

Model 2460 Quick Start Guide



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.

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.

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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 as of January 2013.

Power and environmental specifications

For indoor use only.

| | |
|-----------------------|--|
| Power supply | 100 V to 240 V RMS, 50 Hz to 60 Hz (autosensing) |
| Maximum VA | 350 VA |
| Operating altitude | Maximum 2000 m (6562 ft) above sea level |
| Operating temperature | 0 °C to 50 °C (32 °F to 122 °F), 70% relative humidity up to 35 °C (95 °F); derate 3% relative humidity/°C, 35 °C to 50 °C (95 °F to 122 °F) |
| Storage temperature | -25 °C to +65 °C (-13 °F to 149 °F), 5% to 90% relative humidity noncondensing |
| Pollution degree | 1 or 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 Model 2460 High-Current Interactive SourceMeter® instrument is a precise, low-noise instrument that combines a stable DC power supply, true high-current source, electronic load, and high-impedance multimeter. The design of this instrument features intuitive set up and control, enhanced signal quality and range, and better resistivity and resistance capabilities than similar products on the market.

The Model 2460 can source up to 7 A and features 1 μ A to 7 A ranges. With 0.012 percent basic accuracy at 6½-digit resolution, the Model 2460 is a good solution for testing a wide variety of materials and devices in applications such as power semiconductors, solar energy, high-brightness LEDs, power conversion, electrochemistry, batteries, and more.

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

CD-ROM contents

The CD-ROM that is included with your instrument contains the following PDF user documentation:

- **Quick Start Guide (this document):** Provides unpacking instructions, describes basic connections, reviews basic operation information, and provides a quick test procedure to ensure the instrument is operational.
- **User's Manual:** Provides application examples that you can use as a starting point to create your own applications.
- **Reference Manual:** Includes advanced operation topics, maintenance information, troubleshooting procedures, optimization strategies, and in-depth descriptions of programming commands.
- **KickStart Software Quick Start Guide:** Provides instructions to quickly make measurements and get results without having to program test scripts.
- **Accessories information:** Documentation for accessories that are available for the Model 2460.

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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 optional accessories.
4. Remove optional accessories (such as rack-mount hardware).
5. Remove the packaging insert.
6. Remove the Model 2460 from the box.

CAUTION

Do not use the front bezel to lift the Model 2460. Using the front bezel can cause damage to the instrument.

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



You should have received the Model 2460 with the following accessories, shown in the photograph:

- 1 USB-B-1 USB Cable, Type A to Type B (1 m)
- 2 Model 8608 Safety Clip-Lead Set
- 3 Power line cord
- 4 KKS-903-01 KickStart Quick Start Guide
- 5 Model 2460-903-01 Quick Start Guide (this document)
- 6 24GDI-950-01 Interactive SourceMeter Instrument Product Information CD-ROM
- 7 Model CS-1616-3 Mini-clamp II Plug for the interlock
- 8 Model 2460-KIT Screw Terminal Connector kit
- 9 Model CA-180-3A CAT5 Crossover Cable for TSP-Link or Ethernet
- 10 PA-853 Users Guide Safety Standards Conformance Information

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



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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, Inc. 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, when the instrument is powering on, 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 Model 2460 on a bench or in a rack. Please see the instructions that came with your rack-mount kit if you are installing the Model 2460 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.

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

Wiring the interlock

WARNING

The Model 2460 is provided with an interlock circuit that must be positively activated in order for the high-voltage output to be enabled. The interlock helps facilitate safe operation of the equipment in a test system. Bypassing the interlock could expose the operator to hazardous voltages that could result in personal injury or death.

To perform high-voltage measurements, the Model 2460 interlock must be connected to an interlock switch in the testing environment. When properly connected, the safety interlock of the Model 2460 places the outputs of the instrument in a safe state. When the safety interlock signal is asserted, all voltage ranges of the instrument are available and the green front-panel INTERLOCK indicator is on.

When the safety interlock signal is not asserted, the high-voltage ranges are disabled, limiting the nominal output to less than ± 42 V and the front-panel INTERLOCK indicator is not illuminated.

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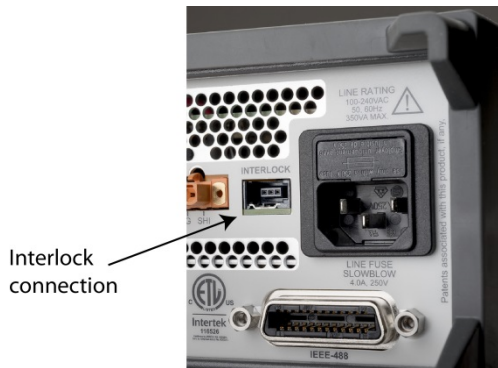
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You can only use the high-voltage outputs when the interlock is asserted. If you try to assign a high-voltage output and turn the source on when the interlock is not asserted, you see event code 5074, “Output voltage limited by interlock.” Note that the SOURCE swipe screen displays the value that was selected for the voltage source, but the source value is limited to less than ± 42 V.

An interlock circuit is provided on the rear panel of the instrument, as shown in the following figure. This circuit must be closed to enable the Model 2460 to produce voltages greater than ± 42 V.



The interlock is intended for use through a normally open switch, which may be installed on the lid of a test fixture, on the enclosure of a semiconductor prober or device handler, or on the door or doors of a test equipment rack. The circuit opens when an access door is opened, and closes when the door is closed.

When the interlock is asserted, the FORCE and GUARD terminals should be considered hazardous voltages, even if they are programmed to a non-hazardous voltage or current.

WARNING

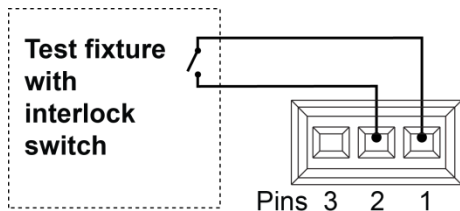
Potentially hazardous voltages of up to ± 250 V may be present at the Force HI, Sense HI, and Guard terminals when the interlock circuit is closed. To prevent electrical shock, do not expose these lines.

You can use the Keithley Instruments connector CS-1616-3, supplied with the Model 2460, to make the interlock connection to the rear panel. You must supply connection wire.

To ensure proper interlock operation, the external interlock switch and connection wires must be less than 10Ω when the switch is closed.

The pin locations and connections are shown in the following figure.
The pins are:

- Pin 3: Earth and chassis ground
- Pin 2: Interlock
- Pin 1: +6 V DC out (current limited)



NOTE

For the examples shown in this quick start guide, you do not need to use an interlock. The Model 2460 functions on all current ranges and up to ± 42 volts without asserting the interlock.

Power on the instrument

The Model 2460 operates from a line voltage of 100 V to 240 V at a frequency of 50 Hz or 60 Hz. The instrument senses the line voltage automatically. Before connecting line power, make sure the operating voltage in your area is compatible.

WARNING

The power cord supplied with the Model 2460 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.

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To connect line power:

1. Make sure the front panel power switch is in the off (O) 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 starts.



Overview of the front-panel options

The front panel of the Model 2460 allows you to set up most instrument functions and features and perform sourcing and measuring operations. The front panel includes:

- A touchscreen display that allows you to access instrument settings and measurement readings
- Keys that select menu options and start measurement operations
- A navigation knob that can be used to select screen options
- An OUTPUT ON/OFF switch that turns the source output on or off.
- Banana jack connections for FORCE HI and LO, SENSE HI and LO, and chassis ground.
- A TERMINALS switch that determines if the instrument uses the front or rear panel connections for sourcing and measuring.

Touchscreen display overview

You can use the touchscreen display to set up the instrument and tests. You use the keys and touch capabilities to make selections.

To use the touchscreen, select options with your finger. You can also use the navigation knob to highlight an item, and then press the knob to select it.

The following text describes some of the most commonly used screens. For more detail and descriptions of all the screens, see the *Model 2460 Reference Manual*. For detail about an option, select it and press the **HELP** key to read a brief description of the option.

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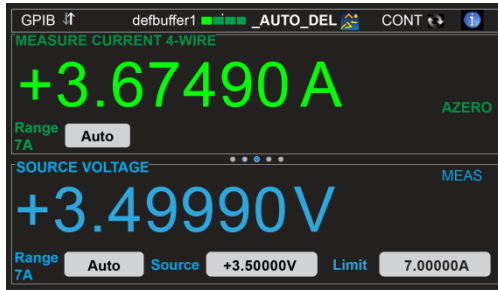
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Home screen overview

The Home screen is the first screen that opens when the instrument is powered on. 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 measure section of the Home screen displays the present measurement. It also displays the measure functions and allows you to select a measure range.

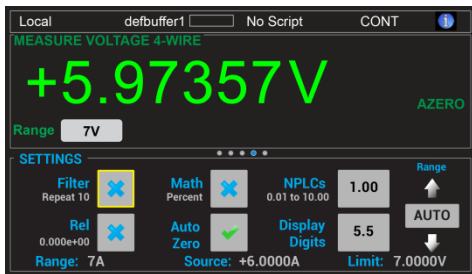
The source section of the Home screen displays the source settings. When the output is on, this displays either the programmed source value or the actual source, depending on the setting of source readback. In the source section, you can set the source range, source value, and source limit.

You can swipe the source section to access additional screens, including the following screens:

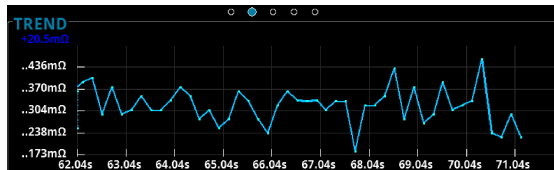
- **SETTINGS** swipe screen: Allows you to turn features on and off, such as the measurement filter, math functions, relative offset, and NPLCs.
- **STATISTICS** swipe screen: Contains statistics based on the readings in the active buffer.
- **USER** swipe screen: Displays information that you can define through a remote interface.
- **TREND** swipe screen: Shows a graph of the readings in the presently selected buffer. You can swipe up on the graph to open it to a full-screen view.

Examples of the SETTINGS and TREND swipe screens are shown below.

In the SETTINGS swipe screen shown here, the Auto Zero feature is turned on. The other settings are turned off.



In the TREND swipe screen shown here, you can view the measurements as they occur. To see a full-screen graph, swipe up on the graph to go to the Graph screen. In the full-screen graph, you can also change the data and scale of the information that is displayed on the graph.



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ENTER and EXIT keys

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

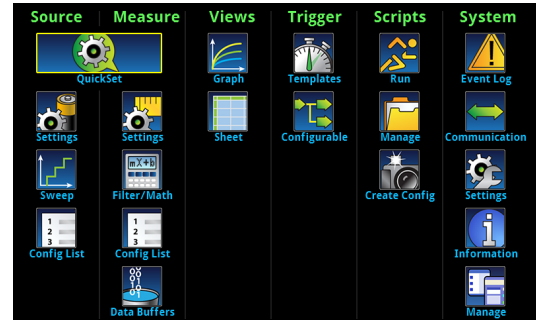
TRIGGER key

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

- If you set the instrument to continuously trigger, this displays a dialog box that allows you to select another measurement method.
- If you set the instrument to manually trigger, pressing the **TRIGGER** key causes the instrument to make a measurement.
- If you defined a trigger model, pressing the **TRIGGER** key initiates the trigger model.

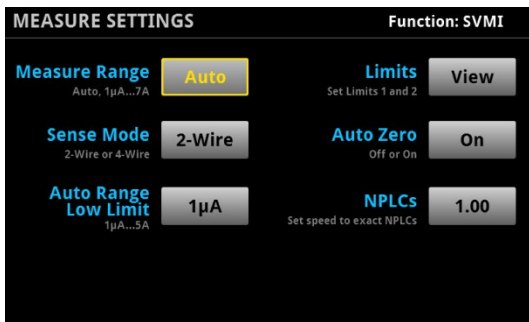
Menu screen overview

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



From this screen, you can select source, measure, graphing, trigger, scripting, and system setup menus. These menus allow you to choose options to set up your instrument to meet the needs of your applications.

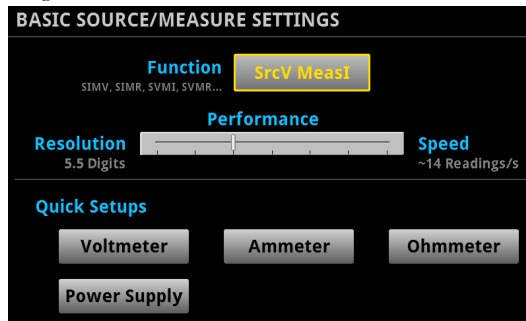
An example of the options that are available when you select the Settings option under Measure is shown below.



Quick Setup options

When you press QUICKSET, the BASIC SOURCE/MEASURE SETTINGS screen is displayed. From this menu, you can:

- Choose the source and measure functions.
- Use the Performance slider to select the best balance between measurement resolution and measurement speed.
- Choose from a selection of Quick Setups that automatically make the settings required for that setup, turn the output on, and begin making measurements.



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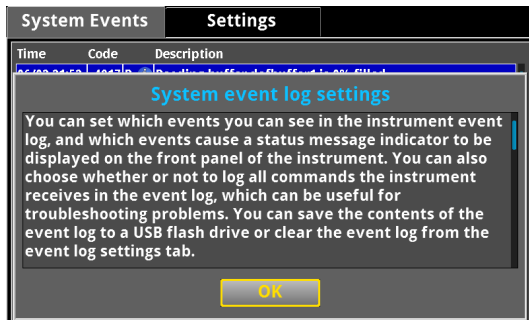


CAUTION

When you select a Quick Setup, the instrument turns the output on. Carefully consider and configure the appropriate output-off state, source, and limits before connecting the Model 2460 to a device that can deliver energy, such as other voltage sources, batteries, capacitors, or solar cells. Configure the settings that are recommended for the instrument before making connections to the device. Failure to consider the output-off state, source, and limits may result in damage to the instrument or to the device under test (DUT).

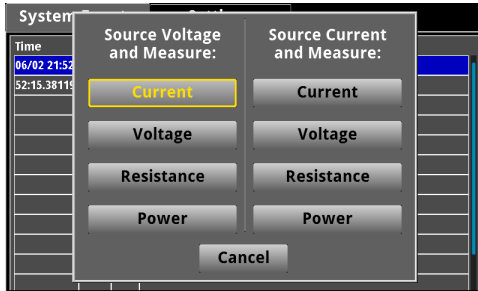
Help

You can display help screens for the menu items and buttons. The help screens give a brief description of the option that the menu or button sets. To display the description, highlight the menu item or button and press the **HELP** key. The graphic below shows an example of the help when you are on the System Events tab of the event log.



FUNCTION

The **FUNCTION** key opens the **FUNCTION** selection dialog box, which allows you to select the source and measure functions.



The instrument saves many of the commands with the source or measure function that was active when you set them. For example, if you set the measure function to current and you set a value for NPLCs, the instrument saves the NPLC value for that measure function. When you change the measure function to voltage, the NPLC value changes to the value that was last set for the voltage measure function.

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Connections for testing

The following figures show the physical connections for the front panel. Note that you must use either the front terminals or rear terminals — you cannot mix connections. The rear-panel connection is a screw terminal. The front-panel connections are safety banana jacks.

The example in this guide shows you how to make connections to the front panel and short the connections.

For this example, you can make the connections with the insulated banana cables that are supplied with the Model 2460, the Keithley Instruments Model 8608 Safety Clip Lead Set.

1. Make sure the front-panel power switch is in the off (O) position.
2. Connect the red lead to the FORCE HI connection.
3. Connect the black lead to the FORCE LO connection.



Verify measurement operation

The following steps provide a quick way to verify that the instrument is operating correctly.

To verify measurement operation:

1. Turn the instrument on.
2. On the front panel, press the **HOME** key.
3. Press the **FUNCTION** key.
4. Under Source Current and Measure, select **Voltage**.
5. Select the button next to Source (at the bottom of the Home screen). The Current Source Value dialog box is displayed.
6. Enter 10 mA.
7. Short the connections.
8. Press the **OUTPUT ON/OFF** switch to enable the output and start making measurements.
9. When measurements are complete, press the **OUTPUT ON/OFF** switch to disable the output.

The voltage measurements appear in the Measure Voltage area of the Home screen.

To save the data to a USB flash drive:

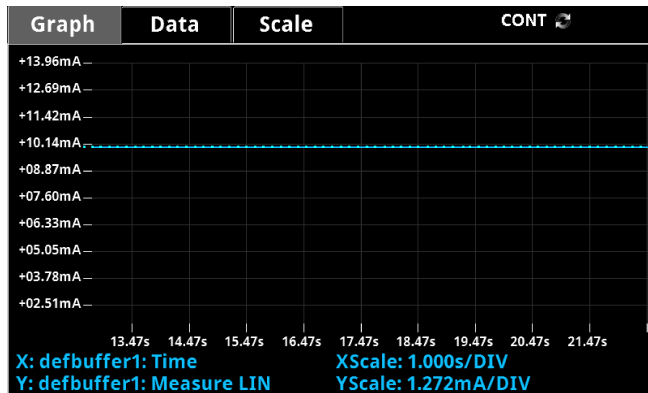
1. Insert a USB flash drive into the front panel USB connector.
2. Press the **MENU** key.
3. Under Measure, select **Data Buffers**.
4. Select **defbuffer1**. A menu is displayed.
5. Select **Save To USB**.
6. Enter the file name.
7. Select **OK** (on the screen).
8. A confirmation message is displayed. Select **Yes**.

The instrument saves the data to a .csv file on the flash drive.

To view the measurements on the front-panel graph:

1. Press the **MENU** key.
2. Under Views, select **Graph**.

You can swipe and use pinch and zoom to change the view of data on the graph. You can also adjust the graph settings using the options in the Data and Scale tabs.



FAQs

My data looks odd or is wrong. What should I do?

Verify the connections from the instrument to the test fixture. Also check the connections from the DUT to the test fixture socket.

How do I change the command set?

In addition to the front-panel options, you can use a remote interface to set up the instrument. You can choose one of the following command sets:

- SCPI: An instrument-specific language built on the SCPI standard.
- TSP: A programming language that you can use to send individual commands or combine commands into scripts.

You cannot combine the command sets.

As delivered from Keithley Instruments, the Model 2460 is set to work with the SCPI command set.

To set the command set using the front panel:

1. Press the **MENU** key.
2. Under System, select **Settings**.
3. Select the button next to Command Set.
4. Select the command set.
5. You are prompted to reboot.

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Why did my settings change?

The instrument saves many of the commands with the source or measure function that was active when you set them. For example, assume you have the measure function set to current and set a value for NPLCs. When you change the measure function to voltage, the NPLC value changes to the value that was last set for the voltage measure function. When you return to the current measure function, the NPLC value returns to the value you set previously.

Next steps

For more information, refer to the 24GDI-950-01 Interactive SourceMeter Product Information CD-ROM, which includes the following documents:

- **Model 2460 User Manual:** Contains basic information about the instrument, plus application-based examples that will help familiarize you with the instrument.
- **Model 2460 Reference Manual:** Provides detailed information about all features of the instrument.

Also see the **Keithley Instruments website**, www.keithley.com, for support and additional information about the instrument.

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