

RE-INVENTING TEST & MEASUREMENT THROUGH *SPEED* AND *SIMPLICITY*

# Series 2280 Precision Measurement DC Power Supplies Quick Start Guide



A GREATER MEASURE OF CONFIDENCE

**KEITHLEY**  
A Tektronix Company

## Safety precautions

Observe the following safety precautions 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 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 V DC 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.



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



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



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



This symbol indicates a connection terminal to the equipment frame.



If the mercury 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.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

**WARNING** This 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.

**CAUTION** This 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, remove power from the 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 and servicing. Safety precaution revision of January 2013.

## Power and environmental specifications

For indoor use only.

Power supply	100 V/120 V/220 V/240 V AC, 50 Hz or 60 Hz
Operating altitude	Maximum 2000 m (6562 ft.) above sea level
Operating temperature	0 °C to 40 °C (32 °F to 104 °F), full accuracy to 80% relative humidity at up to 35 °C (95 °F), non-condensing
Storage temperature	-20 °C to 70 °C (-4 °F to 158 °F), 5% to 95% relative humidity at up to 40 °C (+104 °F) and 5% to 60% RH above 40 °C (+104 °F) up to 70 °C (+158 °F)
Pollution degree	2



### CAUTION

Carefully consider and configure the appropriate output-off state, and source and compliance levels before connecting the instrument to a device that can deliver energy. Failure to consider the output-off state and source and limit levels may result in damage to the instrument or to the device under test.

# Introduction

Thank you for choosing a Keithley Instruments product. The Series 2280 Precision Measurement DC Power Supplies are high-sensitivity, accurate, programmable instruments that source low noise, stable voltage, and can monitor load currents over a wide dynamic range from amperes to nanoamperes. With a high-resolution, 4.3 inch color display, numerous parameters describing the state of the instrument are displayed to enable you to get the most information from your measurements.

In addition, you can monitor trends such as drift with the built-in plotting functionality. As a power supply in an automated test system, this power supply provides a list mode and triggers, and speed optimization to minimize test time.

Model number	Description
2280S-32-6	Precision Measurement Programmable DC Power Supply. 32 V, 6 A
2280S-60-3	Precision Measurement Programmable DC Power Supply. 60 V, 3.2 A

## CD-ROM contents

The CD-ROM that is included with your instrument contains: **Manuals and specifications.** PDFs of the Reference Manual, Quick Start Guide, and accessory manuals.

For additional support information, see <http://www.keithley.com/support>.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

## Unpack and inspect the instrument

### *To unpack and inspect the instrument:*

1. Inspect the box for damage.
2. Open the top of the box.
3. Remove the bag that contains the documentation, standard accessories, CD-ROM, and cable housing.
4. Remove the packaging insert.
5. Remove the Series 2280 from the box.



### CAUTION

Do not lift the Series 2280 from the front bezel. Lifting the instrument by the front bezel can cause instrument damage.

6. Inspect the instrument for any obvious signs of physical damage. Report any damage to the shipping agent immediately.



You should have received the Series 2280 with the following accessories, shown in the photograph:

- 1 Power line cord
- 2 KKS-903-01C KickStart Quick Start Guide
- 3 Series 2280 Quick Start Guide (this document)
- 4 Series 2280 Precision Measurement DC Power Supplies Product Information CD-ROM
- 5 Model CA-180-3A CAT5 Crossover Cable for Ethernet
- 6 PA-853D User's Guide Safety Standards Conformance Information
- 7 Cable housing

Refer to the packing list for additional items that might have shipped with your instrument.



Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

# Connect the instrument

## Important test system safety information

This product is sold as a stand-alone instrument that may become part of a system that could contain hazardous voltages and energy sources. It is the responsibility of the test system designer, integrator, installer, maintenance personnel, and service personnel to make sure the system is safe during use and is operating properly.

You must also realize that in many test systems a single fault, such as a software error, may output hazardous signal levels even when the system indicates that there is no hazard present.

It is important that you consider the following factors in your system design and use:

- The international safety standard IEC 61010-1 defines voltages as hazardous if they exceed  $30 V_{RMS}$  and  $42.4 V$  peak, or  $60 V$  DC for equipment rated for dry locations. Keithley Instruments products are only rated for dry locations.
- Read and comply with the specifications of all instruments in the system. The overall allowed signal levels may be constrained by the lowest rated instrument in the system. For example, if you are using a  $500 V$  power supply with a  $300 V$  DC rated switch, the maximum allowed voltage in the system is  $300 V$  DC.
- Make sure any test fixture connected to the system protects the operator from contact with hazardous voltages, hot surfaces, and sharp objects. Use shields, barriers, insulation, and safety interlocks to accomplish this.
- Cover the device under test (DUT) to protect the operator from flying debris in the event of a system or DUT failure.
- Double-insulate all electrical connections that an operator can touch. Double insulation ensures the operator is still protected even if one insulation layer fails. Refer to IEC 61010-1 for specific requirements.
- Make sure all connections are behind a locked cabinet door or other barrier. This protects the system operator from accidentally removing a connection by hand and exposing hazardous voltages. Use high-reliability fail-safe interlock switches to disconnect power sources when a test fixture cover is opened.
- Where possible, use automatic handlers so operators are not required to access the DUT or other potentially hazardous areas.



- Provide training to all users of the system so they understand all potential hazards and know how to protect themselves from injury.
- In many systems, during power up, the outputs may be in an unknown state until they are properly initialized. Make sure the design can tolerate this situation without causing operator injury or hardware damage.

## NOTE

To keep users safe, always read and follow all safety warnings provided with each of the instruments in your system.

## Install the instrument

You can use the Series 2280 on a bench or in a rack. Please see the instructions that came with your rack-mount kit if you are installing the Series 2280 in a rack.

To prevent damaging heat build-up and ensure specified performance, make sure there is adequate ventilation and air flow around the instrument to ensure proper cooling. Do not cover the ventilation holes on the top, sides, or bottom of the instrument.

Make sure the instrument is positioned so that it is easy to reach any disconnecting devices, such as the power cord and the power switch.

## Power up the instrument

The Series 2280 operates at 100 V, 120 V, 220 V, or 240 V with a frequency of 50 Hz or 60 Hz. Make sure that the AC line voltage indicator in the center of the rear-panel power module matches the AC line voltage in your facility. If it does not, refer to the "Maintenance" section of the Reference Manual to change the setting on the power entry module.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

## ⚠ WARNING

The power cord supplied with the Series 2280 contains a separate protective earth (safety ground) wire for use with grounded outlets. When proper connections are made, the instrument chassis is connected to power-line ground through the ground wire in the power cord. In addition, a redundant protective earth connection is provided through a screw on the rear panel. This terminal should be connected to a known protective earth. In the event of a failure, not using a properly grounded protective earth and grounded outlet may result in personal injury or death due to electric shock. Do not replace detachable mains supply cords with inadequately rated cords. Failure to use properly rated cords may result in personal injury or death due to electric shock.

### To connect line power:

1. Make sure the front panel power switch is in the off (0) position.
2. Connect the socket of the supplied power cord to the power module on the rear panel.
3. Connect the plug of the power cord to a grounded AC outlet.
4. Turn on the instrument by pressing the front panel **POWER** switch to the on (I) position. The instrument will power up.



## ⚠ CAUTION

Operating the instrument on an incorrect line voltage may cause damage to the instrument, possibly voiding the warranty.

## Connections for testing

Before making the connections, prepare the wires as described in the following table.

Usage	Specifications
Front panel binding posts	AWG 20 to AWG 12
Rear panel output terminals	AWG 20 to AWG 12

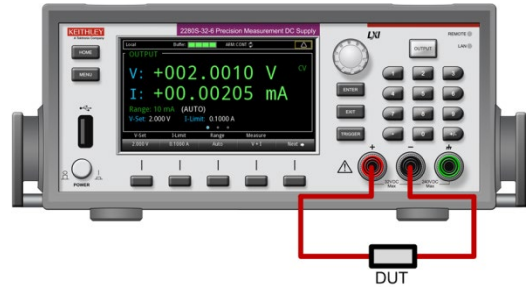
### CAUTION

The wire must be heavy enough not to overheat while carrying the short-circuit output current of the unit. Please meet the wiring requirements described above.

## Two-wire connection

The two-wire connections are used for basic operation when maximum accuracy is not required. Keep the wire as short as possible to reduce lead inductance and noise pickup. If you want to compensate for the voltage drop in the load leads, use a four-wire sense connection.

Two-wire (local sensing) DUT connection to front panel



Safety

Introduction

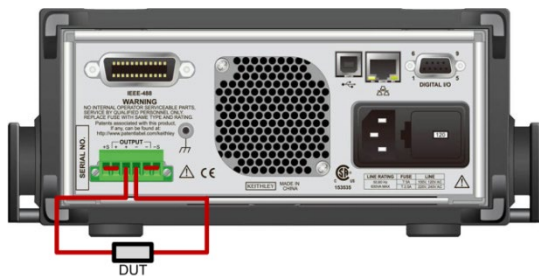
Unpack

Connect

Test

FAQs  
Next steps

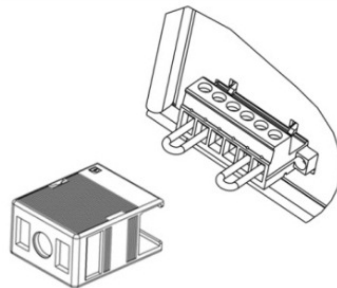
## Two-wire (local sensing) DUT connection to rear panel



### NOTE

When making two-wire connections with the Series 2280, you must short both Output Hi and Sense Hi and Output Lo and Sense Lo with the shorting jumpers. If you do not do this, the display will show incorrect voltage output readings.

After making the connections, slide the cable housing over the output mating connector and wires.



### ! WARNING

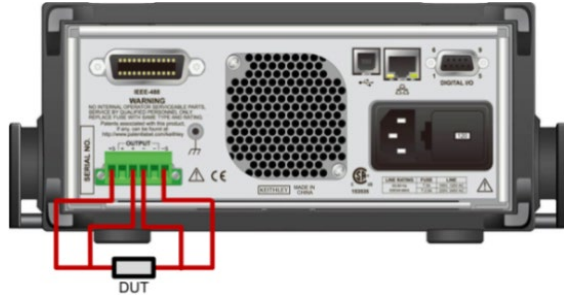
Failure to install the cable housing may result in personal injury or death due to electric shock.

## Four-wire remote sense connection

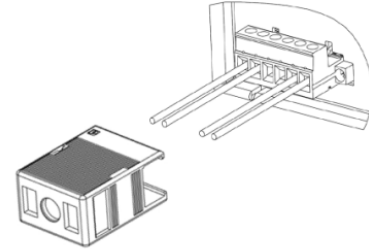
Using four-wire remote sensing connections ensures that the programmed voltage is applied to the load and compensates for the voltage drop in the leads between the power supply and the load.

As shipped, the sense terminals are connected to the output terminals by shorting jumpers. Before connecting the wire, make sure the shorting jumpers have been removed. When you connect the power supply for remote sensing, the overprotection (OVP) circuit senses the voltage at the sensing points (load) and not the output terminals.

Four-wire (remote sensing) DUT connection to rear panel



After making the connections, slide the cable housing over the output mating connector and wires.



### WARNING

Failure to install the cable housing may result in personal injury or death due to electric shock.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

## Overview of the front-panel options



The front panel of the Series 2280 allows you to set up most instrument functions and features and perform sourcing and measuring operations. The front panel includes:

- A high-resolution color display that allows you to access instrument settings and measurement readings
- Keys that select menu options and start measurement operations
- A navigation control that can be used to select screen options
- An output ON/OFF switch that turns the source output on or off
- Front-panel binding posts for output connections

## ENTER and EXIT keys

The **ENTER** key selects a highlighted option. In most cases, it opens the menu or dialog box that allows you to change settings for that option.

The **EXIT** key returns to the previous menu or closes a dialog box. For example, if you are in the Menu screen, pressing **EXIT** returns you to the Home screen.

## TRIGGER key

The action of the **TRIGGER** key depends on the trigger method that is selected:

- If manual triggering is selected, TRIGGER causes the instrument to make a measurement.
- If the trigger model is in idle, TRIGGER initiates the trigger model.

## Front-panel user interface overview

The front-panel user interface gives you quick access to source settings, measure settings, system configuration, instrument status, reading buffer information, and other instrument functionality.

## Home screen overview

The Home screen is the first screen that opens on power up. You can always return to the Home screen by pressing the **HOME** key.



The top row on the Home screen displays the status and event indicators. You can select these options to open dialog boxes that provide additional information about the status or event.

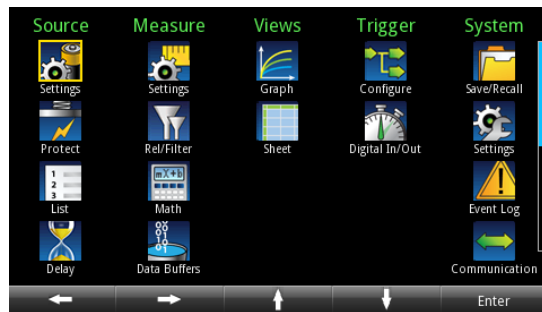
The OUTPUT view area of the Home screen displays the value of the present outputs and status indicators. The outputs show dashed lines until the output is turned on.

The setting area of the Home screen is located in the lower left corner of the OUTPUT view area. It shows the presently set measure range, voltage, and current limit.

The soft-key area is located on the bottom of the Home screen. It shows the present setting values. You can change these values by pressing the buttons below the screen.

## Menu screen overview

When you press the **MENU** key on the front panel, the Menu screen is displayed.



Safety

Introduction

Unpack

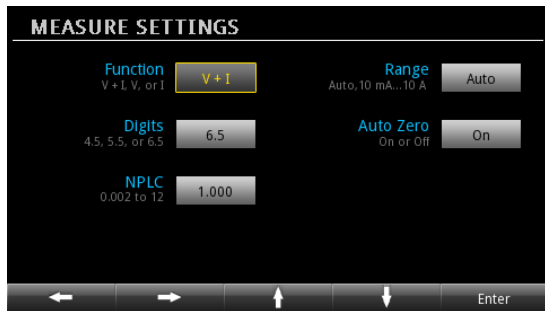
Connect

Test

FAQs  
Next steps

From this screen, you can select source, measure, graph, trigger, and system setup menus. These menus allow you to choose options to set up your instrument for your applications. Select a setup item by either scrolling the navigation control or using the arrow keys to highlight an icon. Then press **ENTER**.

An example of the options that are available when you select the Settings option under Measure is shown below.



## Simple voltage output and current measurement

The following example demonstrates the steps to configure a voltage output and perform a precision voltage and current measurement using the default instrument configuration.

Connect the DUT (for this example, a 1 k $\Omega$  resistor) to the output binding post on the front panel. For details, refer to [Two-wire connection](#). You can also use four-wire connections to compensate for voltage drops on the load leads.

### *To set the voltage and current limit on the front panel:*

1. Press the **Home** key. The Home screen is displayed.
2. Press the **V-Set** soft key. The editing window is displayed at the bottom.
3. Set the voltage to 5 V. Enter 5 using the numerical keys on the right of the front panel. You can also change the value using either the arrows keys or navigation control.
4. Press the **I-Limit** soft key. The editing window is displayed at the bottom.
5. Set the current limit to 1 A. Press **ENTER**.

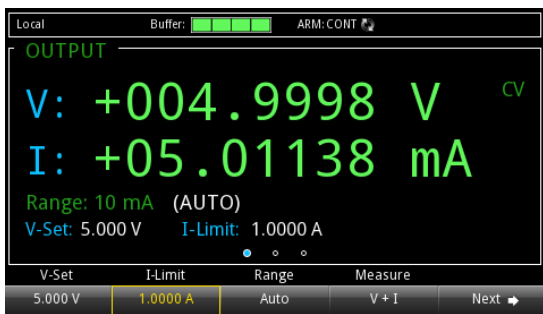




## CAUTION

When the output is turned on, changing the value with the navigation control can source voltage and current instantly. Make sure the output does not damage your device under test (DUT).

6. Press the **OUTPUT** switch to turn the output on.



See the "General operation" section of the Reference Manual for additional details and remote interface examples.

## Select a measure function

The Series 2280 allows you to perform the following measure functions.

Measure functions	What the instrument measures
Concurrent (V + I)	Measure voltage and current at the same time
Voltage (V)	Only measure voltage
Current (I)	Only measure current

### *To set the measure function from the Menu screen:*

1. Press the **Menu** key.
2. Under Measure, select **Settings**.
3. Select the button next to **Function** and press the **ENTER** key. The selection window is displayed.
4. Select a measure function.

### *To set the measure function from the Home screen:*

1. Press the **Measure** soft key. The selection window is displayed.
2. Select a measure function.

See the "General operation" section of the Reference Manual for additional details and remote interface examples.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

## Specify a measurement range

You can set ranges for the measurement values. You can set specific ranges or allow the instrument to choose the ranges automatically.

The measurement range determines the full-scale input for the measurement. The measurement range also affects the accuracy of the measurements and the maximum signal that can be measured.

The Series 2280 has multiple current measurement ranges and one voltage range. The ranges are listed in the following table.

### *To set the ranges from the Home screen:*

1. Press the **HOME** key and select **Range** button. The Range dialog box is displayed.
2. Use the up and down arrow soft keys to select the range. The Home page is updated with the new range setting. Press **ENTER** or **EXIT** to close the Range dialog box.

### *To set the ranges from the Menu screen:*

1. Press the **MENU** key.
2. Highlight the **Settings** icon under Measure using either the navigation control or the softkeys. Press **ENTER**.
3. On the MEASURE SETTINGS page, select the button next to **Range**. The Range dialog box is displayed.

4. Select the range. You are returned to the MEASURE SETTINGS screen.

Model number	Current measurement range	Voltage measurement range
2280S-32-6	10 A	32 V
	1 A	
	100 mA	
	10 mA	
2280S-60-3	10 A	60 V
	1 A	
	100 mA	
	10 mA	

See the "General operation" section of the Reference Manual for additional details and remote interface examples.

## Configure and execute a 10-step linear list sweep

The following example demonstrates the steps to set up the power supply to output a linear list sweep from 1 V to 10 V in 1 V steps (default settings). Each step in the list sweep will dwell for 3 seconds. The list will be stored in list location 1. The output will turn on at 0 V and return to 0 V at the end of the list execution.

### *To configure a list on the front panel:*

1. Press the **MENU** key.
2. Under Measure, highlight the **List** icon using either the navigation control or the soft keys. Press **ENTER**.
3. Select point 1 and press **ENTER** to put a check mark in the box.
4. Highlight **Insert** and press **ENTER** to increment the points display until it reads 10.
5. Select the Voltage box in the point 1 row. Press **ENTER**.
6. Make the value 1 V and press **ENTER**.
7. Select the Current box in the point 1 row. Press **ENTER**.
8. Make the value 2 A and press **ENTER**.
9. Select the Dwell box in the point 1 row. Press **ENTER**.
10. Make the value 3 s and press **ENTER**.

Points	Voltage	Current	Dwell
<input checked="" type="checkbox"/> 1	1.000 V	2.0000 A	3.000 s
<input type="checkbox"/> 2	2.000 V	2.0000 A	3.000 s
<input type="checkbox"/> 3	3.000 V	2.0000 A	3.000 s

11. Repeat steps 5 to 8 for points 2 to 10 and increase the voltage by 1 V at each higher step.
12. Select the **Save** button to store the list in memory location 1.
13. Enter a name for the list on the displayed keypad and press **ENTER**.
14. Press the **EXIT** key.

### *To delete a row on the front panel:*

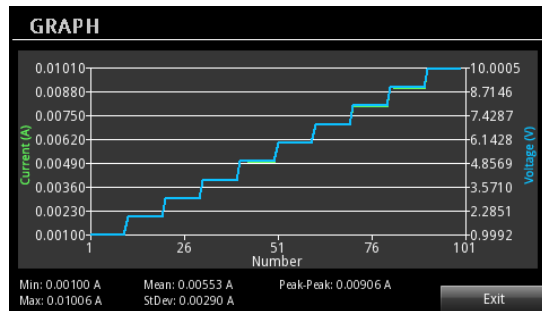
1. Highlight the Points cell of the row you want to delete.
2. Press **ENTER** to select the cell row.
3. Navigate to **Delete**.
4. Press **ENTER**.

### *To execute a list sweep on the front panel:*

1. Press the **MENU** key.
2. Under Trigger, highlight the **Configure** icon using either the navigation control or the soft keys. Press **ENTER**.
3. Select the button next to **Sample Count** and press the **ENTER** key.
4. Set the sample count to 10.
5. Press the **HOME** key.
6. Press the **NEXT** soft key twice to navigate to the 3rd Home screen.
7. Press the **List** soft key. The List dialog box is displayed.
8. If the **Number** soft key is not showing a 1, press the **Number** soft key and enter the value, 1.
9. Press the **Enable** soft key to run list 1.

### *To view the measurements on the front panel:*

1. Press the **Exit** key to close the List dialog box.
2. Press the **View** soft key under Graph to view a plot of the measurements.



See the "Functions and features" section of the Reference Manual for additional details and remote interface examples.

## Next steps

For more information, refer to the Product Information CD-ROM, which includes the Series 2280 Reference Manual. It provides detailed information about all features of the instrument.

Also see the Keithley Instruments website, [www.keithley.com](http://www.keithley.com) for support and additional information about the instrument.

Safety

Introduction

Unpack

Connect

Test

FAQs  
Next steps

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