scan For Instruments on the GPIB Explorer toolbar so that the power supply will be found (see Figure 48).

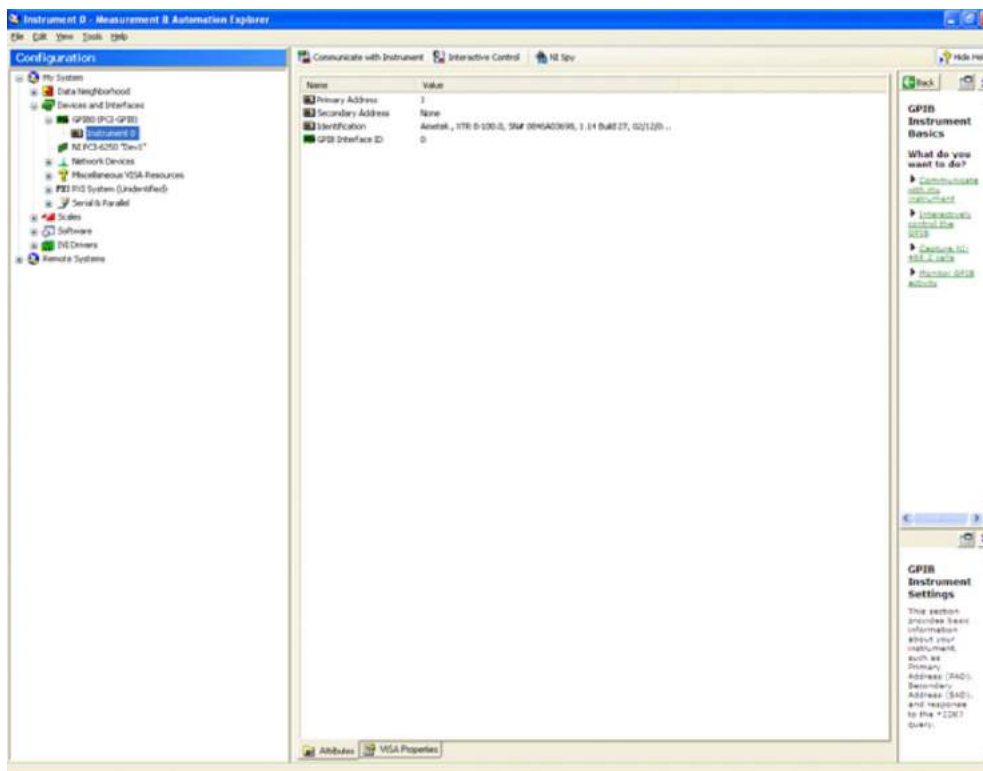
Important: This section uses the National Instruments™ MAX program to communicate with the power supply. This is for demonstration purposes only. Any software that is capable of addressing a GPIB device and sending and receiving text could be used in its place. Consult your GPIB card manufacturer to see if they provide an equivalent program.

Figure 48: Scanning for Instruments



7. In the “Connected Instruments” panel of the GPIB explorer window, click on Instrument 0 and review the device properties. See Figure 49.

Figure 49: Instrument Properties



8. Click Communicate with Instrument in the GPIB Explorer toolbar. (See Figure 49).
NI-488.2 Communicator appears.
9. In the Send String box of the NI-488.2 Communicator window, type *IDN? and click the Query button.

Important: If you press Enter while typing the string to be sent, the NI-488.2 Communicator program will exit.

10. The String Received window in the lower half of the NI-488.2 Communicator window will show the ID string for the instrument.
The ID string indicates the model, serial number, firmware version as well as the GPIB card firmware version.

CONFIGURING REMOTE CONTROL USING ETHERNET/LAN (ENET)

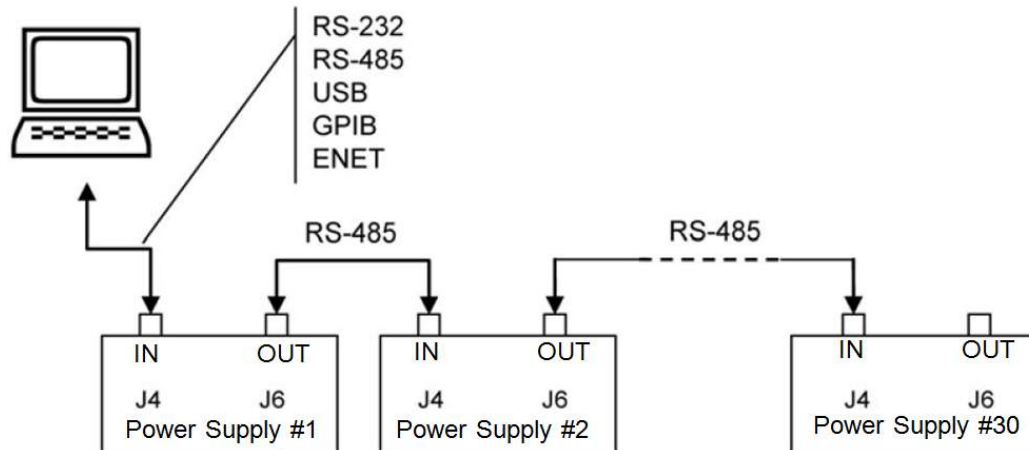
The power supply also can be programmed from a remote terminal using the Ethernet (ENET). For more information, refer to Section 6, [LAN/Ethernet Setup and Communication](#).

MULTIPLE POWER SUPPLY CONNECTIONS TO RS-485 BUS

Up to 30 units may be connected to the RS-485 bus. The first unit (master unit) connects to the controller via any appropriate port, and the other units (slave units) are connected with the RS-485 bus via the J6 connector. All units connected together should also have unique multichannel addresses.

A standard straight-through RJ-45 Ethernet network cable can be used to provide the connection between the power supplies. See Figure 48.

Figure 50: Multi Power Supply Connection to RS-485 Bus



Multiple Power Supply Setup

Master Setup:

- ◆ Configure the master unit by selecting the communication interface you wish to use to communication with the Master and follow the setup instructions in this section.

Important: If either RS-232 or RS-485 are used for communications with the master, the data rate must be configured for 57600 bps to properly communicate with the slave units.

Slave Setup:

1. Turn the 9-position mode control to PGM.
 rE is displayed in the output voltage display.
2. Turn the rotary Adjust/Enter control to select $485L$ if the master is using LAN mode, otherwise select LAN and press the control to enter the setting.
3. Set a unique address. See “Multichannel Address Setting” on page 123.

TERMINAL CONFIGURATION

The terminal program allows serial communication with the power supply. To use a terminal program, set it up using the parameters from the following sections. If you wish to use HyperTerminal, see “HyperTerminal” on page 119 for instructions setting it up.

Data Format

Serial data format is 8 bit, one stop bit. No parity bit. Flow control: none.

End of Message

The end of message is the Carriage Return character (ASCII 13, 0x0D). The power supply ignores the Line Feed (ASCII 10, 0x0A) character.

HyperTerminal

The HyperTerminal program is a standard windows program and can be found in **Start >All Programs >Accessories >Communications >Hyper Terminal**.

Setting up a HyperTerminal Connection

To set up a HyperTerminal connection:

1. When HyperTerminal opens, it will immediately enter the New Connection wizard.

If you don't already have a connection saved, continue.

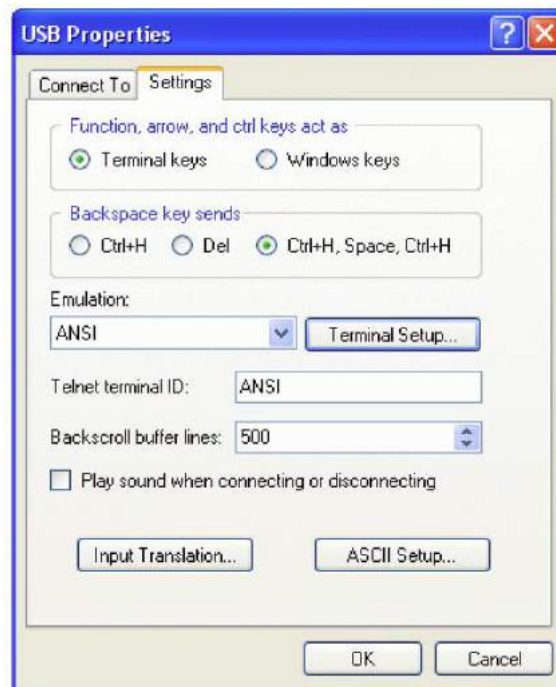
If you do, click cancel and then open the pre-existing connection and skip the remaining steps in this procedure.

2. Enter a name.
Include the name of the interface you are intending to use for the connection as part of the name.
3. Click OK.
4. Select the COM port that is connected to the interface you wish to use to connect to the power supply.

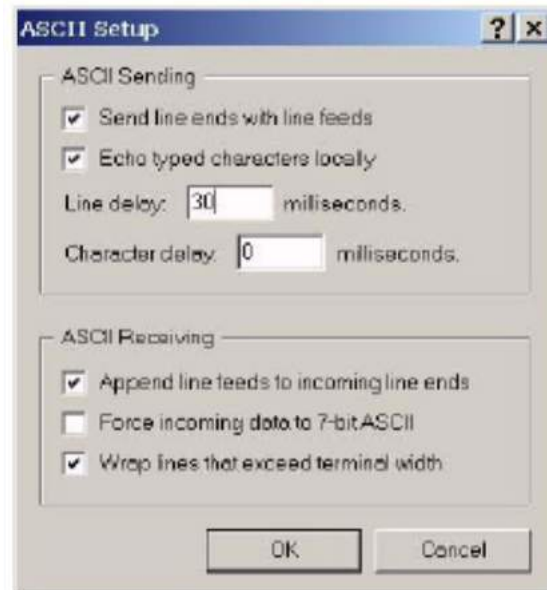
This is the COM port that you have your serial cable hooked up to or in the case of USB the one that was configured to be used in the FDTI software.

5. Click OK when done.
6. Setup the data format to be used. See “Data Format” on page 119 for details.
7. Set up the Hyper terminal you will need to configure the properties.
8. Click **File>Properties** to bring up the connection properties dialog and click on the Settings tab.

Figure 51: USB Settings



9. Fill out the following selections in the connection properties dialog:
 - Terminal keys
 - Ctrl+H, Space, Ctrl+H.
 - On the Emulation list, select ANSI.
10. Click on the ASCII Setup button to bring up the ASCII Setup dialog.

Figure 52: ASCII Setup

11. Check the following boxes:
 - Send line ends with line feeds.
 - Echo typed characters locally.
 - Append line feeds to incoming line ends.
 - Wrap lines that exceed terminal width.
 12. Change the Line delay to 30 milliseconds.
 13. Click OK in the ASCII Setup window.
 14. Click OK in the Properties window.
- HyperTerminal has now been configured to communicate with the power supply.

SELECTING THE APPROPRIATE COMMUNICATION PORT

Five ports are available for remote digital programming and readback:

- RS-232
- RS-485
- USB
- GPIB
- ENET

To select a communication port:

1. Turn the 9-position mode control to PGM.
 rE is displayed in the output voltage display.
2. Turn the rotary Adjust/Enter control to select one of the communication ports: 232, 485, GPIB, USB, LAN.

LOCL LOC is also an available option which lets you lock the front panel to prevent the settings from being changed.

Important: The remote interface that was previously configured when the local lock setting was activated will still be available for remote control while the front panel is locked.

Data Rate Setting (Kbps)

The data rate setting is available for RS-232 and RS-485 protocols only. Four optional rates are possible: 9.6 (default), 19.2, 38.4, and 57.6 kilobits per second (Kbps).

To select the desired rate:

1. Turn the 9-position mode control to PGM.
 rE is displayed in the output voltage display.
2. Turn the rotary Adjust/Enter control to select 232 (RS-232) or 485 (RS-485) communication ports.
3. Press the rotary Adjust/Enter control.
 $HbPS$ is displayed on the output voltage display and the currently set data rate is displayed on the output current display.
4. Turn the rotary Adjust/Enter control to select the desired data rate.
5. Press enter to commit the new data rate.

The multichannel address setting will now be configured.

Multichannel Address Setting

Important: Always start communication with the Series 2268 by sending the *ADR <address> command to select the unit you want to talk to. If you do not do this, the instrument may not respond to commands. This applies to all remote interfaces.

You must set the address even if you are using only one Series 2268 instrument. Multichannel addressing is always used, so commands must be sent with a proper multichannel address.

The power supply multichannel address can be set to any address from 1 to 30. All units that are connected together via the RS-232 or RS-485 connector must have a unique multichannel address.

To set the address:

1. Select the appropriate communication port as described in “Selecting the Appropriate Communication Port” on page 122.

If more than one unit has the same multichannel address when connected through the RS-485 connector, then collisions are possible, resulting in garbled responses to queries.

2. Press the rotary Adjust/Enter control.
Addr is displayed on the output voltage display.
3. Turn the rotary Adjust/Enter control to select the desired multichannel address from 1 to 30.
4. Press the rotary Adjust/Enter control to commit the new address.

Remote Interface Addressing

All commands must be issued with a multichannel address or the device must be selected using the:

*adr or :SYST[<channel>]:COMM[:MCH]:ADDR commands.

Once a device is selected all commands sent without a multichannel address will be handled by the selected device. The use of multichannel addresses supersedes the selected device as the destination for a message.

To change the selected device simply issue the *adr or :SYST[<channel>]:COMM[:MCH]:ADDR command with a different multichannel address. The previously selected device will be deselected and the new device will be selected. From that point on, all messages without a multichannel address will be destined for the newly selected device. It is possible to deselect all devices by using the aforementioned commands with the broadcast address, 0.

The SCPI Commands for these instructions are:

[:]SYSTem:COMMunicate[:MCHannel]:ADDRess <address>

or

*ADR <address>

Where:

<address> is the multichannel address of the device to be selected. The address is an integer value from 1 to 30.

Multichannel Commands Explained

The use of multichannel addressing allows you to send messages to one device, more than one device or to all devices. Any of the remote interface types can be used to send a multichannel command through the device that is physically connected to the PC to all the devices, provided that all other devices are connected to via the RS-485 bus. In order to use multichannel addressing, the setup of the wiring should be completed as described in “Multiple Power Supply Connections to RS-485 Bus” on page 117.

All SCPI commands in the power supply support the use of multichannel addressing; however, only one device can respond to a message. Responses will be sent according to the conditions defined below.

Rules for Multichannel Responses

| Condition | Response | Example |
|---|---|--|
| No multichannel address used | Only the device selected using the *adr or :SYST[<address>] :COMM[:MCH] :ADDR commands will respond. | SYSTem:VERSion? |
| Single multichannel address specified | The device addressed in the command will respond regardless of if it has been selected. | SYSTem2:VERSion? |
| ALL or broadcast multichannel address specified | Only the device selected using the *adr or :SYST[<channel>] :COMM[:MCH] :ADDR commands will respond. If none of the devices have been selected then no response will be seen. | :SYSTem ALL:VERSion? or :SYSTem0:VERSion? |
| Multiple multichannel addresses specified | Only the device selected using the *adr or :SYST[<address>] :COMM[:MCH] :ADDR commands will respond. If none of the devices have been selected then no response will be seen. | SYSTem 1,2,4,5,6:VERSion? |

Multichannel commands are particularly useful for configuring groups of devices that require identical configurations.

The SCPI Commands for these instructions are:

```
[:]<root command> <ALL|addr1>[, [ ]<addr2>][, [ ]<addr3>][, ...]:<command> <parameter>
```

For example:

```
sour1, 2, 3, 7:volt 4.5
syst4,5,6:oper:enab 255
sourALL:volt 5
output0:stat on
```

Note: ALL and 0 do not work for query commands (i.e. SOUR:VOLT?, MEAS:VOLT?, SOUR:CURR?, MEAS:CURR?)

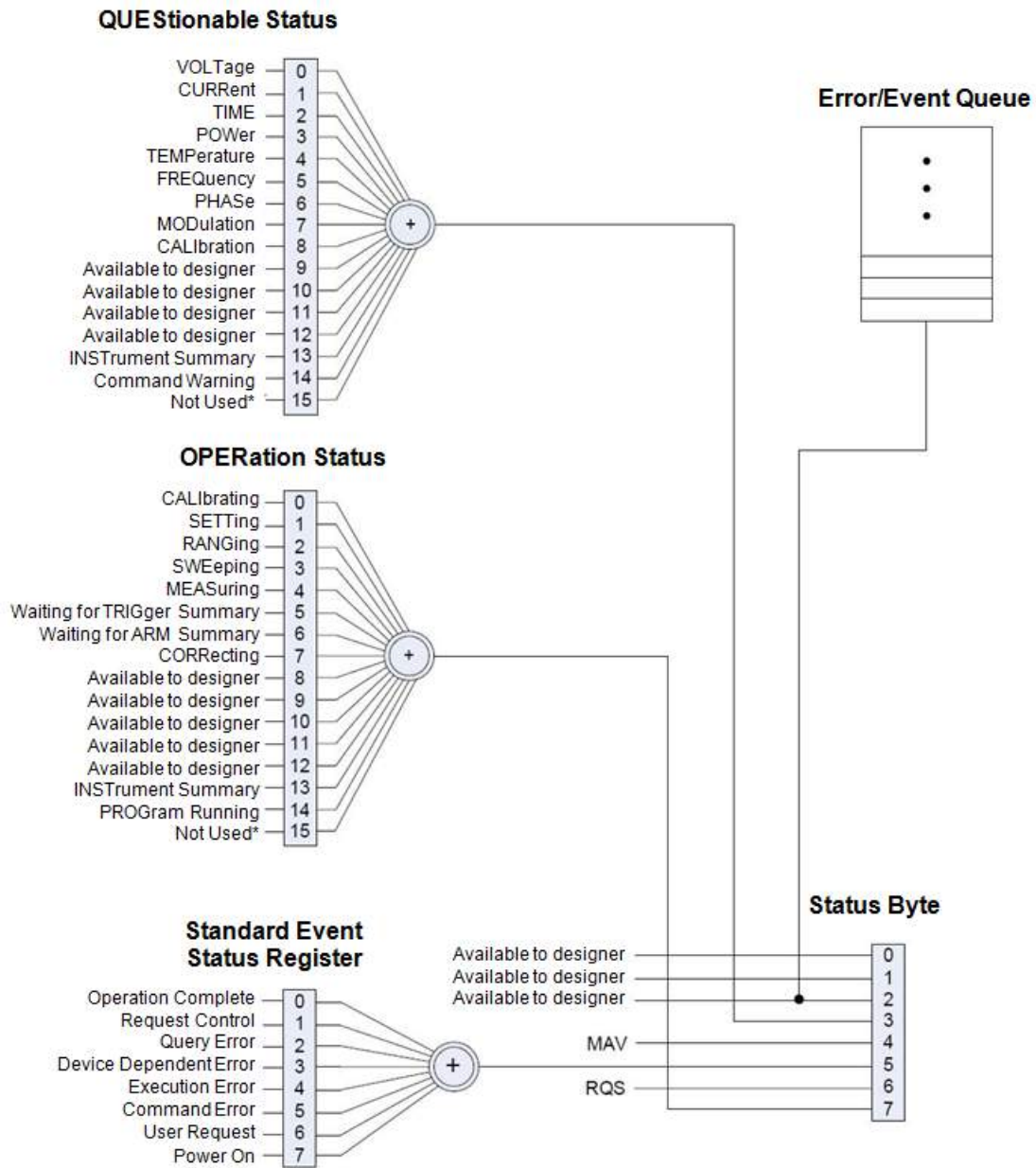
STATUS REPORTING IN SCPI

The status reporting implemented in the power supply is primarily dictated by the SCPI standard. This section provides a high level review of the standard status reporting required by SCPI and then covers the specific reporting that is implemented within the SCPI status reporting framework.

Figure 53 is taken from the SCPI 99 standard and shows the minimum status reporting requirements for a SCPI compliant device.

Throughout this section, figures are used to explain the relationship between the registers, enable/disabling register and their summary bits. The figures use four logical symbols to demonstrate the relationship between the register. The “!” block represents logical not or complement of the input signal. The “&” block represents the logical AND operator. The “|” block represents the logical OR operation. The “+” block represents the logical OR of all the bits from the enable register. The model has several ellipses which are there to indicate that the pattern of logic shown is repeated for all bits in the registers.

Figure 53: SCPI Status Reporting Model

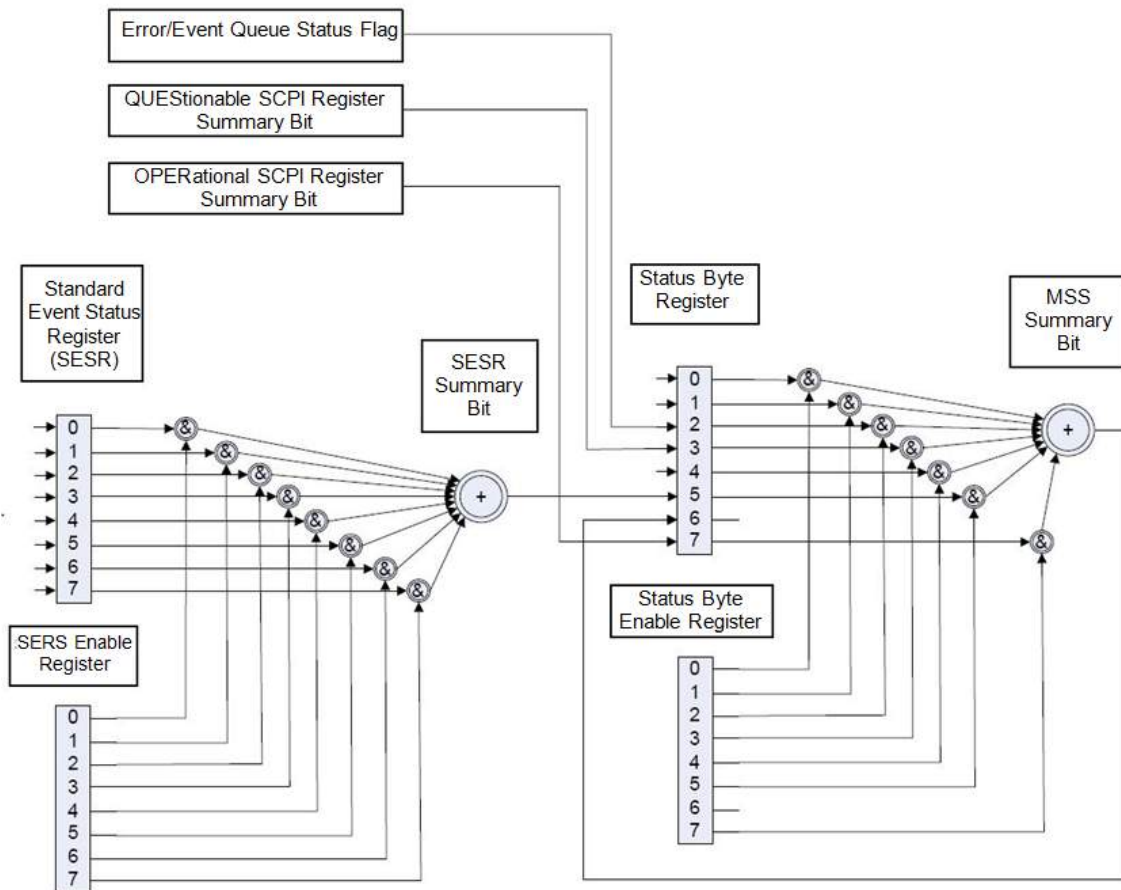


STATUS REGISTERS MODEL FROM IEEE 488.2

The IEEE 488.2 registers shown in the bottom rectangle of Figure 53 follow the IEEE 488.2 model for status registers. The IEEE 488.2 register only has enable registers for masking the summary bits.

Figure 54 shows the details on the relationship between the mask/enable registers and the summary bits. Sections describing the bits for both registers will follow Figure 51.

Figure 54: IEEE 488.2 Register Model



Status Byte

The Status byte register contains the STB and RQS (MSS) messages as defined in 488.1. You can read the status byte register using a 488.1 serial poll or the 488.2 *STB? common command.

The *STB? query causes the device to send the contents of the Status Byte Register and the Master Summary Status (MSS) summary message. The *STB? query does not alter the status byte, MSS, or RQS.

Status Byte Summary Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|---|--|
| 0 | 1 | Reserved | Reserved |
| 1 | 2 | Reserved | Reserved |
| 2 | 4 | Error/Event Queue (ERR) | Set if any errors are present in the Error/Event queue. |
| 3 | 8 | Questionable Status Register (QSR) | Set if any bits are set in the Questionable Status Event register. |
| 4 | 16 | Message Available (MAV) | Indicates whether the output queue is empty. MAV is TRUE if the device is ready to accept a request from the controller. |
| 5 | 32 | Standard Event Status Bit Summary (ESB) | A summary of the Standard Event Status Register. |
| 6 | 64 | Request Service (RQS) / Master Status Summary (MSS) | Not Implemented / MSS indicates that the device has at least one reason for requesting service. |
| 7 | 128 | Operation Status Register (OSR) | Present if a bit is set in the Operation status register. |

Error/Event Queue (ERR)

This bit is TRUE if any errors are present in the Error/Event Queue.

Questionable Status Register Summary (QSR)

This bit is TRUE when a bit in the Questionable Event Status Register is set and its corresponding bit in the Questionable Status Enable Register is TRUE.

Message Available (MAV)

This bit is TRUE whenever the power supply is ready to accept a request by the Digital Programming Interface to output data bytes. This message is FALSE when the output queue is empty.

Standard Event Status Summary (ESB)

This bit is TRUE when a bit is set in the Standard Event Status Register.

Master Summary Status (MSS)

This is caused by one of the following:

- Status Byte bit 0 AND Service Request Enable Register bit 0
- Status Byte bit 1 AND Service Request Enable Register bit 1
- Status Byte bit 2 AND Service Request Enable Register bit 2
- Status Byte bit 3 AND Service Request Enable Register bit 3
- Status Byte bit 4 AND Service Request Enable Register bit 4
- Status Byte bit 5 AND Service Request Enable Register bit 5
- Status Byte bit 7 AND Service Request Enable Register bit 7.

Request Service (RQS)

RQS is TRUE if the Service Request Enable Register has a bit set and there is a corresponding bit within the Status Byte.

Operation Status Register Summary (OSR)

This bit is TRUE when a bit in the Operation Event Status Register is set and its corresponding bit in the Operation Status Enable Register is set.

Service Request Enable Register

The Service Request Enable Register allows you to select the reasons for the power supply to issue a service request. The Service Request Enable Register allows you to select which summary messages in the Status Byte Register may cause service requests.

To clear the Service Request Enable Register send `*SRE 0`. A cleared register does not allow status information to generate a service request.

For example:

Sending `*SRE 8` sets bit 3 of the Service Request Enable Register. This will cause the Summary bit of the Questionable Status register (bit 3) in the Status Byte to generate a service request message whenever it gets set. (See “Status Byte” on page 128 for details.)

Command:

```
*SRE <Service-Request-Enable>, *SRE?
```

The SCPI equivalent for multichannel use:

```
[ : ]STATus[ <channel> ]:SREQuest[ :ENABLE ] <status-enable>
[ : ]STATus[ <channel> ]:SREQuest[ :ENABLE? ]
```

Query the Status Byte

The status byte query will return the contents of the status byte register and the MSS (Master Summary Status) message. The response is in the format of a weighted decimal value representing the status byte register and the MSS message (bit 6). Thus, the response to `*STB?` is identical to the response to a serial poll except that the MSS message appears in bit 5 in place of the RQS message. (See “Status Byte” on page 128 for details.)

Command:

```
*STB?
```

SCPI equivalent:

```
[ : ]STATus[ <address> ]:SBYTE[ :EVENT ] ?
```

Standard Event Status Register (SESR)

The standard event status register sets bits for specific events during power supply operation. All bits in the standard event status registers are set through the error event queue. The register is defined by IEEE 488.2 register and is controlled using 488.2 common commands: *ESE, *ESE?, and *ESR? as well as SCPI aliases for multichannel use.

Standard Event Status Enable Register

The Event Summary Enable command determines which bits in the Standard Event Status Register are summarized in the Event Summary Bit (ESB) of the Status Byte. This register will be cleared at power up. To enable events, you must make the logical sum of all values for the events that you to be reported and send this parameter in decimal format.

See the table that follows for values for the events to be enabled in <status-enable> parameter.

For example, sending *ESE 16 sets bit 4 of the Standard Event Status Enable Register. This will cause the Event Summary bit (ESB) in the Status Byte to be set whenever the Execution Error bit (bit 4) in the Standard Event Status Register gets set.

Command:

```
*ESE <status-enable>, *ESE?
```

The SCPI equivalent for multichannel use:

```
[ : ]STATus[ <channel(s)> ]:STANdard:ENABle <status-enable>
```

```
[ : ]STATus[ <channel(s)> ]:STANdard:ENABle?
```

Standard Event Status Register Query

The Standard Event Status Register query allows you to determine the current contents of the Standard Event Status Register. (See “Standard Event Status Register (SESR)” on page 131. Reading this register clears it.

Command:

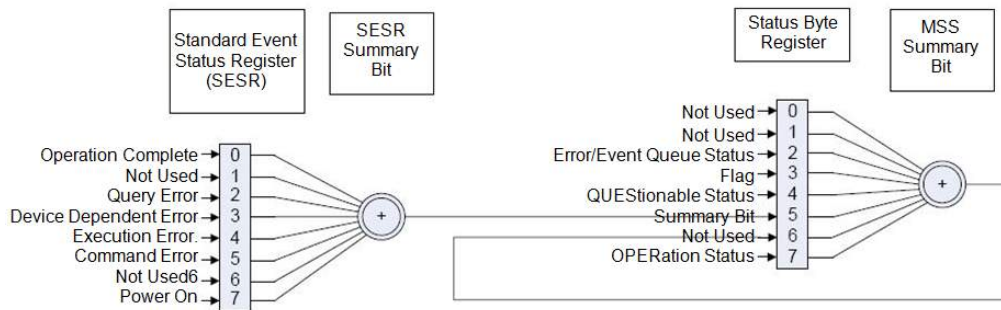
```
*ESR?
```

The SCPI equivalent for multichannel use:

```
[ : ]STATus[ <channel(s)> ]:STANdard[ :EVENT ]?
```

Figure 55 summarizes the Standard Event Status Register.

Figure 55: Summary of Standard Event Status Register



Standard Event Status Register

| Bit | Bit Weight | Bit Name | Description |
|------|------------|------------------------------|--|
| 0 | 1 | Operation Complete (OPC) | Set if * OPC command has been received and all pending operations have been completed. |
| 1 | 2 | Request Control (RQC) | Not implemented. Always set to 0. |
| 2 | 4 | Query Error (QYE) | Not implemented. |
| 3 | 8 | Device Dependent Error (DDE) | Set if there is a device-specific error. See “Device-Specific Error List” on page 246 for a list possible error codes and descriptions. |
| 4 | 16 | Execution Error (EXE) | Set if a program data element, following a header, was evaluated by the power supply as outside of its legal input range, or is otherwise inconsistent with the power supply's capabilities. Suggests that a valid program message could not be properly executed due to some power supply condition. See “Execution Error List” on page 245 for a list of possible error codes and descriptions. |
| 5 | 32 | Command Error (CME) | Set if an IEEE488.2 syntax error has been detected by the parser, an unrecognized header was received, or a group Execute Trigger was entered into the input buffer inside an IEEE 488.2 program message. See “Command Error List” on page 244 for a list of possible error codes and descriptions. |
| 6 | 64 | User Request (URQ) | Not Implemented |
| 7 | 128 | Power ON (PON) | Not Implemented |
| 8-15 | N/A | Reserved | Reserved for possible future use by IEEE. Bit values are reported as zero. |

Operation Complete

The Operation Complete command causes the power supply to generate the operation complete message in the Standard Event Status Register when all pending operations have been finished. See bit 0 in the Standard Events Register table above for more details.

Command:

*OPC, *OPC?

Wait-to-Continue Command

The Wait-to-Continue command prevents the power supply from executing any further commands or queries until the no-operation-pending flag is TRUE.

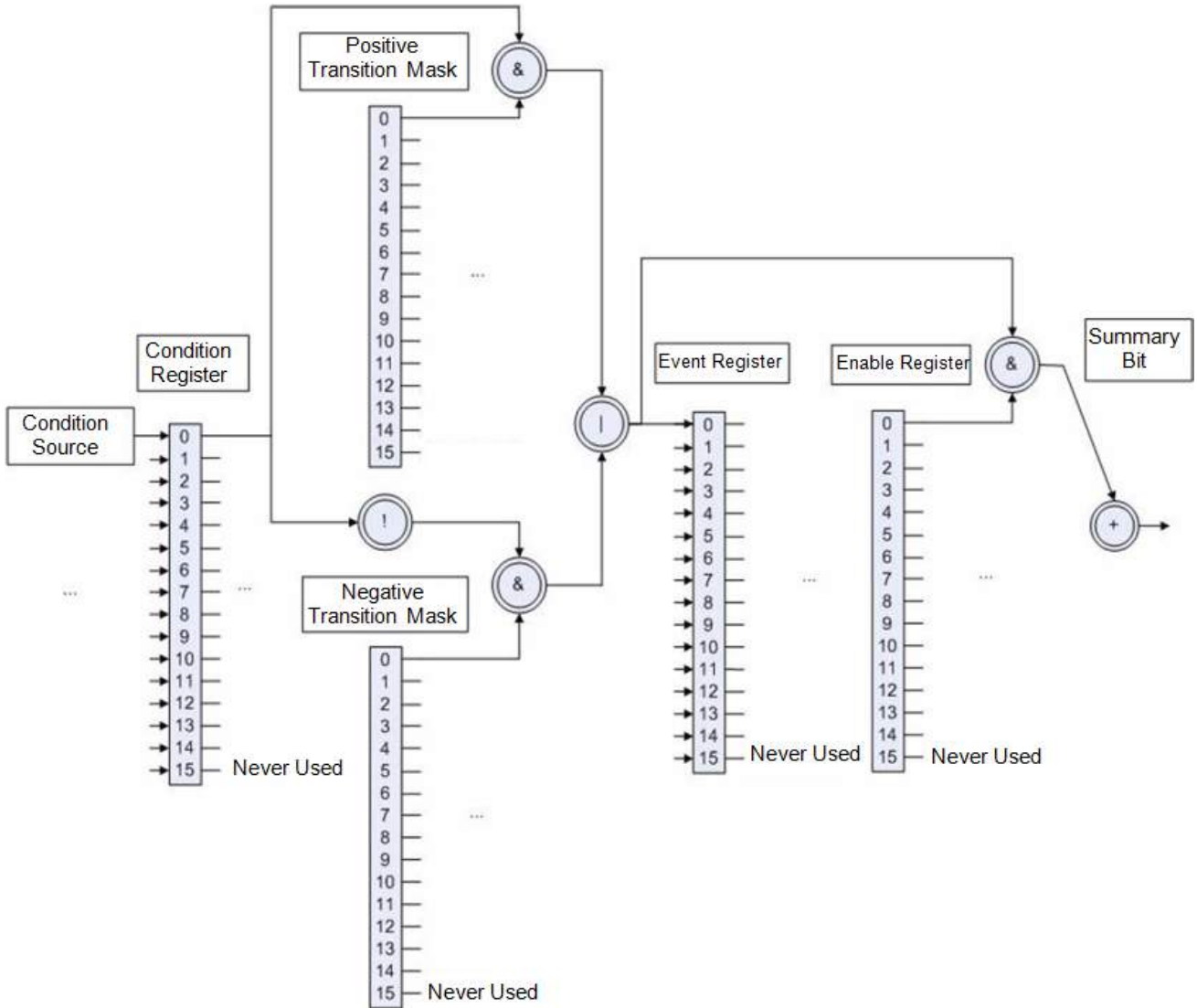
Command:

*WAI

STANDARD SCPI REGISTER STRUCTURE

All registers except the SERS and Status registers will have the following structure which control how they report status information. In all subsequent figures that have SCPI registers, this structure will be condensed down into a single block to simplify the figures. The simplified block will show a 16-bit register and the summary bit. See Figure 56 for details on the structure used for each standard SCPI register.

Figure 56: SCPI Register Model

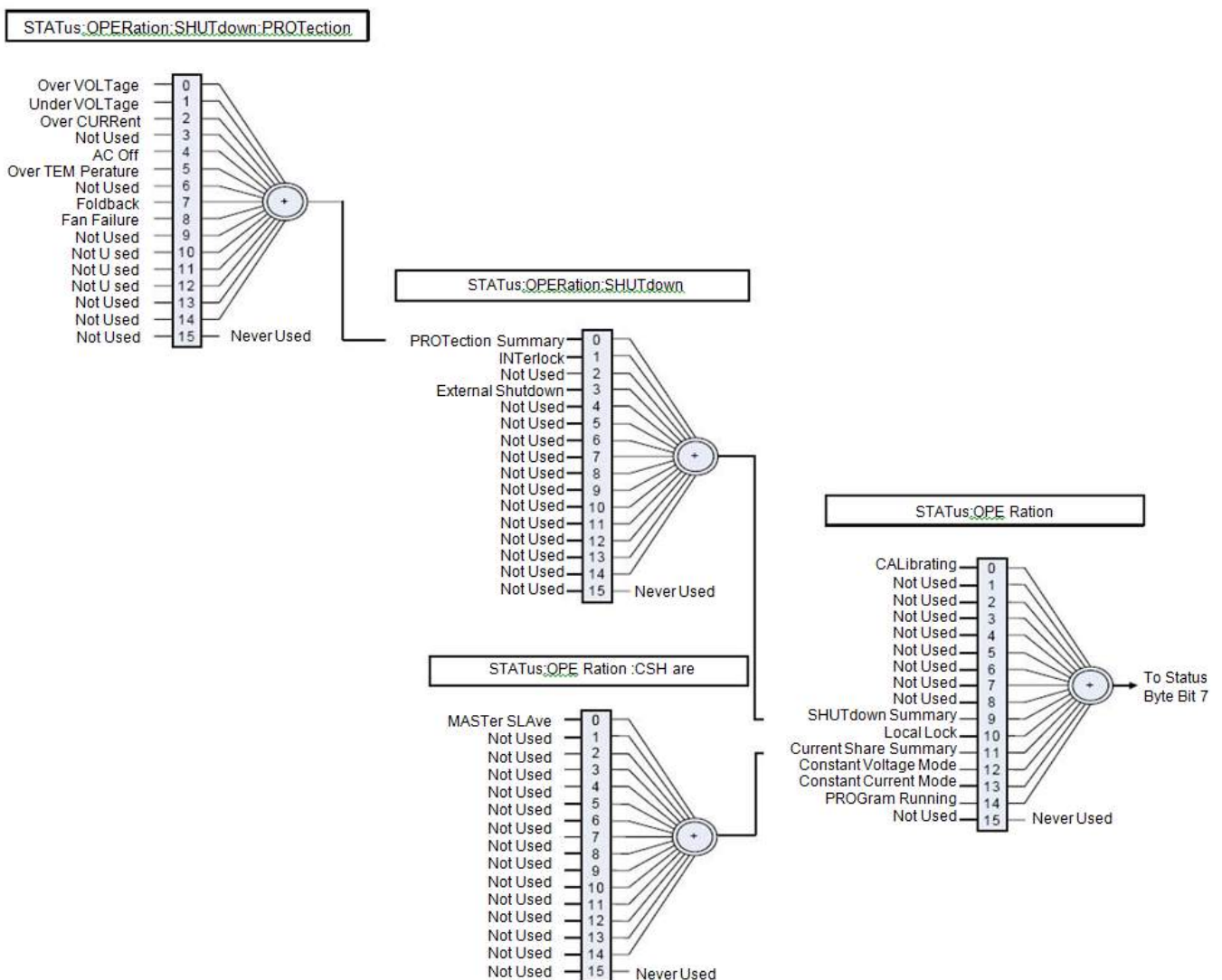


OPERATION STATUS REGISTER

The operation status register is a standard SCPI, 16-bit register which contains information about conditions which are part of the power supply's normal operation. The Operation Status data structure has the operation status register and two sub-registers to represent shutdown and protection shutdown. Each of the sub-registers is summarized in a summary bit.

Figure 57 represents the Operation Status data structure. The “+” represents the logical summation/or of bits in a register. The next three tables describe the meanings of each bit as well as the bit number and bit weight.

Figure 57 Operation Status Register Fanout



OPERation Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|-----------------------|--|
| 0 | 1 | CALibrating | Indicates that the supply is in CALibration Mode. |
| 1 | 2 | SETTling | Not implemented |
| 2 | 4 | RANGing | Not implemented |
| 3 | 8 | SWEEping | Not implemented |
| 4 | 16 | MEASuring | Not implemented |
| 5 | 32 | Waiting for Arm | Not implemented |
| 6 | 64 | Waiting for Trigger | Not implemented |
| 7 | 128 | CORREcting | Not implemented |
| 8 | 256 | Not Used | Not Used |
| 9 | 512 | SHUTdown Summary | Reflects the summary of the SHUTdown Sub-Register. |
| 10 | 1024 | Local Lockout | Front panel lockout |
| 11 | 2048 | Current Share Summary | Reflects the summary of the CShare Sub-Register. |
| 12 | 4096 | Constant Voltage Mode | Reflects the output mode of the supply. |
| 13 | 8192 | Constant Current Mode | Reflects the output mode of the supply. |
| 14 | 16384 | Program Running | Indicates if an Autosequence program is currently running. |

The operation shutdown status register describes the cause of the power supply shutting down the output. More than one bit may be active and multiple actions will be required to restart the unit. The protection shutdown sub-register indicates which protection mechanisms have caused the power supply to shut down.

OPERation SHUTdown Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|-------------------|--|
| 0 | 1 | PROTection | Reflects the summary of the PROTection sub-register. |
| 1 | 2 | INTErlock | The power supply is shut down by INTErlock signal. |
| 2 | 4 | Not Used | Not Used |
| 3 | 8 | External Shutdown | The power supply is shut down by External Shutdown signal. |

OPERation SHUTdown PROTection Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|----------|--|
| 0 | 1 | OVP | Over Voltage protection has tripped. |
| 1 | 2 | UVP | Under Voltage protection has tripped. |
| 2 | 4 | OCP | Over Current protection has tripped. |
| 3 | 8 | Not Used | Not Used |
| 4 | 16 | AC Off | AC failure protection has tripped. |
| 5 | 32 | OTP | Over Temperature protection has tripped. |
| 6 | 64 | Not Used | Not Used |
| 7 | 128 | Foldback | Foldback protection has tripped. |
| 8 | 256 | Fan | Fan failure protection has tripped. |

Current Share Sub-Register

This register shows the state of the current share configuration, which can either be set through the front panel Current Share Config menu, or through the SCPI command.

Important: If current sharing is not being used, the unit must be configured as a controller. Failure to do so will result in unpredictable operation.

The SCPI command (s) for these instructions are:

```
[[:]SOURCE]:COMBine:CSHare[:MODE]
```

OPERation CSHare Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|------------|--|
| 0 | 1 | CONTroller | The power supply is configured to be a Current Share CONTroller. |
| 1 | 2 | SLAVe | The power supply is configured to be a Current Share Slave. |

Operation Status Register Commands

The response format for all register queries will be in decimal notation.

Query Operation Status Register Event

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation[:EVENT]?
```

Query Operation Status Register Condition

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:CONDition?
```

Enable Operation Status Register

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:ENABLE <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:OPERation:ENABLE?
```

Set Operation Status Positive Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:PTRansition <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:OPERation:PTRansition?
```

Set Operation Status Negative Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:NTRansition <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:OPERation:NTRansition?
```

Current Sharing Sub-Register Commands

Query Current Share Event

SCPI command:

```
[:]STATUS[<channel>]:OPERation:CSHare[:EVENT]?
```

Query Current Share Condition

SCPI command:

```
[:]STATUS[<channel>]:OPERation:CSHare:CONDition?
```

Enable Current Share Sub-Register

SCPI command:

```
[:]STATUS[<channel>]:OPERation:CSHare:ENABLE <statusenable>
```

Query format:

```
[:]STATUS[<channel>]:OPERation:CSHare:ENABLE?
```

Set Current Share Positive Transition Filter

SCPI command:

```
[:]STATUS[<channel>]:OPERation:CSHare:PTRansition <status-enable>
```

Query format:

```
[:]STATUS[<channel>]:OPERation:CSHare:PTRansition?
```

Set Current Share Negative Transition Filter

SCPI command:

```
[:]STATUS[<channel>]:OPERation:CSHare:NTRansition <status-enable>
```

Query format:

```
[:]STATUS[<channel>]:OPERation:CSHare:NTRansition?
```

Shutdown Sub-Register Commands

Query Shutdown Event

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown[ :EVENT ]?
```

Query Shutdown Condition

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:CONDition?
```

Enable Shutdown Sub-Register

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation: SHUTdown:ENABLE <status-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:ENABLE?
```

Set Shutdown Positive Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PTRansition <status-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PTRansition?
```

Set Shutdown Negative Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:NTRansition <status-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:NTRansition?
```

Protection Sub-Register Commands

Query Protection Event

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection[:EVENT]?
```

Query Protection Condition

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:CONDition?
```

Enable Protection Sub-Register

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation: SHUTdown:PROTection:ENABLE  
<status-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:ENABLE?
```

Set Protection Positive Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:PTRansition  
<stats-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:PTRansition?
```

Set Protection Negative Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:NTRansition  
<status-enable>
```

Query format:

```
[ : ]STATUS[ <channel> ]:OPERation:SHUTdown:PROTection:NTRansition?
```

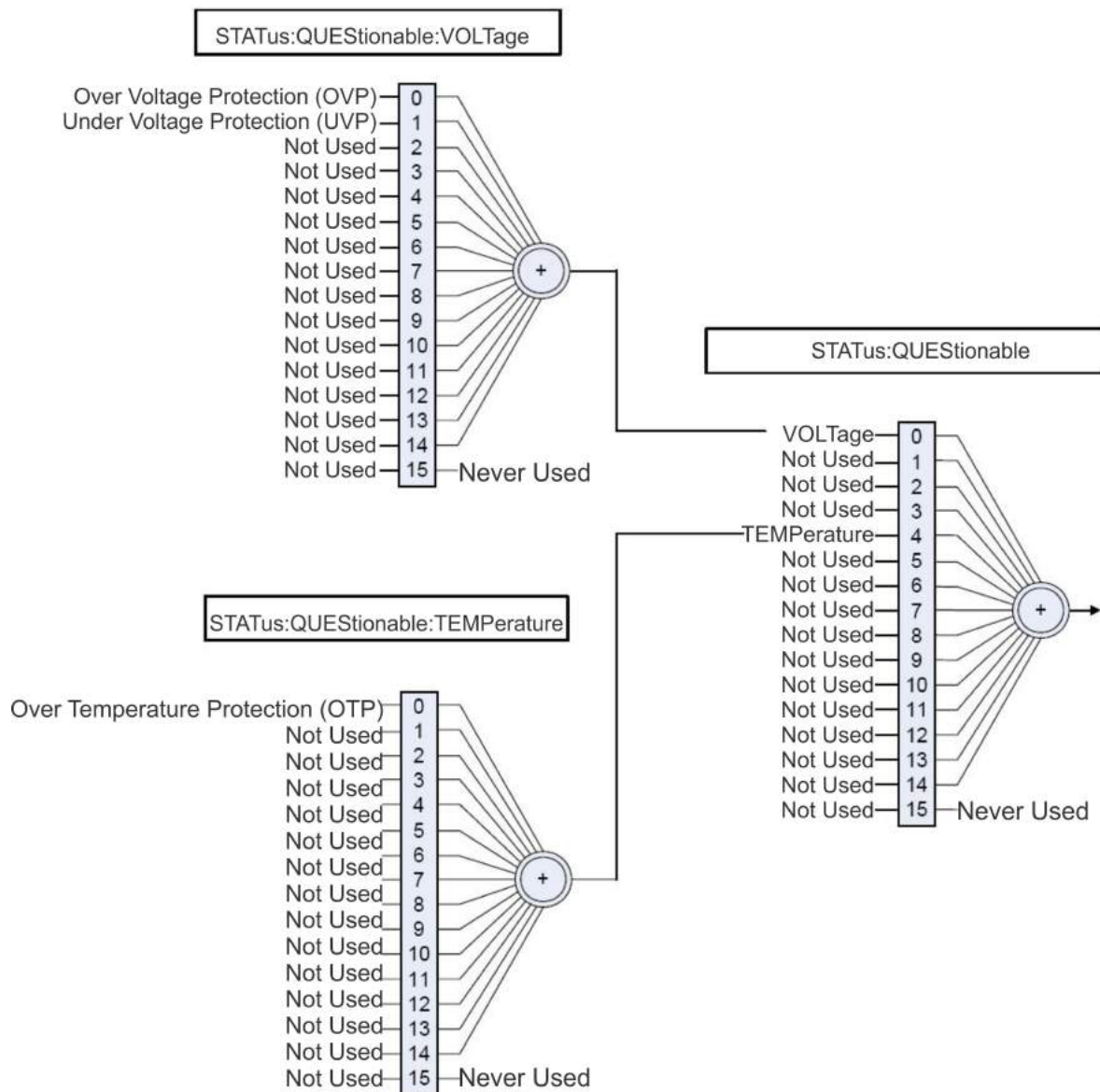
QUESTIONABLE STATUS REGISTER

The Questionable Status register is a standard SCPI, 16-bit register that stores information about questionable events or status during power supply operation. That is, bits in these registers may indicate that the output of the supply is of undesirable or questionable quality.

The Questionable Status data structure consists of a questionable status register and two sub-registers representing the status of the voltage outputs and temperature.

Figure 58 gives an overview of the Questionable Status data structure. The “+” represents the logical summation of bits in a register. The next three tables describe the meanings of each bit as well as the bit number and bit weight.

Figure 58: SCPI QUESTIONable Registers Fanout



QUESTionable Status Register

| Bit | Bit Weight | Bit Name | Description |
|------------|-------------------|-----------------|---------------------------------|
| 0 | 1 | VOLTage | Summary of Voltage Register |
| 1 | 2 | CURRent | Not Implemented |
| 2 | 4 | TIME | Not Implemented |
| 3 | 8 | POWer | Not Implemented |
| 4 | 16 | TEMPerature | Summary of Temperature Register |
| 5 | 32 | FREQuency | Not Implemented |
| 6 | 64 | PHASe | Not Implemented |
| 7 | 128 | MODulation | Not Implemented |
| 8 | 256 | CALibration | Not Implemented |
| 9 | 512 | Not Used | Not Used |
| 10 | 1024 | Not Used | Not Used |
| 11 | 2048 | Not Used | Not Used |
| 12 | 4096 | Not Used | Not Used |
| 13 | 8192 | Not Used | Not Used |
| 14 | 16384 | Not Used | Not Used |
| 15 | 32768 | Not Used | Not Used |

VOLTage Sub-Register

This shows whether the present voltage level is over or under the specified trip limit.

QUEStionable VOLTage Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|----------|--------------------------|
| 0 | 1 | OVP | Over Voltage Protection |
| 1 | 2 | UVP | Under Voltage Protection |

TEMPerature Sub-Register

This shows whether the temperature of critical components is near or over the maximum operating temperature.

QUEStionable TEMPerature Status Register

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|----------|-----------------------------|
| 0 | 1 | OTP | Over Temperature Protection |

Reading Internal Temperature Measurements

Internal temperatures are measured by the channels of a fan controller. The Series 2268 850-Watt power supply has one fan controller, Fan0, with two channels, 0 and 1, that each control a fan and measure temperature.

The SCPI command (s) for these readings are:

```
DIAGnostic:MEMory:FAN<n>:READ #h0<n>
```

Example: to read the temperatures in the Series 2268 850-Watt power supply,

```
DIAG:MEM:FAN0:READ #h00 //this reads the 1st channel
```

```
DIAG:MEM:FAN0:READ #h01 //this reads the 2nd channel
```

Questionable Status Register Commands

Query Questionable Status Register Event

SCPI command:

```
[:]STATUS[<channel>]:QUESTionable[:EVENT]?
```

Query Questionable Status Register Condition

SCPI command:

```
[:]STATUS[<channel>]:QUESTionable:CONDition?
```

Enable Questionable Status Register

SCPI command:

```
[:]STATUS[<channel>]:QUESTionable:ENABle <status-enable>
```

Query Format:

```
[:]STATUS[<channel>]:QUESTionable:ENABle?
```

Set Questionable Status Positive Transition Filter

SCPI command:

```
[:]STATUS[<channel>]:QUESTionable:PTRansition <status-enable>
```

Query Format:

```
[:]STATUS[<channel>]:QUESTionable:PTRansition?
```

Set Questionable Status Negative Transition Filter

SCPI command:

```
[:]STATUS[<channel>]:QUESTionable:NTRansition <status-enable>
```

Query Format:

```
[:]STATUS[<channel>]:QUESTionable:NTRansition?
```

Voltage Status Register Commands

Query Voltage Status Register Event

SCPI command:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage[:EVENT]?
```

Query Voltage Status Register Condition

SCPI command:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:CONDition?
```

Enable Voltage Status Register

SCPI command:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:ENABle <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:ENABle?
```

Set Voltage Status Positive Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:PTRansition <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:PTRansition?
```

Set Voltage Status Negative Transition Filter

SCPI command:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:NTRansition <status-enable>
```

Query Format:

```
[ : ]STATUS[ <channel> ]:QUESTIONable:VOLTage:NTRansition?
```

Temperature Status Register Commands

Query Temperature Status Register Event

SCPI command:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature [ :EVENT ]?
```

Query Temperature Status Register Condition

SCPI command:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :CONDition?
```

Enable Temperature Status Register

SCPI command:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :ENABle  
<status-enable>
```

Query Format:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :ENABle?
```

Set Temperature Status Positive Transition Filter SCPI command:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :PTRansition  
<status-enable>
```

Query Format:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :PTRansition?
```

Set Temperature Status Negative Transition Filter

SCPI command:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :NTRansition  
<status-enable>
```

Query Format:

```
[ : ]STATus[ <channel> ]:QUEStionable:VOLTage:TEMPerature :NTRansition?
```

SCPI ERROR/EVENT QUEUE

The error/event queue contains items that include a numerical and textual description of the error or event. Querying for the full queue item (for example, with SYSTem: ERRor [:NEXT] ?) will return a response with the following syntax:

```
<Error/Event Number>, "<Error/Event Description>;<Optional Device  
Dependent Info>"
```

The <Error/event_number> is a unique integer in the range [-32768, 32767]. All positive numbers are instrument-dependent. All negative numbers are reserved by the SCPI standard with certain standard error/ event codes described in the SCPI 1999 standard document. The value, zero, is also reserved to indicate that no error or event has occurred.

The second parameter of the full response is a quoted string containing an <Error/event_description> followed by optional <Device-dependent info> text. Each <Error/event_number> has a unique and fixed <Error/ event_description> associated with it.

The maximum string length of <Error/event_description> plus <Device-dependent_info> is 255 characters.

As errors and events are detected, they are placed in a queue. This queue is first in, first out. If the queue overflows, the last error/event in the queue is replaced with error:

```
-350,"Queue overflow
```

Any time the queue overflows, the least recent errors/events remain in the queue, and the most recent error/event is discarded. The error queue implemented in the power supply is capable of holding 4 errors.

When the error queue is not empty the error queue bit in the Status register will be set.

Querying For the Errors

Executing a query of the event queue will respond with the oldest error currently on the queue. This error is removed. The response format is discussed in the error/event queue description section.

Command:

```
[ : ]SYSTem:ERRor [ :EVENT ]?
```

Examples:

```
SYST:ERR?
SYST:ERR:EVENT?
```

Responses might be:

```
-102, "syntax error;"
0, "No Error;"
```

Querying For the Error Code Only

It is possible to query for only the error code. When querying the error code only the response will be the numeric error code only, no additional description will be given. The error queried will be removed from the queue.

Command:

```
[ : ]SYSTem:ERRor:CODE[ :EVENT ]?
```

Example:

```
:SYST:ERR:CODE?
SYST:ERR:CODE:EVENT ?
```

Responses might be:

```
-102
0
```

Querying For the Number of Errors in the Queue

To query the device for the number of errors currently stored in the error queue you should use the following command.

Command:

```
[ : ]SYSTem:ERRor:COUNT?
```

Example:

```
:SYST:ERR:COUN?
```

Response might be:

```
3
```

RESET COMMAND

Important: This command takes longer to execute than other commands. Be sure to allow extra time (approximately two seconds) for the command to run before sending another command..

The Reset command performs a device reset. The Reset command is the third level of reset in a three level reset strategy, set out in IEEE 488.2 (see IEEE 488.2 standard, section 17.1.2).

The Reset command shall do the following:

1. Set the device-specific functions to a known state that is independent of the past-use history of the device.
2. Force the device into the OCIS state, (see IEEE 488.2 standard, section 12.5.2).
3. Force the device into the OQIS state, (see IEEE 488.2 standard, section 12.5.3).

The reset command explicitly shall NOT affect the following:

1. The state of the IEEE 488.1 interface.
2. The selected IEEE 488.1 address of the device.
3. The Output Queue.
4. The Standard Status Register Enable setting.
5. The Standard Event Status Enable (SESR) setting.
6. The Operation and Questionable SCPI status registers and their fan out registers.
7. Calibration data that affects device specifications.
8. The Protected User Data query response.

Commands:

*RST

[:]SYSTem[<channel>]:RESet

CLEAR ALL STATUS REGISTERS

Clear Status Command

Clears all Event Registers, including the Status Byte, the Standard Event Status and the Error Queue.

Command:

*CLS

[:]STATUS[<channel>]:CLEAr

SCPI Preset Status

Configures the status data structures to ensure that certain events are reported at a higher level through the status-reporting mechanism. These events are summarized in the mandatory structures, the Operation Status Register and Questionable Status Register.

The PRESet command affects only the enable registers and the transition filter registers of the status data structures. PRESet does not clear any of the event registers or any item from the error/event queue. The *CLS command is used to clear all event registers and queues in the device status-reporting mechanism.

For the device-dependent status data structures, the PRESet command sets the enable register to all 1s and the transition filter register to report only positive transitions. For the SCPI mandatory status data structures, the PRESet command sets the transition filter registers to recognize only positive transitions and sets the enable register to 0s. The following will not be affected by this command: Service Request Enable Register, Parallel Poll Enable Register, the memory register associated with the * SAV command, the power supply address, Output Queue, and the power-on-status-clear flag setting.

| Register | Filter/Enable | Preset Value |
|--------------|------------------------------|--------------|
| Operational | Operational Enable Register | 0 |
| | Positive Transition Filter | 1 |
| | Negative Transition Filter | 0 |
| Questionable | Questionable Enable Register | 0 |
| | Positive Transition Filter | 1 |
| | Negative Transition Filter | 0 |
| All others | All other Enable Register | 1 |
| | Positive Transition Filter | 1 |
| | Negative Transition Filter | 1 |

SCPI command:

[:]STATUS[<channel>]:PRESet

COMMAND LINE HELP SYSTEM

The Help system is made up of a series of commands that can be used to get help on all available commands and details on their syntax.

The Help commands are:

```
[ : ]SYSTem[ <channel> ]:HELP[ :HEADers ]?
[ : ]SYSTem[ <channel> ]:HELP:LEGacy?
```

Querying Help for all Command Headers

The [:] SYSTem [<channel>] : HELP [: HEADers] ? query shall return all SCPI commands and queries and IEEE 488.2 common commands and common queries implemented. No single line will be longer than 80 characters long. The full path for every command and query shall be returned separated by line feeds.

A <SCPI header> is defined as:

It shall contain all the nodes from the root. The <SCPI program mnemonic> contains the node in standard SCPI format. The short form shall use uppercase characters while the additional characters for the long form shall be in lowercase characters. Default nodes shall be surrounded by square brackets ([]).

Command:

```
[ : ]SYSTem[ <channel> ]:HELP[ :HEADers ]?
```

For example:

```
:SYST1:HELP:HEAD?
```

Might return:

```
#44513
*IDN?/qonly/
*RST/nquery/
*TST?/qonly/
*OPC/nquery/
*OPC?/qonly/
*WAI/nquery/
*CLS/nquery/
*ESE
*ESR?/qonly/
*SRE
*SRE?/qonly/
*STB?/qonly/
*SAV
*RCL
*TRG/nquery/
*ADR
*HELP?/qonly/
*ERR?/qonly/
[ : ]SYSTem:PROTection[ :MASK]
[ : ]SYSTem:ERRor[ :NEXT]?/qonly/
[ : ]SYSTem:ERRor:CODE[ :NEXT]?/qonly/
[ : ]SYSTem:ERRor:COUnT?/qonly/
```

```

...
[:]OUTPut:PROTection:FOLDback[:MODE]
[:]OUTPut:PROTection:FOLDback:
[:]OUTPut:POLarity
[:]OUTPut[:POWer][:STATe]
[:]OUTPut[:POWer]:PON[:STATe]
[:]OUTPut:AUXilliary[:STATe]
[:]OUTPut:AUXilliary:PON[:STATe]
[:]MEASure[:SCALar][:VOLTagE][:DC]?/qonly/
[:]MEASure[:SCALar]:CURRent[:DC]?/qonly/
[:]MEASure[:SCALar]:APROgram[:VOLTagE][:DC]?/qonly/
[:]MEASure[:SCALar]:APROgram[:VOLTagE]:ISOLated[:DC]?/ qonly/
[:]MEASure[:SCALar]:APROgram:CURRent[:DC]?/qonly/
[:]MEASure[:SCALar]:APROgram:CURRent:ISOLated[:DC]?/ qonly/
[:]INITiate:IMMediate/nquery/
[:]CALibration:REStore/nquery/
[:]CALibration[:VOLTagE]:PROTection[:OVER][:DATA]/nquery/
[:]CALibration:OUTPut[:VOLTagE][:DATA]/nquery/
[:]CALibration:OUTPut:CURRent[:DATA]/nquery/
[:]CALibration:OUTPut:ANALog[:VOLTagE][:DATA]/nquery/
[:]CALibration:OUTPut:ANALog[:VOLTagE]:ISOLated[:DATA]/nquery/

```

Querying Help for Legacy Command Headers

The [:] SYSTem [<channel>]: HELP: LEGacy? query is essentially the same as the [:] SYSTem [<channel>]: HELP [:HEADers]? query, but it lists legacy commands. If executed it returns all legacy commands and queries implemented. The response shall be on a page by page basis. No single line will be longer than 80 characters and each page will be 23 lines long. The full path for every command and query shall be returned separated by line feeds. After a full page of headers has been displayed you will be prompted to press any key to continue or the ESC key to stop any further listing of the command headers.

Command:

```
[:]SYSTem[<channel>]:HELP:LEGacy?
```

For example:

```
:SYST2:HELP:LEG?
```

Might return:

```

#296
AUX
OUT
ERR?/qonly/
CLR/nquery/
FOLD
DLY
VSET
ISET
TRG/nquery/
OVP
UVP
HELP?/qonly/
HLP?/qonly/

```

LOCKING AND UNLOCKING THE FRONT PANEL

Locking out the front panel will prevent any of the buttons from functioning. All the buttons and knobs on the front panel will display the LOCL LOC message to be display on the Current and Voltage displays if pressed or rotated. This mode prevents any changes to the unit from the front panel. See the following procedure to lock and unlock the front panel.

The SCPI Commands for these instructions are:

```
[ : ]SYSTem[ <channel> ]:REMote:STATe { ? | LOCa1 | REMote }
```

Where:

LOCa1 is used to set the front panel mode to local.

REMote is used to set the front panel into locked mode (remote).

For example:

```
SYST:REM:STAT REM Front panel is locked (remote digital programming mode only).
```

```
SYST:REM:STAT LOC Front panel is unlocked.
```

```
SYST:REM:STAT ? Query for status
```

AUTO SEQUENCE PROGRAMMING

Auto Sequence programming lets you execute a program stored in the power supply's memory. The program that can be stored in memory can be composed of any of the SCPI commands described in this Manual.

For example, Auto Sequence programming allows you to set the timer to turn the power output of the supply Off or On after a time interval or to program voltage sequences.

When a program is activated each command stored in the buffer is executed as if the operator had sent the command by typing it in. A variable delay time called dwell is spent between commands. The dwell time can range from 0 seconds to 180 seconds. See "Setting Dwell Time" on page 155.

The Auto Sequence program will be cleared after AC power is turned off; however, a procedure exists for storing it in a text file which can be reloaded at a later date.

Setting Dwell Time

The dwell time is the amount of time that is delayed between each command during the execution of an Auto Sequence program. The dwell time can be from 0 to 180 seconds and can be changed during the program execution. The dwell time has a minimum step size of 1 second.

Command:

```
[ : ]PROGram[ <channel> ][ : STEP ]:DWELl { ? | <dwell time> }
```

Where:

<dwell time > is an integer value from 0 to 180.

For Example:

:PROG:DWEL 12 Results in 12 seconds of wait time after each command is executed.

Storing an Auto Sequence Program

Loading a program into memory is done by using the [:] PROGAm [<channel>] [: RECord] : START command. After the start command has been issued, the power supply will record all subsequent commands into the auto sequence program buffer. The commands will be recorded into the buffer until the

: PROGAm [<channel>] [: RECord] : STOP command is issued.

Commands:

```
[ : ]PROGAm[ <channel> ][ : RECord ]:START
```

```
[ : ]PROGAm[ <channel> ][ : RECord ]:STOP
```

Important: If the start recording command is executed then any previously stored Auto Sequence program is deleted.

For example:

```
:PROG:STAR
:VOLT 12
:OUTP ON
:PROG:DWEL 60
:OUTP OFF
:OUTP ON
:OUTP OFF
:PROG:DWEL 0
:PROG:STOP
```

This program will send a 12 V square wave with 120 seconds 50% duty cycle. When the program is finished, the dwell time is restored to 0 seconds.

Saving an Auto Sequence Program to File

The following procedure indicates how to save an Auto Sequence program to a text file on the attached PC.

To save an Auto Sequence Program to a file:

1. Start the text capture by selecting **Transfer>Capture Text ...** from the Hyper Terminal program.
2. Set the location and name of the auto sequence to be captured.
3. Click the Start button.
4. Execute a program read back by sending:
`:PROG[<channel>] :READ?`
5. Stop the text capture by selecting **Transfer>Capture Text>Stop** from the Hyper Terminal program.
6. Using any text editor ,open the file that you captured the Auto Sequence program to.
7. Remove the first line which should read “:PROG[<channel>]:READ?” and the first blank line. This makes the first line of the program the first line of the file.
8. Save the file and exit the text editor.

The Auto Sequence program has now been stored and can be sent to any unit. See “Reloading an Auto Sequence Program” on page 157 for details.

Readback and Troubleshooting an Auto Sequence Program

Since the Auto Sequence programming function records the commands at program time without verifying the syntax, it can be difficult to spot an error in the sequence, for example, if a typo was made when entering a command during the record phase. A readback command has been provided to output the stored auto sequence program currently in memory.

Another benefit to the readback command is it allows the auto sequence program to be captured and stored on the client side for reloading when the program is to persist beyond power cycles.

Command:

```
[ : ]PROGram[ <channel> ]:READback?
```

For Example:

```
:PROG:START  
*CLS  
:VOLT 5.4  
:CURR 0.25  
*IDN?  
:PROG:STOP  
:PROG:READ?
```

Response:

```
*CLS  
:VOLT 5.4  
:CURR 0.25  
*IDN?  
:PROG:STOP
```

Reloading an Auto Sequence Program

The following procedure will demonstrate how to store a command beyond a power cycle of the unit.

Important: This functionality is only available through USB, RS-232 and RS-485. It is not possible to reload an auto sequence program over the GPIB and Ethernet/LAN interfaces.

To reload Auto Sequence program from file:

1. Set the data rate of the device to be 1200 bps.
2. Close the connection to the hyperterminal program and configure the connection data rate to be 1200 bps.
3. Execute the program recording command:

```
:PROG:START
```

4. From the Hyper Terminal (or any other terminal program) select the **Transfer>Send Text File...**
5. Navigate to and select the text file that was previously stored. Click the Open button.
6. Execute the program recording stop command:
:PROG:STOP
7. Execute the readback command to verify the entire program was transferred correctly:
PROG:READ?
8. Set the data rate back to the original speed.
9. Close the connection to the HyperTerminal program and configure the connection data rate to be the original speed.

Running an Auto Sequence Program

Once an auto sequence program has been stored, there are a few commands that can be used to run the program. Once a program begins running, it will continue running until completion and then repeat the number of times specified by the repeat command. The default at power on is to have repeat set to 1.

Commands:

```
*TRG
[:]INITiate[<channel>][:IMMediate]
[:]PROGram[<channel>]:STATe {?|RUN|STOP|PAUSe}
```

Where:

RUN causes the program to begin execution.

STOP causes the program to stop execution

PAUSe causes the program to stop executing at the current command. If a subsequent run is sent, the program will resume executing with the next command in the program.

For Example:

```
:PROG:STAR
*IDN?
*IDN?
:PROG:STOP
:PROG:STAT RUN
```

The output after the last command might be as follows:

```
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
```

Important: Execution of the program may be terminated at any time by pressing the Esc key in the MS Windows Hyper Terminal window. The power supply can be controlled during program execution.

Deleting an Auto Sequence Program

It is possible to delete the current Auto Sequence Program using the SCPI noted below.

Command:

```
[:]PROGram[<channel>]:DELeTe[:ALL]
```


Repeating an Auto Sequence Program

An Auto Sequence Program can be configured to repeat any number of times or infinitely. The default at power up is to have the repeat count default to once. The program will repeat if the repeat count can be changed using the :PROG: [<channel>] : REPEAT command. If a program is running or pause the :PROG: [<channel>] : REPEAT command will not work.

Commands:

```
[ : ]PROG: [ <channel> ] : REPEAT { ? | <count> | INFINITY }
```

Where:

<count> is the repeated count from 1 to 65 534.

INFINITY is the character mnemonic for repeating without end.

For Example:

```
:PROG:STAR
*IDN?
*IDN?
:PROG:STOP:PROG:REP 2
:PROG:STAT RUN
```

The output after the last command might be as follows:

```
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
KEITHLEY INST.,2268-33-25, 1352A00499, 1.00,09/10/14
```

CONFIGURE OTHER PROTECTION MECHANISMS

Foldback Protection

Foldback protection causes the output of the power supply to shut down if the selected regulation mode is entered and the configured delay time expires. A delay time may be specified as well. The only way to clear foldback is by pressing the rotary Adjust/Enter control for 3 seconds and executing the Clear command.

Command:

```
[ : ]OUTPut[ <channel> ]:PROTection:CLEar
```

Setting the Foldback Mode

The following command will set the foldback mode. The mode selected by the character mnemonic sent will indicate which mode will trigger the foldback alarm to begin counting. For example, if the command is sent with the CV mnemonic and the output is enabled with no load attached (open circuit), the unit will operate in constant voltage mode and the foldback counter will begin counting. If the CC mode was set and the output was enabled with no load connected, the unit will operate in CV mode and the foldback counter will not trigger.

To set the foldback mode, send the command:

Command:

```
[ : ]OUTPut[ <channel> ]:PROTection:FOLDback { ? | CC | CV | NONE }
```

Where:

NONE indicates foldback protection is disabled.

CC indicates the supply will shut down due to constant current condition.

CV indicates the supply will shut down due to constant voltage.

The default value is NONE.

To set the foldback delay, send the command:

Command:

```
[ : ]OUTPut[ <channel> ]:PROTection:FOLDback:DElay <delay_time>
```

Where:

<delay_time> is a value in the range of 0.5-50 seconds. The unit of second is the default and no units should be used with this parameter. (Increments of 0.1 seconds are allowed.). The default value is 0.5 seconds.

Over Temperature Protection

The over temperature protection (OTP) is the alarm that protects the unit in case of ventilation blockage, fan failure, or some other event that causes the unit to overheat. The OTP cannot be masked to disable it. The OTP alarm can have its output latch on clearing. See “Alarm Output Latching” on page 48.

The SCPI command (s) for these instructions are:

```
[ : ]SYSTem[ <channel(s)> ]:PROTection:LATCh
```

The On setting shown by the front panel (“Using Over Temperature Protection Lock (OTP)” on page 52), maps to having the OTP latch flag set. The OFF setting maps to having the OTP latch flag cleared. The default is to have the flag cleared.

Loop Protection Enable/Disable

The Loop Protection is described in “Loop Protection” on page 54. Enabling Loop Protection (LOOP PRO on front panel) will allow the Loop Protection feature to trigger based on the conditions described in “Loop Protection”, page 54. This feature can be controlled by either front panel operation or SCPI command as shown below. The default value of Loop Protection is set to Disabled.

Important: While Loop Protection is enabled (set to ON), the external shutdown function will be automatically set to low active. When Loop Protection is disabled (set to OFF), the external shutdown function will be set to the user’s last setting.

Commands:

```
[ : ]OUTPut [ <channel> ]:PROTection:LOOP{ ? | ON | OFF }
```

Where

ON enables the use of Loop protection. Returns 1.

OFF disables the use of Loop protection. Returns 0.

Interlock Enable/Disable

The Interlock feature is explained in “Interlock Function” on page 56. Use the command below to enable and disable interlock. Enabling interlock will allow the interlock feature to trigger based on the conditions described in “Interlock Function” on page 56. This feature can only be controlled using a SCPI command as there is no front panel equivalent. The default value of the interlock is set to Disabled.

Important: The Interlock alarm cannot be masked or latched through the alarm protection mechanisms. It can only be enabled or disabled using the following command.

Commands:

```
[ : ]SENSe [ <channel> ]:PROTection:INTeRlock [ : STATE ] { ? | ON | OFF }
```

Where

ON enables the use of interlock protection.

OFF disables the use of interlock protection.

SAVE AND RECALL

The save and recall of user settings can be done using commands as well as at the front panel. Executing the save and recall commands will have the same outcome as following the procedure outlined in “Saving User Setting Memory Locations” on page 59 and “Recalling User Setting Memory Locations” on page 60.

Commands:

```
[ : ]SYSTem[ <channel> ]:SAVE { <user settings slot> }
[ : ]SYSTem[ <channel> ]:RECall { <user settings slot> }
```

Where:

<user settings slot> is any integer between 1 and 3. The value corresponds to the setting to be operated on.

SET ANALOG PROGRAMMING LEVEL

Setting the analog programming level is used to define the range from 0 to the level that will be input into the analog programming lines to control the output. The command is equivalent to the procedure described in “Analog Programming Mode” on page 76.

Commands:

```
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel [ :VOLTage] [ :ISOLated]
{ ? | <level> }
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel [ :VOLTage] { ? | <level> }
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel
:CURRent [ :ISOLated] { ? | <level> }
[ : ]SYSTem[ <channel> ]:COMMunicate:APROgram:LEVel
:CURRent { ? | <level> }
```

Where:

<level> is the maximum voltage or resistance that will be input to the analog inputs. The acceptable range is from 2 to 10 V and 2 to 10kΩ.

SET REMOTE PROGRAMMING INTERFACE

The remote source can be select using the following SCPI commands. These commands are equivalent to the procedure on “Voltage-Controlled Voltage APG Setup” on page 77 and “Voltage-Controlled Current APG Setup” on page 79.

Commands:

```
[ : ]SYSTem[ <channel> ]:REMote:SOURce [ :VOLTage]
{ ? | LOCAL | AVOLTage | ARESistive }
[ : ]SYSTem[ <channel> ]:REMote:SOURce:CURRent
{ ? | LOCAL | AVOLTage | ARESistive }
```

Where:

LOCAL indicates the value is controlled by the set point.

AVOLTage is used to set the output to be controlled by an analog voltage input.

ARESistive is used to set the output to be controlled by a resistor circuit.

IAVoltage is used to set the output to be controlled by the isolated analog voltage input.

IAResistive is used to set the output to be controlled by the isolated analog resistor circuit.

PROTECTION MASK (ENABLE ALARMS)

The protection mask allows for the different alarms to be masked, completely disabling them. This means that the SCPI status and operations registers will not detect the alarms. You will have no way of knowing the current operation state of the alarm. The protection mask is a feature that is only accessible using the SCPI command noted below.

Command:

```
[ : ]SYSTem[ <channel> ]:PROTection[:MASK] { ? | <mask> }
```

Where:

<mask> is the bit mask for disabling the alarms. See below for details.

Alarms Bit Mask

| Bit | Bit Weight | Bit Name | Description |
|-----|------------|-----------|---------------------------|
| 0 | 1 | AC Fail | Not used. Always 1. |
| 1 | 2 | OTP | Not used. Always 1. |
| 2 | 4 | Not used | |
| 3 | 8 | Fan Stop | Fan on the main board. |
| 4 | 16 | Not used | |
| 5 | 32 | Interlock | Not used. Always 1. |
| 6 | 64 | OVP | Not used. Always 1. |
| 7 | 128 | OCP | Not used. Always 1. |
| 8 | 256 | Foldback | Foldback protection. |
| 9 | 512 | Shutdown | External Shutdown pin |
| 10 | 1024 | UVP | Under Voltage protection. |

See “Alarms and Errors” on page 44.

LAN/Ethernet Setup and Communication

In this section:

This section describes the remote operation of the power supply via the communication ports.

INTRODUCTION

This section contains setup and programming information for remote control of the 2268 Series power supply through a LAN/Ethernet connection. The information presented here will guide you in making the connections necessary to control your power supply remotely.

SETTING UP LAN/ETHERNET

This section is intended for network administrators responsible for the configuration and maintenance of devices on the network.

BASICS

Communication Cable Requirements

Use a standard RJ-45 or RJ-45 crossover Ethernet cable.

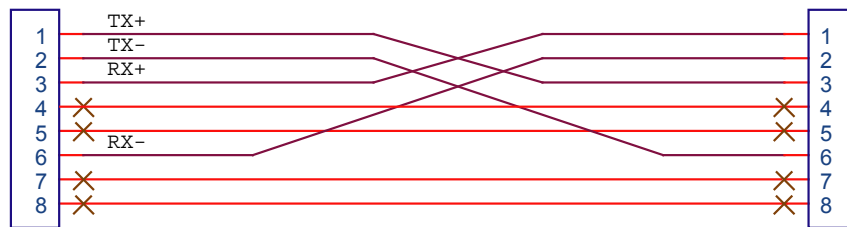
Figure 59: RJ-45 Plug



Description of Pins on RJ-45 Plug

| Pin# | Name | Description |
|------|------|-----------------|
| 1 | TX+ | Transmit data + |
| 2 | TX- | Transmit data - |
| 3 | RX+ | Receive data + |
| 4 | Gnd | Ground |
| 5 | Gnd | Ground |
| 6 | RX- | Receive data - |
| 7 | Gnd | Ground |
| 8 | Gnd | Ground |

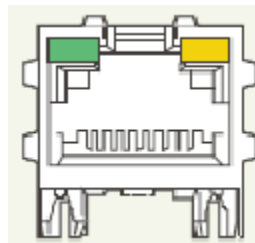
Figure 60: Scheme of crossover Ethernet cable



ENET Connector

The ENET connector is located on the rear panel of the power supply. See Figure 61. At the top left corner is the link LED, and at the top right corner of the connector is the activity LED. See the table that follows for a description of their colors and what each indicates.

Figure 61: ENET Connector and LEDs



ENET Connector LEDs

The device contains two bi-color LEDs built into the front of the ENET connector. See Figure 61.

| LED | Color | Description |
|---------------------------|-------|-------------|
| Link LED (Left side) | Off | No link |
| | Amber | 10 Mbps |
| | Green | 100 Mbps |
| Activity LED (Right side) | Off | No activity |
| | Amber | Half-duplex |
| | Green | Full-duplex |

LOCAL AREA NETWORK (LAN)

The ENET/LAN interface, which operates with auto detection, only supports 100Base-T.

Using LAN allows remote communication with the instrument; it is fast, simple and the LAN from your PC does not require any additional proprietary software or cards.

Media Access Control (MAC) Address

The Ethernet/LAN interface of the power source has a unique network address known as the MAC address, a unique hexadecimal address, which is listed on a rear panel label of the power source. To operate the power source on a network, this MAC address needs to be assigned to a TCP/IP address, which will be used to address the device on the network.

Communication Configuration

Presented here are three connection choices for remote control of the instrument:

- through a local area network (LAN)
- direct to a PC
- through a private network

Each requires an IP address; the LAN also requires a Gateway address. The addresses can be set automatically through a Dynamic Host Configuration Protocol (DHCP) server or set manually with a static IP address.

LAN Connection

Connect the instrument directly to a network Ethernet port with an Ethernet cable, and allow the DHCP server to automatically assign a dynamic IP and Gateway address. If DHCP is not enabled, see the section on “Setting LAN Parameters” on page 173 or contact your network administrator.

Factory Default LAN Settings

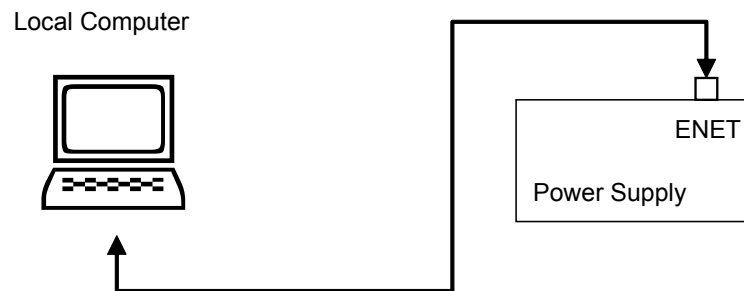
| Parameter | Setting |
|-------------|---------------------------|
| User Name | admin |
| Password | Admin |
| Description | DC Power Supply |
| TCP Port | 5025 |
| Class | 16 |
| IP Address | 0.0.0.0 (i.e., DHCP mode) |

Direct-to-PC Connection

Connect the instrument directly to a PC Ethernet port with a crossover Ethernet cable (similar to a standard Ethernet cable but wired differently to enable direct connection rather than through a network). Next, establish an IP address for the instrument. You can assign a static IP address by using the same address as the PC that the instrument is connected to. To find the PC’s IP address, use the “ipconfig.exe” command in the section on Private Network Connection next.

Figure 62 shows the connection between the ENET unit and Local Computer through a crossover Ethernet cable.

Figure 62: Single Computer, Single Power Supply



Private Network Connection

A private network has no DHCP server; therefore, the instrument would be connected to a Windows PC with a crossover Ethernet cable, and manually assigned a static IP address matching that of the PC. The available IP address range assigned by the Internet Assigned Network Authority (IANA) for Automatic Private IP Addressing (APIPA) is 169.254.0.0 to 169.254.255.255.

When setting up a private network, you will have to log off and disconnect first from any network connection and re-log in to Windows.

To check the PC's IP address, run the "ipconfig.exe" program from the command prompt. The screen on a private network should look as follows:

```
Microsoft(R) Windows DOS
(C)Copyright Microsoft Corp 1990-2001.

C:\>ipconfig

Windows IP Configuration

Ethernet adapter Local Area Connection:

    Connection-specific DNS Suffix  . :
    IP Address. . . . . : 169.254.0.208
    Subnet Mask . . . . . : 255.255.0.0
    Default Gateway . . . . . :
```

To determine what IP address to use, use the first 2 octets (in the above case "169.254") of the PC's IP address and set a unique value for the third and fourth octet as long as there are no conflicts with any other IP addresses (other instruments) on the same private network. In this example, 169.254.0.209 would work.

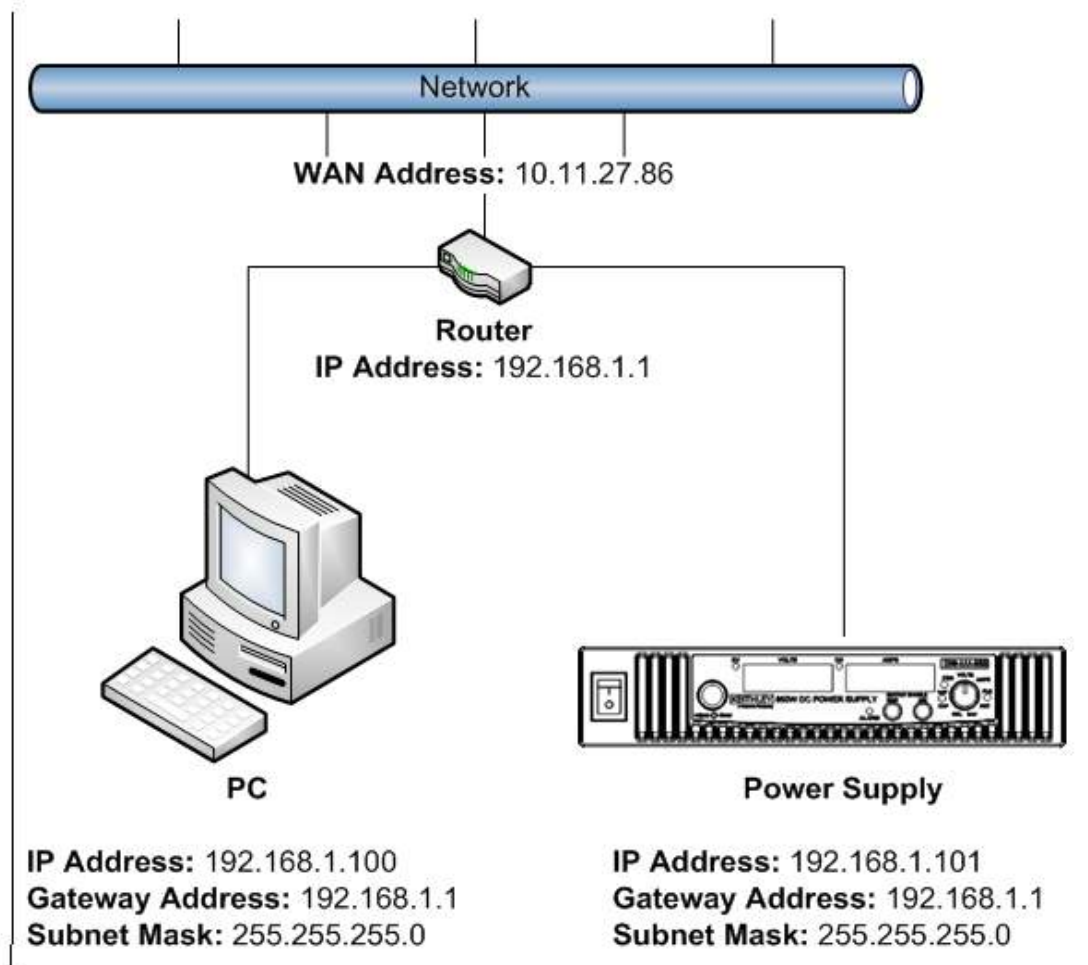
Note: For private network configurations, no Gateway address is required. (0.0.0.0)

CONNECTING TO A NETWORK

There are two basic situations to deal with in communicating with the power supply from a PC. They depend on whether or not the PC is on the same side of a router as the power supply.

Connecting with PC on Same Side of Router as Power Supply

Figure 63: PC on Same Side of Router as Power Supply



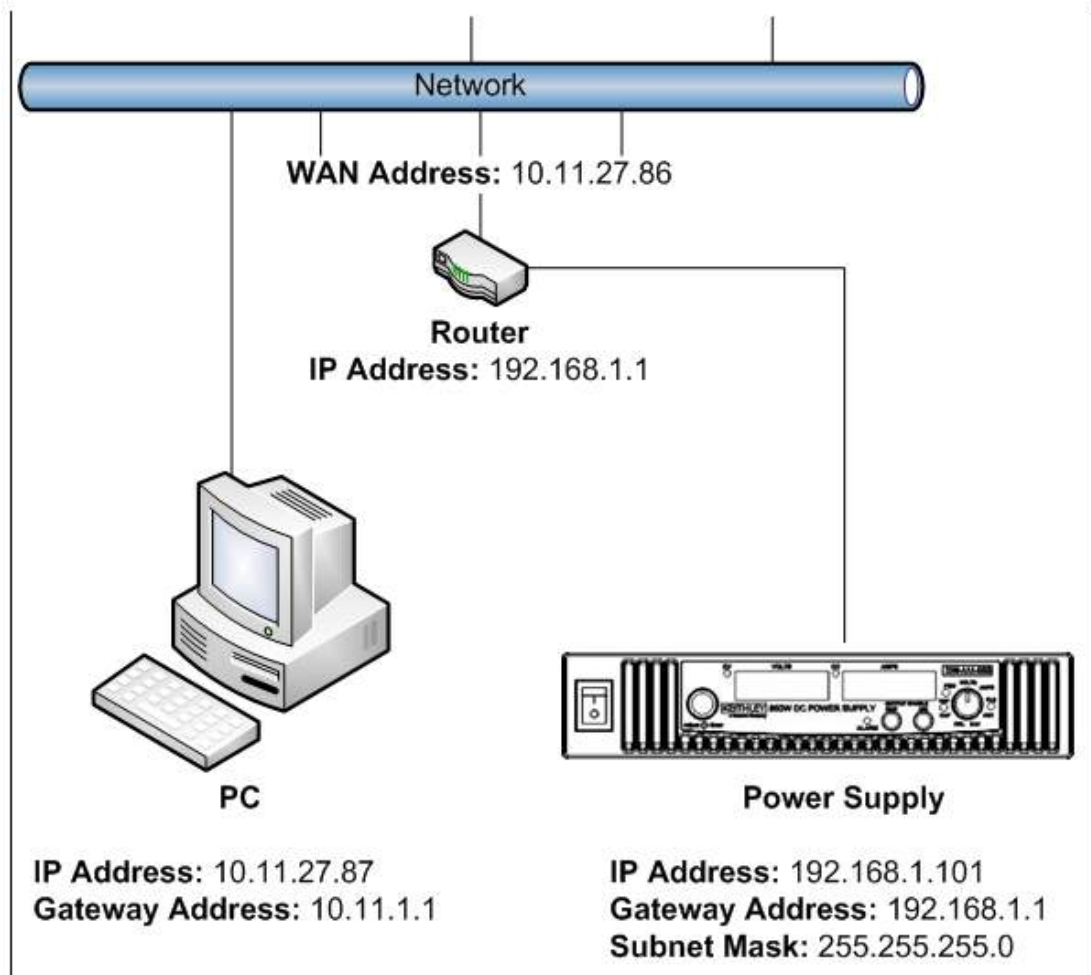
The simplest case is when they are both on the same side as in Figure 63. In this example the router has assigned addresses to the power supply (192.168.1.101) and to the PC (192.168.1.100) using DHCP. To connect to the power supply by a Web browser, simply enter the power supply's router-assigned address of "192.168.1.101" into the Web browser's address bar. This will open up the power supply's Home page.

Please note that the Web page may require Java to be installed on the Web browser for it to display properly. Java can be installed from the [Java website](#).

Connecting with Power Supply Hidden Behind a Router

It is more difficult to communicate with the power supply when it is “hidden” from the PC by a router. An example of such a situation is in Figure 64. In this case the PC cannot “see” the power supply. Instead it only sees the router at its address of 10.11.27.86 (this address is given as an example only.)

Figure 64: Power Supply Hidden Behind a Router



In order to send messages from the PC to the power supply, it is necessary to instruct the router to perform **port forwarding**. This will instruct the router to forward messages it sees on a certain port to another address. In this case the other address will be the power supply's address. This example will show how to perform port forwarding for a Linksys router.

Consult your router's documentation if you have a different router model.

Connect to your router's home page. If you have a PC connected on the same side of the router as the power supply, then you can usually do this by pointing your Web browser to the address of "192.168.1.1". (Most Linksys routers use this address for the router.) You should get a home page similar to the following:

Figure 65: Router Home Page

LINKSYS
A Division of Cisco Systems, Inc. Firmware Version: 1.02.15

WRT54GX

Setup

Setup | Wireless | Security | Access Restrictions | Applications & Gaming | Administration | Status

Basic Setup | DDNS | MAC Address Clone | Advanced Routing

Internet Setup

Internet Connection Type: Automatic Configuration - DHCP

Optional Settings (required by some ISPs)

Router Name: WRT54GX

Host Name:

Domain Name:

MTU: Auto

Size: 1500

Network Setup

Router IP

Local IP Address: 192 . 168 . 1 . 1

Subnet Mask: 255 . 255 . 255 . 0

Network Address Server Settings (DHCP)

DHCP Server: Enable Disable

Starting IP Address: 192.168.1.100

Maximum Number of DHCP Users: 50

Client Lease Time: 0 minutes (0 means one day)

IP Address Range: 192.168.1.100 ~ 192.168.1.149

Static DNS 1: 0 . 0 . 0 . 0

Static DNS 2: 0 . 0 . 0 . 0

Time Setting

Time Zone: (GMT-08:00) Pacific Time (USA & Canada)

Automatically adjust clock for daylight saving changes

Automatic Configuration - DHCP: This setting is most commonly used by Cable operators.

Host Name: Enter the host name provided by your ISP.

Domain Name: Enter the domain name provided by your ISP.

More...

Local IP Address: This is the address of the router.

Subnet Mask: This is the subnet mask of the router.

DHCP Server: Allows the router to manage your IP addresses.

Starting IP Address: The address you would like to start with.

Maximum number of DHCP Users: You may limit the number of addresses your router hands out.

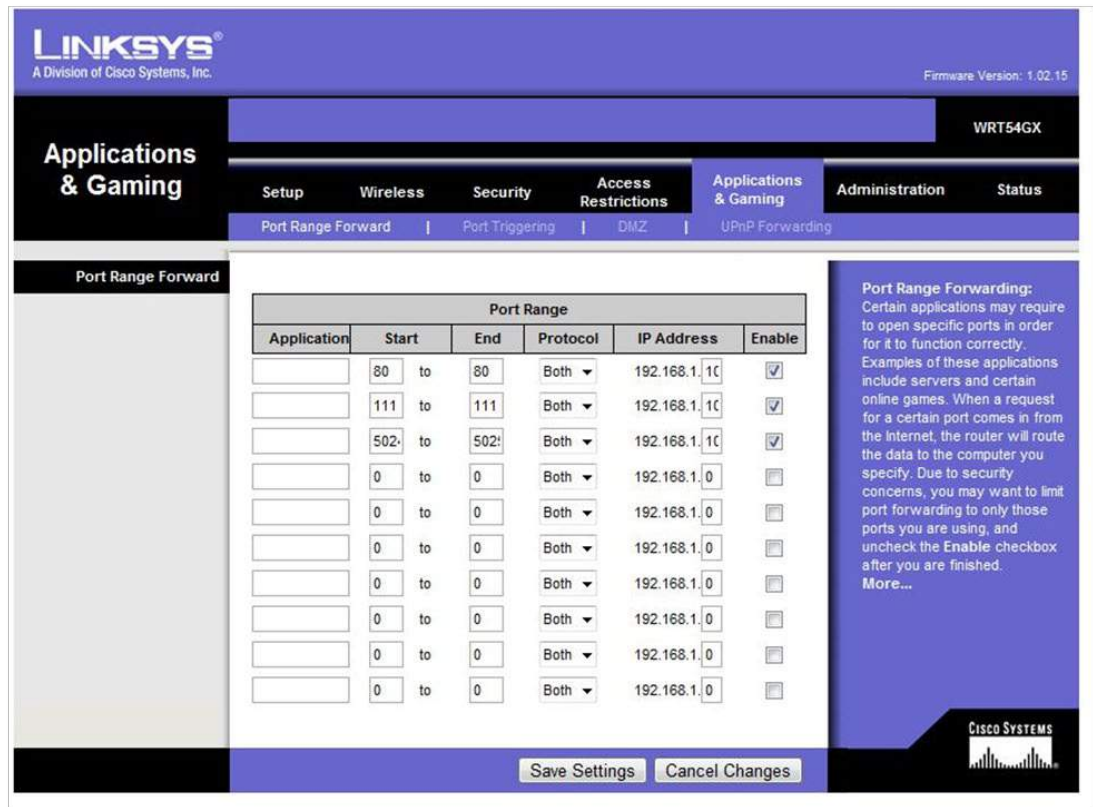
More...

Time Setting: You may choose Automatically if you wish to use a NTP server to keep the most accurate time.

More...

Look for a tab that will take you to a location for port forwarding. In this case, it is the tab for **Application & Gaming**. Forward messages on ports 80, 111, 5024, and 5025 to the power supply's address (in this case it is 192.168.1.101). When finished, the page should look similar to Figure 66. Click the **Save Settings** button when complete.

Figure 66: Port Forwarding



Looking at the **Status** tab, you should be able to find the router’s address. Now you should be able to connect to the power supply from the original PC (the one not behind the router) using the router’s address.

Socket Port Number

Now that a connection has been verified, you can develop your application code. If you are using one of the Microsoft environments, the Winsock protocol, which is part of the Windows operating system, can be used. Similar capabilities are supported on other operating systems.

To use Winsock, you will have to specify the port number of the power source’s LAN interface. The port number determines the protocol for the communication. The power source uses ASCII characters and instrument SCPI commands for remote control. The IANA registered Port number for the Instrument SCPI interface is 5025.

TCP Remote port = 5025

The socket number can be changed on the power source using the `SYST:COMM:LAN:PORT` command. Refer to the **SYSTEM COMMANDS** section that follows.

Instrument Drivers and Application Software

Instrument drivers for National Instruments LabWindows/CVI and LabView are generally available for download from the Keithley Instruments Support website (www.keithley.com/support).

LXI DISCOVERY BROWSER SOFTWARE

You can use the LXI Discovery Browser to identify the IP addresses of the Series 2268 instruments.

Once identified, you can double-click the IP address in the LXI Discovery Browser to open the web interface for the instrument.

The Keithley LXI Discovery Browser is available on the Keithley Instruments website (<http://www.keithley.com>).

To locate the Keithley LXI Discovery Browser on the Keithley website:

1. Select the Support tab.
2. In the model number box, type 2268.
3. From the list, select Software and click the search icon. A list of software applications for the instrument is displayed.
4. See the readme file included with the application for more information.

To run the LXI Discovery Browser software:

1. From the Microsoft Windows Start menu, select Keithley Instruments.
2. Select LXI Discovery Browser.
3. Click LXI Discovery Browser. The Keithley LXI Discovery Browser window is displayed. The LXI Discovery Browser displays the instruments that it finds on the network and their associated IP addresses.
4. Double-click an IP address in the LXI Discovery Browser dialog box. The instrument web page for that instrument opens.

SETTING LAN PARAMETERS

There are two ways to set the required LAN information on the power source: through the serial or USB port, or through the Web interface.

Setting LAN Parameters via Serial or USB Port

Set the parameters using SCPI commands; refer to the section on “Remote Operation” on page 101.

Refer to the table in the next section for step by step details.

Setting LAN Parameters via Web Interface

To reach the Web page interface, follow the instructions in the section on “Connecting to a Network” on page 169. Click on the Configuration tab to get to the Login page.

By default the user name and password are both “admin”. Entering admin in both fields will bring up the IP Address Configuration page from where the various LAN parameters can be set.

The following table provides a list of the LAN parameters and their descriptions.

| LAN Parameter | Description |
|---------------|--|
| IP Address | <p>Use the SYST:COMM:LAN:ADDR command from a terminal to change the address</p> <p>To set a fixed IP address (i.e. 192.168.1.100) enter SYST:COMM:LAN:ADDR “192.168.1.100”</p> <p>Note that the IP address is placed in quotes.</p> <p>To set the unit for DHCP mode enter SYST:COMM:LAN:ADDR “0.0.0.0”</p> <p>Note that this setting will not be made until either the power is cycled or the SYST:COMM:LAN:APPL command is entered.</p> |
| MAC Address | <p>This is the Media Access Control address. It is a 16 digit hexadecimal value. This number is unique to each device and may not be changed by the user. It is visible as a serial tag which is placed on the rear of the unit.</p> <p>The MAC address may be displayed with the query command, SYST:COMM:LAN:MACA?</p> <p>Note: If the MAC Address displayed is corrupted or does not match the serial tag, there may have been a problem retrieving the LAN port settings. This can happen if a static IP was set that conflicts with another device on the network. To recover, turn on power to the unit while holding down the SET key. This will allow the unit to boot without attempting to collect the IP settings. You can then set the required IP values. [See IP Address above].</p> |
| GWAddress | <p>Gateway address setting. A default gateway is a node (a router) on a computer network that serves as an access point to another network.</p> <p>Note: If the power supply is connected to a router that does not have a gateway (i.e. the uplink port is not connected on the router) then a random IP address will appear on the gateway when it is queried.</p> <p>This value can be changed by using the command, SYST:COMM:LAN:GWAD <address></p> <p>For example to set the gateway address to 192.168.1.1, use the command SYST:COMM:LAN:GWAD “192.168.1.1”</p> <p>Any change to this value will NOT take effect until after power to the unit has been cycled.</p> |

| LAN Parameter | Description | | | | | | | | |
|--------------------------|---|--------------------------|--|---------------|----|-------------|----|-----------|---|
| Host Bits | <p>Number of host bits as opposed to network bits in network mask. A CIDR class C network uses 24 network bits and 8 host bits. (Class A = 24, Class B = 16). This value can be changed with the command, SYST:COMM:LAN:CLASS <number></p> <p>As an example, to set to Class A, the command would be SYST:COMM:LAN:CLASS 24</p> <p>Note that many systems refer to an alternate description referred to as the subnet mask. Some conversions from subnet mask to class are:</p> <table border="0" data-bbox="716 621 951 772"> <tr> <td colspan="2"><u>Subnet Mask Class</u></td> </tr> <tr> <td>255.255.255.0</td> <td>24</td> </tr> <tr> <td>255.255.0.0</td> <td>16</td> </tr> <tr> <td>255.0.0.0</td> <td>8</td> </tr> </table> <p>Any change to this value will NOT take effect until after power on the unit has been cycled.</p> | <u>Subnet Mask Class</u> | | 255.255.255.0 | 24 | 255.255.0.0 | 16 | 255.0.0.0 | 8 |
| <u>Subnet Mask Class</u> | | | | | | | | | |
| 255.255.255.0 | 24 | | | | | | | | |
| 255.255.0.0 | 16 | | | | | | | | |
| 255.0.0.0 | 8 | | | | | | | | |
| Port No | <p>TCP remote port number. This value must be set to 5025 (SCPI) to support the built in Web page.</p> <p>This value can be changed with the port number command: SYST:COMM:LAN:PORT <number></p> <p>For example to set the TCP port to 5025, the command would be SYST:COMM:LAN:PORT 5025</p> <p>Any change to this value will NOT take effect until after power on the unit has been cycled.</p> | | | | | | | | |
| LAN Default | <p>Factory default settings for LAN are entered by setting the right knob to the PGM location, and then selecting LAN with the left knob and pressing and holding it until the "LAN R5t" message appears on the front panel. The IP address is set to DHCP or AUTO IP.</p> <p>Alternatively, the LAN may be reset with the SCPI command, SYST:COMM:LAN:DEF</p> | | | | | | | | |

Once you have an IP address, you can test the IP address from your Windows PC by using the ping utility under MS DOS. To use the ping utility, bring up a DOS window using the start menu:

Start>Programs>Accessories>Command Prompt

At the command prompt type:

ping <IP address>

This will send an IP ping request to the power source. For this to work, the power source must be turned on and connected to the same network as the PC. Also, the power source interface configuration must be set to use a baud rate of 460,800. If the IP address is found, it will look like this:

```
Microsoft(R) Windows DOS
(C)Copyright Microsoft Corp 1990-2001.

C:\>ping 100.10.1.63

Pinging 100.10.1.63 with 32 bytes of data:

Reply from 100.10.1.63: bytes=32 time<1ms TTL=64
Reply from 100.10.1.63: bytes=32 time<1ms TTL=64
Reply from 100.10.1.63: bytes=32 time<1ms TTL=64
Reply from 100.10.1.63: bytes=32 time<1ms TTL=64

Ping statistics for 100.10.1.63:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milliseconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

SETTING A STATIC IP ADDRESS THROUGH ETHERNET, USB, AND SERIAL INTERFACES

Ethernet

Locate the power supply and determine the IP address (see “LXI Discovery Browser Software” on page 173). This address will be entered into the **Host** field of the Ethernet Test Utility. The **Port** field should be set to the default of 5025.

If the power supply initially appears in DHCP mode, it would respond to the query, **SYST:COMM:LAN:ADDR?**, with “0.0.0.0”

To set a static IP address, use the following command, **SYST:COMM:LAN:ADDR “N”** where *N* will be the IP address of your choice. Query the command **SYST:COMM:LAN:ADDR?** to verify the static IP address has been set.

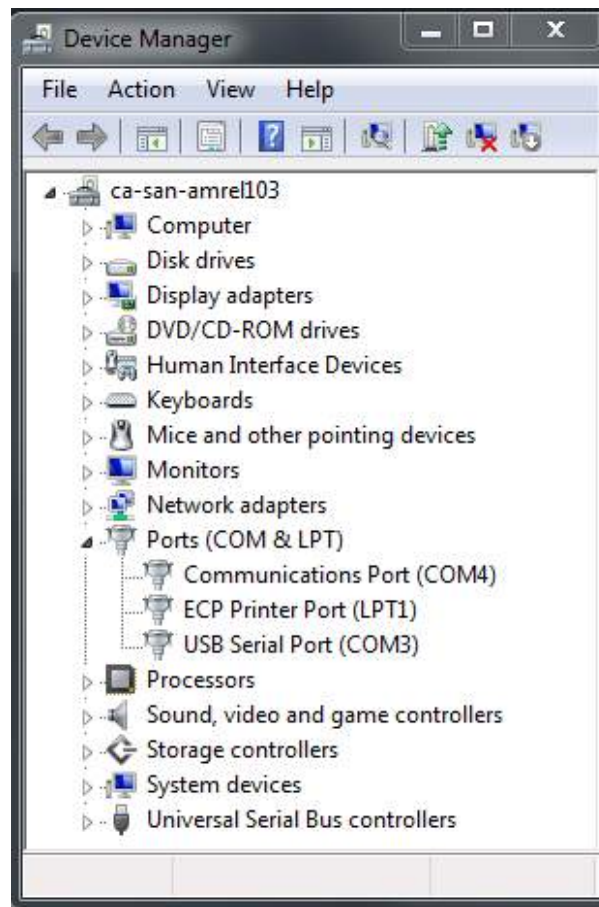
Following these steps the static IP address is now set.

USB

Before communicating through the USB interface, you will need to follow the directions for “Setting Up the PC to Use the USB Connection” on page 108. Once you’ve done that and you have a USB connection from the power supply to a PC, verify the port # through the Device Manager.

From the front panel controls, verify the communication port is set to USB and the desired address # (1-31).

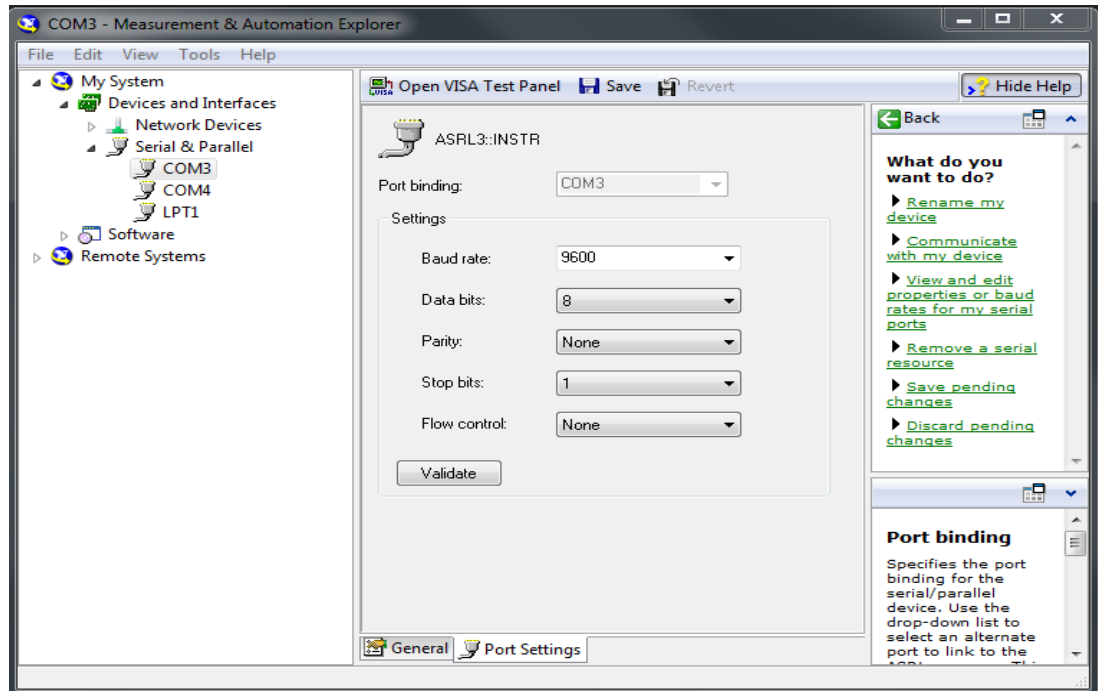
Figure 67: Device Manager Interface



To communicate with the power supply, use the program, National Instruments Measurement and Automation Explorer (NI MAX). You can download the program from <http://www.ni.com>.

Important: This section uses the National Instruments™ MAX program to communicate with the power supply. This is for demonstration purposes only. Any software that is capable of addressing a serial device and sending and receiving text could be used in its place.

Figure 68: NI Measurement & Automation Explorer Interface



Boot up NI MAX and click the **Serial & Parallel** section. You should be able to see the port # from which you referenced the Device Manager earlier. Verify the settings are the same as above and click **Open VISA Test Panel**.

Figure 69: Serial Settings

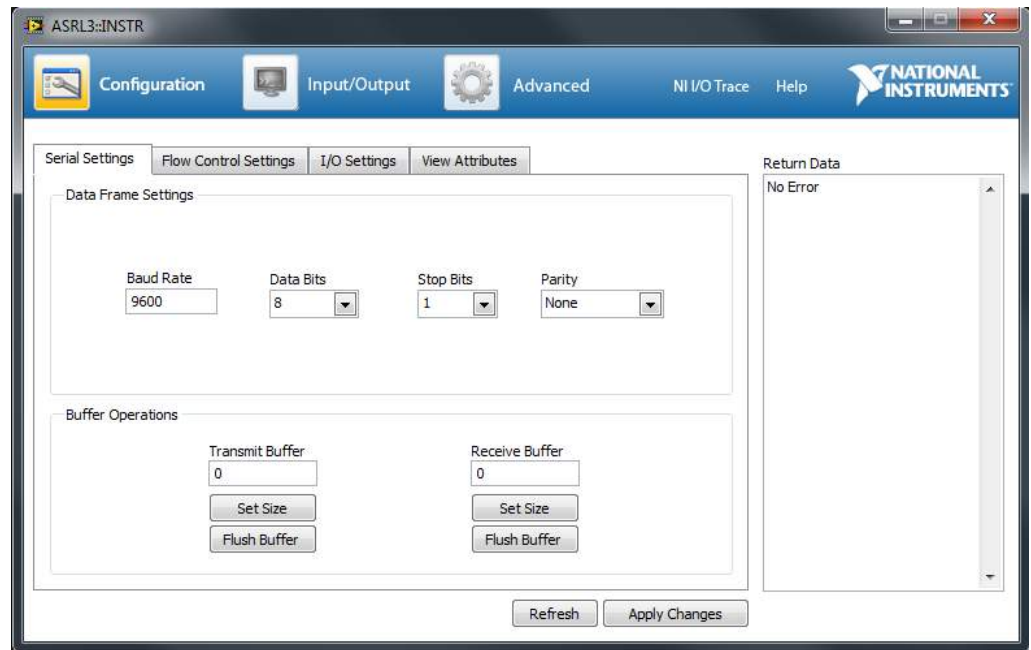


Figure 70: Flow Control Settings

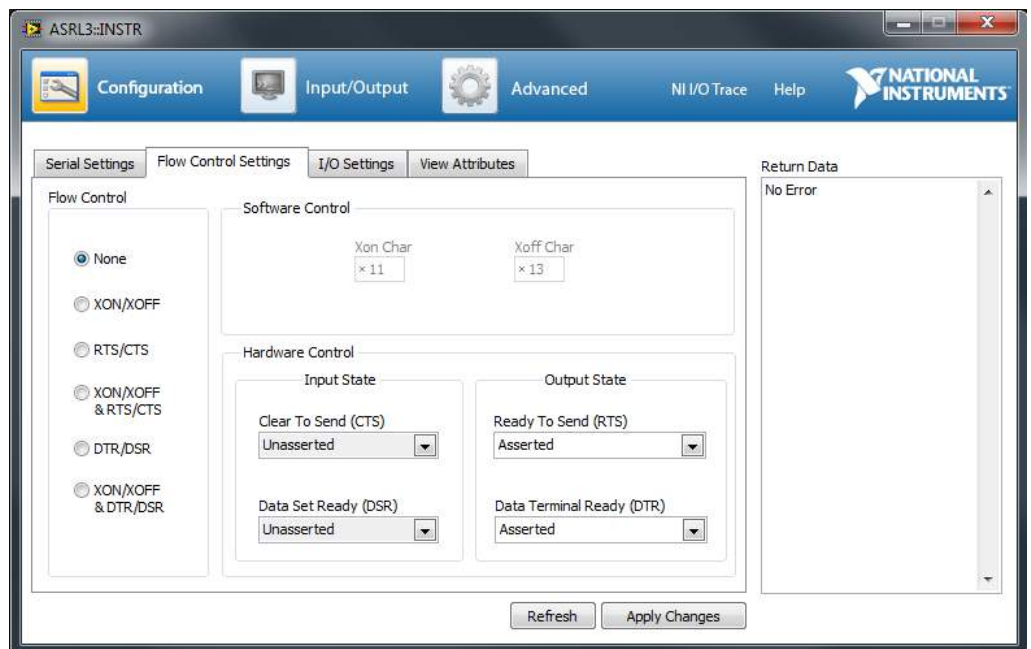
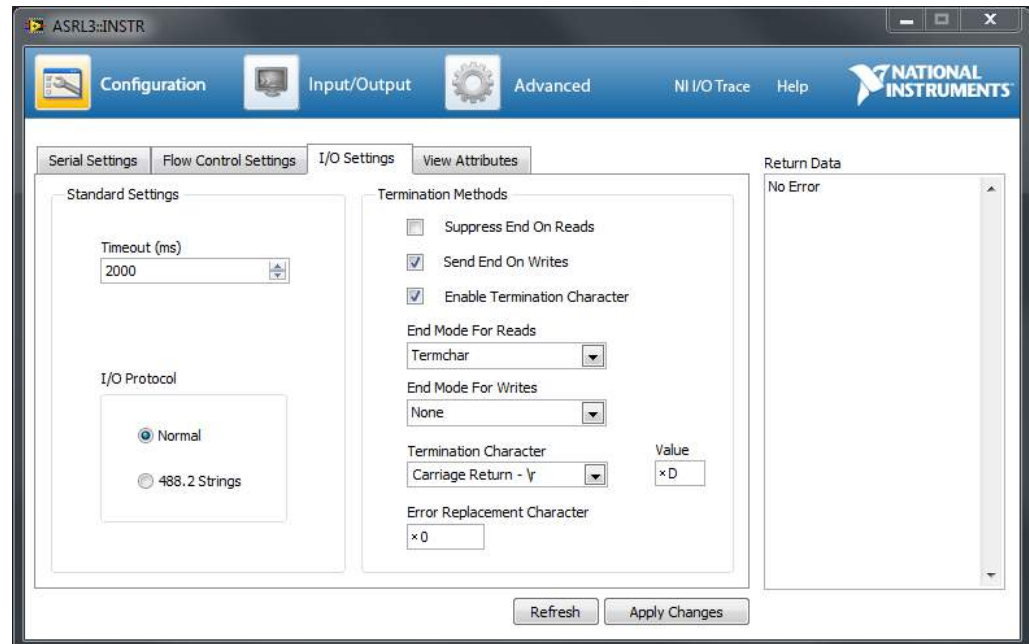


Figure 71: I/O Settings

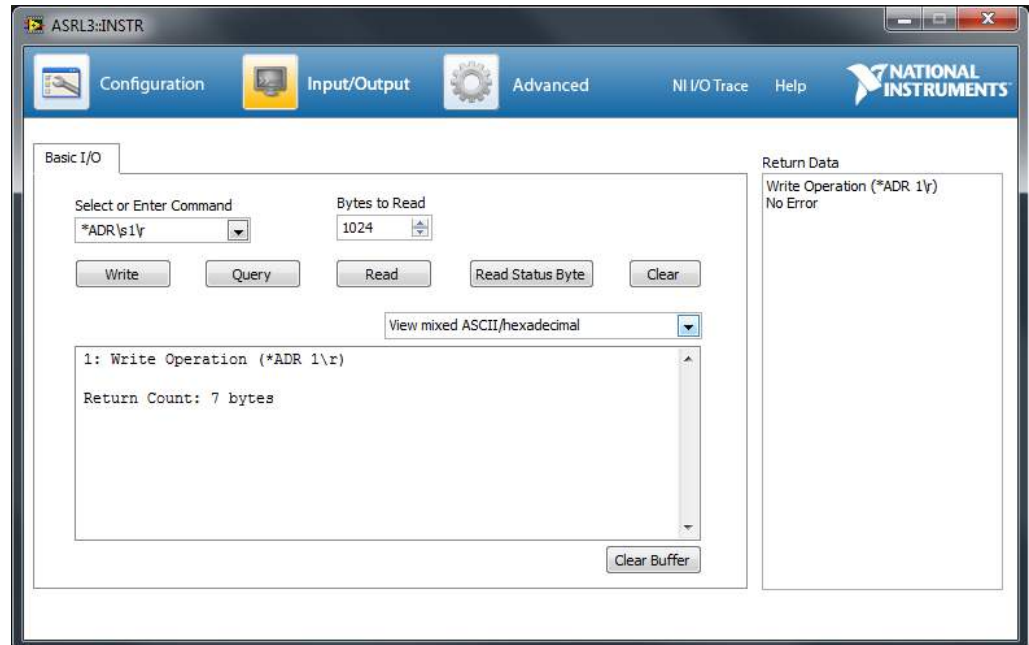


The Configuration for Serial Settings and Flow Control Settings should be the same as the above figures. In the I/O settings, check the Enable Termination Character and choose *Carriage Return - \r* in the drop down menu for Termination Character. Click Apply Changes.

Click **Input/Output** to begin communicating with the unit.

Verify after every command sent that you are also using the correct termination character which in this case is `\r`.

Figure 72: Verifying Correct Termination Character

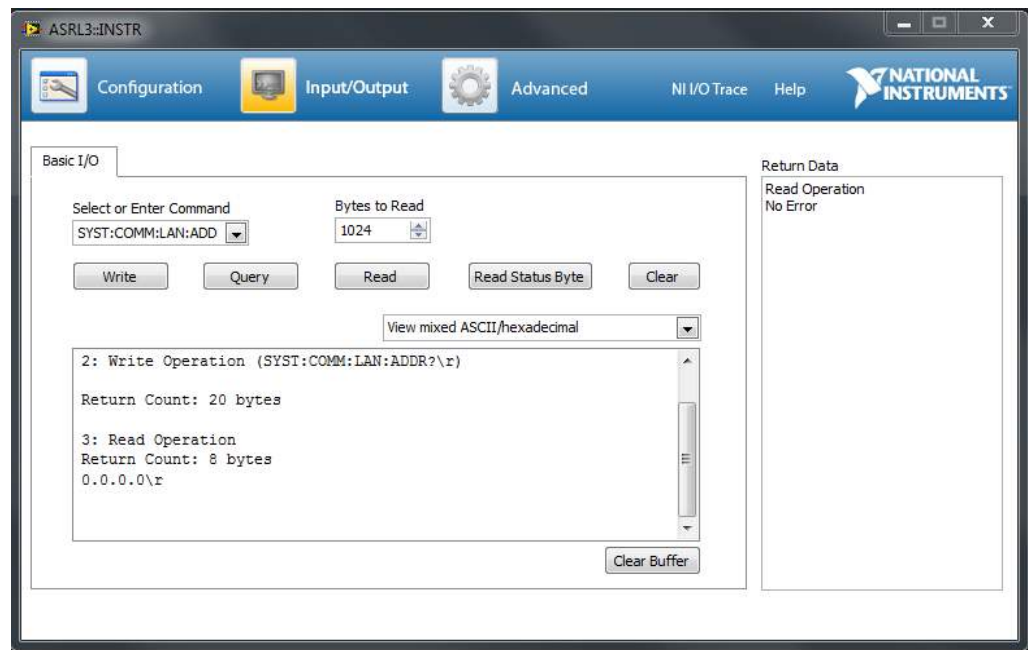


Before starting communicating with the power supply, you need to first set the address from what you set the unit to via front panel controls using the command `*ADR N` where N is the address #. For example, if the unit address was set to 1, send the command `*ADR 1`.

Then send an identification query to the unit using `*IDN?` to verify communication. Your response should be the identification string of the unit.

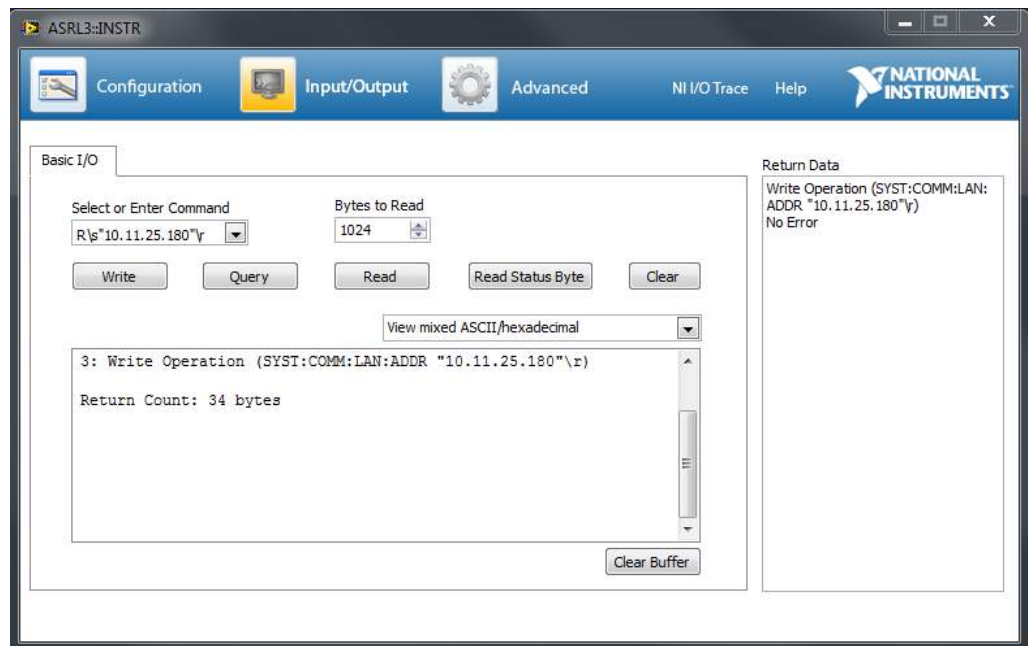
To verify the IP address of the power supply, send the command query **SYST:COMM:LAN:ADDR?**

Figure 73: Verifying IP Address of Power Supply



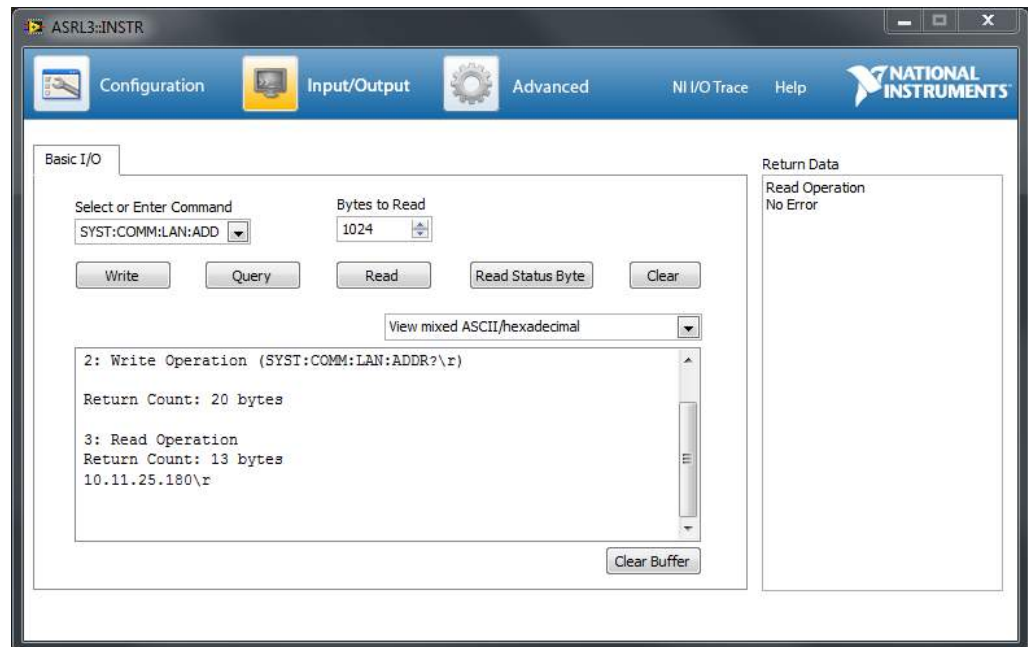
If the response to that query is “0.0.0.0”, that means the unit is in DHCP mode and it received that address from a DHCP server that provided it.

Figure 74: Setting a Static IP Address



To set a Static IP Address, use the command **SYST:COMM:LAN:ADDR “N”** where *N* is the desired IP address you want to set.

Figure 75: Verifying the Static IP Address was Set



To verify that the IP address was set, query the address using **SYST:COMM:LAN:ADDR?** and the response to your query should be the IP address you had set.

The static IP address is now set.

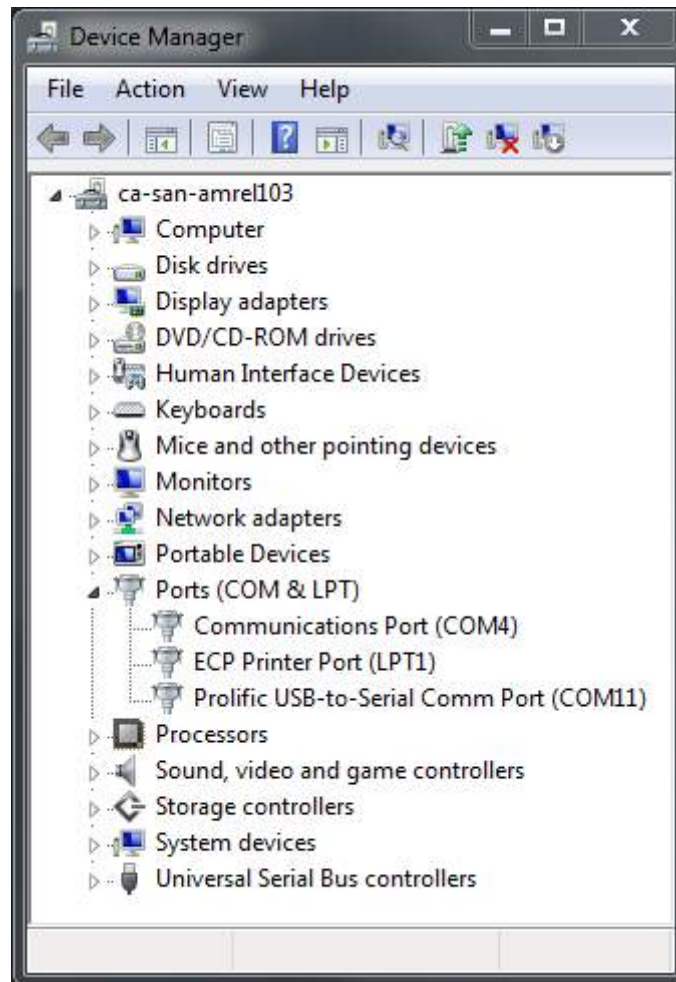
RS232 (SERIAL)

From the front panel controls, verify the communication port is set to RS232, the baud rate is set to 9.6, and the desired address # (1-31).

Note: the factory default Baud rate is set to 9600 Baud.

Connect the PC to the power supply using a serial communication cable and verify the port # through the Device Manager.

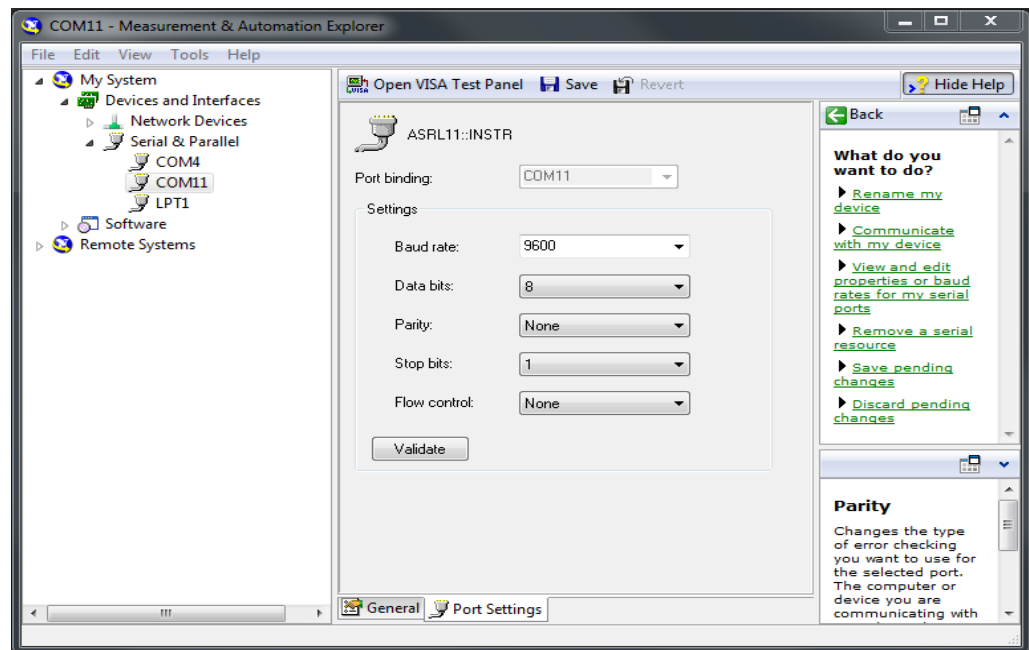
Figure 76: Device Manager Interface



To communicate with the power supply, use the program, National Instruments Measurement and Automation Explorer (NI MAX). You can download the program from <http://www.ni.com>.

Important: This section uses the National Instruments™ MAX program to communicate with the power supply. This is for demonstration purposes only. Any software that is capable of addressing a serial device and sending and receiving text could be used in its place.

Figure 77: NI Measurement & Automation Explorer Window



Boot up NI MAX and click the **Serial & Parallel** section. You should be able to see the port # from which you referenced the Device Manager earlier. Verify the settings are the same as above and click **Open VISA Test Panel**.

Figure 78: Serial Settings

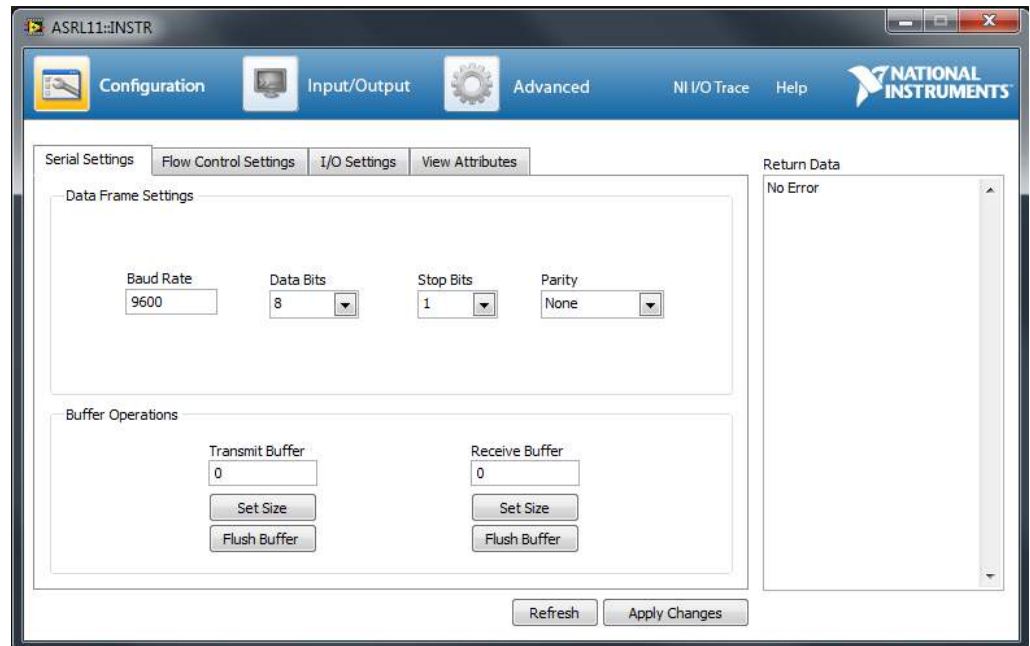


Figure 79: Flow Control Settings

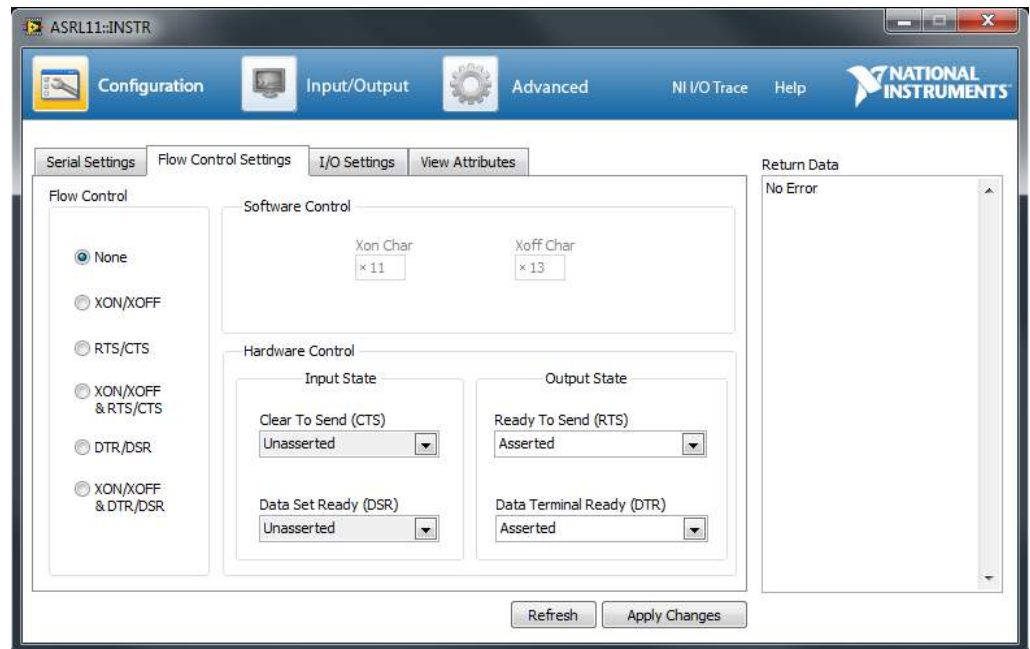
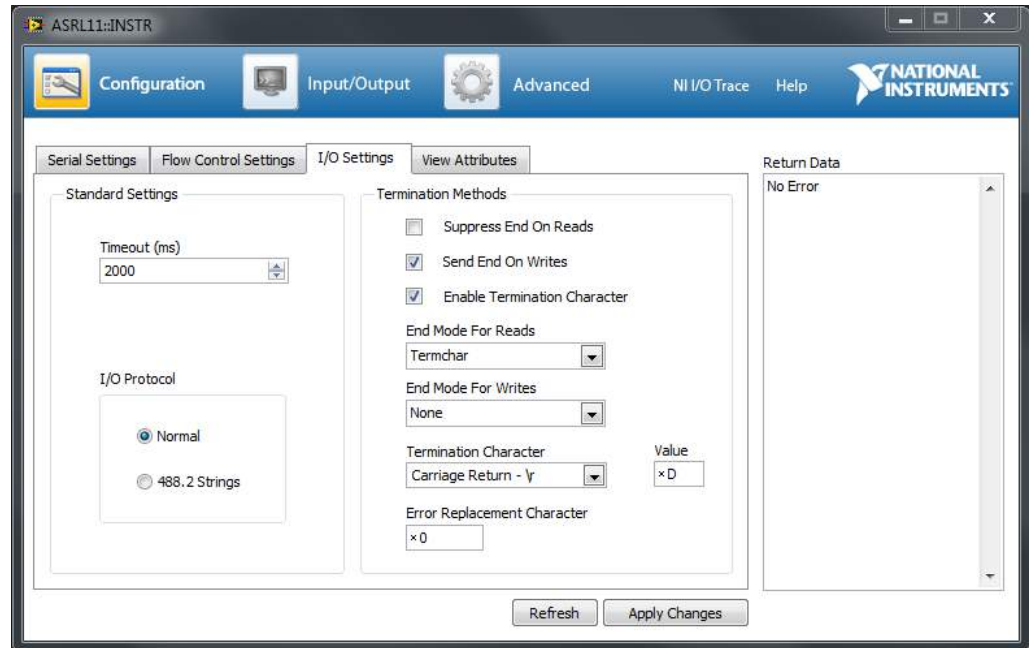


Figure 80: I/O Settings

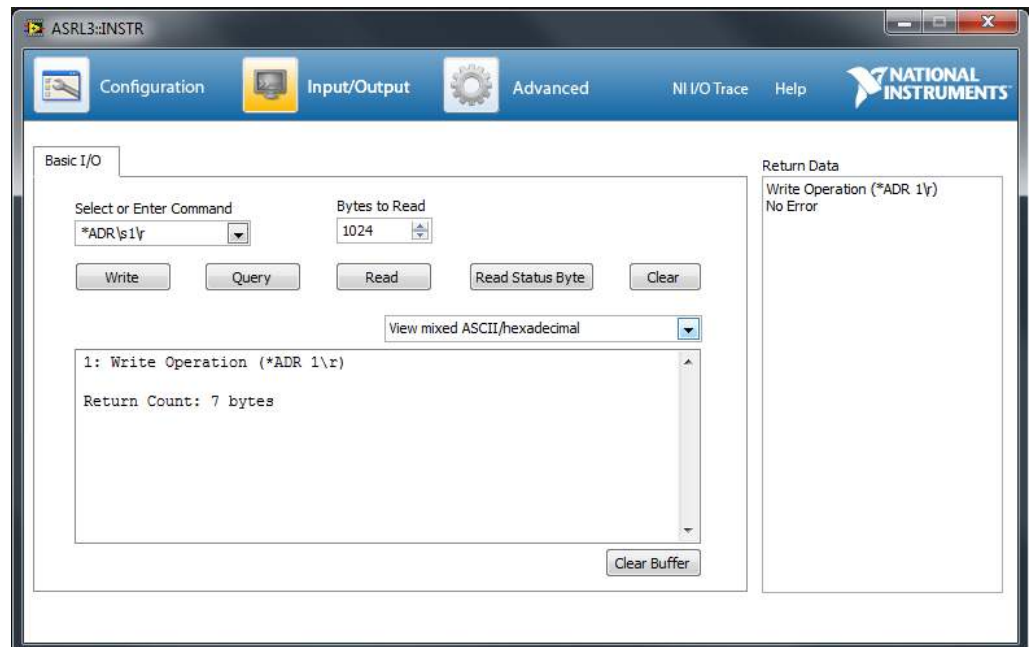


The Configuration for Serial Settings and Flow Control Settings should be the same as the preceding figures. In the I/O settings, check the Enable Termination Character and choose *Carriage Return - \r* in the drop down menu for Termination Character. Click Apply Changes.

Click **Input/Output** to begin communicating with the unit.

Verify after every command sent that you are also using the correct termination character which in this case is *\r*.

Figure 81 Verifying Correct Termination Character

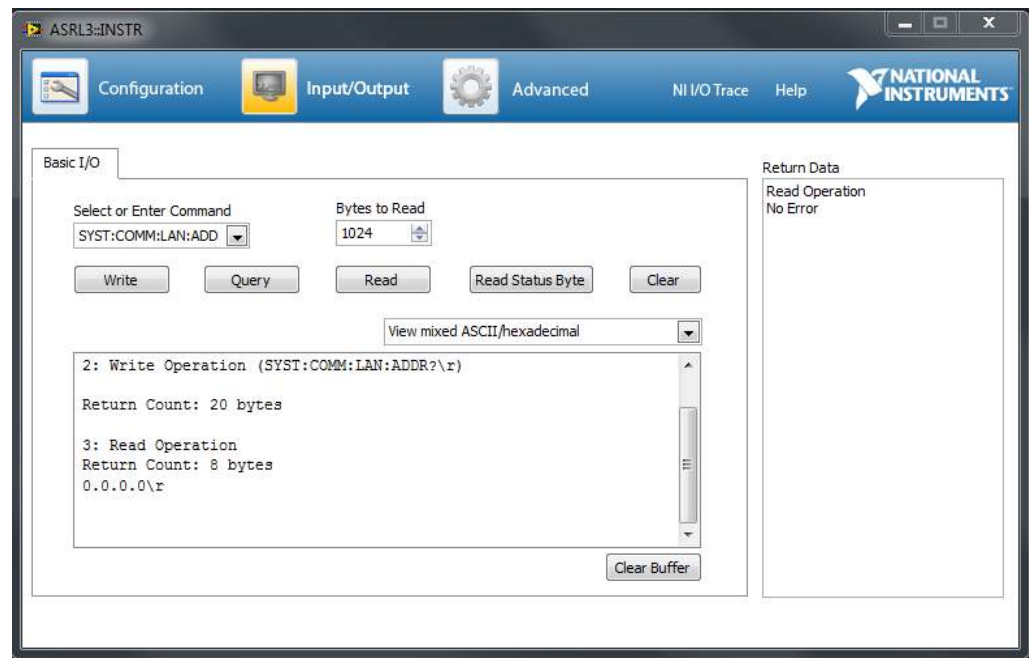


Before starting communication with the power supply, you need to first set the address per the address that you set the unit to via front panel controls using the command ***ADR N** where *N* is the address #. For example, if the unit address was set to 1, send the command ***ADR 1**.

Then send an identification query to the unit using ***IDN?** to verify communication. Your response should be the identification string of the unit.

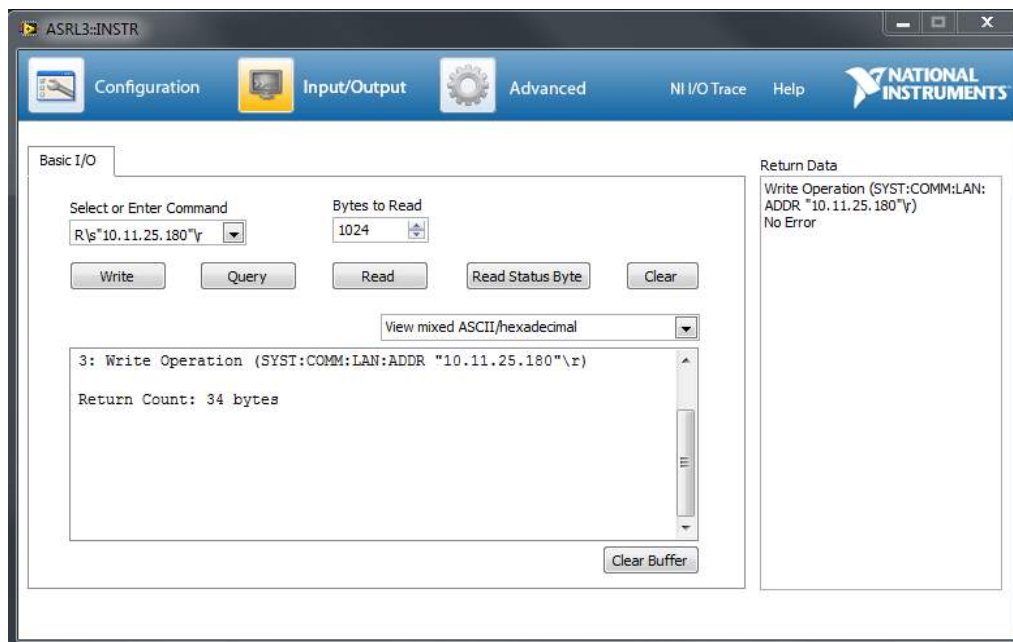
To verify the IP address of the power supply, send the command query **SYST:COMM:LAN:ADDR?**

Figure 82: Verifying IP Address of Power Supply



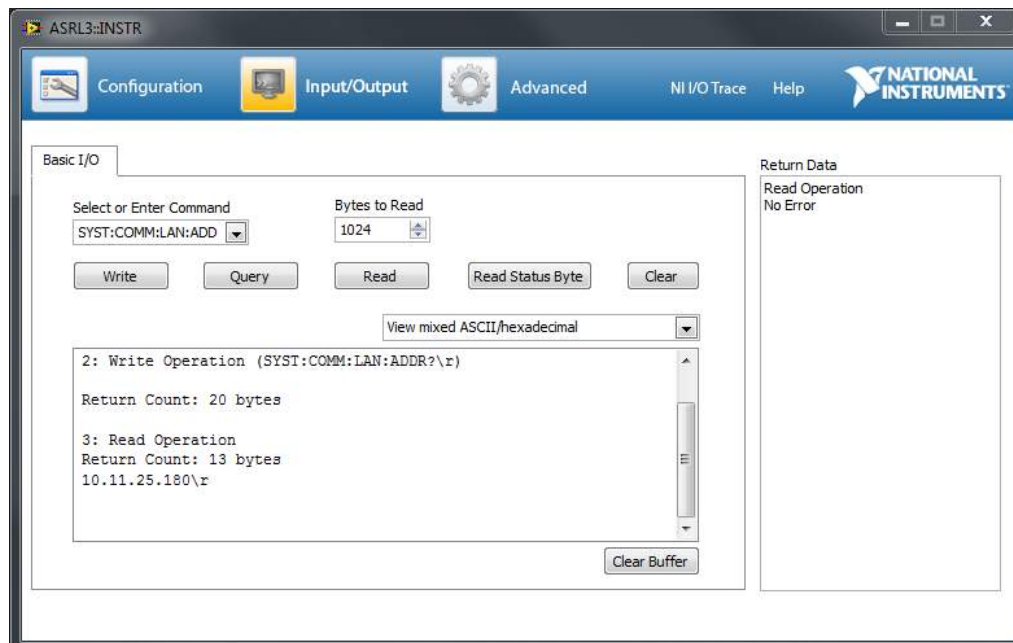
If the response to that query is “0.0.0.0”, that means the unit is in DHCP mode and it received that address from a DHCP server that provided it.

Figure 83: Setting a Static IP Address



To set a Static IP Address, use the command **SYST:COMM:LAN:ADDR "N"** where *N* is the desired IP address you want to set.

Figure 84: Verifying the Static IP Address was Set



To verify the IP address was set, query the address using **SYST:COMM:LAN:ADDR?** and the response to your query should be the IP address that you had set.

The static IP address is now set.

SYSTEM COMMANDS

The system commands control the system-level functions of the power source.

Subsystem Syntax

| | |
|--------------|------------------------------------|
| SYSTem | |
| :COMMunicate | |
| :LAN | |
| :ADDRess | Set LAN IP address |
| :APPLY | Apply the change in setting |
| :CLASs | Set LAN Host bits |
| :DEFault | Set LAN to a default known setting |
| :DESCRiption | Set user description |
| :DNSaddress | Set LAN DNS address |
| :GWADdress | Set LAN Gateway |
| :PASSword | Set LAN password |
| :PORT | Set LAN socket port address |
| :MACAddress | Read the MAC address |

SYSTem:COMMunicate:LAN:ADDRess

This command will set the LAN IP address. The query format returns the IP address set. To query the actual IP address used by the LAN interface (in case the IP address is not static but assigned by a DHCP server), the NCON parameter (Network Connection Setting) must be added to the query. The default value is 0.0.0.0.

| | |
|---------------------|---|
| Command Syntax | SYSTem:COMMunicate:LAN:ADDRess <NRF> |
| Parameters | ddd.ddd.ddd.ddd <IP address> |
| Example | SYST:COMM:LAN:ADDR 255.255.167.2 |
| Query Syntax | SYST:COMM:LAN:ADDR? SYST:COMM:LAN:ADDR? NCON |
| Returned Parameters | <CRD> |

SYSTem:COMMunicate:LAN:APPLY

This command will apply the changes in LAN setting. The controller will go to reset condition and the new LAN setting will take effect.

| | |
|---------------------|------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:APPLY |
| Parameters | none |
| Example | SYST:COMM:LAN:APPL |
| Query Syntax | no query for this command |
| Returned Parameters | none |

SYSTem:COMMunicate:LAN:CLASs

This command will set the number of host address bits or a class. The query format returns the number of bits set. To query the actual number of bits used by the LAN interface (in case the IP address is not static but assigned by a DHCP server), the NCON parameter (Network Connection Setting) must be added to the query. The default value is 8. In general Class A network is 24 bits, Class B is 16 bits and Class A is 8 bits.

| | |
|---------------------|---|
| Command Syntax | SYSTem:COMMunicate:LAN:CLASs <NRF> |
| Parameters | 8 to 32 |
| Example | SYST:COMM:LAN:CLAS 8 |
| Query Syntax | SYST:COMM:LAN: CLAS? SYST:COMM:LAN: CLAS? NCON |
| Returned Parameters | <NR1> |

SYSTem:COMMunicate:LAN:DEFault

This command will apply the changes in LAN setting to the default setting. The controller will go to reset condition and the default LAN setting will take effect. Both IP address and Gateway address are set to zero. The Host name is cleared. The password is reset to "admin." The unit is set to DHCP or Auto IP.

| | |
|---------------------|--------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:DEFault |
| Parameters | none |
| Example | SYST:COMM:LAN:DEF |
| Query Syntax | no query for this command |
| Returned Parameters | none |

SYSTem:COMMunicate:LAN:DESCription

This command will set the user description. The description is limited to 24 characters

| | |
|---------------------|--|
| Command Syntax | SYSTem:COMMunicate:LAN:DESCription <SRD> |
| Parameters | <SRD> |
| Example | SYST:COMM:LAN:DESC "EVAL UNIT" |
| Query Syntax | SYST:COMM:LAN:DESC? |
| Returned Parameters | <SRD> |

SYSTem:COMMunicate:LAN:GWADdress

This command will set the LAN Gateway address. The query format returns the Gateway address set. To query the actual gateway address used by the LAN interface (in case the IP address is not static but assigned by a DHCP server), the NCON parameter (Network Connection Setting) must be added to the query. The default value is 0.0.0.0. Note: If the power supply is connected to a router that does not have a gateway (i.e. the uplink port is not connected on the router) then a random IP address will appear on the gateway when it is queried).

| | |
|---------------------|---|
| Command Syntax | SYSTem:COMMunicate:LAN:GWADddress <NRF> |
| Parameters | ddd.ddd.ddd.ddd <Gateway address> |
| Example | SYST:COMM:LAN:GWAD 255.255.255.0 |
| Query Syntax | SYST:COMM:LAN:GWAD? SYST:COMM:LAN:GWAD? NCON |
| Returned Parameters | <CRD> |

SYSTem:COMMunicate:LAN:HOST

This command will set the Host name. The name is limited to 16 characters

| | |
|---------------------|-----------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:HOST <SRD> |
| Parameters | <SRD> |
| Example | SYST:COMM:LAN:HOST "ACS" |
| Query Syntax | SYST:COMM:LAN:HOST? |
| Returned Parameters | <SRD> |

SYSTem:COMMunicate:LAN:PASSword

This command will set the user password. The password is used to access to LAN configuration screen from the Web page. The default password is "admin". The description is limited to 8 characters.

| | |
|---------------------|---------------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:PASSword <SRD> |
| Parameters | <SRD> |
| Example | SYST:COMM:LAN:PASS "admin" |
| Query Syntax | SYST:COMM:LAN:PASS? |
| Returned Parameters | <SRD> |

SYSTem:COMMunicate:LAN:PORT

This command will set the socket port number. The query format returns the port number set. The default value is 5025.

| | |
|---------------------|----------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:PORT<NRF> |
| Parameters | 0- 65535 |
| Example | SYST:COMM:LAN:PORT 5025 |
| Query Syntax | SYST:COMM:LAN: PORT? |
| Returned Parameters | <NR1> |

SYSTem:COMMunicate:LAN:MACAddress

This command allows for reading out the MAC address. This command can only be used to query the MAC address. The MAC address is set at the factory and may not be changed.

| | |
|---------------------|-----------------------------------|
| Command Syntax | SYSTem:COMMunicate:LAN:MACAddress |
| Parameters | None |
| Example | SYST:COMM:LAN:MACA? |
| Query Syntax | SYST:COMM:LAN:MACA? |
| Returned Parameters | <SRD> |

Calibration and Troubleshooting

In this section:

This section contains information and procedures for calibrating and troubleshooting the power supply.

INTRODUCTION

The calibration of the power supply is software dependent, and there are no potentiometers to adjust.

Calibration is performed via SCPI commands. The following items need to be calibrated:

- Programmed voltage
- Voltage readback
- Programmed current
- Current readback
- Non-isolated voltage monitoring
- Isolated voltage monitoring
- Non-isolated current monitoring
- Isolated current monitoring
- Isolated source for analog programming
- Non-isolated source for analog programming
- Over voltage protection system



CAUTION: Equipment damage

Calibration procedures should only be performed by qualified user.

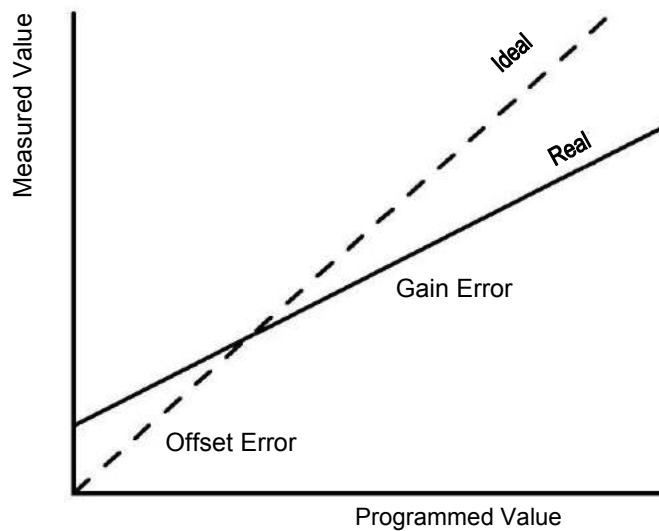
MAIN VOLTAGE AND CURRENT CALIBRATION PRINCIPLE

Understanding the Problem

Figure 85 illustrates two sources of analog programming error: gain error and offset error. Gain error is the departure from the ideal slope of the measured versus programmed line. Offset error is the magnitude of the measured value when the programmed value is zero. Calibrating one will affect the other so an iterative calibration procedure is used.

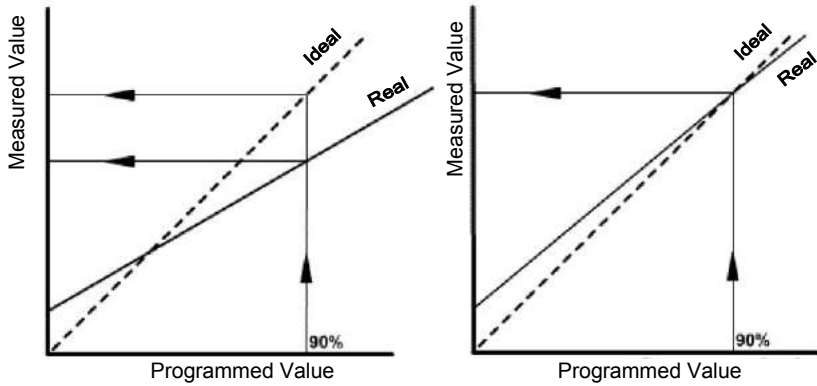
For best results, iterative calibration of gain and offset will be required. After first calibration of both, repeat gain calibration for 90% of maximum value and offset calibration for 10% of maximum value. Repeat as necessary.

Figure 85: Offset (Intercept) Error and Gain (Slope) Error



Step 1: Gain Calibration

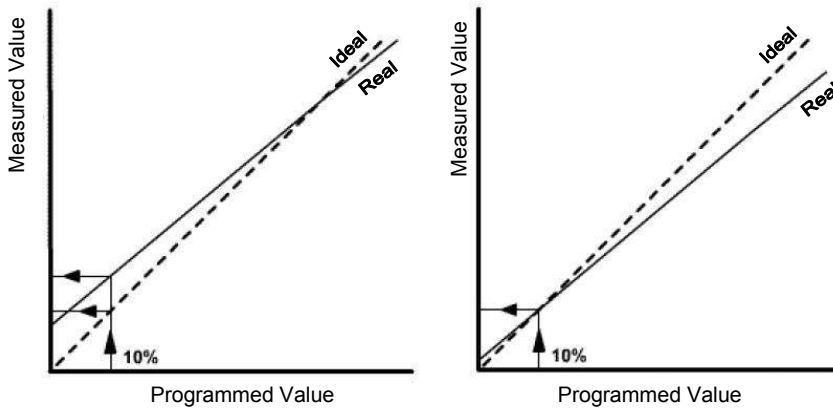
Figure 86: Calibration: Step 1 Gain Calibration



Adjust the gain so that the real line and ideal line intersect at a programmed value of 90%.

Step 2: Offset Calibration

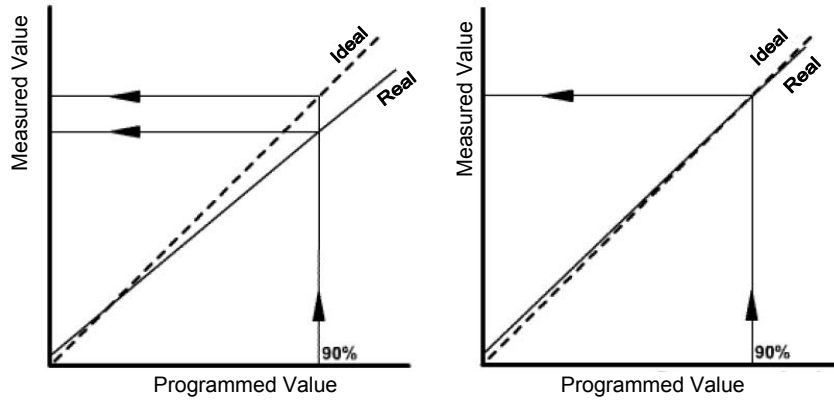
Figure 87: Calibration: Step 2 Offset Calibration



Adjust the offset so that the real and ideal lines intersect at a programmed value of 10%.

Step 3: Recalibrate Gain

Figure 88: Calibration: Step 3 Recalibrate Gain



Repeat Step 1 for best results.

STORING CALIBRATION DATA

Calibration data will not be stored until a CAL:STOR command is issued. Without calling this command, the new calibration will be lost after a power cycle.

If desired, the unit may be returned to its calibration state when it shipped from the factory. To do this, the CAL:REST command may be issued.

Important: The CAL:REST command will cause the nonvolatile memory of the supply to be overwritten with the factory calibration state.

| Command | Description |
|------------------------|--|
| [:]CALibration:STORe | Saves calibration data to nonvolatile memory |
| [:]CALibration:RESTore | Resets the calibration to the Factory state |

CALIBRATING THE OUTPUT VOLTAGE

Gain calibration of the power supply has the greatest effect on the accuracy in the high voltage range. Offset calibration has the greatest effect on accuracy of the power supply at low voltages. The same calibration command is used for the gain and offset calibrations. The type of calibration is determined internally by the instrument depending on if the set point is above 10% of the maximum output voltage value or not. If it is above 10% of the maximum voltage, the calibration is a gain calibration; if it is below 10%, it is an offset calibration.

Gain Calibration

To perform gain calibration:

1. Disconnect the power supply from the load.
2. Connect the output terminals to a precision voltmeter.
3. Turn both the power supply and the voltmeter to On.
4. Set the current set point to maximum. Set the supply output to 90% of the nominal voltage level.
5. Turn on the output power.
6. Read the voltage value on voltmeter display.
7. Type the SCPI command with voltage value as parameter “data”.

For example, type :CAL:OUTP 138.3 if you had a model 150-5.6 calibrating with the voltage set point set to 135 V and the voltmeter was reading 138.3 volts.

Offset Calibration

To perform offset calibration:

1. After performing gain calibration, set the programmed voltage 10% from nominal.
2. Read the voltage value on the voltmeter display.
3. Type the SCPI command with voltage value as parameter “data”.

For example, you would type : CAL: OUT P1 2 . 3 if you had a model 150-5.6 calibration with the voltage set point set to 10V and the voltmeter was reading 12.3 volts.

After performing offset calibration, it is recommended that you repeat gain calibration.

Important: For best results, both calibrations may be repeated several times.

The SCPI Command (s) for these instructions are:

```
[ : ]CALibration[ <channel> ] :OUTPut { :VOLTage } { <voltmeter reading in volts> }
```

CALIBRATING THE OUTPUT CURRENT

Gain Calibration

To perform gain calibration:

1. Disconnect the power supply from the load.
2. Connect the output terminals to a load representing a short circuit using a precision ammeter.
3. Turn both the power supply and the load On.
4. Set the voltage set point to maximum. Set the supply output to 90% of the nominal current level.
5. Turn on the output power.
6. The power supply starts up in Constant Current mode.
7. Read the current value on the ammeter display.
8. Type SCPI command with current value as parameter “data”.

For example, type : CAL: OUTP 5.07 if you had a model 150-5.6 calibrating with the current set point set to 5.04 A and the ammeter was reading 5.07 amps.

Offset Calibration

Offset calibration of the power supply provides the best accuracy in low-range current.

To perform offset calibration:

1. After performing gain calibration, set the current to 10% from the nominal.
2. Read the current value on the ammeter display.
3. Type SCPI command with the current value as parameter “data”.

For example, you would type : CAL : OUT P: CURR 0.50 if you had a model 150-5.6 calibrating with the current set point set to 0.56 A and the actual current measured was 0.50A.

After performing offset calibration, it is highly recommended that you repeat gain calibration.

Important: For best results, both calibrations may be repeated several times. To maintain the high current accuracy of the Series 2268 power supplies, user current calibration should only be done with a high accuracy calibrated shunt resistor of at least 0.025% tolerance.

SCPI Command

```
[ : ]CALibration[ <channel> ]:OUTPut:CURRent{ <ammeter reading in amps> }
```


OVER VOLTAGE PROTECTION CALIBRATION

Important: The Voltage Calibration must be done before performing this procedure. If this is not done the OVP calibration will be inaccurate.

To calibrate the over voltage protection:

1. Turn on the power supply.
2. Select the VAP mode to be Off.
3. Set the voltage set point to be 90% of the model voltage and the current to be 10% of the model current.
4. Turn on the main power output.
5. Execute the OVP calibration SCPI command:
:CAL:PROT
6. The power supply will enter into self-calibration mode. The output voltage display blinks OVP CAL. After several seconds, the calibration will complete and the display will return to normal operation with output off.

Calibration of the power supply is complete.

Important: The output (main) voltage must be precalibrated.

The SCPI command (s) for these instructions are:

[:]CALibration[:VOLTage]:PROTection

NON-ISOLATED ANALOG PROGRAMMING CALIBRATION

Prior to this, the main output must be calibrated first.

Important: In calibration commands, when + or - keys are expected, any other key will exit from the calibration mode.

Non-isolated Voltage Monitoring Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 8.

To calibrate the non-isolated voltage monitoring:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the voltmeter to the non-isolated voltage monitoring output lines (J1.13 - J1.7).
3. Set the Voltage APG level to 4 V. Send the SCPI command:
`SYST:COMM:APR:LEV 4`
4. Set the input source as Local. Send the SCPI command:
`SYST:REM:SOUR LOC`
5. Set the main output voltage to 100% by sending the command:
`SOUR:VOLT<ModelVolt>`
or use the rotary adjust/Enter control.
6. Turn the main output On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter interactive calibration mode by sending the SCPI command:
`CAL:MON`
8. Press on the terminal keys - or + to reduce or increase monitoring value. Adjust the monitoring value displayed on the voltmeter that was set up in Step 1 to read as close as possible to 4.000 V.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Non-isolated Current Monitoring Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 9.

To calibrate the non-isolated current monitoring:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the voltmeter to the non-isolated current monitoring output lines (J1.12 - J1.7).
3. Set the Current APG level to 4 V. Send the SCPI command:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source as Local.
5. The SCPI command is:
`SYST:REM:SOUR:CURR LOC`
6. Set the main output voltage to 100% by sending the command `SOUR: VOLT <ModelVolt>` or use the rotary adjust/Enter control.
7. Turn the main output On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
8. Enter interactive calibration mode by sending SCPI command:
`CAL:MON:CURR`
9. Press on the terminal keys - or + to reduce or increase the monitoring value. Adjust the monitoring value displayed on the voltmeter that was set up in Step 1 to read as close as possible to 4.000 V.
10. Press any key other than the + or - keys to exit from interactive calibration mode.

Non-isolated Voltage Programming of Voltage Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 4.

To calibrate the non-isolated voltage programming of voltage:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the input voltage source to the non-isolated connector, voltage programming (J1.9 - J1.7).
3. Set the Voltage APG level to 4 V. Send the SCPI command:
`SYST:COMM:APR:LEV 4`
4. Set input source voltage to 4.000 V.
5. Set the input source as Voltage Non-Isolated for Voltage Programming. The SCPI command is:
`SYST:REM:SOUR AVOL`
6. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL`
8. Press the terminal keys - or + to reduce or increase the main output voltage value. Adjust the main output voltage to 100%, measured on the external voltmeter on the output.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Non-isolated Resistive Programming of Voltage Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating resistance level in steps 2 and 3.

To calibrate the non-isolated resistive programming of voltage:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the 4.000k Ω resistor to the non-isolated connector, resistive programming of voltage, and voltage programming (J1.9-J1-11, and J1.7).
3. Set the resistive APG level to 4k Ω The SCPI command is:
`SYST:COMM:APR:LEV 4`
4. Set the input source as Resistive Non-Isolated for Voltage Programming. The SCPI command is:
`SYST:REM:SOUR ARES`
5. Turn the main output On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
6. Enter the interactive calibration mode by sending the SCPI command:
`CAL :OUTP:ANAL:RES`
7. Press the terminal keys - or + to reduce or increase main output voltage value. Adjust the main output voltage to 100%.
8. Press any key other than the + or - keys to exit from interactive calibration mode.

Non-isolated Voltage Programming of Current Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 4.

To calibrate the non-isolated voltage programming of current:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the input voltage source to the non-isolated connector, current programming (J1.10 - J1.7).
3. Set the Voltage APG level to 4 V. The SCPI command is:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source voltage to 4.000 V.
5. Set the input source as Voltage Non-Isolated for Current. The SCPI command is:
`SYST:REM:SOUR:CURR AVOL`
6. Turn the main output On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUT P:ANAL:CURR`
8. Press the terminal keys - or + to reduce or increase the main output current value. Adjust the main output current to 100%.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Non-isolated Resistive Programming of Current Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating resistance level in steps 2 and 3.

To calibrate the non-isolated resistive programming of current:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the 4.000 k Ω resistor to the non-isolated connector (APG -J1), one terminal to resistive programming of current (J1 .12) and voltage programming of current (J1.10), and the other terminal to the common (J1.7).
3. Set the resistive APG level to 4 k Ω The SCPI command is:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source as Resistive Non-Isolated for Current Programming. The SCPI command is:
`SYST:REM:SOUR:CURR ARES`
5. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
6. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL:CURR:RES`
7. Press the terminal keys - or + to reduce or increase the main output current value. Adjust the main output current to 100%.
8. Press any key other than the + or - keys to exit from interactive calibration mode.

CALIBRATION PROCEDURE FOR ISOLATED MODES

The main output and the non-isolated mode must be calibrated first.

Isolated Voltage Monitoring Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 8.

To calibrate the isolated voltage monitoring:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the voltmeter to the isolated voltage monitoring output lines (J3.5 - J3.6).
3. Set the Voltage APG level to 4 V. The SCPI command is:
`SYST:COMM:APR:LEV 4`
4. Set the input source to local for voltage analog programming. The SCPI command is:
`SYST:REM:SOUR LOC`
5. Set the main output voltage to 100% by sending the command:
`SOUR:VOLT <ModelVolt>`
or use the rotary adjust/Enter control.
6. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:MON:ISOL`
8. Press the terminal keys - or + to reduce or increase the monitoring value. Adjust the monitoring value displayed on the voltmeter that was setup in Step 1 to read as close as possible to 4.000 V.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Isolated Current Monitoring Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in steps 3 and 8.

To calibrate the isolated current monitoring:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the voltmeter to the Isolated monitoring output lines (J3.10 and J3.6).
3. Set the current APG level to 4 V. The SCPI command is:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source to local for voltage analog programming. the SCPI command is:
`SYST:REM:SOUR:CURR LOC`
5. Set the main output voltage to 100% by sending the command:
`SOUR:VOLT<ModelVOLT>`
or use the rotary Adjust/Enter control.
6. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:MON:CURR:ISOL`
8. Press the terminal keys - or + to reduce or increase the monitoring value. Adjust the monitoring value displayed on the voltmeter that was set up in Step 1 to read as close as possible to 4.000 V.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Isolated Voltage Programming of Voltage Calibration

Important: For maximum accuracy at a specific APG level, repeat the calibration procedure but use the intended operating voltage level in step 3.

To calibrate the isolated voltage programming of voltage:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the input voltage source to the Isolated connector (J3.3 and J3.6).
3. Set the Voltage APG level to 4 V. The SCPI command is:
`SYST:COMM:APR:LEV 4`
4. Set the input source voltage to 4.000 V.
5. Set the input source as Voltage Isolated for Voltage. The SCPI command is:
`SYST:REM:SOUR AVOL`
6. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL:ISOL`
8. Press on the terminal keys - or + to reduce or increase the main output voltage value. Adjust the main output voltage to 100%.
9. Press any key other than the + or - keys to exit from interactive calibration mode.

Isolated Resistive Programming of Voltage Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating resistance level in step 3.

To calibrate the isolated resistive programming of voltage:

1. Disconnect the load and connect the voltmeter to the output.
2. Connect the 4.000 k Ω resistor to the isolated connector. One terminal to resistive programming of voltage (J3.8), and voltage programming of voltage (J3.3), and the other to common (J3.2).
3. Set the resistive APG level to 4 k Ω The SCPI command is:
`SYST:COMM:APR:LEV 4`
4. Set input source as Resistive Isolated for Voltage Programming. The SCPI command is:
`SYST:REM:SOUR IAR`
5. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
6. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL:RES:ISOL`
7. Press on the terminal keys - or + to reduce or increase the main output voltage value. Adjust the main output voltage to 100%.
8. Press any key than the + or - keys to exit from interactive calibration mode.

Isolated Voltage Programming of Current Calibration

Important: For maximum accuracy at a specific APG level, follow the calibration procedure again but use the intended operating voltage level in step 3.

To calibrate the isolated voltage programming of current:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the input voltage source to the Isolated connector (J3.4 -J3.6).
3. Set the Current APG level to 4 V. The SCPI command is:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source voltage to 4.000 V.
5. Set the input source as Voltage Isolated for Current. The SCPI command is:
`SYST:REM:SOUR:CURR IAV`
6. Turn the main output to On by pressing the OUTPUT ENABLE Main button on the front panel or send the command:
`:OUTP ON`
The OUTPUT ENABLE Main button will illuminate.
7. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL:CURR:ISOL`
8. Press the terminal keys - or + to reduce or increase the main output current value. Adjust the main output current to 100%.
9. Press any key other than the + or - keys to exit from the interactive calibration mode.

Isolated Resistive Programming of Current Calibration

To calibrate the isolated resistive programming of current:

1. Short the main output with a shunt. Connect a multimeter to measure the voltage across the shunt.
2. Connect the 4.000 k Ω resistor to the isolated connector. One terminal to resistive programming of current (J3.7), and voltage programming of current (J3.3), and the other to common (J3.2).
3. Set the Resistive APG level to 4 k Ω The SCPI command is:
`SYST:COMM:APR:LEV:CURR 4`
4. Set the input source as Resistive Isolated for Current Programming. The SCPI command is:
`SYST:REM:SOUR:CURR IAR`
5. Turn the main output On or send the command:
`:OUTP ON`
6. Enter the interactive calibration mode by sending the SCPI command:
`CAL:OUTP:ANAL:CURR:RES:ISOL`
7. Press the terminal keys - or + to reduce or increase the main output current value. Adjust the main output current to 100%.
8. Press any key other than the + or - keys to exit from the interactive calibration mode.

APG CALIBRATION

Calibrating the Input Voltage APG Signal

The input voltage APG calibration is necessary to ensure accurate measurements when using the `:MEAS:APR?` and `:MEAS:APR:ISOL?` SCPI command queries to monitor the APG input signal.

Gain Calibration

To calibrate the VAP APG input gain:

1. Connect a voltmeter and a DC voltage source to the non-isolated voltage APG input lines (J1.9 and J1.7).
2. Turn the power supply On.
3. Set the Voltage APG level to 4 V. Send the SCPI command:
`SYST:COMM:APR:LEV 4`
4. Set the input source as Voltage analog APG. Send the SCPI command:
`SYST:REM:SOUR:VOLT AVOL`
5. Set the voltage source attached to the non-isolated voltage APG input to 90% of the nominal voltage level, in this case 3.6 V.
6. Turn the output power on.
7. The power supply starts up in Constant Voltage mode.
8. Read the input voltage value from the voltmeter connected in step 1.
9. Type the SCPI input Voltage calibration command with voltage noted in step 8 as the parameter “data”.

For example, you would type `:CAL:INP:ANAL 3.53` if you were reading 3.53 volts from the voltmeter.

Offset Calibration

Offset calibration of the power supply provides the best accuracy in low-range input voltage.

To perform offset calibration:

1. Set the voltage source attached to the non-isolated Voltage APG input to 10% of the nominal voltage level, in this case 0.400 V.
2. Turn on the output power.
3. Read the input voltage value from the voltmeter connected in step 1 of the gain calibration.
4. Type SCPI input Voltage calibration command with voltage noted in step 3 as the parameter “data”.

For example, you would type `:CAL:INP:ANAL:CURR 0.43` if you read 0.43 volts from the voltmeter.

After performing offset calibration, it is highly recommended that you repeat gain calibration.

SCPI Command

```
[:]CALibration[<channel>]:INPut:ANALog[:VOLTage] {<voltmeter reading in volts>}
```

Calibrating the Input Current APG Signal

The input voltage APG calibration is necessary to ensure accurate measurements when using the :MEAS:APR? and :MEAS:APR:ISOL? SCPI command queries to monitor the APG input signal.

Gain Calibration

To calibrate the CAP APG input gain calibration:

1. Connect a short across the power supply output.
2. Connect a voltmeter and a DC voltage source to the non-isolated current APG input lines (J1.10 and J1.7).
3. Turn the power supply On.
4. Set the Current APG level to 4 V. Send the SCPI command:
SYST:COMM:APR:LEV:CURR 4
5. Set the input source as Voltage analog APG. Send the SCPI command: SYST:REM:SOUR:CURR AVOL
6. Set the voltage source attached to the non-isolated current APG input to 90% of the nominal current level, in this case 3.6 V.
7. Turn the output power on.
8. The power supply starts up in Constant Current mode.
9. Read the input voltage value from the voltmeter connected in step 2.
10. Type the SCPI input current calibration command with voltage noted in step 9 as the parameter "data".

For example, you would type :CAL:INP:ANAL:CURR 3.49 if you were reading 3.49 volts from the voltmeter.

Offset Calibration

Offset calibration of the power supply provides the best accuracy in low-range input current.

To perform offset calibration:

1. Set the voltage source attached to the non-isolated current APG input to 10% of the nominal current level, in this case 0.400 V.
2. Turn the output power on.
3. Read the input voltage value from the voltmeter connected in step 2 of the gain calibration.
4. Type SCPI input current calibration command with voltage noted in step 3 as the parameter "data".

For example, you would type `:CAL:INP:ANAL:CURR 0.43`.

After performing offset calibration, it is highly recommended that you repeat gain calibration.

SCPI Command

```
[:]CALibration[<channel>]:INPut:ANALog:CURRent{<voltmeter reading in volts>}
```

RESTORE FACTORY CALIBRATION

To restore factory calibration, use the SCPI command for returning the power supply to factory calibration settings.

The SCPI Command (s) for these instructions are:

```
[:]CALibration:REStore
```

RESTORE DEFAULT CALIBRATION

To restore default calibration (unit gain and zero offset for all calibration parameters), use the SCPI command for returning the power supply to default calibration settings. This can be useful when recalibrating the unit to a specific load but causes ALL calibration values to return to default values. All types of calibration must be done to restore the unit to fully functional condition. It is strongly recommended that the calibration coefficients be saved before using this command.

The SCPI Command (s) for these instructions are:

```
[:]CALibration:DEFault
```

USER DIAGNOSTICS

If your power supply is not performing as described in this Manual, read through the procedures and checks in this section before calling your service technician. These procedures are limited to operator level functions only. They do not require cover-off servicing of the unit.

EMERGENCY SHUTDOWN

In an emergency, carry out these steps:

1. Shut the power supply OFF immediately.
2. Disconnect the mains supply.
3. Disconnect the power supply from the load.

UNUSUAL OR ERRATIC OPERATION

If the power supply displays any unusual or erratic operation, follow these steps:

1. Shut the power supply OFF immediately.
2. Disconnect the power supply from the load and external programming.
3. Test the power supply with no load, running the tests in “Step 5: Performing Functional Tests” on page 23.
4. If the tests show that the power supply is functioning normally, check all load, programming, and monitoring connections and circuits.
5. Check the AC input for correct voltage and frequency.

If the problem is not solved after you have followed this procedure, or if the unit fails to operate correctly upon retesting, call your service technician.

TROUBLESHOOTING FOR OPERATORS

Troubleshooting

| Symptom | Check | Further Checks and Corrections |
|--|-------------------------------|--|
| The power supply is not operating. <i>FLA FAIL</i> is displayed. | Flash memory check sum error. | Do a reset. See “Resetting the Power Supply” on page 62. |

Important: The power supply will boot with default options and calibration values.

SCPI Command Reference

In this section:

This section provides a summary of the Standard Commands for Programmable Instruments (SCPI) that are supported by the Series 2268 power supplies.

Important: When using SCPI commands, wait at least 100 ms before sending another command. The preceding command must finish executing before another command is received to avoid input buffer overrun. Some commands take longer than 100 ms to execute; those commands are noted in this reference.

SCPI CONFORMANCE INFORMATION

Codes and Standards

This power supply conforms to the following international standards:

- IEEE Std. 488.2-1992, “IEEE Standard Codes, Formats, Protocols, and Common Commands For Use With IEEE Std. 488.1-1987”
- IEEE Std. 488.1-1987 “IEEE Standard Digital Interface for Programmable Instrumentation”
- TIA/EIA-232F
- Standard Commands for Programmable Instruments (SCPI) Version 1999.0

IEEE 488.2 Requirements

GPIB control implements all IEEE 488.2 requirements.

SCPI Requirements

The power supply conforms to the following SCPI requirements:

- SCPI mandated commands
- Questionable Status Register (QSR), Condition, Event, Enable

- Operation Status Register (OSR), Condition, Event, Enable
- Status Byte Register (SBR)
- Standard Event Status Register (SESR)

IEEE 488.2/SCPI Syntax and Style

Parameters: Units of Measure and Multipliers

Refer to IEEE 488.2, section 7.7.3 for the definition of units of measure. The default units of measure include:

- V (Volt - voltage)
- A (Ampere - current)
- W (Watt - power)
- S (seconds - time)

These units are only supported as defaults. To place the unit in the command will cause an error to be pushed into the error queue.

SCPI Command Hierarchy

SCPI is an ASCII-based command language designed for use in test and measurement equipment. The command structure is organized around common roots, or nodes, which are the building blocks of SCPI subsystems. An example of a common root is CALibration, and some of the commands that reside in the CALibration subsystem are:

```
[ : ]CALibration
  [ :OUTPut ]
    [ :VOLTage ]
      [ :DATA ]<NR1>
    :CURRent
      [ :DATA ]<NR1>
```

CALibration is the root keyword of the command. OUTPut is a second-level keyword, and VOLTage and DATA are third-level keywords. A colon (:) is used to separate a command keyword from a lower-level keyword.

Using SCPI Commands

This Manual shows SCPI commands in the following format:

```
CALibration:CURRENT:LEVel {<current>|MIN|MAX}
```

The command is expressed as a mixture of upper- and lowercase letters. The uppercase letters suggest how the command can be abbreviated into a short form. SCPI commands can be sent in long or short forms. The short form is better for data entry. The long form is better for readability.

Command strings are not case sensitive: `CURR`, `Curr`, and `curr` are all acceptable abbreviations for `CURRENT`. As for the long form, `CURRENT`, `Current`, and `current` are all acceptable. It is not possible to write for example, `CALibrat:CURR:LEV` because the extra first node does not explicitly match the short or long form of the calibration node.

The command strings include punctuation. While some punctuation is sent with the string, other markings are used to identify different elements of the command syntax and are not sent with the string.

The following punctuation is sent with the command string:

- **Colons (:)** separate command keywords from lower-level keywords. For example, `CAL:CURR:STAT`.
- **Blank spaces** separate command keywords from parameter values. For example, `CURR 0.1`.
- **Commas** separate parameters from each other when more than one parameter is sent in the same string. For example, `CAL:STAT OFF,"1234."`
- **Semicolons (;)** separate multiple commands from the same subsystem. This allows for greater efficiency.

For example: `CAL:CURR:LEV MIN;VOLT:LEV MIN`

is the same as typing:

```
CAL:CURR:LEV MIN
CAL:VOLT:LEV MIN
```

- **Colons and semicolons** can be used together to link commands from different subsystems. For example:

```
CAL:CURR:LEV MIN;:MEAS:CURR?
```

The short form is made up of 3 or 4 letters. There can only be an absolute short or long form. For example, it is not possible to write `CALibrat:CURR:LEV` because the extra the first node does not match explicitly the short or long form of the calibration node.

The following punctuation is not sent with the command string:

- **Braces** ({ }), or curly brackets, identify a selection of choices. Choose one of the enclosed values.
- **Vertical bars, or pipes**, (|) can be read as “or” and is used to separate the choices found within the braces.
- **Angle brackets** (< >) identify where specific values must be entered for a parameter. For example, in the example at the top of the page, the parameter <current> appears in the command string. To set the current set point to 0.1 A, the syntax is `CAL:CURR:LEV 0.1`.
- **Square brackets** ([]) identify optional parameters. If an optional parameter is not sent with the command string, a default parameter is sent in its place.

Using Minimum and Maximum

In the following example, Minimum and Maximum are offered as alternative choices to declaring a specific parameter value.

```
CAL:CURRENT:LEVEL {<current>|MIN|MAX}
```

The string `CAL:CURR:LEV MIN` sets the current calibration level to the minimum model value.

Using Queries

A question mark lets you query the present value for most parameters. For example, to query the current calibration state use:

```
CAL:SEC:STAT?
```

You can also use the following to query minimum and maximum allowed values for most parameters:

```
:VOLT? MIN
:VOLT? MAX
```

Important: If you send two queries, it is best to read and respond to the first response before trying to read the second. Otherwise, you may receive an incomplete first response followed by a complete second response. To avoid this, you can either wait for and read the first response before sending the second query, or send a device clear message before sending the second query.

Terminating Characters

Every command string must end with a terminating <carriage return> character. It is also acceptable to use a <carriage return> followed by a <new line>. Terminating a command string always resets the SCPI command path to the root level.

Common Commands

The IEEE-488.2 standard includes a set of common commands for functions such as reset and self-test. These common commands always start with an asterisk (*), contain 4 or 5 characters, and may have one or more parameters. The command is always separated from the parameter by a blank space. Multiple commands sent in the same string are separated by a semi-colon (;). The following is an example of how 3 common commands can be sent together in the same string:

```
*OPC; *PSC Off; *TRG
```

Parameter Types

Several different data types are defined for use in program messages and response messages.

Boolean Parameters

Boolean parameters are single binary conditions such as 1 and 0, or ON and OFF. The following is an example of a command that uses Boolean parameters:

```
SYST:COMM:GPIB:PONS {ON|OFF|1|0}
```

Discrete Parameters

Discrete parameters are used when program settings have a limited number of values. If you query a discrete parameter, the response will always be in the short form with all uppercase letters. The following is an example of a command that uses discrete parameters:

```
TRIG:SOUR {BUS|EXT|IMM|NONE}
```

Numeric Parameters

Numeric parameters are number representations such as decimal points, optional signs, and scientific notation. Values such as MINimum and MAXimum are accepted as substitutes for numbers. When DEFault is provided as a parameter, the machine selects the default value automatically. No units' suffix should be included with the parameter, only support for defaults units is available. In cases where specific numeric values are accepted, the power unit will round the input parameters. The following is an example of a command that uses numeric parameters:

```
VOLT:PROT {<voltage>|MAX|MIN}
```

String Parameters

String parameters are used when a series of ASCII characters is required. Strings must be enclosed within single or double quotations. The beginning and ending quotation marks must be matching. Quote delimiters may be included in the string by typing the quotation marks twice without any characters in between.

SCPI COMMAND TREE

The SCPI commands are organized into a tree structure. To illustrate the tree structure, the following tree has been provided. Each level of indentation presents a branch. The command to execute can then be found by following the tree from the root or farthest left node all the way down to the leaf node.

For example, to do the analog isolated programming command, start at the [:]CALibration root node, go through the :OUTPut node and then move down past the [:VOLTage] and :CURRent nodes which appear at that level to the :ANALog node and then move through the optional [:VOLTage] node to the :ISOLated node.

Thus, the command would then be

```
[:]CALibration:OUTPut:ANALog[:VOLTage]:ISOLated
```

All commands can be formed by looking at this tree and taking the unique path from the root node to the leaf node. The table that follows shows all the commands fully formed with parameters.

[:]CALibration

```

:INPut
  :ANALog
    [:VOLTage]
    :CURRent
:OUTPut
  [:VOLTage]
  :CURRent
:MONitor
  [:VOLTage]
    :ISOLated
  :CURRent
    :ISOLated
:ANALog
  [:VOLTage]
```



```

        :ISOLated
        :RESistive
            :ISOLated
    :CURRent
        :ISOLated
        :RESistive
            :ISOLated
[:VOLTage]
    :PROTection
        [:OVER]
:RESTore
:DEFault
[:]INITiate
    [:IMMediate]
[:]MEASure
    :APROgram
        [:VOLTage]
            [:DC]
            :ISOLated
                [:DC]
        :CURRent
            [:DC]
            :ISOLated
                [:DC]
[:SCALAR]
    [:VOLTage]
        [:DC]?
    :CURRent
        [:DC]?
[:]OUTPut
    :PROTection
        :CLEAr
        :FOLDback
            [:MODE]
            :DELay

```

```
        :LATch
:POLarity
[:POWER]
    [:STATe]
    :PowerON
        [:STATe]
:AUXiliary
    [:STATe]
    :PowerON
        [:STATe]
[:]PROGram
:READback
:STATe
[:RECORD]
    :START
    :STOP
:DELEte
    [:ALL]
:REPEAT
[:STEP]
    :DWELL
[:]SOURCE
:COMBine
    :CSHare
        [:MODE]
:VOLTage
    [:LEVel]
        [:IMMediate]
            [:AMPLitude]
:PROTEction
    [:OVERvoltage]
        [:LEVel]
    :UNDer
        [:LEVel]
:CURREnt
```

```
[ :LEVel]
    [ :IMMediate]
        [ :AMPLitude]

[ :]SENSe:
    :PROTection
        :INTErlock
            [ :STATe]
        :TEMPerature
            [ :LATCh]

[ :]STATus
    :PRESet
    :QUEStionable
        [ :EVENT]?
        :ENABle
        :CONDition?
        :PTRansition
        :NTRansition
    :VOLTage
        [ :EVENT]?
        :ENABle
        :CONDition?
        :PTRansition
        :NTRansition
    :TEMPerature
        [ :EVENT]?
        :ENABle
        :CONDition?
        :PTRansition
        :NTRansition
    :OPERation
        [ :EVENT]?
        :ENABle
        :CONDition?
        :PTRansition
```

```
:NTRansition
:CSHare
    [:EVENT]?
    :ENABle
    :CONDition?
    :PTRansition
    :NTRansition
:SHUTdown
    [:EVENT]?
    :ENABle
    :CONDition
    :PTRansition
    :NTRansition
    :PROTection
        [:EVENT]?
        :ENABle
        :CONDition?
        :PTRansition
        :NTRansition
:STANdard
    [:EVENT]?
    :ENABle
:CLEar
:SBYTE
    [:EVENT]?
:SREQuest
    [:ENABle]
[ : ]SYSTem
:FPANel
    [:TIMEout]
:PROTection
    :LATCh
    [:MASK]
:RESet
:WAIT
```

```
:TEST?
:RESet
:IDENtify?
:REMOte
  :STATe
  :SOURce
    [:VOLTage]
    :CURRent
:COMMunicate
  :APROgram
  :LEVel
    [:VOLTage]
    [:ISOLated]
  :CURRent
    [:ISOLated]
  [:MCHannel]
  :ADDRESS
:PON
  :VOLT
  :CURR
  :ENA
    :VOLT
    :CURR
:SAVE
:RECall
:VERSion?
:ERRor
  [:NEXT]?
  :CODE
    [:NEXT]?
  :COUNT?
:HELP
  [:HEADers]?
  :SYNTAX?
  :LEGacy?
```

SCPI COMMAND SUMMARY

The SCPI commands supported by this programmable power supply are described in the tables in the remainder of this section. These tables use the following column headings:

- **Function** The commonly used name for the function.
- **SCPI Command** The full command in long form.
- **Description** Explains what the command does or what is affected by it.
- **Query?** Indicates whether the unit supports a query version of the listed command.
- **N/A** Indicates “not applicable” (the command has no query form and will respond with an error if queried.)

IEEE 488.2 Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|--------------------------------------|--|---|-----------------------|-------|
| Select Address | *ADR | Select the power supply unit to communicate with. This command is required even if you are using a single instrument. | ? <Address (1–30)> | Yes |
| Clear Status | *CLS [:]STaTus[<channel>]:CLear | Clears all the status data structures. | | N/A |
| Query the Error Queue | *ERR | Query the Error Queue for the oldest error event. | | |
| Standard Event Status Enable Query | *ESE? [:]STaTus[<channel>]:STANdard:ENABle | Query the Standard Event Status Enable register settings. | | Yes |
| Standard Event Status Enable | *ESE [:]STaTus[<channel>]:STANdard:ENABle <ESE-word> | Set the Standard Event Status Enable Register bits. | <Enable Flags(0–255)> | N/A |
| Standard Event Status Register Query | *ESR? [:]STaTus[<channel>]:STANdard[:EVENT]? | Query the Standard Event Status Register (SERS). | | Yes |
| Display All SCPI Command Headers | *HELP? | Display all the SCPI command headers available on this device. | | Yes |
| Identification Query | *IDN? [:]SYSTem[<channel>]:IDENtify? | Query device identification string. | | Yes |
| Operation Complete Command | *OPC | Operation Complete Command | | N/A |
| Query Operation Complete Command | *OPC? | Operation Complete Query | | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|------------------------------|---|---|-----------------------|-------|
| Recall | *RCL OR [:]SYSTem[<channel>]:RECall <setting_location> | Recall a User Memory Setting. See *SAV below. | <Setting Index (1–5)> | N/A |
| Reset | *RST [:]SYSTem[<channel>]:RESet | Resets all values to default state (excluding calibration data). This command takes longer to execute than other commands. Be sure to allow extra time for the command to run before sending another command (approximately two seconds). | | N/A |
| Save User Settings | *SAV [:]SYSTem[<channel>]:SAVE <setting_location> | Save a User Memory Setting. | | N/A |
| Query Service Request Enable | *SRE? [:]STATus[<channel>]:SREQuest:ENABle? | Service Request Enable Query | | Yes |
| Service Request Enable | *SRE [:]STATus[<channel>]:SREQuest:ENABle <status-enable> | Service Request Enable Command | <Enable Flags(0–255)> | N/A |
| Read Status Byte | *STB? [:]STATus[<channel>]:SBYTe[EVENT]? | Read the status byte. | | Yes |
| Trigger | *TRG | Trigger system | | N/A |
| Self-Test Query | *TST? [:]SYSTem[<channel>]:TEST? | Perform unit Self Test (Pass=0). | | Yes |
| Wait To Continue | *WAI [:]SYSTem[<channel>]:WAIT | Wait to continue command. | | N/A |

Readback Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|---------------------------------|--|--|---------------------|-------|
| Read Output Current | [:]MEASure[<channel>] [: SCALar] : CURRent [: DC] ? | Measure and readback output current at the output terminals. | | Yes |
| Read Output Voltage | [:]MEASure[<channel>] [: SCALar] [: VOLTage] [: DC] ? | Measure and readback output voltage at the output terminals. | | Yes |
| Read APG Input Voltage | [:]MEASurement [: SCALar] : APROgram [: VOLTage] [: DC] ? | Measure and readback the voltage being input to the non isolated voltage analog programming input pin. | | Yes |
| Read Isolated APG Input Voltage | [:]MEASurement [: SCALar] : APROgram [: VOLTage] : ISOLated [: DC] ? | Measure and readback the voltage being input to the isolated voltage analog programming input pin. | | Yes |
| Read APG Input Current | [:]MEASurement [: SCALar] : APROgram : CURRent [: DC] ? | Measure and readback the voltage being input to the non isolated current analog programming input pin. | | Yes |
| Read isolated APG Input Current | [:]MEASurement [: SCALar] : APROgram : CURRent : ISOLated [: DC] ? | Measure and readback the voltage being input to the isolated current analog programming input pin. | | Yes |

SCPI Commands for Output Control

| Function | SCPI Command | Description | Parameter and Range | Query |
|--------------------------------------|---|--|---------------------------------------|-------|
| Set Current Sharing Mode | [[[:]]SOURce[<channel>]]:COMBine:CSHare[:MODE] | Set the unit to operate in the current share controller or slave mode. If only a single unit is being used it should be set to controller. | ? CONTRoller SLAVE | Yes |
| Set (Immediate) Current Set point | [[[:]]SOURce[<channel>]]:CURRent[:LEVEl][:IMMEDIATE][:AMPLitude] | Set current set point (immediate) | ? <Current Set Point> MAXimum MINimum | Yes |
| Set Constant Power Set point | [:]SOURce:POWer:LEVEl | Set constant power set point (immediate) | ? <Power Set Point> | Yes |
| Set Constant Power Mode ¹ | [:]SOURce:POWer:MODE | Set constant power mode (Enable/Disable) | ? ON OFF | Yes |
| Set (Immediate) Voltage Set point | [[[:]]SOURce[<channel>]]:VOLTagE[:LEVEl][:IMMEDIATE][:AMPLitude] | Change voltage set point (immediate) | ? <Voltage Set Point> MAXimum MINimum | Yes |
| Set Over Voltage Protection Level | [[[:]]SOURce[<channel>]]:VOLTagE:PROTEction[:OVERvoltage][:LEVEl] | Set the over voltage protection level. | ? <OVP Set Point> MAXimum MINimum | Yes |
| Set Under Voltage Protection Level | [[[:]]SOURce[<channel>]]:VOLTagE:PROTEction:UNDEr[:LEVEl] | Set the under voltage protection level. | ? <UVP Set Point> MAXimum MINimum | Yes |

SCPI Commands for Calibration

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|---|--|--|-------|
| Restore Factory Calibration | [:]CALibration[<channel>]:REStore | Restores the calibration to the factory defaults. | N/A | N/A |
| Restore Default Calibration | [:]CALibration[<channel>]:DEFault | Restores the default calibration for all variables. (Unit gain and zero offset). | N/A | No |
| Calibrate OVP protection. | [:]CALibration[<channel>][:VOLTage]:PROTEction[:OVER] | Calibrate the over voltage protection. | <OVP Voltage Set in Volts> | No |
| Enter Output Voltage Data | [:]CALibration[<channel>]:OUTPut[:VOLTage] | Sets the voltage output calibration level. | <Voltage set in volts> | No |
| Enter Output Current Data | [:]CALibration[<channel>]:OUTPut[:CURRent] | Sets the current output calibration level | <Current set in amps> | No |
| Calibrate the Voltage controlled Non Isolated Voltage APG feature | [:]CALibration[<channel>]:MONitor[:VOLTage] | Calibrate the voltage monitor signal system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Isolated Voltage APG feature | [:]CALibration[<channel>]:MONitor[:VOLTage]:ISOLated | Calibrate the isolated voltage monitor signal system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Non Isolated Current APG feature | [:]CALibration[<channel>]:MONitor[:CURRent] | Calibrate the current monitor signal system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Isolated Current APG feature | [:]CALibration[<channel>]:MONitor[:CURRent]:ISOLated | Calibrate the isolated current monitor signal system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage APG Input | [:]CALibration:INPut:ANALog[:VOLTage] | Calibrates the isolated and non-isolated VA P measurement commands. | <? NR1> | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|--|--|--|-------|
| Calibrate the Current APG Input | [:]CALibration:INPut:ANALog:CURRent | Calibrates the isolated and non-isolated CAP measurement commands. | <? NR1> | Yes |
| Calibrate the Voltage controlled Non Isolated Voltage APG feature | [:]CALibration[<channel>]:OUTPut:ANALog[:VOLTage] | Calibrate the voltage analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Isolated Voltage APG feature | [:]CALibration[<channel>]:OUTPut:ANALog[:VOLTage]:ISOLated | Calibrates the voltage analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Non Isolated Current APG feature | [:]CALibration[<channel>]:OUTPut:ANALog:CURRent | Calibrate the current analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Voltage controlled Isolated Current APG feature | [:]CALibration[<channel>]:OUTPut:ANALog:CURRent:ISOLated | Calibrates the current analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Resistive controlled Non Isolated Voltage APG feature | [:]CALibration[<channel>]:OUTPut:ANALog[:VOLTage]:RESistive | Calibrate the Resistive controlled voltage analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Resistive controlled Isolated Voltage APG feature | [:]CALibration[<channel>]:OUTPut:ANALog[:VOLTage]:RESistive:ISOLated | Calibrates the Resistive controlled voltage analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |
| Calibrate the Resistive controlled Non Isolated Current APG feature | [:]CALibration[<channel>]:OUTPut:ANALog:CURRent:RESistive | Calibrate the Resistive controlled current analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|---|--|--|-------|
| Calibrate the Resistive controlled Isolated Current APG feature | [:]CALibration[<channel>]:OUTPut:ANALog:CURRent:RESistive:ISOLated | Calibrates the Resistive controlled current analog programming system. | ? <NR1> <nothing for interactive mode> | Yes |

SCPI Commands to Clear All Protection Mechanisms

| Function | SCPI Command | Description | Parameter and Range | Query |
|-------------------------|--|----------------------------------|---------------------|-------|
| Clear Output Protection | [:]OUTPut[<channel>]:PROTection:CLEar | Clears the currently set alarms. | | N/A |

SCPI Commands for Foldback Protection

| Function | SCPI Command | Description | Parameter and Range | Query |
|---------------------------|---|---|----------------------|-------|
| Set Output Foldback Delay | [:]OUTPut[<channel>]:PROTection:FOLDback:DELay | Set the delay time (seconds) before foldback protection is triggered. | ? <Delay - (0.5-50)> | Yes |
| Set Output Foldback Mode | [:]OUTPut[<channel>]:PROTection:FOLDback[:MODE] | Select condition for foldback. | ? CV CC NONE | Yes |

SCPI Commands for Power

| Function | SCPI Command | Description | Parameter and Range | Query |
|--------------------------------|------------------------------------|--|---------------------|-------|
| Shutdown Logic Control | [:]OUTPut:POLarity | Sets the TTL level that will trigger an External Shutdown. | ? HIGH LOW | Yes |
| Main Output Control | [:]OUTPut[:POWER][:STATE] | Control Main Output State (Enable/Disable) | ? ON OFF | Yes |
| Power On Main Output Control | [:]OUTPut[:POWER]:PON[:STATE] | Control Main Output Autostart State (Enable/Disable) | ? ON OFF | Yes |
| Aux Output Control | [:]OUTPut:AUXiliary[:STATE] | Control Aux Output State (Enable/Disable) | ? ON OFF | Yes |
| Power Auxiliary Output Control | [:]OUTPut:AUXiliary:PON[:STATE] | Control Aux Output Autostart State (Enable/Disable) | ? ON OFF | Yes |

SCPI Commands for Triggering

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|--|------------------------------------|---------------------|-------|
| Set Immediate Initiation of Trigger System | [:]INITiate[<channel>][:IMMediate] | Triggers the Autosequence Program. | | N/A |

System Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|---|---|-------------------------------------|-------|
| Set the menu system timeout | [:]SYSTem:FPANel [:TIMEout] | Sets the menu system timeout. | <1–20 to one decimal place seconds> | Yes |
| Resets the Instrument to default values. | [:]SYSTem[<channel>]:RESet | Resets all values to default state (excluding calibration data). | | N/A |
| Wait to Continue | [:]SYSTem[<channel>]:WAIT | Wait to continue command. | | N/A |
| Self Test | [:]SYSTem[<channel>]:TEST? | Perform unit self test, returns 0 if pass, non zero value for failure. | | Yes |
| ID Query | [:]SYSTem[<channel>]:IDENtify | Query device ID string. | | Yes |
| Save User Preset | [:]SYSTem[<channel>]:SAVE | Save the user preset values. Select any slot from 0-3. | <Setting Index (0-3)> | No |
| Recall User Preset (previously saved) | [:]SYSTem[<channel>]:RECall | Load the user preset values. Select any slot from 0-3. | <Setting Index (0-3)> | No |
| Query System Error | [:]SYSTem[<channel>]:ERRor[:NEXT]? | Returns the next error in the instrument's error queue | | Yes |
| Query System Error Code | [:]SYSTem[<channel>]:ERRor:CODE [:NEXT]? | Returns the error code only for the next error in the instrument's error queue. | | Yes |
| Query the Error Queue for the number of entries. | [:]SYSTem[<channel>]:ERRor:COUNT? | Returns the number of errors currently in the error queue. | | Yes |
| Select Voltage Analog Programming Input Voltage Input Level/ Range | [:]SYSTem[<channel>]:COMMunicate :APROgram:LEVel [:VOLTage] [:ISOLated] | Select level for Voltage APG. Level can be between 2 -10 volts. | ? <Level (2–10)> MAXimum MINimum | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|--|--|---|-------|
| Select Current Analog Programming Input Voltage Input Level/ Range | [:]SYSTem[<channel>]:COMMunicate :APROgram:LEVel:CURRent[:ISOLated] | Select level for Current APG. Level can be between 2 -10 volts. | ? <Level(2-10)> MAXimum MINimum | Yes |
| Select the address to communicate with. | [:]SYSTem[<channel>]:COMMunicate [:MCHannel]:ADDRESS | Select the current device to receive the commands. The parameter for this command is the address set on the front panel under the remote | | Yes |
| Setup the Voltage control APG source | [:]SYSTem[<channel>]:REMote:SOURce [:VOLTagE] | Alter or query the state of the remote programming voltage APG source. | ? LOCAL AVOLtagE IAVOLTage AREsistive IAResistive | Yes |
| Setup the Current control APG source | [:]SYSTem[<channel>]:REMote:SOURce :CURRent | Alter or query the state of the remote programming current APG source. | ? LOCAL AVOLtagE IAVOLTage AREsistive IAResistive | Yes |
| Set Front Panel lock state. | [:]SYSTem[<channel>]:REMote:STATE | Change front panel control mode | ? LOCAL REMote | Yes |
| Power On Voltage Low | [:]SYSTem[<channel>]:PON:VOLTagE | Set the voltage set point to zero when the power is turned on. | ? ON OFF | Yes |
| Power On Current Low | [:]SYSTem[<channel>]:PON:CURRent | Set the current set point to zero when the power is turned on | ? ON OFF | Yes |
| Output Enable Voltage Low | [:]SYSTem[<channel>]:PON:ENable:VOLTagE | Set the voltage set point to zero when the output enable button is pressed. | ? ON OFF | Yes |
| Output Enable Current Low | [:]SYSTem[<channel>]:PON:ENable:CURRent | Set the current set point to zero when the output enable button is pressed. | ? ON OFF | Yes |
| Query SCPI Version | [:]SYSTem[<channel>]:VERSion? | Returns the SCPI version to which the instrument complies. Format is YYYY.V | | Yes |
| SCPI Help | [:]SYSTem[<channel>]:HELP[:HEADers]? | Query system for all supported SCPI command headers. | | Yes |
| Legacy Help | [:]SYSTem[<channel>]:HELP:LEGacy? | Query the system for all supported legacy commands. | | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|--------------------------|--|-----------------------------------|--------------------------------|-------|
| Alarm Masking | [:]SYSTem[<channel>]:PROTection[:MASK] | Enable/disable alarms/protection. | ? <Alarm Mask - (0–2047)> | Yes |
| Set Alarm Output Latches | [:]SYSTem[<channel>]:PROTection:LATCh | Sets the Alarm Output Latches. | ? <Sum of output latch flags> | Yes |

Status Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|--|--|----------------------------------|-------|
| Query Operation Status Condition Register | [:]STATus[<channel>]:OPERation:CONDition? | Query the Operations Condition Register. | | Yes |
| Set Operation Status Enable Register | [:]STATus[<channel>]:OPERation:ENABle | Access the Operations Enable Register. | ? <Enable Flags - (0–65535)> | Yes |
| Query Operation Status Event Register | [:]STATus[<channel>]:OPERation[:EVENT]? | Query the Operations Event Register. | | Yes |
| Set Operation Status Negative Transition Register | [:]STATus[<channel>]:OPERation:NTRansition | Access the Operation Negative Trans Filter Register. | ? <Transition Flags - (0–65535)> | Yes |
| Set Operation Status Positive Transition Register | [:]STATus[<channel>]:OPERation:PTRansition | Access the Operation Positive Trans Filter Register. | ? <Transition Flags - (0–65535)> | Yes |
| Query Operation Status Shutdown Condition Register | [:]STATus[<channel>]:OPERation:SHUTdown:CONDition? | Query the Operation Shutdown Condition Register | | Yes |
| Set Operation Status Shutdown Enable Register | [:]STATus[<channel>]:OPERation:SHUTdown:ENABle | Access the Operation Shutdown Enable Register. | ? <Enable Flags - (0–65535)> | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|--|---|----------------------------------|-------|
| Query Operation Status Shutdown Event Register | [:]STATUS[<channel>]:OPERation :SHUTdown[:EVENT]? | Query the Operation Shutdown Event Register. | | Yes |
| Set Operation Status Shutdown Negative Transition Register | [:]STATUS[<channel>]:OPERation :SHUTdown:NTRansition | Access the Operation Shutdown Negative Transition Register. | ? <Transition Flags - (0-65535)> | Yes |
| Set Operation Status Shutdown Positive Transition Register | [:]STATUS[<channel>]:OPERation :SHUTdown:PTRansition | Access the Operation Shutdown Positive Trans Filter Register. | ? <Transition Flags - (0-65535)> | Yes |
| Query Operation Status Shutdown Protection Condition Register | [:]STATUS[<channel>]:OPERation :SHUTdown:PROTection:CONDition? | Query the Operation Shutdown Protection Condition Register. | | Yes |
| Set Operation Status Shutdown Protection Enable Register | [:]STATUS[<channel>]:OPERation :SHUTdown:PROTection:ENABle | Access the Operation Shutdown Protection Enable Register. | ? <Enable Flags - (0-65535)> | Yes |
| Query Operation Status Shutdown Protection Event Register | [:]STATUS[<channel>]:OPERation :SHUTdown:PROTection[:EVENT]? | Query the Operation Shutdown Protection Event Register. | | Yes |
| Set Operation Status Shutdown Protection Negative Transition Register | [:]STATUS[<channel>]:OPERation :SHUTdown:PROTection:NTRansition | Access the Operation Status Shutdown Protection Negative Transition Register. | ? <Transition Flags - (0-65535)> | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|---|---|----------------------------------|-------|
| Set Operation Status Shutdown Protection Positive Transition Register | [:]STATus[<channel>]:OPERation :SHUTdown:PROTEction:PTRansition | Access the Operation Shutdown Protection Positive Trans Filter Register. | ? <Transition Flags - (0–65535)> | Yes |
| Query Operation Status Event Register | [:]STATus[<channel>]:OPERation :CSHare[:EVENT]? | Query the Operations Event Register. | | Yes |
| Set Operation Status Enable Register | [:]STATus[<channel>]:OPERation :CSHare:ENABle | Access the Operations Enable Register. | ? <Transition Flags - (0–65535)> | Yes |
| Query Operation Status Condition Register | [:]STATus[<channel>]:OPERation :CSHare:CONDition? | Query the Operations Condition Register. | | Yes |
| Set Operation Status Positive Transition Register | [:]STATus[<channel>]:OPERation :CSHare:PTRansition | Access the Operation Positive Trans Filter Register. | ? <Transition Flags - (0–65535)> | Yes |
| Set Operation Status Negative Transition Register | [:]STATus[<channel>]:OPERation :CSHare:NTRansition | Access the Operation Negative Trans Filter Register. | ? <Transition Flags - (0–65535)> | Yes |
| Preset Enable, Positive Transition and Negative Transition Status Registers | [:]STATus[<channel>]:PRESet | Restores the configuration of the SCPI status registers to known reporting conditions, i.e., Transition registers and Enable register. See “Status Reporting in SCPI” on page 125 for more details. | | |
| Query Questionable Status Register | [:]STATus[<channel>]:QUESTionable { :EVENT }? | Query the Questionable Status Register | | Yes |
| Set Questionable Status Enable Register | [:]STATus[<channel>]:QUESTionable :ENABle <status-enable> { ? } | Access the Questionable Status Register. | | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|---|--|----------------------------------|-------|
| Query Questionable Status Condition Register | [:]STATUS[<channel>]:QUESTionable:CONDition? | Query the Questionable Status Register Condition | | Yes |
| Set Questionable Status Negative Transition Register | [:]STATUS[<channel>]:QUESTionable:NTRansition | Access the Questionable Negative Trans Filter Register. | ?[<Transition Flags - (0-65535)> | Yes |
| Set Questionable Status Positive Transition Register | [:]STATUS[<channel>]:QUESTionable:PTRansition | Access the Questionable Positive Trans Filter Register. | ?[<Transition Flags - (0-65535)> | |
| Query Questionable Status Temperature Condition Register | [:]STATUS[<channel>]:QUESTionable:TEMPerature:CONDition? | Query the Questionable Temp Conditions Register. | | Yes |
| Set Questionable Status Temperature Enable Register | [:]STATUS[<channel>]:QUESTionable:TEMPerature:ENABle | Access the Questionable Temp Enable Register. | ?[<Enable Flags - (0-65535)> | Yes |
| Query Questionable Status Temperature Event Register | [:]STATUS[<channel>]:QUESTionable:TEMPerature[:EVENT]? | Query the Questionable Temp Event Register. | | Yes |
| Set Questionable Status Temperature Negative Transition Register | [:]STATUS[<channel>]:QUESTionable:TEMPerature:NTRansition | Access the Questionable Temp Negative Trans Filter Register. | ?[<Transition Flags - (0-65535)> | Yes |
| Set Questionable Status Temperature Positive Transition Register | [:]STATUS[<channel>]:QUESTionable:TEMPerature:PTRansition | Access the Questionable Temp Positive Trans Filter Register. | ?[<Transition Flags - (0-65535)> | Yes |

| Function | SCPI Command | Description | Parameter and Range | Query |
|--|---|---|----------------------------------|-------|
| Query Questionable Status Voltage Condition Register | [:]STATUS[<channel>]:QUESTionable:VOLTage:CONDition? | Query the Questionable Voltage Condition Register | | Yes |
| Set Questionable Status Voltage Enable Register | [:]STATUS[<channel>]:QUESTionable:VOLTage:ENABLE | Access the Questionable Voltage Enable Register.. | ? <Enable Flags - (0-65535)> | Yes |
| Query Questionable Status Voltage Event Register | [:]STATUS[<channel>]:QUESTionable:VOLTage[: EVENT]? | Query the Questionable Voltage Event Register. | | Yes |
| Set Questionable Status Voltage Negative Transition Register | [:]STATUS[<channel>]:QUESTionable:VOLTage:NTRansition | Access the Questionable Voltage Negative Trans Filter Register. | ? <Transition Flags - (0-65535)> | Yes |
| Set Questionable Status Voltage Positive Transition Register | [:]STATUS[<channel>]:QUESTionable:VOLTage:PTRansition | Access the Questionable Voltage Positive Trans Filter Register. | ? <Transition Flags - (0-65535)> | Yes |
| Query the Standard Event register (ESR?) | [:]STATUS[<channel>]:STANdard[: EVENT]? | Query the Standard Event Status Register (SERS) | . | Yes |
| Enable the Standard Event register (*ESE,*ESE?) | [:]STATUS[<channel>]:STANdard:ENABLE | Access the Standard Event Status Register (SERS) Enable Flags. | ? <Enable Flags - (0-255)> | Yes |
| Query the Status Byte (*STB) | [:]STATUS[<channel>]:SBYTE[: EVENT]? | Query the Status Byte.. | | Yes |
| Service Request Enable (*SRE,*SRE?) | [:]STATUS[<channel>]:SREQuest:ENABLE | Access Service Request Enable Command. | ? <Enable Flags - (0-255)> | Yes |
| Clear Status | [:]STATUS[<channel>]:CLEAr | Clears all the Status Data Structures. | | |

Protection Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|-------------------------------------|---|---|---------------------|-------|
| Enable the interlock functionality. | [:]SENSE[<channel>]:PROTECTION :INTERLOCK[:STATE] | Control the Enable/Disable state of the Interlock System. | ? ON OFF | Yes |

Auto Sequence Commands

| Function | SCPI Command | Description | Parameter and Range | Query |
|---|--|--|-------------------------------------|-------|
| Delete all sequences. | [:]PROGRAM[<channel>]:DELETE:ALL | Erases the sequence currently in memory. | | N/A |
| Change Auto Sequence operating state. | [:]PROGRAM[<channel>]:STATE | Access to the run state of the Sequence. | ? RUN STOP PAUSE | Yes |
| Program selected sequence end action. | [:]PROGRAM[<channel>]:REPEAT | Sets the number of times to repeat the sequence. | ? <Repeat count (1–65534)> INFINITY | Yes |
| Begin Recording Auto Sequence Program | [:]PROGRAM[<channel>][:RECORD]:START | Start recording new sequence (overwrites old sequence). | | N/A |
| Stop Recording Auto Sequence Program | [:]PROGRAM[<channel>][:RECORD]:STOP | Stop recording the auto sequence program. (Sequence ready to run.) | | N/A |
| Set the Program Command Execution Delay Time | [:]PROGRAM[<channel>][:STEP]:DWELL | Sets the amount of time to delay between commands in a Sequence. | ? <Dwell time in seconds> | Yes |
| Read the current contents of the Autosequence programming buffer. | [:]PROGRAM[<channel>]:READBACK? | Read the current contents of the Autosequence programming buffer. | ? | Yes |

Error Messages

In this section:

This section provides information on the error messages which may appear. Errors are placed in a queue as they are detected.

ERROR MESSAGES

Errors are placed in a queue as they are detected. The queue works on a first in, first out (FIFO) basis. If the queue overflows, the last error in the queue is replaced with error -350, “Queue Overflow”. When all errors have been read from the queue, further error queries return 0, “No error”.

The error queue is cleared when any of the following occur (IEEE 488.2, section 11.4.3.4):

- Upon receipt of a *CLS command
- Upon reading the last item from the queue

Command Error List

An error in the range [-199, -100] indicates that an IEEE 488.2 syntax error has been detected by the instrument's parser. The occurrence of any error in this class causes the command error bit (bit 5) in the Event Status Register to be set.

Command Error List

| Error Code | Error Message Description |
|------------|--|
| -100 | Command error This is the generic syntax error |
| -102 | Syntax Error An unrecognized command or data type was encountered; for example, a string was received when the device does not accept strings. |
| -108 | Parameter not Allowed More parameters were received than expected for the header; for example, the *SRE common command only accepts one parameter, so receiving *SRE 0,1 is not allowed. |
| -109 | Missing Parameter Fewer parameters were received than required for the header; for example, the *SAV common command requires one parameter, so receiving *SAV is not allowed. |
| -110 | Command header error An error was detected in the header. |
| -113 | Undefined header The header is syntactically correct, but it is undefined for this specific device; for example, *XYZ is not defined for any device. |
| -121 | Invalid character in number An invalid character for the data type being parsed was encountered; for example, an alpha in a decimal numeric or a "9" in octal data. |
| -140 | Character data error This error is generated when parsing a character data element. |
| -150 | String data error This error is generated when parsing a string data element fails. |
| -151 | Invalid string data A string data element was expected, but was invalid for some reason (see <i>IEEE 488.2, 7.7.5.2</i>); for example, an END message was received before the terminal quote character. |

Execution Error List

An error in the range [-299, -200] indicates that an error has been detected by the instrument's execution control block. The occurrence of any error in the class causes the execution error bit (bit 4) in the Event Status Register to be set.

Execution errors are reported by the device after rounding and expression evaluation operations have taken place.

Execution Error List

| Error Code | Error Message Description |
|------------|---|
| -200 | Execution Error This is the generic syntax error for devices that cannot detect more specific errors. This code indicates only that an Execution Error as defined in <i>IEEE 488.2</i> , 11.5.1.1.5 has occurred. |
| -203 | Command protected Indicates that a legal password-protected program command or query could not be executed because the command was disabled. Check the calibration state. |
| -220 | Parameter error Indicates that a program data element related error has occurred |
| -221 | Setting conflict Indicates that a legal program data element was parsed, but could not be executed due to the current power supply state. The following list is not exhaustive but does cover some of the more common conditions that may contribute to this error: <ul style="list-style-type: none"> • OVP/UVS Set Points —The OVP and UVS limit the setting of the voltage set point so that you cannot accidentally trigger these alarms by changing the set point outside of their range. Conversely, setting the OVP set point to be less than the voltage set point will also trigger this error. • Changing the Set Point while in APG mode —The user will be unable to change the set point while APG is being used to control that parameter: voltage or current. • Autosequence Programming —Various conflicts can occur while using Autosequence programming; for example, using the trigger command while the program is running will result in this error. • Calibration mode —When in calibration mode, certain settings will cause an error. |
| -222 | Data out of range Indicates that a legal program data element was parsed but could not be executed because the interpreted value was outside the legal range as defined by the device (see <i>IEEE 488.2</i> , 11.5.1.1.5) |
| -224 | Illegal parameter value Used where the exact value, from a list of possible values, was expected. |
| -291 | Out of memory Used when the Autosequence programming buffer is full. |

Device-Specific Error List

An error in the range [-399, 300] or [1, 32767] indicates that the instrument has detected an error which is not a command error, a query error, or an execution error; some device operations did not properly complete, possibly due to an abnormal hardware or firmware condition. These codes are also used for self-test response errors. The occurrence of any error in the class causes the device-specific error bit (bit 3) in the Event Status Register to be set.

Device-Specific Error List

| Error Code | Error Message Description |
|------------|---|
| -300 | Device-specific error. Indicates that the power supply could not complete the operation due to some condition of the power supply. |
| -313 | Calibration Memory Lost |
| -314 | Save/Recall Memory Lost |
| -315 | Configuration Memory Lost |
| -350 | Queue Overflow A specific code entered into the queue in lieu of the code that caused the error. This code indicates that there is no room in the queue and an error occurred but was not recorded. |
| -360 | Communication error This is the generic communication error for devices. |
| -363 | Input buffer overrun Software or hardware input buffer on serial port overflows with data caused by improper or nonexistent pacing. |
| -365 | Time out error This is a generic device-dependent error. |

Query Error List

An error number in the range [-499, -400] indicates that the output queue control of the instrument has detected a problem with the message exchange protocol described in IEEE 488.2, section 6. The occurrence of any error in this class causes the query error bit (bit 2) in the Event Status Register to be set.

Query Error List

| Error Code | Error Message Description |
|------------|--|
| -400 | This is the generic query error for the power supply, used only when the other types of errors do not apply. |

Specifications

In this section:

This section provides the output performance, environmental, and mechanical specifications as well as regulatory approvals.

SPECIFICATIONS

Output Performance Specifications

| | |
|--|---|
| Aux output ¹ | +5V: +0.4V, – 0.5V at 0.4A +15V: +1.2V, – 1.4V at 0.4A |
| Temperature Coefficient | 100 PPM/° C from rated output voltage, after a 30-minute warm-up |
| Drift (8 hours) | 0.05% of rated output (over an 8 hour interval with constant line, load and temperature, after a 30-minute warm-up) |
| Hold-up Time | Typical 20 ms at any rated input line. |
| Transient Response Time ^{2,3} | Less than 1 ms for 20 V to 60 V models. Less than 2 ms for 80 V to 150 V models |
| OVP trip point accuracy | 1% of set point |
| Meter Accuracy ⁵ | 0.5% of actual output voltage or current ± 1 count |
| Data readback transfer time ⁴ | 3 ms |
| Programming and read back time | Less than 300ms for the whole time loop from sending the command to getting the readback voltage and current data |
| Isolation | |
| AC Input to Output | 1500 Vac |
| AC Input to Chassis | 1500 Vac |
| Output to Chassis ³ | 500 Vac |

1. Current: 0.51A minimum guaranteed, 0.72A typically available. Overcurrent protection (each output) is automatic, non-latching. When OCP is tripped the aux voltage folds back and will recover to nominal condition when the over current condition is removed (typ. < 0.2A).
To protect external circuits attached to the aux outputs it is recommended that customers use an appropriately rated fuse in series with the aux outputs being used.
2. Time for the output voltage to recover within 0.5% at its rated output for a load change 10–90% of rated output current. Output set point 10–100%.
3. ≤3 ms time for the output voltage to recover within 1% at its rated output for a load change 50% –100% or 100% - 50% of rated output current.
4. Time to provide data back to the controller using LAN interface (does not include A/D conversion time)
5. 0.5% of actual output voltage or current ± 1 count, floating display dot (for ex. 150-5.6 model accuracy will be 0.75V, for voltage and 0.025 for current, in the appropriate measure range). Contact factory for details regarding this mode of operation.

Environmental Specifications (Indoor use)

| | |
|-----------------------------|-----------------------------|
| Operating Temperature Range | 0 °C to 50 °C, 100% load |
| Storage Temperature Range | -20 °C to 70 °C |
| Operating Humidity Range | 30–90% RH (no condensation) |
| Storage Humidity Range | 10–95% RH (no condensation) |
| Operating Altitude | Up to 6,500 feet (2,000 m) |
| Installation Category | II (IEC 1010-1) |
| Pollution Degree | 2 (IEC 1010-1) |

Mechanical Specifications

| | |
|--------------------|---|
| Dimensions (W×H×D) | 8.4 × 1.7 × 19.0 inch (214 × 43.6 × 483 mm) |
| Weight | 11 lb (5kg) |
| Cooling | Forced air cooling by internal fans |

Regulatory Approvals

| | |
|--------|--|
| Safety | CSA 22.2 No. 61010-1 and UL61010-1. Marked with cCSAus, CE EN61010-1 |
| EMC | Complies with EN61326-1 Complies with EN55022, Class A, FCC Part 15A for conducted emissions Complies with EN55022, Class A, FCC Part 15A for radiated emissions Complies with EN61000-4 series of standards for immunity |

MECHANICAL DIMENSIONS

Figure 89: 850 Watt Mechanical Dimensions: 20 to 40 V Models

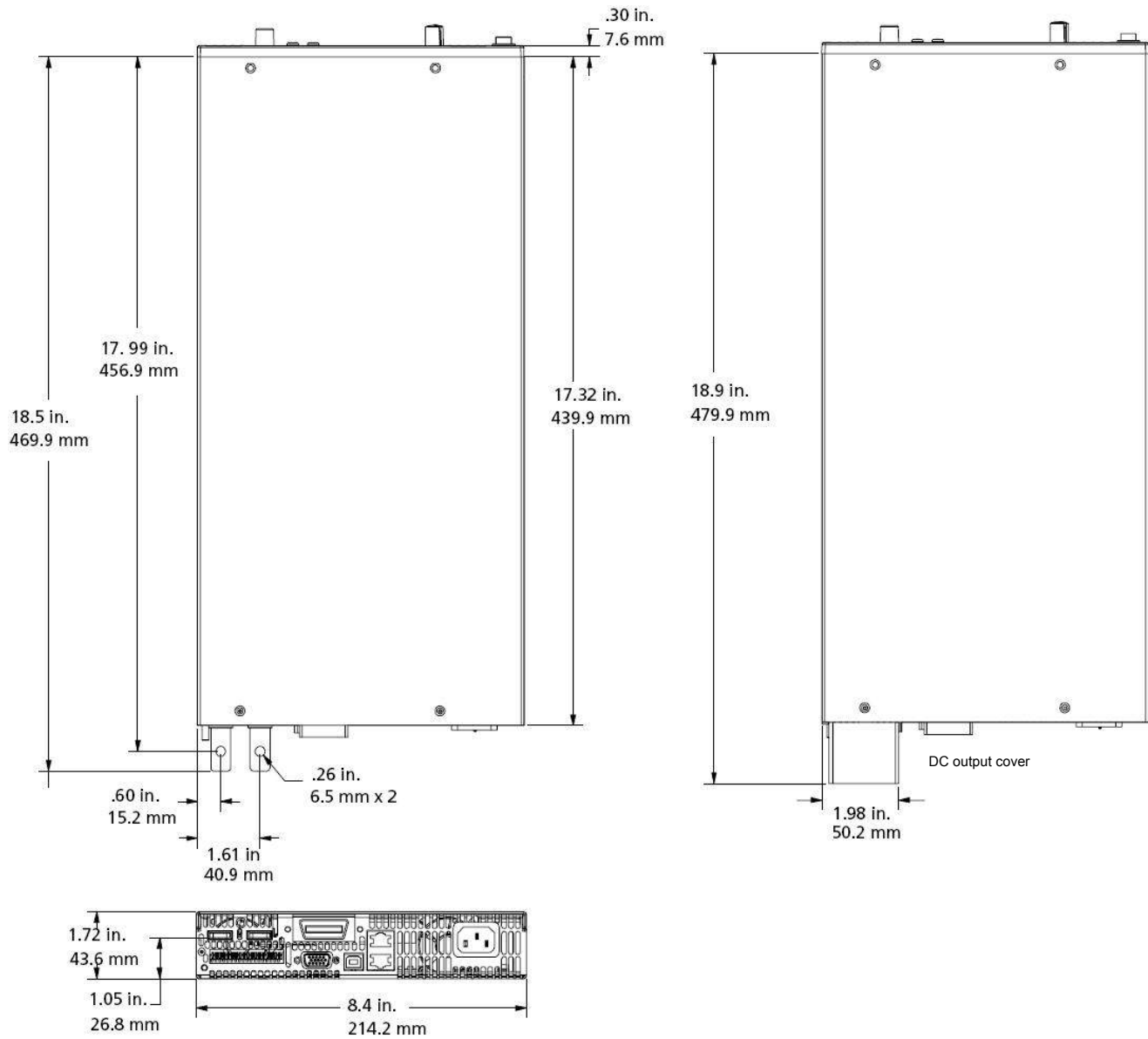
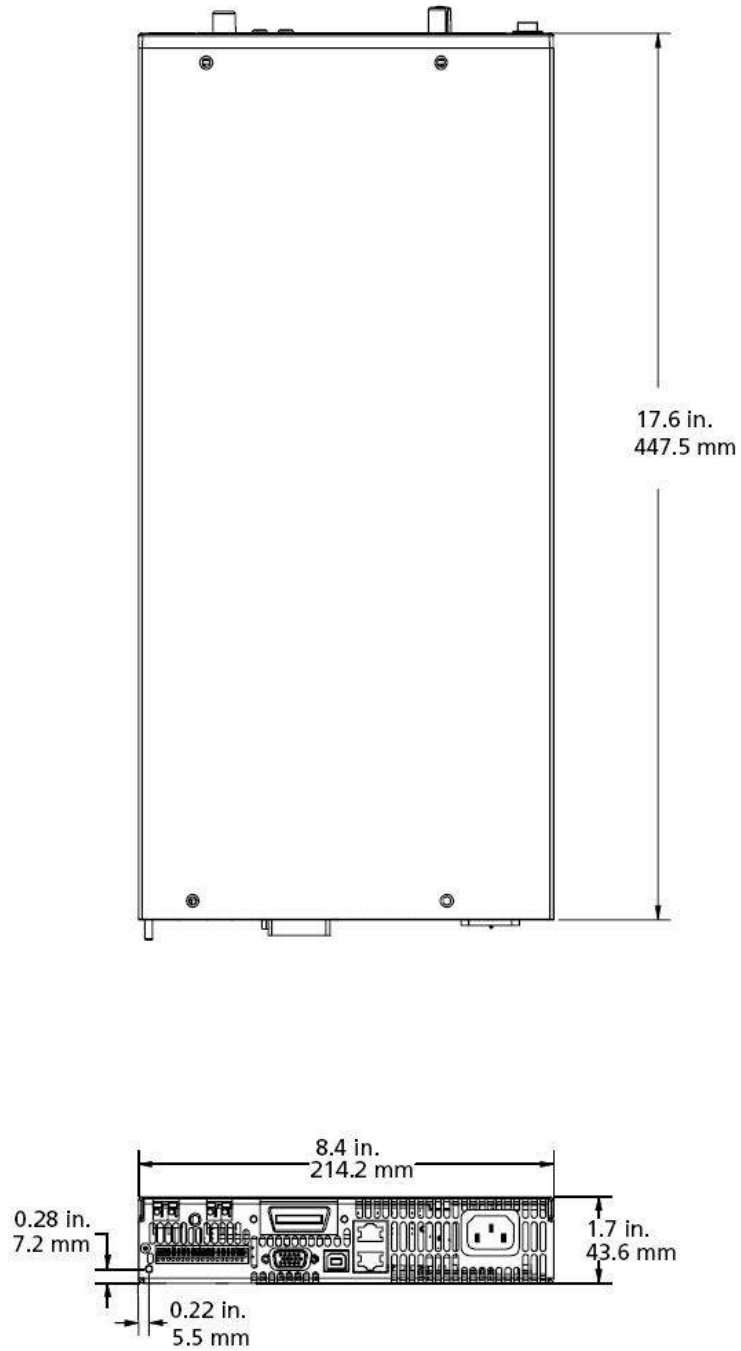


Figure 90: 850 Watt Mechanical Dimensions: 60 V to 150 V Models



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