

# Series 2600B System SourceMeter<sup>®</sup> Instrument

## User's Manual

2600BS-900-01 Rev. A August 2021



2600BS-900-01A

Series 2600B  
System SourceMeter<sup>®</sup> instrument  
User's Manual

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Document number: 2600BS-900-01 Rev. A August 2021

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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 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 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. Maximum signal levels are defined in the specifications and operating information and shown on the instrument panels, test fixture panels, and switching cards.

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 hazard. 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 warning, 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 hazards 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.

The **CAUTION** heading with the  symbol in the user documentation explains hazards that could result in moderate or minor injury or damage the instrument. Always read the associated information very carefully before performing the indicated procedure. Damage to the instrument 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. Standard fuses with applicable national safety approvals may be used if the rating and type are the same. The detachable mains power cord provided with the instrument may only be replaced with a similarly rated power cord. 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 to maintain accuracy and functionality of the product). If you are unsure about the applicability of a replacement component, call a Keithley office for information.

Unless otherwise noted in product-specific literature, Keithley instruments are designed to operate indoors only, in the following environment: Altitude at or below 2,000 m (6,562 ft); temperature 0 °C to 50 °C (32 °F to 122 °F); and pollution degree 1 or 2.

To clean an instrument, use a cloth dampened with deionized water 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 June 2018.

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## Introduction

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## Welcome

Thank you for choosing a Keithley Instruments product. The Series 2600B System SourceMeter® instrument provides manufacturers of electronic components and semiconductor devices with an instrument that combines source and measurement capabilities in a single instrument called a source-measure unit (also called a SMU). This combination simplifies test processes by eliminating synchronization and connection issues associated with multiple instrument solutions. A 2600B provides a scalable, high throughput, highly cost-effective solution for precision dc, pulse, and low frequency ac source-measure testing that also maintains code compatibility throughout the Series 2600B SourceMeter instruments.

This manual describes basic operation for the Models 2601B, 2602B, 2604B, 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B.

## 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 office, sales partner, or distributor 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. You can also call the Tektronix corporate headquarters (toll-free inside the U.S. and Canada only) at 1-800-833-9200. For worldwide contact numbers, visit [tek.com/contact-us](http://tek.com/contact-us).

## Customer documentation

The documentation for the 2600B includes a Quick Start Guide, User's Manual, and Reference Manual. A Quick Start Guide is provided as a hard copy with the instrument. You can also access it from [tek.com/keithley](http://tek.com/keithley) as an Adobe Acrobat PDF file.

- **Quick Start Guide:** Provides unpacking instructions, describes basic connections, and reviews basic operation information. If you are new to Keithley Instruments equipment, refer to the Quick Start Guide to take the steps needed to unpack, set up, and verify operation.
- **User's Manual:** Includes installation, instrument description, operation, and maintenance information.
- **Reference Manual:** Includes advanced operation topics and maintenance information. Programmers looking for a command reference and users looking for an in-depth description of how the instrument works (including troubleshooting and optimization) should refer to the Reference Manual.

## Product software and drivers

Go to the [Product Support and Downloads web page \(tek.com/product-support\)](http://tek.com/product-support) to download drivers and software for your instrument.

Available drivers and software include:

- **KickStart Software:** Enables quick test setup and data visualization when using one or more instruments.
- **Test Script Builder (TSB):** This software provides an environment to develop a test program and the ability to load the test program onto the instrument. Running a program loaded on the instrument eliminates the need to send individual commands from the host computer to the instrument when running a test.
- **IVI-COM Driver:** An IVI instrument driver you can use to create your own test applications in C/C++, VB.NET, or C# programming languages. It can also be called from other languages that support calling a DLL or ActiveX (COM) object. Refer to [IVI Foundation \(ivifoundation.org\)](http://ivifoundation.org) for additional information.
- **LabVIEW™ Software drivers:** Drivers to communicate with National Instruments LabVIEW Software.
- **Keithley I/O layer:** Manages the communications between Keithley instrument drivers and software applications and the instrument itself. The I/O Layer handles differences in communications required to support GPIB, serial, ethernet, and other communications buses so that drivers and software applications do not need to handle the differences themselves.

To identify IP addresses of instruments that are connected to the local area network (LAN) and support the VXI-11 discovery protocol, you can also use LXI Discovery Tool, available from the [Resources \(lxistandard.org/Resources/Resources.aspx\)](http://lxistandard.org/Resources/Resources.aspx) page of the [LXI Consortium website \(lxistandard.org\)](http://lxistandard.org).

## General ratings

| Category                     | Specification   |
|------------------------------|---|
| Supply voltage range         | 100 V ac to 240 V ac, 50 Hz or 60 Hz (autosensing), 240 VA maximum  |
| Input and output connections | See <a href="#">Front panel</a> (on page 3-1) and <a href="#">Rear panel</a> (on page 3-5)  |
| Environmental conditions     | <b>For indoor use only.</b><br><b>Altitude:</b> Maximum 2,000 meters (6,562 feet) above sea level<br><b>Operating:</b> 0 °C to 50 °C, 70% relative humidity up to 35 °C. Derate 3% relative humidity per °C, 35 °C to 50 °C<br><b>Storage:</b> -25 °C to 65 °C<br><b>Pollution degree:</b> 1 or 2 |

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# Installation

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## Introduction

This section provides the information you need to install the 2600B, make communications connections, and power up the instrument.

## Cooling vents

The 2600B has side and top intake and rear exhaust vents. One side must be unobstructed to dissipate heat.

Excessive heat could damage the 2600B and degrade its performance. Only operate the 2600B in an environment where the ambient temperature does not exceed 50 °C.

Do not place a container of liquid (water or coffee, for instance) on the top cover. If it spills, the liquid may enter the case through the vents and cause severe damage.

---

### CAUTION

**To prevent damaging heat build-up and ensure specified performance, use the following guidelines.**

**The rear exhaust vent and either the top or both side intake vents must be unobstructed to properly dissipate heat. Even partial blockage could impair proper cooling.**

**Do not position any devices adjacent to the 2600B that force air (heated or unheated) toward its cooling vents or surfaces. This additional airflow could compromise accuracy.**

**When rack mounting the 2600B, make sure there is adequate airflow around both sides to ensure proper cooling. Adequate airflow enables air temperatures within approximately one inch of the 2600B surfaces to remain within specified limits under all operating conditions.**

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## CAUTION

If high power dissipation equipment is rack mounted next to the 2600B, it could cause excessive heating. To produce specified 2600B accuracies, maintain the specified ambient temperature around the surfaces of the 2600B. In rack configurations with convection cooling only, proper cooling practice places the hottest non-precision equipment (for example, the power supply) at the top of the rack away from and above precision equipment (such as the 2600B).

Mount precision equipment as low as possible in the rack, where temperatures are coolest. You can add space panels above and below the 2600B to help provide adequate airflow.

---

## Turning the instrument on and off

The 2600B operates from a line voltage of 100 V to 240 V at a frequency of 50 Hz or 60 Hz. Line voltage is automatically sensed (there are no switches to set). Make sure the operating voltage in your area is compatible.

Follow the procedure below to connect the 2600B to line power and turn on the instrument.

---

## CAUTION

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

---

### *To turn a 2600B on and off:*

1. Before plugging in the power cord, make sure that the front-panel POWER switch is in the off (O) position.
2. Connect the female end of the supplied power cord to the ac receptacle on the rear panel.
3. Connect the other end of the power cord to a grounded ac outlet.

---

## WARNING

The power cord supplied with the 2600B 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 chassis ground 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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## WARNING

Hazardous voltages may be present in the test system. To prevent injury or death, remove power from the instrument or test system and discharge any energy storage components (for example, capacitors or cables) before changing any connections that might allow contact with an uninsulated conductor.

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## NOTE

On some sensitive or easily damaged devices under test (DUTs), the instrument power-up and power-down sequence can apply transient signals to the DUT that may affect or damage it. When testing this type of DUT, do not make final connections to it until the instrument has completed its power-up sequence and is in a known operating state. When testing this type of DUT, disconnect it from the instrument before turning the instrument off.

To prevent any human contact with a live conductor, connections to the DUT must be fully insulated and the final connections to the DUT must only use safety-rated safety-jack-socket connectors that do not allow bodily contact.

---

4. To turn your instrument on, press the front-panel **POWER** switch to place it in the on (I) position.
5. To turn your instrument off, press the front-panel **POWER** switch to place it in the off (O) position.

## Placing a 2600B in standby

---

### WARNING

Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never make or break connections to the 2600B while the instrument is powered on. Turn off the equipment from the front panel or disconnect the main power cord from the rear of the 2600B before handling cables. Putting the equipment into standby does not guarantee that the outputs are powered off if a hardware or software fault occurs.

---

When the instrument is on, the output may be placed in an active output state (output on) or a standby mode (output off). From the front panel, pressing the **OUTPUT ON/OFF** control toggles the output using the present instrument configuration. You can also place the output in standby over the remote interface by sending the following command:

```
smuX.source.output = smuX.OUTPUT_OFF
```

Even though the instrument is placed in standby, the output may not actually be off.

## Warmup period

The 2600B must be turned on and allowed to warm up for at least two hours to achieve rated accuracies.

## Line frequency configuration

The factory configures the 2600B to detect the power line frequency automatically at each power-up. This detected line frequency (either 50 Hz or 60 Hz) is used for aperture (NPLC) calculations.

In noisy environments, you can manually configure the instrument to match the actual line frequency.

### *To configure the line frequency from the front panel:*

1. Press the **MENU** key, then turn the navigation wheel to select **LINE-FREQ**, and then press the **ENTER** key.
2. Turn the navigation wheel to select the appropriate frequency and then press the **ENTER** key. To configure the instrument to automatically detect line frequency at each power-up, select **AUTO**.
3. Press the **EXIT (LOCAL)** key to return to the main display.

### *To configure the line frequency from a remote interface:*

Set the `localnode.linefreq` or the `localnode.autolinefreq` attribute. To set the line frequency to 60 Hz, send:

```
localnode.linefreq = 60
```

To configure the instrument to automatically detect line frequency at each power-up:

```
localnode.autolinefreq = true
```

## System information

You can retrieve serial number, firmware revision, calibration dates, and memory usage from the instrument.

### *To view the system information from the front panel:*

1. Press the **MENU** key.
2. Select **SYSTEM-INFO**.
3. Select one of the following:
  - **FIRMWARE**
  - **SERIAL#**
  - **CAL**
  - **MEMORY-USAGE**

### *To retrieve system information from a remote interface:*

To retrieve the firmware revision and serial number, send the `*IDN?` query.

For more information on system information, see the *Series 2600B Reference Manual*. In particular:

- To determine memory usage, see the `meminfo()` function.
- To determine when calibration was last run, see `smuX.cal.date`.
- To determine when calibration is due, see `smuX.cal.due`.

## Instrument description

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## Controls, indicators, and connectors

2600B controls, indicators, and the USB port are on the [front panel](#) (on page 3-1). Make connections to the 2600B through connectors on the [rear panel](#) (on page 3-5).

### Front panel

The front panel of the 2600B is shown below. The descriptions of the front-panel controls, USB port, and indicators follow the figure.

**Figure 1: Front panel of single-channel SMU (2601B, 2611B, and 2635B)**

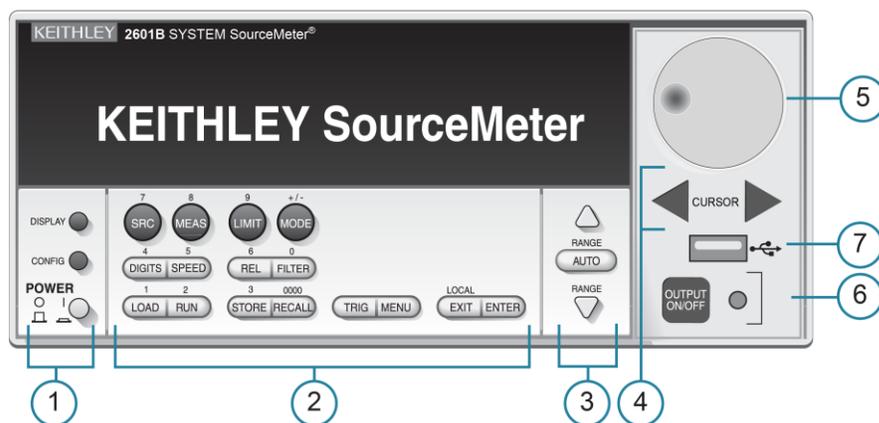
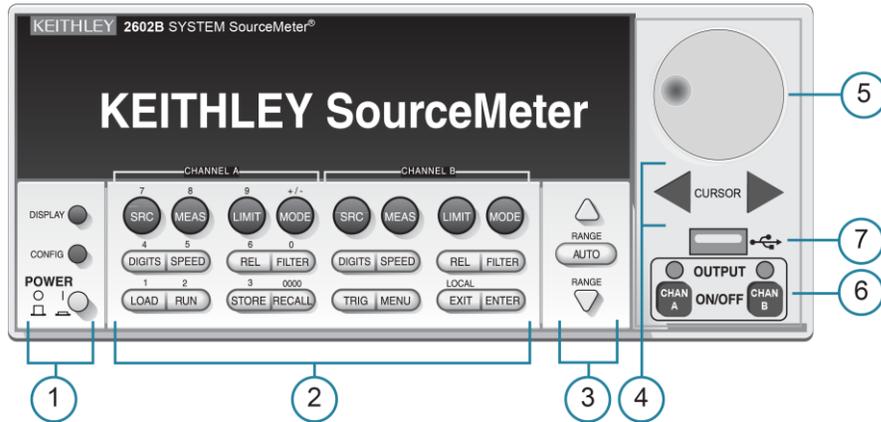


Figure 2: Front panel of two-channel SMU (2602B, 2604B, 2612B, 2614B, 2634B, and 2636B)



### 1. Power switch, display and configuration keys

- 
Toggles between the source-measure displays and the user message mode.
  
- 
Configures a function or operation.
  
- 
Power switch. The in position turns the 2600B on (I); the out position turns it off (O).

### 2. SMU setup, performance control, special operation, and numbers

#### SMU (source-measure unit) setup



|              |   |
|--------------|---|
| <b>SRC</b>   | Selects the source function (voltage or current) and places the cursor in the source field for editing.                         |
| <b>MEAS</b>  | Cycles through measure functions (voltage, current, resistance, or power).  |
| <b>LIMIT</b> | Places the cursor in the compliance limit field for editing. Also selects the limit value to edit (voltage, current, or power). |
| <b>MODE</b>  | Selects a meter mode (I-METER, V-METER, OHM-METER, or WATT-METER).  |

#### Performance control



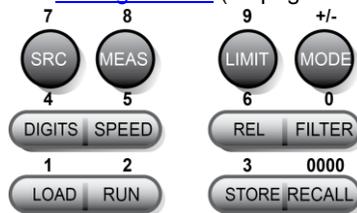
|               |   |
|---------------|---|
| <b>DIGITS</b> | Sets the display resolution (4½, 5½, or 6½ digits).   |
| <b>SPEED</b>  | Sets the measurement speed (FAST, MEDIUM, NORMAL, HI-ACCURACY, or OTHER). Speed and accuracy are set by controlling the measurement aperture. |
| <b>REL</b>    | Controls relative measurements, which allows a baseline value to be subtracted from a reading.  |
| <b>FILTER</b> | Enables or disables the digital filter. You can use this filter to reduce reading noise.  |

**Special operation**

|               |  |
|---------------|--|
|               |       |
| <b>LOAD</b>   | Loads a test for execution (FACTORY, USER, or SCRIPTS).  |
| <b>RUN</b>    | Runs the last selected factory or user-defined test.   |
| <b>STORE</b>  | <p>Accesses reading buffers and makes readings:</p> <ul style="list-style-type: none"> <li>▪ <b>TAKE_READINGS:</b> Use to make readings and store them in a reading buffer.</li> <li>▪ <b>SAVE:</b> Use to save a reading buffer to nonvolatile memory or to a user-installed flash drive (USB1) in CSV or XML format.</li> </ul> <p>Readings can include measurements, source values, and timestamp values.</p> |
| <b>RECALL</b> | <p>Recalls information (DATA or STATISTICS) stored in a reading buffer:</p> <ul style="list-style-type: none"> <li>▪ <b>DATA:</b> Includes stored readings, and if configured, source values and timestamp values.</li> <li>▪ <b>STATISTICS:</b> Includes MEAN, STD DEV, SAMPLE SIZE, MINIMUM, MAXIMUM, PK-PK.</li> </ul>  |
| <b>TRIG</b>   | Triggers readings.   |
| <b>MENU</b>   | Accesses the <a href="#">main menu</a> (on page 3-12). You can use the main menu to configure many functions and features.   |
| <b>EXIT</b>   | Cancels the selection and returns to the previous menu or display. Also used as a LOCAL key to take the instrument out of remote operation.  |
| <b>ENTER</b>  | Accepts the selection and moves to the next choice or exits the menu.  |

**Numbers**

**Number keys** When enabled and in EDIT mode, the number keys (0 to 9, +/-, 0000) allow direct numeric entry. Press the navigation wheel to enter EDIT mode. For more information, see [Setting a value](#) (on page 3-19).



**3. Range keys**



Selects the next higher source or measure range.



Enables or disables source or measure autorange.



Selects the next lower source or measure range.

In addition to selecting range functions, the up and down range keys change the format for numbers that are not ranges, such as the limit value.

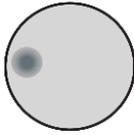
## 4. Cursor keys



Use the CURSOR keys to move the cursor left or right. When the cursor is on the source or compliance value digit, press the navigation wheel to enter edit mode, and turn the navigation wheel to edit the value. Press the navigation wheel again when you finish editing.

Use the CURSOR keys or the navigation wheel to move through menu items. To view a menu value, use the CURSOR keys for cursor control, and then press the navigation wheel to view the value or submenu item.

## 5. Navigation wheel



Turn the navigation wheel to:

- Move the cursor to the left and the right (the cursor indicates the selected value or item)
- While in edit mode, increase or decrease a selected source or compliance value

Push the navigation wheel to:

- Enable or disable edit mode for the selected source or compliance value
- Open menus and submenu items
- Select a menu option or a value

## 6. Output control



One channel

Turns the source output on or off.



Two channel

## 7. USB port



Use the USB port to connect a USB flash drive to the instrument. You can use the USB flash drive to store reading buffer data, scripts, and user setups. You can also use it to upgrade the firmware.

### 8. Display indicators (not shown)

The items listed below represent the possible display indicators and their meanings.

| Indicator    | Meaning  |
|--------------|--|
| 4W           | Remote (4-wire) sense is selected                |
| AUTO         | Source or measure autorange is selected          |
| EDIT         | Instrument is in editing mode                    |
| ERR          | Questionable reading or invalid calibration step |
| FILT         | Digital filter is enabled                        |
| LSTN         | Instrument is addressed to listen                |
| REL          | Relative mode is enabled                         |
| REM          | Instrument is in remote mode                     |
| SRQ          | Service request is asserted                      |
| TALK         | Instrument is addressed to talk                  |
| * (asterisk) | Readings are being stored in the buffer          |

### Rear panel

The rear panels of the 2600B is shown below. The descriptions of the rear-panel components follow the figures.

Figure 3: 2601B and 2611B rear panel

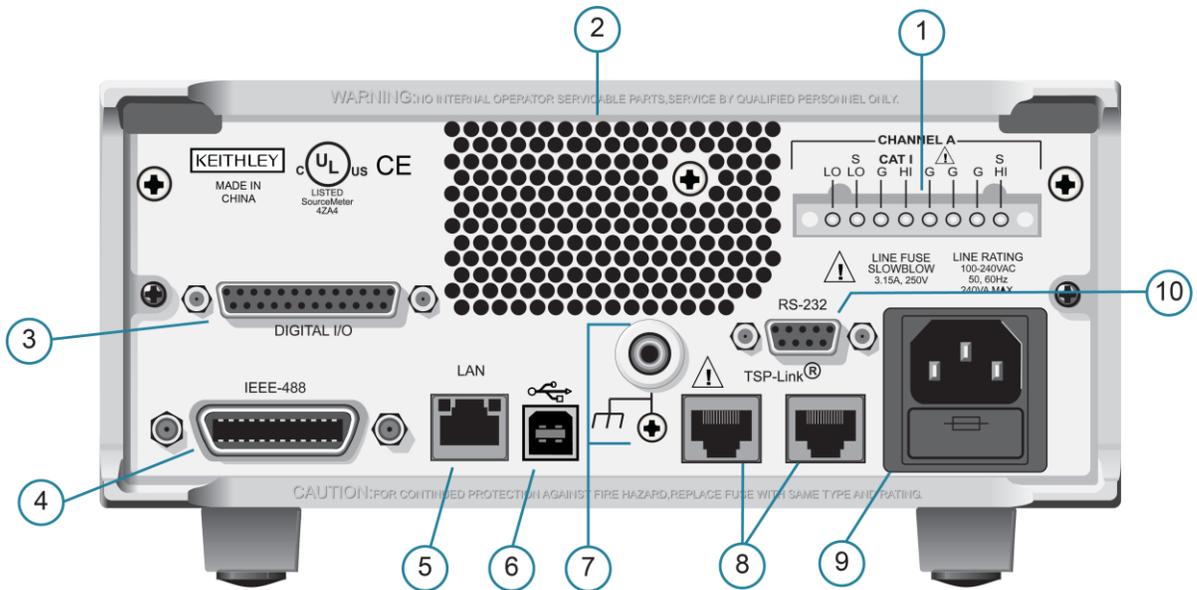


Figure 4: 2602B and 2612B rear panel

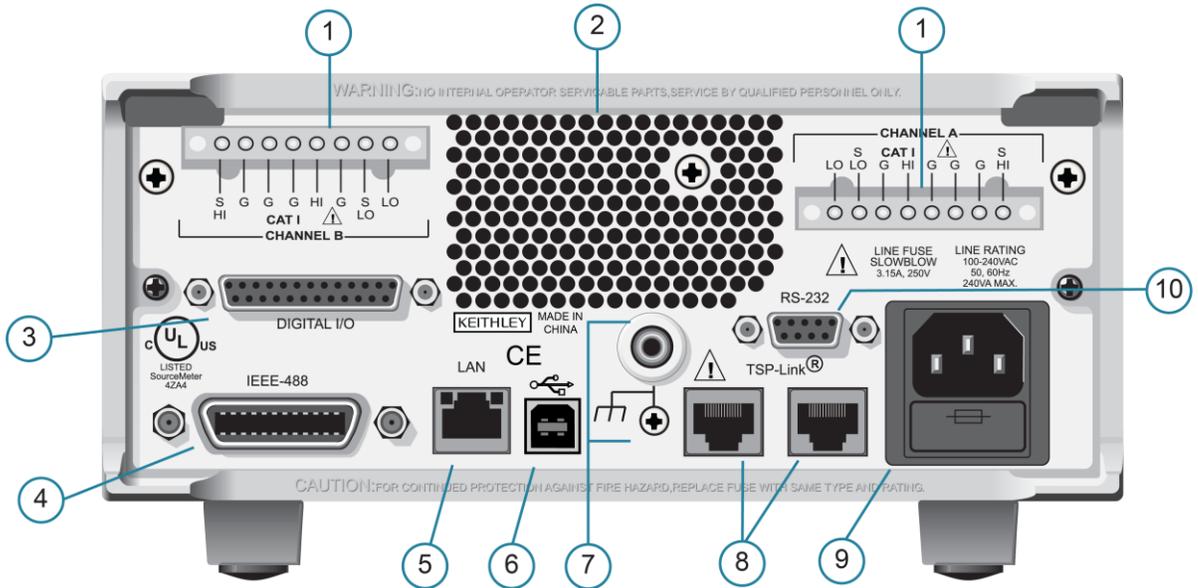


Figure 5: 2604B rear panel

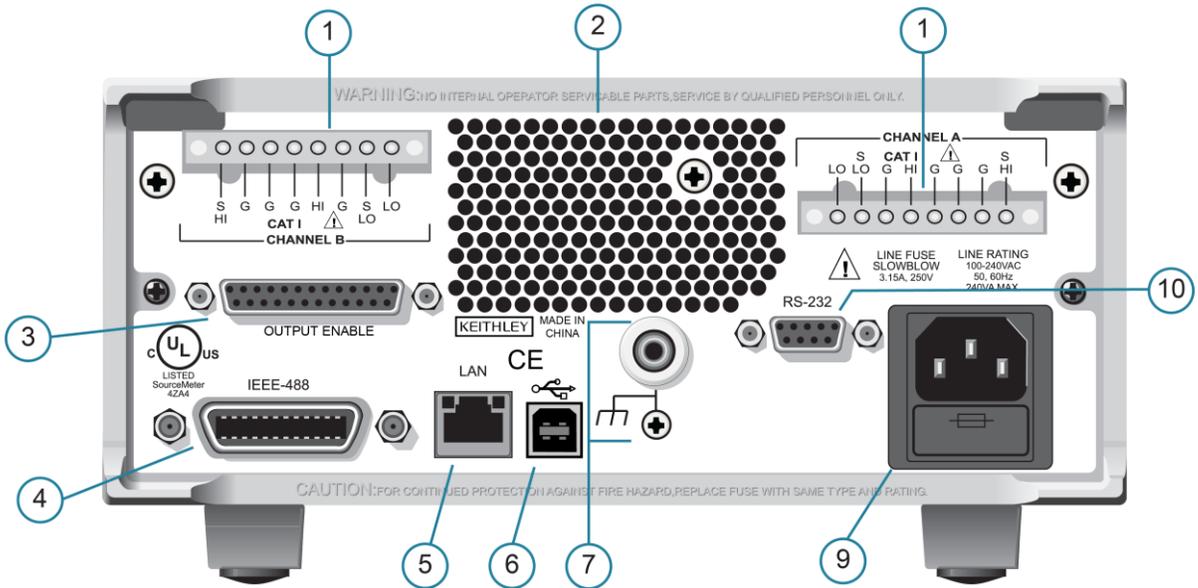


Figure 6: 2614B rear panel

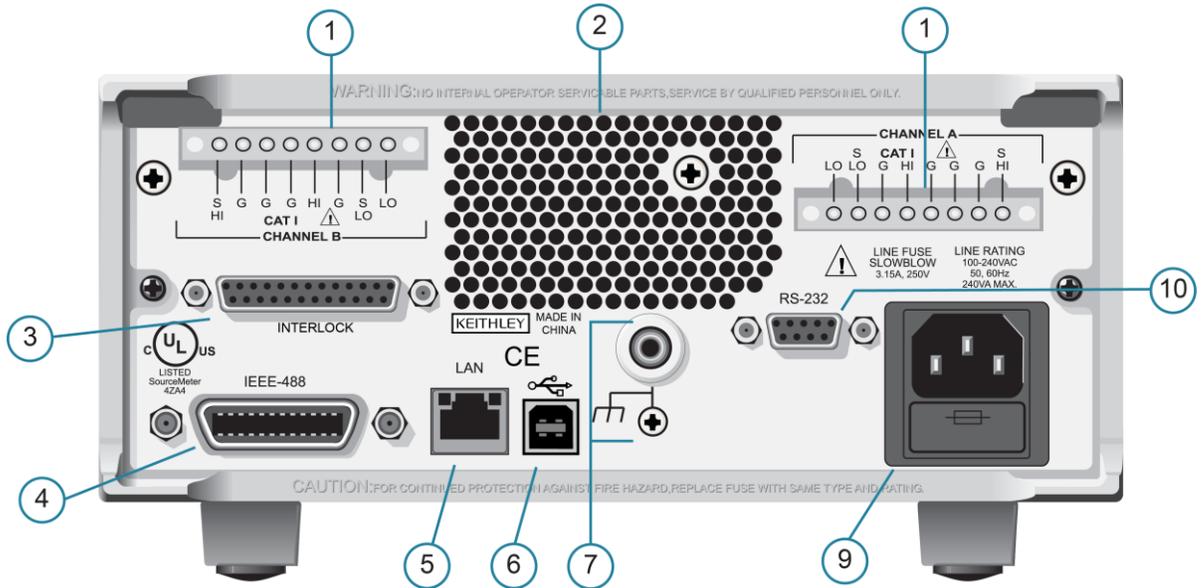


Figure 7: 2634B rear panel

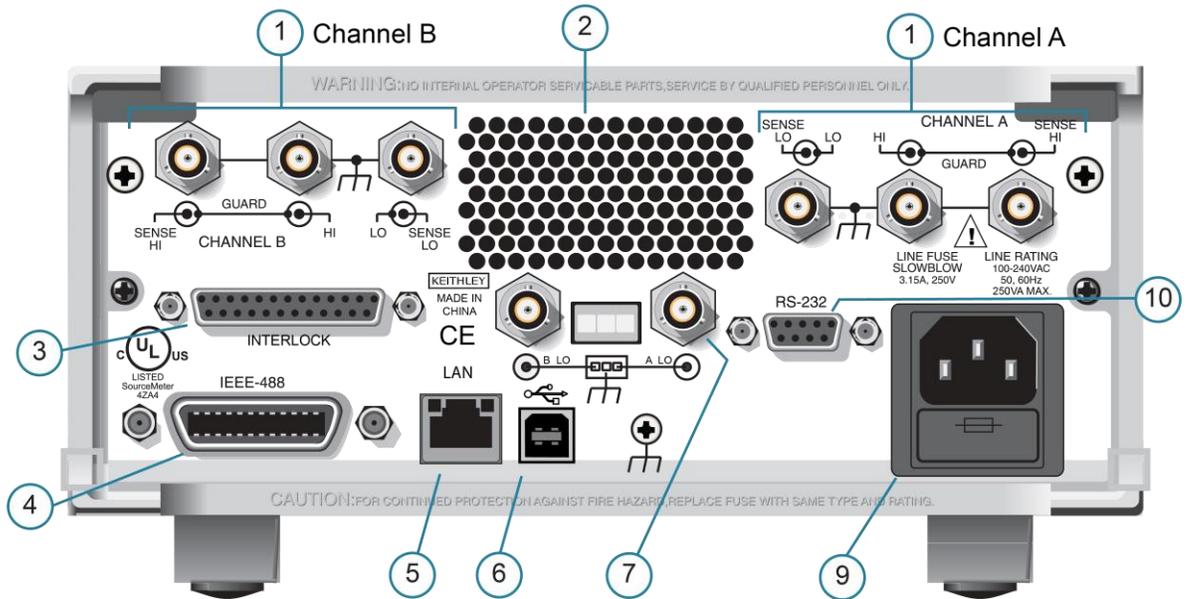


Figure 8: 2635B rear panel

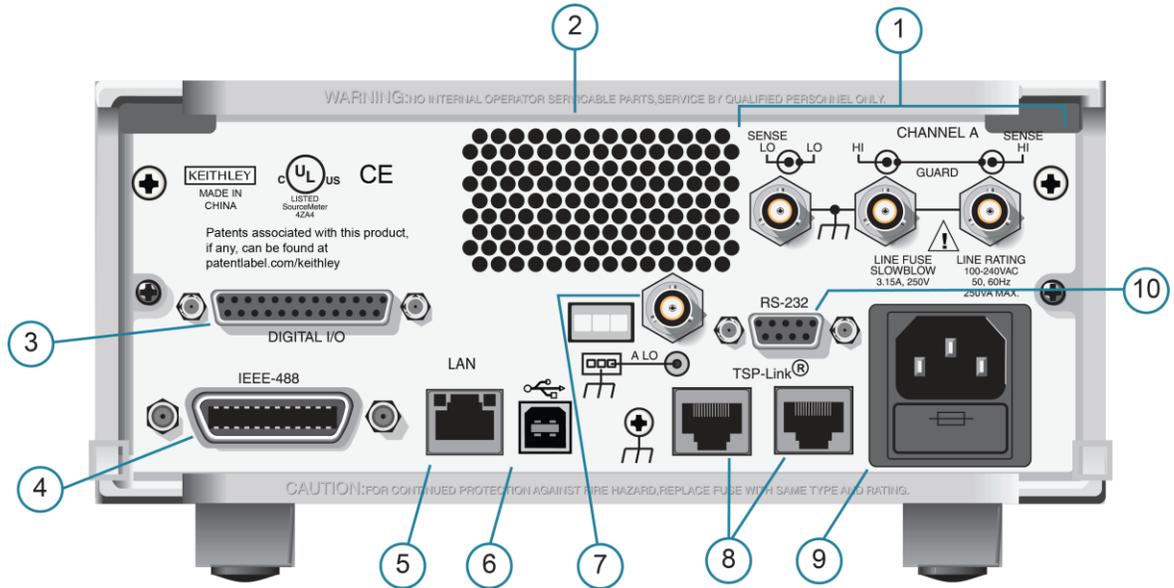
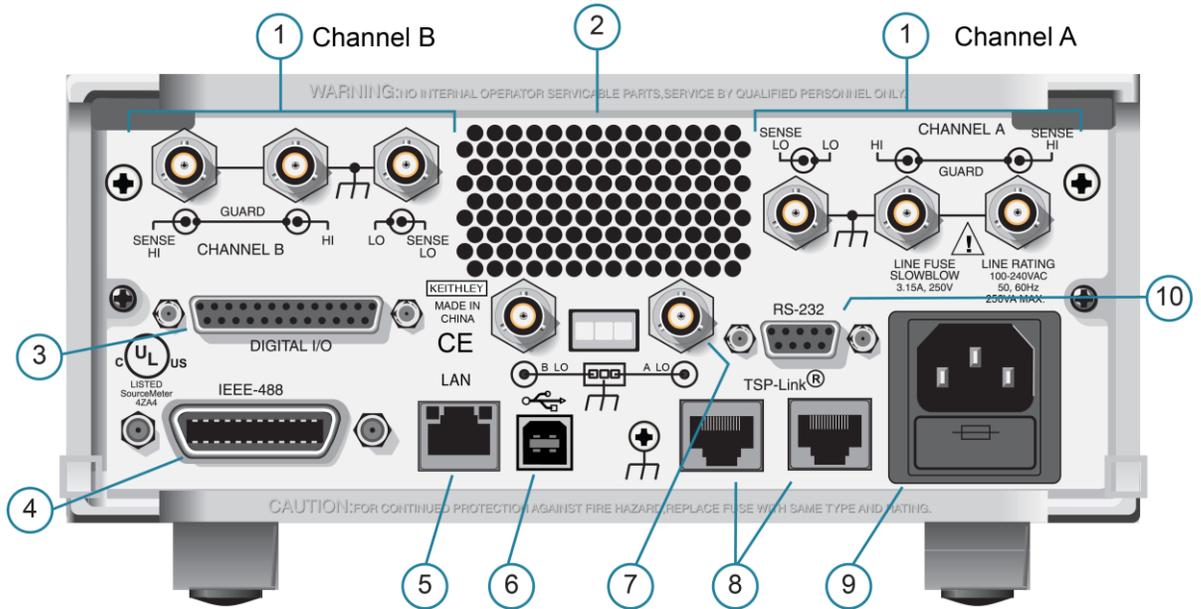


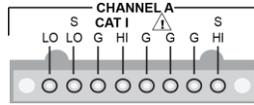
Figure 9: 2636B rear panel



## 1. SMU connector

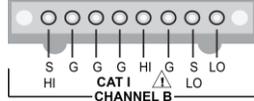
### Channel A

2601B, 2602B, 2604B, 2611B, 2612B, 2614B



### Channel B

2602B, 2604B, 2612B, 2614B

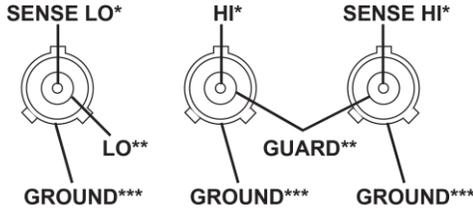


This connector provides input/output connections for HI and LO, sense (S HI/S LO), and guard (G). Connections are as follows:

- LO = LO
- S LO = Sense LO
- G = Guard
- S HI = Sense HI
- HI = HI

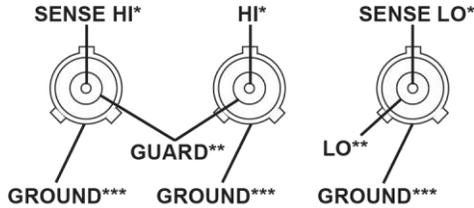
### Channel A

2634B, 2635B, 2636B



### Channel B

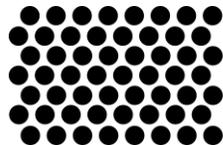
2634B, 2636B



These triaxial connectors provide input/output connections for HI and LO, sense HI and sense LO, guard, and ground. See connections at left. The connector conductors are as follows:

- \* Center conductor
- \*\* Inner shield
- \*\*\* Outer shield

## 2. Cooling exhaust vents



Exhaust vent for the internal cooling fan. Keep the vent free of obstructions to prevent overheating. Also see [Cooling vents](#) (on page 2-1).

### 3. Digital I/O

**2601B, 2602B, 2611B, 2612B, 2635B, 2636B**

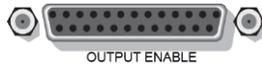


Female DB-25 connector. Use a cable equipped with a male DB-25 connector (L-com part number CSMN25MF-5).

Pins provided: Fourteen digital input or output pins, seven GND pins, and three +5 V pins.

The 2601B, 2602B, and 2604B have an output enable pin. The 2611B, 2612B, 2635B, and 2636B have an interlock pin.

**2604B**



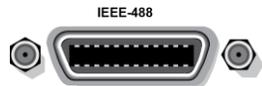
Pins provided: One output enable pin, seven GND pins, and three +5 V pins. The digital input and output pins are not available on the 2604B.

**2614B, 2634B**



Pins provided: One interlock pin, seven GND pins, and three +5 V pins. The digital input and output pins are not available on the 2614B and 2634B.

### 4. IEEE-488



Connector for IEEE-488 (GPIB) operation. Use a shielded cable such as the Keithley Instruments Model 7007-1.

### 5. LAN



RJ-45 connector for a local area network (LAN). The LAN interface supports Auto-MDIX, so you can use either a CAT-5e crossover cable or a normal CAT-5e straight-through cable.

### 6. USB port



Use the USB-2.0 receptacle (Type B) on the rear panel to connect the instrument to a computer. You can use this connection to send commands to the instrument.

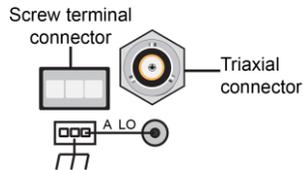
## 7. Ground

2601B, 2602B, 2604B, 2611B, 2612B, 2614B



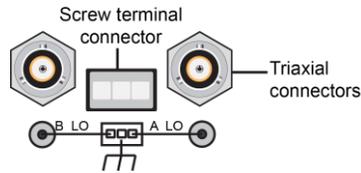
Ground terminal for connection output HI or LO to chassis ground.  
Ground screw for connections to chassis ground.

2635B



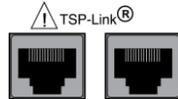
Triaxial connector on ground module.  
Screw terminal connector on ground module.

2634B, 2636B



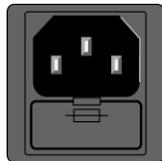
Triaxial connector on ground module.  
Screw terminal connector on ground module.

## 8. TSP-Link



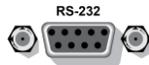
Expansion interface that allows a 2600B and other TSP-enabled instruments to trigger and communicate with each other. Use a category 5e or higher LAN crossover cable.  
The TSP-Link is not available on the 2604B, 2614B, and 2634B.

## 9. Power module



Contains the ac line receptacle and power line fuse. The instrument can operate on line voltages of 100 V ac to 240 V ac at line frequencies of 50 Hz or 60 Hz.

## 10. RS-232



Female DB-9 connector. For RS-232 operation, use a straight-through (not null modem) DB-9 shielded cable to connect to the computer.

## Menu overview

The following topics describe how to work with the front-panel menus.

### Menu navigation

To navigate through the menus and submenus, the 2600B must not be in edit mode (the EDIT indicator is not illuminated).

#### Selecting menu items

To navigate the Main and Configuration menus, use the front-panel keys as follows:

- Press either **CURSOR** arrow key to highlight an option.
- Rotate the navigation wheel (clockwise or counterclockwise) to highlight an option.
- Press the **ENTER** key (or the navigation wheel) to select an option.
- Use the **EXIT (LOCAL)** key to cancel changes or to return to the previous menu or display.

---

#### NOTE

For quick menu navigation, turn the navigation wheel to highlight an option and then press the navigation wheel to select the highlighted option.

---

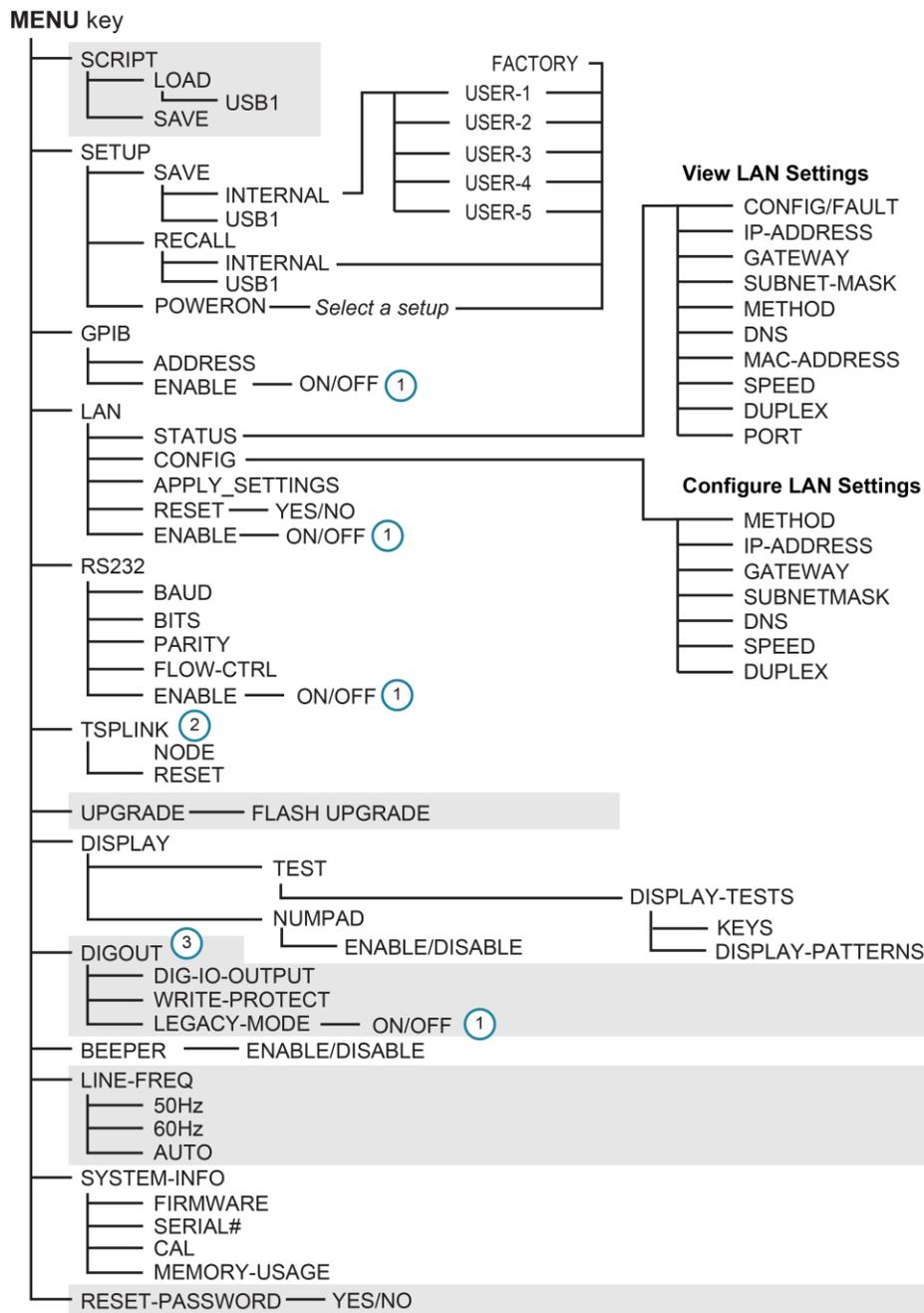
### Menu trees

You can configure instrument operation through the menus that are accessed from the front panel.

#### Main menu

The main menu structure is summarized in the following figure and table. For other menu items, see [Configuration menus](#) (on page 3-15).

Figure 10: Main menu tree



|  |
|--|
| 1 Mutually exclusive                                       |
| 2 TSP-Link is not available on the 2604B, 2614B, and 2634B |
| 3 DIGOUT is not available on the 2604B, 2614B, and 2634B   |

The following table contains descriptions of the main menu options and cross-references to related information.

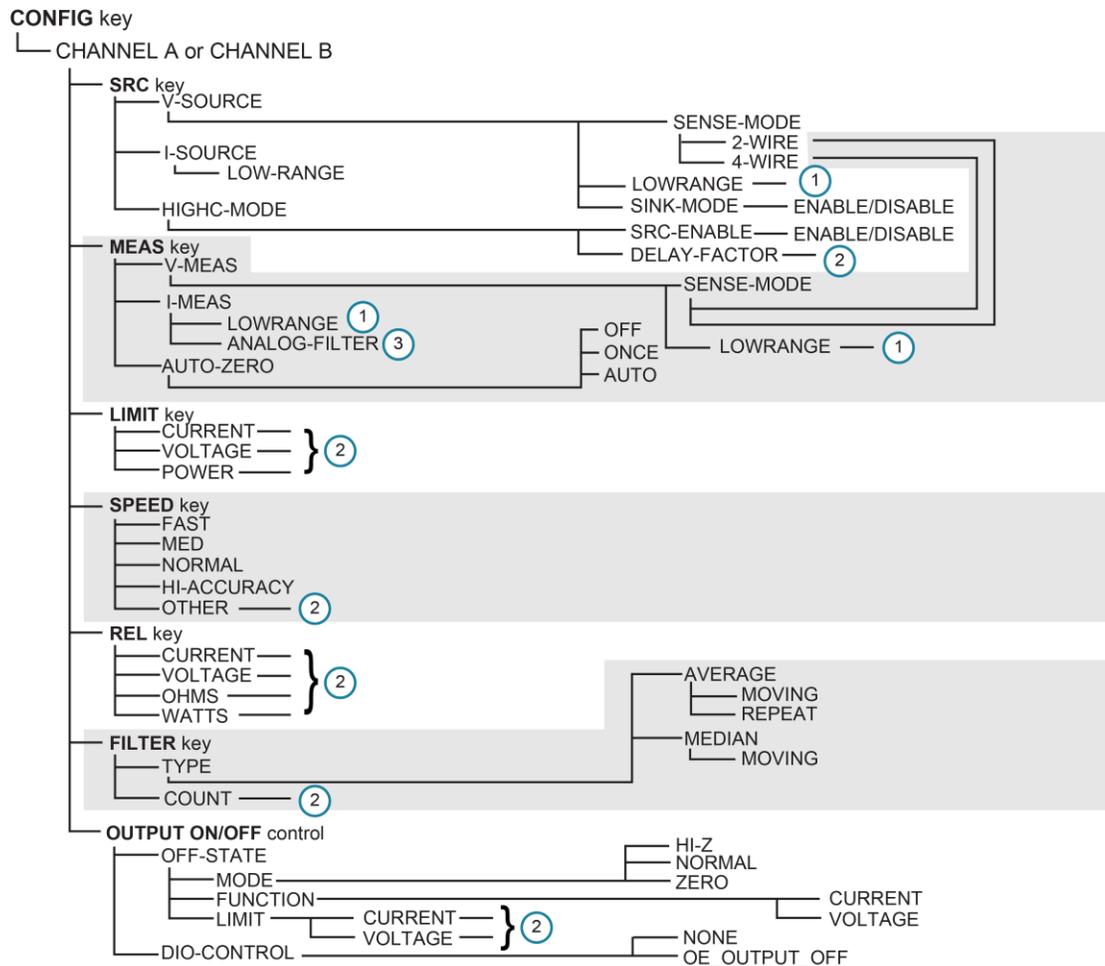
To access a menu option, press the **MENU** key, turn the navigation wheel to move the cursor to select an item, and press the navigation wheel.

| Menu selection  | Description   | For more information, see:  |
|---|---|---|
| <b>SCRIPT</b><br>- LOAD<br>- SAVE   | Saves and recalls user scripts<br>Loads scripts into nonvolatile memory<br>Saves scripts  | <i>Series 2600B Reference Manual</i> ,<br>"Manage scripts"  |
| <b>SETUP</b><br>- SAVE<br>- RECALL<br>- POWERON                               | Saves and recalls user and factory setup options<br>Saves user setup options<br>Recalls user setup options<br>Sets the configuration used during startup  | <i>Series 2600B Reference Manual</i> , "Saved setups"   |
| <b>GPIB</b><br>- ADDRESS<br>- ENABLE  | Configures the GPIB interface options<br>Configures the address for the GPIB interface<br>Enables and disables the GPIB interface   | <i>Series 2600B Reference Manual</i> , "Remote communications interfaces"   |
| <b>LAN</b><br>- STATUS<br>- CONFIG<br>- APPLY_SETTINGS<br>- RESET<br>- ENABLE | Configures the local area network (LAN)<br>Displays LAN connection status<br>Configures the LAN IP address and gateway<br>Applies changes made using the CONFIG menu<br>Restores the default settings<br>Enables and disables the LAN interface | <i>Series 2600B Reference Manual</i> , "LAN communications"   |
| <b>RS232</b><br>- BAUD<br>- BITS<br>- PARITY<br>- FLOW-CTRL<br>- ENABLE       | Controls the options for the RS-232 interface<br>Sets the baud rate<br>Configures the number of bits<br>Sets the parity<br>Configures the flow control<br>Enables and disables the RS-232 interface   | <i>Series 2600B Reference Manual</i> , "Remote communications interfaces"   |
| <b>TSPLINK</b><br>- NODE<br>- RESET   | Configure the instrument in a TSP-Link® network<br>Selects the instrument node identifier<br>Resets the TSP-Link network  | <i>Series 2600B Reference Manual</i> ,<br>"TSP-Link system expansion interface"   |
| <b>UPGRADE</b>  | Upgrades the firmware from a USB flash drive  | <a href="#">Upgrading the firmware</a> (on page 5-4)  |
| <b>DISPLAY</b><br>- TEST<br>- NUMPAD  | Accesses display functions<br>Runs the display test<br>Enables and disables the numeric keypad  | <a href="#">Front-panel tests</a> (on page 5-3)<br>See Numeric entry method in <a href="#">Setting a value</a> (on page 3-19) |
| <b>DIGOUT</b><br>- DIG-IO-OUTPUT<br>- WRITE-PROTECT<br>- LEGACY-MODE          | Controls digital outputs<br>Selects the digital I/O values<br>Write-protects specific digital I/O lines<br>Sets digital I/O to work like an older SourceMeter instrument  | <i>Series 2600B Reference Manual</i> , "Digital I/O"  |
| <b>BEEPER</b><br>- ENABLE<br>- DISABLE  | Controls the key beeps<br>Enables the key beeps<br>Disables the key beeps   | <a href="#">Beeper</a> (on page 3-21)   |
| <b>LINE-FREQ</b><br>- 50Hz<br>- 60Hz<br>- AUTO                                | Configures the line frequency<br>Set the line frequency to 50 Hz<br>Set the line frequency to 60 Hz<br>Enables automatic line-frequency detection during start up   | <a href="#">Line frequency configuration</a> (on page 2-4)  |
| <b>SYSTEM-INFO</b><br>- FIRMWARE<br>- SERIAL#<br>- CAL<br>- MEMORY-USAGE      | Displays the system information<br>Displays the version of firmware installed<br>Displays the serial number of the unit<br>Displays the last calibration date<br>Displays memory usage in percentage  | <a href="#">System information</a> (on page 2-4)  |
| <b>RESET-PASSWORD</b>   | Resets the system password  | <i>Series 2600B Reference Manual</i> ,<br>"Password management"   |

## Configuration menus

The configuration menu structure is summarized in the following figures. More detailed information follows the figures. For directions on navigating the menu, see [Menu navigation](#) (on page 3-12). For other menu items, see [Main menu](#) (on page 3-12).

**Figure 11: CONFIG menu tree CHANNEL menu (models with two SMUs)**

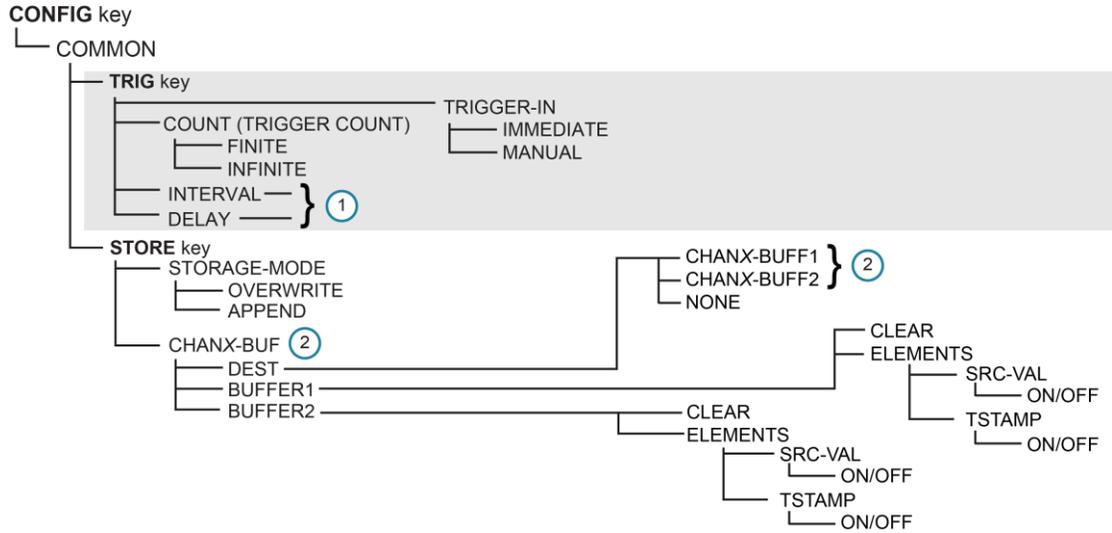


|                        |
|------------------------|
| 1 Select a value       |
| 2 Enter a value        |
| 3 2634B and 2636B only |

### NOTE

Press the **EXIT** key to return to a previous menu.

**Figure 12: CONFIG menu tree COMMON menu (models with two SMUs)**

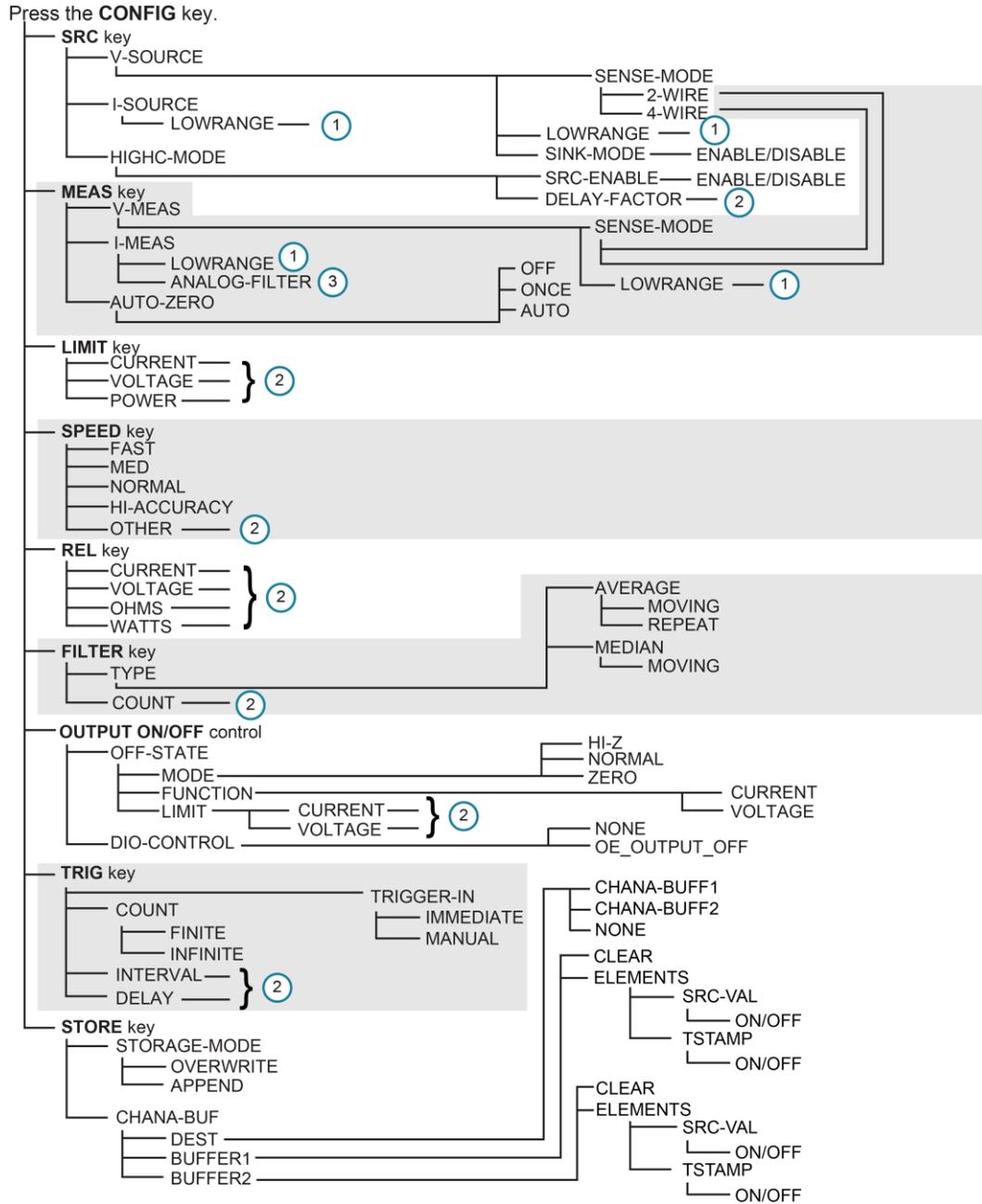


- |   |
|---|
| <b>1</b> Enter a value  |
| <b>2</b> Replace <i>X</i> with <b>A</b> for SMU Channel A (such as in CHANA-BUF) or a <b>B</b> for SMU Channel B (such as in CHANB-BUF) |

## NOTE

Press the **EXIT** key to return to a previous menu.

**Figure 13: CONFIG menu tree (models with a single SMU)**



- 1 Select a value
- 2 Enter a value
- 3 Model 2635B only

**NOTE**

Press the **EXIT** key to return to a previous menu.

The following table contains descriptions of the configuration menus and cross-references to related information. To select a menu for single SMU instruments, press the **CONFIG** key and then the front-panel key associated with the menu (see the description column in the following table). For two-SMU instruments, press the **CONFIG** key, select the appropriate channel (CHANNEL-A, CHANNEL-B) and then the front-panel key associated with the menu. To select TRIG and STORE menus on two-SMU instruments, press the **CONFIG** key and then select COMMON instead of selecting a channel.

| To access, press the CONFIG key and then: | Options   | For more information, see:   |
|---|---|--|
| SRC                                       | V-source sense and low range; I-source low range; and high capacitance mode | <i>Series 2600B Reference Manual</i> , “Range”<br>“Basic source-measure procedure” |
| MEAS                                      | V and I-measure range, V-measure sense, low range, and autozero             | <i>Series 2600B Reference Manual</i> , “Range”<br>“Basic source-measure procedure” |
| LIMIT                                     | V-source and I-source compliance limits                                     | <a href="#">Limits</a> (on page 4-2)   |
| SPEED                                     | Measurement speed (NPLC)  | <i>Series 2600B Reference Manual</i> , “Speed”                                     |
| REL                                       | Set relative values   | <i>Series 2600B Reference Manual</i> , “Relative offset”                           |
| FILTER                                    | Control digital filter  | <i>Series 2600B Reference Manual</i> , “Filters”                                   |
| OUTPUT ON/OFF                             | Set off-state, control digital I/O  | <a href="#">Output-off states</a> (on page 4-31)                                   |
| STORE                                     | Set buffer count and destination  | <i>Series 2600B Reference Manual</i> , “Source-measure concepts”                   |
| TRIG                                      | Set trigger in, count, interval, and delay                                  | <i>Series 2600B Reference Manual</i> , “Triggering”                                |

## Setting values

Through the front panel, you can adjust a value using either the **Navigation wheel method** or **Numeric entry method** (using the keypad).

### Setting a value

#### *To set a value using the navigation wheel method:*

1. Use the **CURSOR** arrow keys (or turn the navigation wheel) to move the cursor to the digit that needs to be changed.
2. Press the navigation wheel or the **ENTER** key to enter edit mode. The EDIT indicator is illuminated.
3. Rotate the navigation wheel to set the appropriate value.
4. Press the **ENTER** key to select the value or press the **EXIT (LOCAL)** key to cancel the change.
5. To return to the main menu, press the **EXIT (LOCAL)** key.

#### *To set a value using the numeric entry method:*

1. If the keypad is disabled, press the **MENU** key, then select **DISPLAY > NUMPAD > ENABLE**.
2. Use the **CURSOR** arrow keys (or turn the navigation wheel) to move the cursor to the value that needs to be changed.
3. Press the navigation wheel or the **ENTER** key to enter edit mode. The EDIT indicator is illuminated.
4. Press any of the number keys (0-9, +/-, 0000) (see [2. SMU setup, performance control, special operation, and numbers](#) (on page 3-3)). The cursor moves to the next digit on the right.
5. Repeat the above steps as required to set the values.
6. Press the **ENTER** key to select the value or press the **EXIT (LOCAL)** key to cancel the change.
7. To return to the main menu, press the **EXIT (LOCAL)** key.

---

## NOTE

To set a value to zero, press the **0000** numeric entry key. To toggle the polarity of a value, press the **+/-** numeric entry key.

---

## Setting source and compliance values

When the 2600B is in the edit mode (EDIT indicator is on), the editing controls are used to set source and compliance values. Note that when you edit the source value, source autoranging is turned off and remains off until you turn it on again.

---

### NOTE

To cancel source editing, press the **EXIT (LOCAL)** key.

---

#### *To edit the source value:*

1. Press the **SRC** key. The cursor flashes in the source value field.
2. Use the **CURSOR** keys (or turn the navigation wheel) to move the cursor to the digit that needs to be changed.
3. Press the navigation wheel or the **ENTER** key to edit the source value. The EDIT indicator is illuminated.
4. Change the source value (see [Setting a value](#) (on page 3-19)).

---

### NOTE

The **+/-** key toggles the polarity. The **0000** key sets the value to 0.

---

5. When finished, press the **ENTER** key (the EDIT indicator is not illuminated).

#### *To edit compliance limit values:*

1. Press the **LIMIT** key.
2. Select the type of compliance (CURRENT, VOLTAGE, or POWER).
3. Press the navigation wheel or the **ENTER** key to enter edit mode. The EDIT indicator is illuminated.
4. Change the compliance value (see [Setting a value](#) (on page 3-19)).
5. When finished, press the **ENTER** key (the EDIT indicator is not illuminated).

---

### NOTE

The up and down range keys change the format of the limit value.

---

## Beeper

The 2600B includes a beeper. When it is enabled, a beep indicates one of the following actions occurred:

- **A front-panel key was pressed:** A short beep, similar to a key click, is issued.
- **The navigation wheel was turned or pressed:** A short beep is issued.
- **The output source was changed:** A longer beep is issued when you select the OUTPUT ON/OFF control (turn the output on or off).

***To turn the beeper on or off from the front panel:***

1. Press the **MENU** key, and then select **BEEPER**.
2. Select one of the following:
  - **ENABLE**
  - **DISABLE**

***To turn the beeper on or off from the TSP command interface:***

Set the `beeper.enable` attribute. For example, to enable the beeper, send:

```
beeper.enable = 1
```

## Displayed error and status messages

During operation and programming, front-panel messages may be briefly displayed. Typical messages are either status or error notifications (refer to the Error summary list for a complete list of these messages and their meanings).

---

### NOTE

Status and error messages are held in a queue. For information about retrieving messages from queues, refer to Queues. For information about error messages, refer to the Troubleshooting guide.

---

# Display operations

This section describes methods for using the display and determining what is displayed.

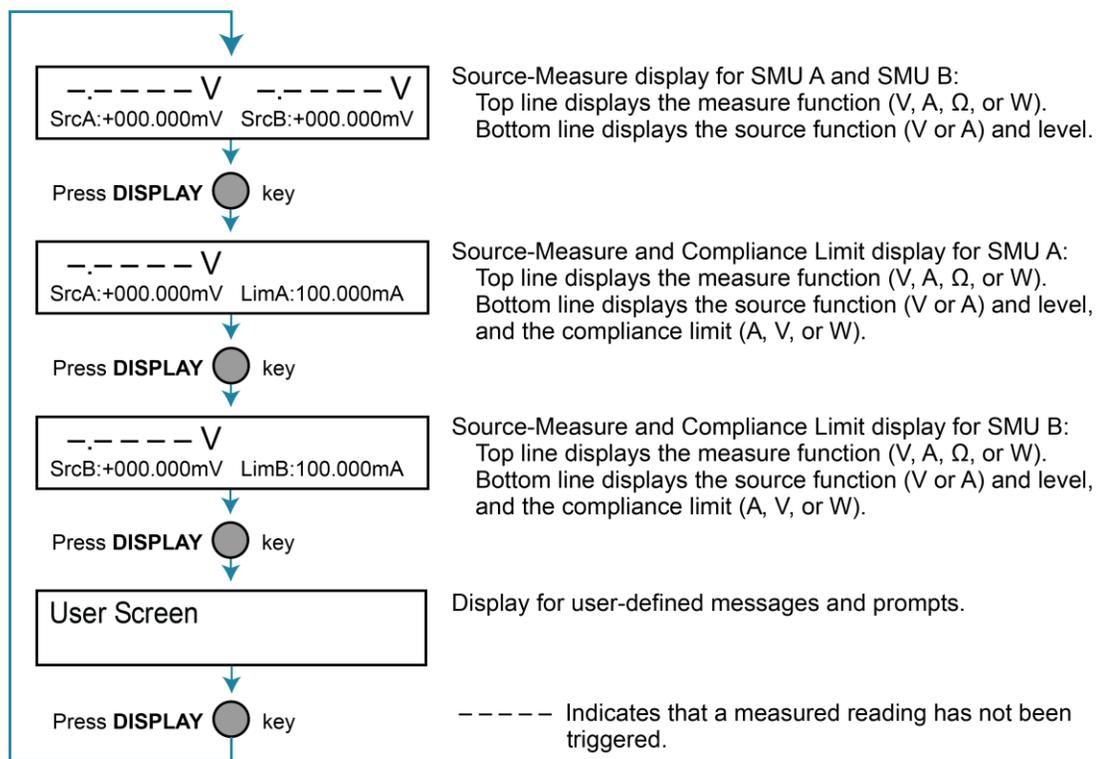
## Display mode

Use the **DISPLAY** key to scroll through the various display modes shown in the figure below. Refer to [Display operations](#) (on page 3-22) for more information about the display.

For the 2602B, 2604B, 2612B, 2614B, 2634B, and 2636B only, press the **DISPLAY** key more than once to cycle through the dual channel and single channel display modes. This applies to CHANNEL A (SMU A) and CHANNEL B (SMU B).

The Models 2601B, 2611B, and 2635B have a single channel (SMU A).

**Figure 14: Display modes**



## Display functions and attributes

The display functions and attributes for the front panel are described in this section. The following table lists each display function and attribute (in alphabetical order) and cross references it to the section topic where the function or attribute is explained.

The TSP command reference provides additional information about the display functions and attributes.

### Cross-referencing functions and attributes to section topics

| Function or attribute*   | Section topic   |
|--|---|
| <code>display.clear()</code>   | <a href="#">Clearing the display</a> (on page 3-25)           |
| <code>display.getannunciators()</code>   | <a href="#">Indicators</a> (on page 3-31)                     |
| <code>display.getcursor()</code>   | <a href="#">Cursor position</a> (on page 3-26)                |
| <code>display.getlastkey()</code>  | Capturing key-press codes                                     |
| <code>display.gettext()</code>   | <a href="#">Displaying text messages</a> (on page 3-27)       |
| <code>display.inputvalue()</code>  | <a href="#">Parameter value prompting</a> (on page 3-30)      |
| <code>display.loadmenu.add()</code><br><code>display.loadmenu.catalog()</code><br><code>display.loadmenu.delete()</code> | <a href="#">Load test menu</a> (on page 3-32)                 |
| <code>display.locallockout</code>  | <a href="#">LOCAL lockout</a> (on page 3-32)                  |
| <code>display.menu()</code>  | <a href="#">Menu</a> (on page 3-29)                           |
| <code>display.numpad</code>  | <a href="#">Setting a value</a> (on page 3-19)                |
| <code>display.prompt()</code>  | <a href="#">Parameter value prompting</a> (on page 3-30)      |
| <code>display.screen</code>  | <a href="#">Display screen</a> (on page 3-24)                 |
| <code>display.sendkey()</code>   | Sending key codes   |
| <code>display.setcursor()</code>   | <a href="#">Cursor position</a> (on page 3-26)                |
| <code>display.settext()</code>   | <a href="#">Displaying text messages</a> (on page 3-27)       |
| <code>display.smuX.digits</code>   | <a href="#">Display resolution</a> (on page 3-24)             |
| <code>display.smuX.limit.func</code>   | <a href="#">Limit functions</a> (on page 3-24)                |
| <code>display.smuX.measure.func</code>   | <a href="#">Measurement functions</a> (on page 3-24)          |
| <code>display.trigger.clear()</code><br><code>display.trigger.wait()</code>  | <a href="#">Display trigger wait and clear</a> (on page 3-25) |
| <code>display.waitkey()</code>   | Capturing key-press codes                                     |

\* `smuX` can be `smua` for channel A or `smub` for channel B

## Display features

You can set the front-panel display to display the units of measure, number of digits, and customized text messages for your applications.

### Display screen

The front panel displays source-measure values and readings or user-defined messages. The display screen options include:

- **Source-measure, compliance screens:** Display SMU source-measure readings and compliance values.
- **User screen:** Displays user-defined messages and prompts.

Configure the type of source-measure and compliance displayed by setting the `display.screen` attribute. The following programming example illustrates how to display source-measure and compliance values, and measure readings for SMU A:

```
display.screen = display.SMUA
```

### Measurement functions

With a source-measure screen selected, the measured reading can be displayed as volts, amperes, ohms, or watts. Configure the type of measured reading displayed by setting the `display.smuX.measure.func` attribute. The following programming example illustrates how to set SMU A to display ohms measurements:

```
display.smua.measure.func = display.MEASURE_OHMS
```

### Limit functions

On single SMU display screens, the displayed limit value can either reflect the primary limit value (current or voltage limit, as applicable), or as the power limit value (that displays the power limit). Configure the type of limit function displayed by setting the `display.smuX.limit.func` attribute. The following programming example illustrates how to set SMU A to display its power limit setting:

```
display.smua.limit.func = display.LIMIT_P
```

### Display resolution

Display resolution for measured readings can be set to 4½, 5½, or 6½. Configure the type of resolution displayed by setting the `display.smuX.digits` attribute. The following programming example illustrates how to set SMU A for 5½ digit resolution for measured readings:

```
display.smua.digits = display.DIGITS_5_5
```

## Display trigger wait and clear

To set the instrument to wait for the front-panel TRIG key to be pressed, send the `display.trigger.wait()` function. To clear the trigger event detector, send the `display.trigger.clear()` function.

## Display messages

You can define text messages that can be displayed on the front panel of the instrument. Most of the display functions and attributes that are associated with display messaging automatically select the user screen. The attribute for the display screen is explained in [Display screen](#) (on page 3-24).

For example, while a test is running, the following message can be displayed on the 2600B front panel:

```
Test in Process
Do Not Disturb
```

The top line of the display can accommodate up to 20 characters (including spaces). The bottom line can display up to 32 characters (including spaces) at a time.

---

### NOTE

The display functions `display.clear()`, `display.setcursor()`, and `display.settext()` are overlapped, nonblocking commands. The script does not wait for one of these commands to complete.

These nonblocking functions do not immediately update the display. For performance considerations, they write to a background file and update the display as soon as processing time becomes available.

The reset functions `reset()` and `smua.reset()` do not change the defined display message or its configuration. The reset functions set the display mode to the previous source-measure display mode. To show the user-defined message again, press DISPLAY until the User screen is displayed.

---

## Clearing the display

When sending a command to display a message, a previously defined user message is not cleared. The new message starts at the end of the old message on that line. It is good practice to routinely clear the display before defining a new message.

After displaying an input prompt, the message is displayed even after the operator performs the prescribed action. The `clear()` function must be sent to clear the display. To clear both lines of the display, but not affect any of the indicators, send the following function:

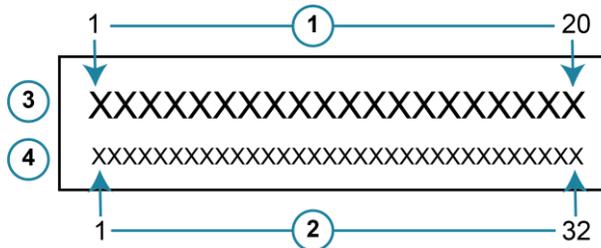
```
display.clear()
```

## Cursor position

When displaying a message, the cursor position determines where the message starts. On power-up, the cursor is positioned at row 1, column 1 (see the following figure). At this cursor position, a user-defined message is displayed on the top row (row 1).

Top line text does not wrap to the bottom line of the display automatically. Any text that does not fit on the current line is truncated. If the text is truncated, the cursor is left at the end of the line.

**Figure 15: Row and column format for display messaging**



|   |                   |
|---|-------------------|
| 1 | Columns for Row 1 |
| 2 | Columns for Row 2 |
| 3 | Row 1             |
| 4 | Row 2             |
| X | Display character |

The function to set cursor position has the following options:

```
display.setCursor(row, column)
display.setCursor(row, column, style)
```

Where:

- row*            1 or 2
- column*        1 to 20 (row 1)  
                  1 to 32 (row 2)
- style*           0 (invisible)  
                  1 (blink)

When set to 0, the cursor is not visible. When set to 1, a display character blinks to indicate the cursor position.

The `display.getcursor()` function returns the present cursor position. You can use it in these ways:

```
row, column, style = display.getcursor()
row, column = display.getcursor()
row = display.getcursor()
```

The following programming example illustrates how to position the cursor on row 2, column 1, and then read the cursor position:

```
display.setCursor(2, 1)
row, column = display.getcursor()
print(row, column)
```

Output:

```
2.00000e+00 1.00000e+00
```

## Displaying text messages

To define and display a message, use the `display.setText(text)` function, where `text` is the text string to be displayed. The message starts at the present cursor position. The following programming example illustrates how to display `Test in Process` on the top line, and `Do Not Disturb` on the bottom line:

```
display.clear()
display.setCursor(1, 1, 0)
display.setText("Test in Process")
display.setCursor(2, 6, 0)
display.setText("Do Not Disturb")
```

## Character codes

The following special codes can be embedded in the `text` string to configure and customize the message:

- `§N`: Starts text on the next line (newline). If the cursor is already on line 2, text is ignored after the '§N' is received.
- `§R`: Sets text to Normal.
- `§B`: Sets text to Blink.
- `§D`: Sets text to Dim intensity.
- `§F`: Set text to background blink.
- `§§`: Escape sequence to display a single "\$".

In addition to displaying alphanumeric characters, you can display other special characters. Refer to the *Series 2600B Reference Manual*, "Display character codes," for a list of special characters and their corresponding codes.

The following programming example illustrates how to display the Greek symbol omega ( $\Omega$ ):

```
display.clear()
c = string.char(18)
display.setText(c)
```

The following programming example illustrates how to use the `$N` and `$B` character codes to display the message `Test in Process` on the top line and the blinking message `Do Not Disturb` on the bottom line:

```
display.clear()
display.setText("Test in Process $N$BDo Not Disturb")
```

The following programming example illustrates how to use the `$$` character code to display the message `You owe me $8` on the top line:

```
display.clear()
display.setCursor(1, 1)
display.setText("You owe me $$8")
```

If the extra `$` character is not included, the `$8` is interpreted as an undefined character code and is ignored. The message `You owe me` is displayed.

---

## NOTE

Be careful when embedding character codes in the text string. It is easy to forget that the character following the `$` is part of the code. For example, if you want to display `Hello` on the top line and `Nate` on the bottom line, send the following command:

```
display.setText("Hello$Nate")
```

The above command displays `Hello` on the top line and `ate` on the bottom line. The correct syntax for the command is as follows:

```
display.setText("Hello$NNate")
```

---

## Returning a text message

The `display.getText()` function returns the displayed message (*text*) and has the following options:

```
text = display.getText()
text = display.getText(embellished)
text = display.getText(embellished, row)
text = display.getText(embellished, row, columnStart)
text = display.getText(embellished, row, columnStart, columnEnd)
```

Where:

|                    |  |
|--------------------|--|
| <i>embellished</i> | Returns text as a simple character string ( <i>false</i> ) or includes character codes ( <i>true</i> ) |
| <i>row</i>         | The row to read text from (1 or 2); if not included, text from both rows is read                       |
| <i>columnStart</i> | Starting column for reading text   |
| <i>columnEnd</i>   | Ending column for reading text   |

Sending the command without the *row* parameter returns both lines of the display. The  $\$N$  character code is included to show where the top line ends and the bottom line begins. The  $\$N$  character code is returned even if *embellished* is set to *false*.

With *embellished* set to *true*, all other character codes that were used in the creation of each message line are returned with the message. With *embellished* set to *false*, only the message is returned.

Sending the command without the *columnStart* parameter defaults to column 1. Sending the command without the *columnEnd* argument defaults to the last column (column 20 for row 1, column 32 for row 2).

## Input prompting

You can use display messaging with front panel controls to make a user script interactive. In an interactive script, input prompts are displayed so that the operator can perform a prescribed action using the front panel controls. While displaying an input prompt, the test pauses and waits for the operator to perform the prescribed action.

## Menu

You can present a user-defined menu on the display. The menu consists of the menu name on the top line and a selectable list of menu items on the bottom line. To define a menu, use the `display.menu(menu, items)` function, where:

*menu*     The name of the menu; use a string of up to 20 characters (including spaces)  
*items*    A string is made up of one or more menu items; each item must be separated by white space

When the `display.menu()` function is sent, script execution waits for the operator to select one of the menu items. Rotate the navigation wheel to place the blinking cursor on a menu item. Items that do not fit in the display area are displayed by rotating the navigation wheel to the right. With the cursor on the menu item, press the navigation wheel (or the **ENTER** key) to select it.

Pressing the EXIT (LOCAL) key does not abort the script while the menu is displayed, but it returns *nil*. The script can be aborted by calling the `exit()` function when *nil* is returned.

The following programming example illustrates how to present the operator with the choice of two menu items: *Test1* or *Test2*. If *Test1* is selected, the message *Running Test1* is displayed. If *Test2* is selected, the message *Running Test2* is displayed.

```
display.clear()
menu = display.menu("Sample Menu", "Test1 Test2")
if menu == "Test1" then
  display.settext("Running Test1")
else
  display.settext("Running Test2")
end
```

## Parameter value prompting

You can use the `display.inputvalue()` and `display.prompt()` functions to create an editable input field on the user screen at the present cursor position.

The `display.inputvalue()` function uses the user screen at the present cursor position. Once the command is finished, it returns the user screen to its previous state. The `display.prompt()` function creates a new edit screen and does not use the user screen.

Each of these functions can be used in the following ways:

```
display.inputvalue(format)
display.inputvalue(format, default)
display.inputvalue(format, default, min)
display.inputvalue(format, default, min, max)
display.prompt(format, units, help)
display.prompt(format, units, help, default)
display.prompt(format, units, help, default, min)
display.prompt(format, units, help, default, min, max)
```

Where:

|                |   |
|----------------|---|
| <i>format</i>  | String that creates an editable input field on the user screen at the present cursor position (examples: +0.00 00, +00, 0.00000E+0)<br><b>Value field:</b><br>+ = Include for positive/negative value entry; omitting the + prevents negative value entry<br>0 = Defines the digit positions for the value (up to six zeros (0))<br><b>Exponent field (optional):</b><br>E = include for exponent entry<br>+ = Include for positive/negative exponent entry; omitting the + prevents negative value entry<br>0 = Defines the digit positions for the exponent |
| <i>default</i> | Option to set a default value for the parameter, which is displayed when the command is sent  |
| <i>min</i>     | Option to specify minimum limits for the input field <ul style="list-style-type: none"> <li>■ When NOT using the “+” sign for the value field, the minimum limit cannot be set to less than zero</li> <li>■ When using the “+” sign, the minimum limit can be set to less than zero (for example, -2)</li> </ul>  |
| <i>max</i>     | Option to specify maximum limits for the input field  |
| <i>units</i>   | Text string to identify the units for the value (8 characters maximum), for example: Units text is “V” for volts and “A” for amperes  |
| <i>help</i>    | Informational text string to display on the bottom line (32 characters maximum)   |

Both the `display.inputvalue()` and `display.prompt()` functions display the editable input field, but the `display.inputvalue()` function does not include the text strings for *units* and *help*.

After one of the above functions is executed, command execution pauses and waits for the operator to input the source level. The program continues after the operator enters the value by pressing the navigation wheel or the ENTER key.

The following programming example illustrates how to prompt the operator to enter a source voltage value for SMU A:

```
display.clear()
value = display.prompt("0.00", "V", "Enter source voltage")
display.screen = display.SMUA
smua.source.levelv = value
```

The script pauses after displaying the prompt message and waits for the operator to enter the voltage level. The display then toggles to the source-measure display for SMU A and sets the source level to `value`.

## NOTE

If the operator presses EXIT(LOCAL) instead of entering a source value, `value` is set to `nil`.

The second line of the above code can be replaced using the other input field function:

```
value = display.inputvalue("0.00")
```

The only difference is that the display prompt does not include the “V” units designator and the `Enter source value message`.

## Indicators

To determine which front-panel display indicators are turned on, use the `display.getannunciators()` function. For example, send the following commands.

```
annun = display.getannunciators()
print(annun)
```

The 16-bit binary equivalent of the returned value is a bitmap. Each bit corresponds to an indicator. If the bit is set to 1, the indicator is turned on. If the bit is set to 0, the indicator is turned off.

The following table identifies the bit position for each indicator. The table also includes the weighted value of each bit. The returned value is the sum of all the weighted values for the bits that are set.

### Bit identification for indicators

| Bit             | B16   | B15   | B14  | B13  | B12  | B11  | B10 | B9   |
|-----------------|-------|-------|------|------|------|------|-----|------|
| Annunciator     | REL   | REAR  | SRQ  | LSTN | TALK | REM  | ERR | EDIT |
| Weighted value* | 32768 | 16384 | 8192 | 4096 | 2048 | 1024 | 512 | 256  |
| Binary value    | 0/1   | 0/1   | 0/1  | 0/1  | 0/1  | 0/1  | 0/1 | 0/1  |

| Bit             | B8   | B7   | B6   | B5  | B4   | B3  | B2   | B1   |
|-----------------|------|------|------|-----|------|-----|------|------|
| Annunciator     | SMPL | STAR | TRIG | ARM | AUTO | 4W  | MATH | FILT |
| Weighted value* | 128  | 64   | 32   | 16  | 8    | 4   | 2    | 1    |
| Binary value    | 0/1  | 0/1  | 0/1  | 0/1 | 0/1  | 0/1 | 0/1  | 0/1  |

\* The weighted values are for bits that are set to 1. Bits set to 0 have no value.

Not all the indicators shown in above table may be used by the 2600B.

For example, assume the returned bitmap value is 34061. The binary equivalent of this value is as follows:

```
1000010100001101
```

For the above binary number, the following bits are set to 1: 16, 11, 9, 4, 3, and 1. Using the table, the following indicators are on: REL, REM, EDIT, AUTO, 4W, and FILT.

## Local lockout

You can use the front-panel EXIT (LOCAL) key to cancel remote operation and return control to the front panel. However, this key can be locked out to prevent a test from being interrupted. When locked, this key becomes a NO-OP (no operation). Configure the following attribute to lock or unlock the EXIT (LOCAL) key:

```
display.locallockout = lockout
```

Where *lockout* is set to one of the following values:

0 or `display.UNLOCK`

1 or `display.LOCK`

For example, to lock out the EXIT (LOCAL) key:

```
display.locallockout = display.LOCK
```

## Load test menu

The LOAD TEST menu lists tests (USER, FACTORY, and SCRIPTS) that can be run from the front panel.

Factory tests are preloaded and saved in nonvolatile memory at the factory. They are available in the FACTORY TESTS submenu.

If you load named scripts into the runtime environment, they can be selected from the front-panel SCRIPTS menu.

## User tests

User tests can be added to or deleted from the USER TESTS submenu.

## Adding USER TESTS menu entries

You can use the following function in either of two ways to add an entry into the USER TESTS menu:

```
display.loadmenu.add(displayname, code)
display.loadmenu.add(displayname, code, memory)
```

Where:

|                    |   |
|--------------------|---|
| <i>displayname</i> | The name string that is added to the USER TESTS menu.   |
| <i>code</i>        | The code that is run from the USER TESTS menu when the RUN button is pressed. It can include any valid Lua code.  |
| <i>memory</i>      | A value that specifies if the <i>code</i> and <i>displayname</i> parameters are saved in nonvolatile memory. Set to one of the following values:<br>0 or <code>display.DONT_SAVE</code><br>1 or <code>display.SAVE</code> (this is the default setting) |

Scripts, functions, and variables that are used in the *code* are not saved when `display.SAVE` is used. Functions and variables need to be saved with the script. If the script is not saved in nonvolatile memory, it is lost when the 2600B is turned off. See Example 1 below.

### Example 1:

Assume a script with a function named `DUT1` has been loaded into the 2600B, and the script has not been saved in nonvolatile memory.

Now assume you want to add a test named `Test` to the USER TESTS menu. You want the test to run the function named `DUT1` and sound the beeper. The following programming example illustrates how to add `Test` to the menu, define the *code*, and then save *displayname* and *code* in nonvolatile memory:

```
display.loadmenu.add("Test", "DUT1() beeper.beep(2, 500)", display.SAVE)
```

When `Test` is run from the front-panel USER TESTS menu, the function named `DUT1` executes and the beeper beeps for two seconds.

Now assume you turn the 2600B power off and then on again. Because the script was not saved in nonvolatile memory, the function named `DUT1` is lost. When `Test` is again run from the front panel, the beeper beeps, but `DUT1` does not execute because it is no longer in the runtime environment.

### Example 2:

The following command adds an entry called `Part1` to the front-panel USER TESTS submenu for the code `testpart([[Part1]], 5.0)` and saves it in nonvolatile memory:

```
display.loadmenu.add("Part1", "testpart([[Part1]], 5.0)", display.SAVE)
```

## Deleting USER TESTS menu entries

You can use the following function to delete an entry from the front-panel USER TESTS menu:

```
display.loadmenu.delete(displayname)
```

Where:

*displayname*      Name to delete from the menu.

The following programming example removes the entry named `Part1` from the front-panel USER TESTS menu:

```
display.loadmenu.delete("Part1")
```

## Running a test from the front panel

**To run a user, factory, or script test from the front panel:**

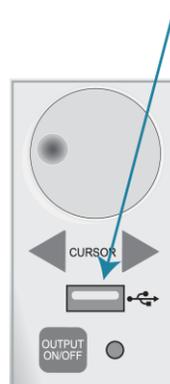
1. Press the **LOAD** key to display the LOAD TEST menu.
2. Select the **USER**, **FACTORY**, or **SCRIPTS** menu item.
3. Position the blinking cursor on the test to be run and press **ENTER** or the navigation wheel.
4. Press the **RUN** key to run the test.

## Connecting the USB flash drive

The 2600B supports flash drives that comply with USB 2.0 standards and USB 1.0 and 1.1 standards. You can save data to the USB flash drive from the front panel, or you can create a script to save data to the USB flash drive.

To connect the USB flash drive, plug the USB flash drive into the USB port on the front panel of the instrument, shown in the figure below.

**Figure 16: USB port**



## Using the web interface

If you are connected to the 2600B using LAN communications, you can use an internet browser to connect to the instrument through the 2600B web interface.

The LXI web interface allows you to change settings and control your instrument through the web interface. The web interface includes:

- A virtual front panel that you can use to control the instrument.
- TSB Embedded, a script management tool that can also be used to send individual commands to the instrument.
- The instrument status, model, serial number, firmware revision, and the last LXI message.
- An ID button to help you locate the instrument.
- Ability to download data from specific reading buffers into a `.CSV` file.
- Administrative options, LAN information, and LXI information.

The web interface resides in the firmware of the instrument. Changes you make through the web interface are immediately made in the instrument.

You can also upgrade the instrument from the web interface. Refer to [Upgrading the firmware](#) (on page 5-4) for instructions.

---

### NOTE

To set up LAN connections, refer to *Series 2600B Reference Manual*, “LAN communications.”

---

## How to access the web interface

You can access the web interface by entering the IP address of the instrument in the address line of an internet browser.

### ***To get the IP address of the instrument:***

1. From the front panel, press the **MENU** key.
2. Select **LAN > STATUS**.
3. Use the navigation wheel to select **IP-ADDRESS**.
4. Press the **ENTER** key to view the active setting.
5. Press the **EXIT (LOCAL)** key once to return to the STATUS menu.

---

### NOTE

To find the IP address of the 2600B from a computer, use the LXI Discovery Tool, a utility that is available from the Resources tab of the [LXI Consortium website \(lxistandard.org\)](http://lxistandard.org).

---

**To access the web interface:**

1. Open a web browser on the host computer.
2. Enter the IP address of the instrument in the web browser address box. For example, if the instrument IP address is 192.168.1.101, enter 192.168.1.101 in the browser address box.
3. Press **Enter** on the computer keyboard to open the web interface of the instrument.

**NOTE**

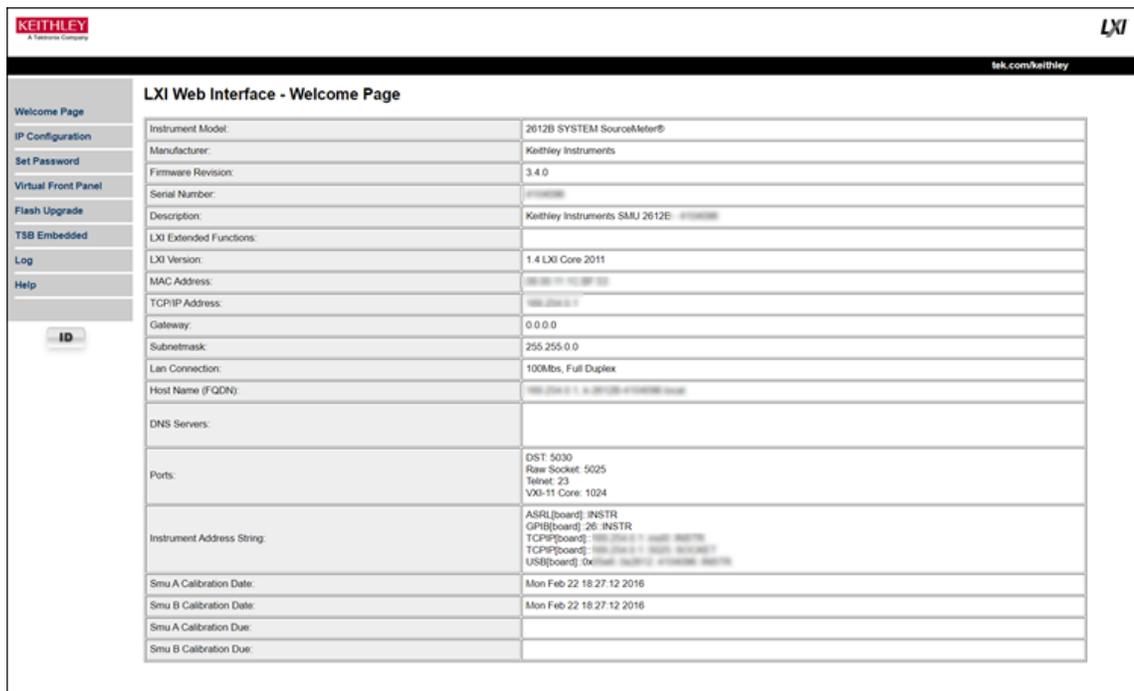
If the web interface does not open in the browser, see LAN troubleshooting suggestions.

**Web interface Welcome page**

The Welcome page provides information about the instrument. It includes:

- The instrument model number, manufacturer, firmware revision number, and instrument serial number.
- LXI information.
- LAN connection information.
- The TCP Raw Socket number and Telnet Port number.
- Instrument address strings.
- Calibration dates.
- The ID button, which helps you find the instrument if you have multiple instruments.

**Figure 17: Web interface Welcome page**



## Use the ID button to identify the instrument

If you have a bank of instruments, you can select the ID button to determine which instrument you are communicating with.

The ID button is below the menu on every page of the web interface.

### **To identify the instrument:**

1. Select **ID**. The button turns green and the message "LAN Status Indicator" is displayed on the front panel of the instrument.
2. Select **ID** again to return the button to its original color and return the front-panel display to its previous state.

## Change the IP configuration through the web interface

You can change the LAN settings through the web interface on the instrument. The LAN settings you can change include the IP address, subnet mask, gateway, and DNS address.

If you change the IP address through the web interface, the web interface tries to redirect to the IP address that is configured in the instrument. In some cases, this may fail. This generally happens if you switch from an IP address assignment that uses a static address to an IP address assignment that uses a DHCP server. If this happens, you need to revert to either using the front panel to set the IP address or use an automatic discovery tool to determine the new IP address.

You can use the host name instead of the IP address to connect to the instrument.

---

### NOTE

You can also change the IP configuration through the front panel or with TSP commands. Refer to "LAN communications" section of the *Series 2600B Reference Manual* for information on setting the configuration through the front panel. Refer to the `lan.config.*` command descriptions in the "TSP command reference" section of the *Series 2600B Reference Manual* for information on using TSP commands to configure the LAN settings.

---

### **To change the IP configuration using the web interface:**

1. Access the web interface as described in [How to access the web interface](#) (on page 3-35).
2. Select **IP Configuration**.
3. Select **Modify**. The Modify IP Configuration page is displayed.
4. Change the values.
5. Click **Submit**. The instrument reconfigures its settings, which may take a few moments.

---

### NOTE

You may lose your connection with the web interface after clicking **Submit**. This is normal. If this occurs, find the correct IP address and reopen the web interface of the instrument to continue.

---

## Set the instrument password

You can change the instrument password from the web interface. The instrument password is used for access to the instrument from any remote interface. When password usage is enabled by the `localnode.passwordmode` command, you must supply a password to change the configuration or to control an instrument a remote command interface.

---

### NOTE

When a password is set for the web interface and `localnode.passwordmode` is set to an option that requires a password, you cannot make changes using the web interface options Virtual Front Panel, Flash Upgrade, and TSB Embedded.

---

The default password is "" (no password).

You cannot retrieve a lost password from any command interface. You can reset the password from the front panel. Select **MENU**, then **RESET-PASSWORD**.

For information on the TSP commands, refer to `localnode.passwordmode` in the *Series 2600B Reference Manual*.

#### ***To change the password:***

1. Select **Set Password**.
2. In the **Current Password** box, enter the presently used password.
3. In the **New Password** and **Confirm New Password** boxes, enter the new password.
4. Select **Submit**.

## Using the virtual front panel

The Virtual Front Panel page allows you to control the instrument from a computer as if you were using the front panel of the instrument. You can operate the instrument using a mouse to select options.

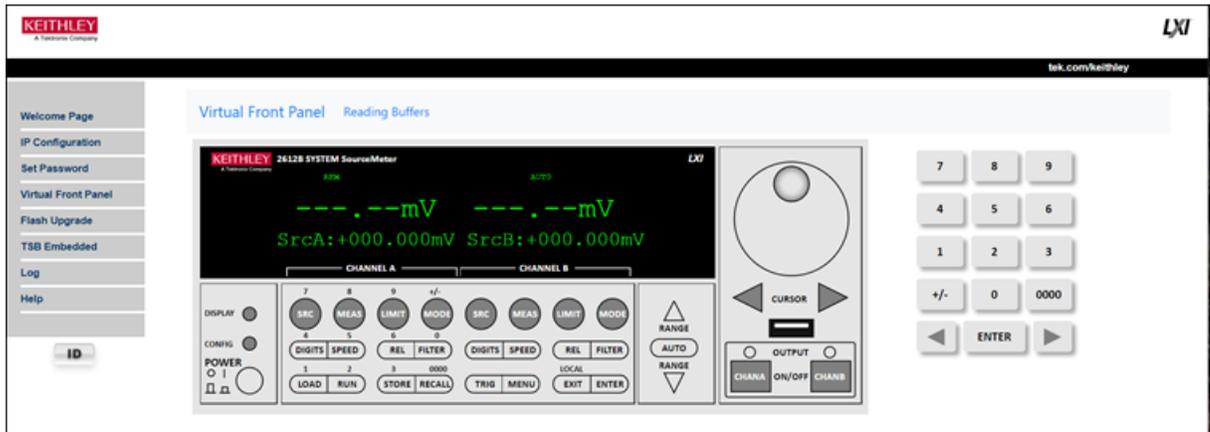
The virtual front panel operates the same way as the actual front panel except that you cannot switch the instrument on or off with the power switch.

For information on the front-panel controls, see [Instrument description](#) (on page 3-1).

To use the virtual front panel, you can use any standard web browser.

You can access the Virtual Front Panel from multiple interfaces and each interface can make changes. You may need to refresh the browser to see changes made by another interface.

Figure 18: Virtual front panel



## View buffer data using the web interface

You can view the data in the reading buffers on the Reading Buffers page of the Virtual Front Panel web page.

To view the data, at the top of the virtual front panel, select **Reading Buffers**. On the Reading Buffers page, select a reading buffer from the Reading Buffer list. The data is displayed in the table.

Initially, the reading number and reading measurement values are displayed. You can display additional data using the filters to the right of the table. You can choose:

- **Measurement:** Include or exclude measurement information.
- **Source:** Include or exclude source information.
- **Other:** Include or exclude status, status detail, and timestamp information. For detail on the Status value, refer to “Buffer status” in the *Series 2600B Reference Manual*.

An example of the Reading Buffers page with the measurement and source functions displayed is shown in the following figure.

Figure 19: Web interface Reading Buffers page

Virtual Front Panel Reading Buffers

Buffer : smua.nvbuffer1

| Reading Buffer | Reading Number | Reading     | Measure Function | Source Function |
|----------------|----------------|-------------|------------------|-----------------|
| smua.nvbuffer1 | 1              | 0.000986814 | Voltage          | Voltage         |
| smua.nvbuffer2 | 2              | 0.00098753  | Voltage          | Voltage         |
| smub.nvbuffer1 | 3              | 0.000985861 | Voltage          | Voltage         |
| smub.nvbuffer2 | 4              | 0.000985384 | Voltage          | Voltage         |
|                | 5              | 0.000984907 | Voltage          | Voltage         |
|                | 6              | 0.000985622 | Voltage          | Voltage         |
|                | 7              | 0.000985622 | Voltage          | Voltage         |
|                | 8              | 0.000986814 | Voltage          | Voltage         |
|                | 9              | 0.000984669 | Voltage          | Voltage         |
|                | 10             | 0.000985384 | Voltage          | Voltage         |
|                | 11             | 0.000985384 | Voltage          | Voltage         |
|                | 12             | 0.000985861 | Voltage          | Voltage         |
|                | 13             | 0.000985861 | Voltage          | Voltage         |
|                | 14             | 0.00098443  | Voltage          | Voltage         |
|                | 15             | 0.000985861 | Voltage          | Voltage         |
|                | 16             | 0.000984907 | Voltage          | Voltage         |
|                | 17             | 0.000984907 | Voltage          | Voltage         |
|                | 18             | 0.000985861 | Voltage          | Voltage         |
|                | 19             | 0.000985384 | Voltage          | Voltage         |

Save

Measurement

- Functions
- Ranges

Source

- Functions
- Ranges
- Values
- Output States

Other

- Status
- Status Details
- Timestamp

## Download reading buffer data using the web interface

You can download reading buffer data to a .csv file from the Reading Buffers page of the web interface.

The data shown in the table on the Reading Buffers page is downloaded.

### **To download buffer data:**

1. From the web interface, select **Virtual Front Panel**.
2. Select **Reading Buffers**.
3. From the Reading Buffer list, select the reading buffer that contains the data you want to download.
4. From the options on the right, filter the reading buffer list to display the data you want to download.
5. Select **Save**. The file is downloaded to your computer.
6. Follow the instructions for your browser to open the file. Typically, the file opens in Microsoft Excel.

## Using TSB Embedded

TSB Embedded is a script management tool that is available through the web interface of the instrument. You can use TSB Embedded to create, modify, and save test scripts, and to send individual commands. TSB Embedded provides some of the features of Test Script Builder (TSB). TSB is a software tool that simplifies building test scripts for Keithley Instruments that are enabled to use Test Script Processor (TSP®).

For more information on using TSB Embedded for script management, refer to “Working with TSB Embedded” in the *Series 2600B Reference Manual*.

## Send individual commands using the web interface

*To send individual commands using the web interface:*

1. Select **TSB Embedded**.
2. In the **Console** box, enter the command.
3. Select **Enter** to send the command to the instrument. The command is displayed in the Output box. If there is a response to the command, it is displayed after the command.
4. To clear the Output box, right-click and select **Clear**.

## Review events in the LXI Event Log

The Log option opens the LXI Event Log. The event log records all LXI events that the instrument generates and receives. The log includes the following information:

- The EventID column, which shows the identifier of the event that generated the event message.
- The PTP Timestamp column, which displays the seconds and fractional (nano) seconds when the event occurred.
- The Data column, which displays the text of the event message.

To clear the event log and update the information on the screen, select **Refresh**.

## Logging LAN trigger events in the event log

You can use the event log to record all LXI triggers generated and received by the 2600B. You can view the event log using any command interface or the embedded web interface. The following figure shows the view of the LXI event log from the Log option in the embedded web interface.

Figure 20: LXI Event Log

The screenshot shows the LXI Event Log interface. At the top, it says 'LXI Event Log 09:51:42.000 25 Apr 2021'. Below this is a table with the following columns: Receive Time, EventID, From, PTP Timestamp (subdivided into Seconds and FractionalSeconds), HWDetect, Sequence, Domain, Flags, and Data. The table contains 18 rows of event data. A 'Refresh' button is located at the bottom of the table.

| Receive Time             | EventID | From      | PTP Timestamp |                   | HWDetect | Sequence   | Domain | Flags | Data |
|--------------------------|---------|-----------|---------------|-------------------|----------|------------|--------|-------|------|
|                          |         |           | Seconds       | FractionalSeconds |          |            |        |       |      |
| 09:51:22.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341530 | 1      | 16    | 0x00 |
| 09:51:23.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341531 | 2      | 16    | 0x00 |
| 09:51:24.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341532 | 3      | 16    | 0x00 |
| 09:51:25.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341533 | 4      | 16    | 0x00 |
| 09:51:26.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341534 | 5      | 16    | 0x00 |
| 09:51:27.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341535 | 6      | 16    | 0x00 |
| 09:51:28.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341536 | 7      | 16    | 0x00 |
| 09:51:30.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341537 | 8      | 16    | 0x00 |
| 09:51:31.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341538 | 9      | 16    | 0x00 |
| 09:51:32.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341539 | 10     | 16    | 0x00 |
| 09:51:33.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341540 | 11     | 16    | 0x00 |
| 09:51:40.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341546 | 17     | 16    | 0x00 |
| 09:51:41.000 25 Apr 2021 | LAN0    | localhost | 0             | 0.000000000       | LXI      | 1619341547 | 18     | 16    | 0x00 |

The timestamp, event identifier, IP address, and the domain name identify the incoming and outgoing LXI trigger packets. The following table provides detailed descriptions for the columns in the event log.

**Event log descriptions**

| Column title | Description  | Example  |
|--------------|--|--|
| Receive Time | Displays the date and time that the LAN trigger occurred in UTC, 24-hour time  | 11:46:44.000 11 Mar 2020   |
| Event ID     | Identifies the <code>lan.trigger[N]</code> that generates an event   | LAN0 = <code>lan.trigger[1]</code><br>LAN1 = <code>lan.trigger[2]</code><br>LAN2 = <code>lan.trigger[3]</code><br>LAN3 = <code>lan.trigger[4]</code><br>LAN4 = <code>lan.trigger[5]</code><br>LAN5 = <code>lan.trigger[6]</code><br>LAN6 = <code>lan.trigger[7]</code><br>LAN7 = <code>lan.trigger[8]</code> |
| From         | Displays the IP address for the device that generates the LAN trigger  | localhost<br>192.168.5.20  |
| Timestamp    | A timestamp that identifies the time the event occurred; the timestamp uses the following: <ul style="list-style-type: none"> <li>PTP timestamp</li> <li>Seconds</li> <li>Fractional seconds; the 2600B does not support the IEEE Std 1588 standard; the values in this field are always 0 (zero)</li> </ul> |  |
| HWDetect     | Identifies a valid LXI trigger packet  | LXI  |

**Event log descriptions**

| Column title | Description  | Example |
|--------------|--|---------|
| Sequence     | Each instrument maintains independent sequence counters: <ul style="list-style-type: none"> <li>▪ One for each combination of UDP multicast network interface and UDP multicast destination port</li> <li>▪ One for each TCP connection</li> </ul> |         |
| Domain       | Displays the LXI domain number; the default value is 0 (zero)  | 0       |
| Flags        | Contain data about the LXI trigger packet; values are: <ul style="list-style-type: none"> <li>▪ 1 - Error</li> <li>▪ 2 - Retransmission</li> <li>▪ 4 - Hardware</li> <li>▪ 8 - Acknowledgments</li> <li>▪ 16 - Stateless bit</li> </ul>            | 16      |
| Data         | The values for this are always 0 (zero)  |         |

**Accessing the event log from the command interface**

You can access the event log from any remote command interface. The event log must be enabled before LXI trigger events can be viewed. To enable the event log, send:

```
eventlog.enable = 1
```

To view the event log from a remote interface, send:

```
print(eventlog.all())
```

This command outputs one or more strings similar to the following:

```
14:14:02.000 17 Jun 2019, LAN0, 10.80.64.191, LXI, 0, 1560780842, not available, 0, 0x10,0x00
```

The string displays the same information as the web interface. Commas separate the fields. The fields output in the following order:

- Received time (UTC time)
- Event ID
- From (Sender)
- HWDetect / version
- Domain
- Sequence number
- Timestamp (PTP time)
- Epoch (from 1588)
- Flags
- Data

See the table in [Logging LAN trigger events in the event log](#) (on page 3-41) for detailed descriptions.

**To generate log traffic, send the code:**

```
local id = 1
lan.trigger[id].ipaddress = lan.status.ipaddress
lan.trigger[id].connect()
for domain = 1, 255 do
    print(domain)
    lan.lxidomain = domain
    lan.trigger[id].assert()
    delay(1)
end
```

## Help

The help page in the web interface provides basic help for the web interface, a glossary of terms, and a link to licenses for the virtual front panel, firmware upgrade tool, and TSB Embedded.

**In this section:**

|   |      |
|---|------|
| Basic operation .....                     | 4-1  |
| Source-measure capabilities .....         | 4-1  |
| Limits.....                               | 4-2  |
| Sink operation .....                      | 4-5  |
| DUT test connections .....                | 4-6  |
| Front-panel source-measure procedure..... | 4-28 |
| Sense mode selection.....                 | 4-30 |
| Output-off modes .....                    | 4-31 |

## Basic operation

---

** WARNING**

For the Models 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B, hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never make or break connections to the 2600B while the instrument is powered on. Turn off the equipment from the front panel or disconnect the main power cord from the rear of the 2600B before handling cables. Putting the equipment into standby does not guarantee that the outputs are powered off if a hardware or software fault occurs.

---

## Source-measure capabilities

From the front panel, you can configure the instrument to perform the following source-measure operations:

- **Source voltage:** Measure and display current, voltage, resistance, or power
- **Source current:** Measure and display voltage, current, resistance, or power
- **Measure resistance:** Display resistance calculated from voltage and current components of measurement (can optionally specify source voltage or source current value)
- **Measure power:** Display power calculated from voltage and current components of measurement (can optionally specify source voltage or source current value)
- **Measure only (V or I):** Display voltage or current measurement

## Voltage and current

The following table lists the source and measure limits for the voltage and current functions. The full range of operation is explained in “Operating boundaries” in the *Series 2600B Reference Manual*.

### Source-measure capabilities

| 2601B, 2602B, 2604B                                   |          |          | 2611B, 2612B, 2614B   |          |          | 2634B, 2635B, 2636B   |          |          |
|---|----------|----------|---|----------|----------|---|----------|----------|
| Range   | Source   | Measure  | Range   | Source   | Measure  | Range   | Source   | Measure  |
| 100 mV  | ±101 mV  | ±102 mV  | 200 mV  | ±202 mV  | ±204 mV  | 200 mV  | ±202 mV  | ±204 mV  |
| 1 V   | ±1.01 V  | ±1.02 V  | 2 V   | ±2.02 V  | ±2.04 V  | 2 V   | ±2.02 V  | ±2.04 V  |
| 6 V   | ±6.06 V  | ±6.12 V  | 20 V  | ±20.2 V  | ±20.4 V  | 20 V  | ±20.2 V  | ±20.4 V  |
| 40 V  | ±40.4 V  | ±40.8 V  | 200 V <sup>2</sup>  | ±202 V   | ±204 V   | 200 V <sup>4</sup>  | ±202 V   | ±204 V   |
| 100 nA  | ±101 nA  | ±102 nA  | 100 nA  | ±101 nA  | ±102 nA  | 100 pA  | N/A      | ±102 pA  |
| 1 µA  | ±1.01 µA | ±1.02 µA | 1 µA  | ±1.01 µA | ±1.02 µA | 1 nA  | ±1.01 nA | ±1.02 nA |
| 10 µA   | ±10.1 µA | ±10.2 µA | 10 µA   | ±10.1 µA | ±10.2 µA | 10 nA   | ±10.1 nA | ±10.2 nA |
| 100 µA  | ±101 µA  | ±102 µA  | 100 µA  | ±101 µA  | ±102 µA  | 100 nA  | ±101 nA  | ±102 nA  |
| 1 mA  | ±1.01 mA | ±1.02 mA | 1 mA  | ±1.01 mA | ±1.02 mA | 1 µA  | ±1.01 µA | ±1.02 µA |
| 10 mA   | ±10.1 mA | ±10.2 mA | 10 mA   | ±10.1 mA | ±10.2 mA | 10 µA   | ±10.1 µA | ±10.2 µA |
| 100 mA  | ±101 mA  | ±102 mA  | 100 mA  | ±101 mA  | ±102 mA  | 100 µA  | ±101 µA  | ±102 µA  |
| 1 A   | ±1.01 A  | ±1.02 A  | 1 A   | ±1.01 A  | ±1.02 A  | 1 mA  | ±1.01 mA | ±1.02 mA |
| 3 A   | ±3.03 A  | ±3.06 A  | 1.5 A   | ±1.515 A | ±1.53 A  | 10 mA   | ±10.1 mA | ±10.2 mA |
| 10 A <sup>1</sup>                                     | ±10.1 A  | ±10 A    | 10 A <sup>3</sup>   | ±10.1 A  | ±10.2 A  | 100 mA  | ±101 mA  | ±102 mA  |
|   |          |          |   |          |          | 1 A   | ±1.01 A  | ±1.02 A  |
|   |          |          |   |          |          | 1.5 A   | ±1.515 A | ±1.53 A  |
|   |          |          |   |          |          | 10 A <sup>5</sup>   | ±10.1 A  | ±10 A    |
| Maximum power = 40.4 W per channel                    |          |          | Maximum power = 30.603 W per channel                                      |          |          | Maximum power = 30.603 W per channel                                      |          |          |
| <sup>1</sup> 10 A range available only in pulse mode. |          |          | <sup>2</sup> 200 V source range available only when interlock is enabled. |          |          | <sup>4</sup> 200 V source range available only when interlock is enabled. |          |          |
|   |          |          | <sup>3</sup> 10 A range available only in pulse mode.                     |          |          | <sup>5</sup> 10 A range available only in pulse mode.                     |          |          |

## Limits

When sourcing voltage, you can set the instrument to limit current or power. Conversely, when sourcing current, you can set the instrument to limit voltage or power. In steady-state conditions, the instrument output does not exceed the limit. The maximum limit is the same as the maximum values listed in the following table.

The limit circuit limits in either polarity regardless of the polarity of the source or limit value. The accuracy of the limit opposite in polarity from the source is diminished unless the instrument is in [sink operation](#) (on page 4-5). The maximum limits are based on source range.

The limit operation of the instrument changes dependent on the source mode (current or voltage), load, and the configured limits (current, voltage, and power). It is important to distinguish both the current and voltage limits from the power limit. As the names imply, the current limit restricts the current for sourced voltage, and the voltage limit restricts the voltage for a sourced current. The power limit, however, restricts power by lowering the present limit in effect (voltage or current) as needed to restrict the SMU from exceeding the specified power limit. For additional details on using limits, including load considerations when specifying both a current (or a voltage) limit and a power limit, see “Operating boundaries” in the *Series 2600B Reference Manual*.

For additional information on limits, refer to “Limit principles” in the *Series 2600B Reference Manual*.

## NOTE

The only exception to the limit not being exceeded is the voltage limit when operating as a current source. To avoid excessive and potentially destructive currents from flowing, the voltage limit sources or sinks up to 102 mA for current source ranges on or below 100 mA. For ranges 1 A and above, the maximum current allowed is the current source setting.

### Maximum limits

| 2601B, 2602B, 2604B |               | 2611B, 2612B, 2614B |               | 2634B, 2635B, 2636B |               |
|---------------------|---------------|---------------------|---------------|---------------------|---------------|
| Source range        | Maximum limit | Source range        | Maximum limit | Source range        | Maximum limit |
| 100 mV              | 3 A           | 200 mV              | 1.5 A         | 200 mV              | 1.5 A         |
| 1 V                 | 3 A           | 2 V                 | 1.5 A         | 2 V                 | 1.5 A         |
| 6 V                 | 3 A           | 20 V                | 1.5 A         | 20 V                | 1.5 A         |
| 40 V                | 1 A           | 200 V               | 100 mA        | 200 V               | 100 mA        |
| 100 nA              | 40 V          | 100 nA              | 200 V         | 1 nA                | 200 V         |
| 1 µA                | 40 V          | 1 µA                | 200 V         | 10 nA               | 200 V         |
| 10 µA               | 40 V          | 10 µA               | 200 V         | 100 nA              | 200 V         |
| 100 µA              | 40 V          | 100 µA              | 200 V         | 1 µA                | 200 V         |
| 1 mA                | 40 V          | 1 mA                | 200 V         | 10 µA               | 200 V         |
| 10 mA               | 40 V          | 10 mA               | 200 V         | 100 µA              | 200 V         |
| 100 mA              | 40 V          | 100 mA              | 200 V         | 1 mA                | 200 V         |
| 1 A                 | 40 V          | 1 A                 | 20 V          | 10 mA               | 200 V         |
| 3 A                 | 6 V           | 1.5 A               | 20 V          | 100 mA              | 200 V         |
|                     |               |                     |               | 1 A                 | 20 V          |
|                     |               |                     |               | 1.5 A               | 20 V          |

## Setting the limit from the front panel

**To set the limit for a single-channel instrument (2601B, 2611B, or 2635B) or the single-channel display mode of a two-channel instrument (2602B, 2604B, 2612B, 2614B, 2634B, or 2636B):**

1. Press the **LIMIT** key. Pressing the LIMIT key while in limit edit mode toggles the display between the complementary function limit and the power limit display.
2. Press the navigation wheel and set the limit to the new value.
3. Press the **ENTER** key or the navigation wheel to complete editing.
4. Press the **EXIT (LOCAL)** key to return to the main display.

**To set the limit for a two-channel instrument (2602B, 2604B, 2612B, 2614B, 2634B, or 2636B) in dual-channel mode:**

1. Press the **LIMIT** key.
2. Select **CURRENT**, **VOLTAGE**, or **POWER** as needed. Press the **ENTER** key or the navigation wheel.
3. Press the navigation wheel and set the limit to the new value.
4. Press the **ENTER** key or the navigation wheel to complete editing.
5. Press the **EXIT (LOCAL)** key to return to the main display.

## Setting the limit from a remote interface

The table below summarizes basic commands to program a limit. For a more complete description of these commands, refer to the “TSP command reference” section of the *Series 2600B Reference Manual*.

### Limit commands

| Command*   | Description  |
|--|--|
| <code>smuX.source.limiti = limit</code>          | Set current limit.   |
| <code>smuX.source.limitv = limit</code>          | Set voltage limit.   |
| <code>smuX.source.limitp = limit</code>          | Set power limit.   |
| <code>compliance = smuX.source.compliance</code> | Test if in limit ( <code>true</code> = in limit; <code>false</code> = not in limit). |

\* `smuX` can be `smua` for channel A or `smub` for channel B

To set the limit, send the command with the limit value as the parameter. The following programming example illustrates how to set the current, voltage, and power limit to 50 mA, 4 V, and 1 W, respectively:

```
smua.source.limiti = 50e-3
smua.source.limitv = 4
smua.source.limitp = 1
```

The following programming example illustrates how to print the limit state:

```
print(smua.source.compliance)
```

A returned value of `true` indicates one of these things:

- If the instrument is configured as a current source, the voltage limit has been reached
- If the instrument is configured as a voltage source, the current limit has been reached

## Sink operation

### CAUTION

Carefully consider and configure the appropriate output-off state, source function, and compliance limits before connecting the 2600B to a device that can deliver energy (for example, other voltage sources, batteries, capacitors, solar cells, or other 2600B instruments). Configure recommended instrument settings before making connections to the device. Failure to consider the output-off state, source, and compliance limits may result in damage to the instrument or to the device under test (DUT).

When operating as a sink (voltage and current have opposite polarity), the instrument is dissipating power rather than sourcing it. An external source (for example, a battery) or an energy storage device (for example, a capacitor) can force operation into the sink region. For example, if a 12 V battery is connected to the voltage source (HI to battery +) that is programmed for +10 V, sink operation occurs in the second quadrant (source +V and measure -I).

When operating as a sink, limit inaccuracies are introduced. Enabling sink mode reduces the source limit inaccuracy seen when operating in quadrants II and IV. Quadrants I and III show this source limit inaccuracy.

The sink operating limits are shown in “Continuous power operating boundaries” in the *Series 2600B Reference Manual*.

### CAUTION

When using the current source as a sink, always set the voltage compliance to a level that is higher than the external voltage level. Failure to do so could result in excessive current flow into the instrument and incorrect measurements. See [Limits](#) (on page 4-2) for details about compliance limits.

## Setting the sink mode using the front panel

*To enable or disable the sink mode from the front panel:*

1. Press the **CONFIG** key and then the **SRC** key.
2. Select **V-SOURCE**.
3. Select **SINK-MODE**.
4. Select **ENABLE** or **DISABLE**.
5. Press the **ENTER** key. Sink mode is enabled or disabled, as applicable.
6. Press the **EXIT (LOCAL)** key twice to return to the main display.

## Setting the sink mode from a remote interface

*To enable sink mode from the remote interface, send:*

```
smua.source.sink = smua.ENABLE
```

*To disable sink mode, send:*

```
smua.source.sink = smua.DISABLE
```

## DUT test connections

---

### **WARNING**

Hazardous voltages may be present in the test system. To prevent injury or death, remove power from the instrument or test system and discharge any energy storage components (for example, capacitors or cables) before changing any connections that might allow contact with an uninsulated conductor.

---

### **NOTE**

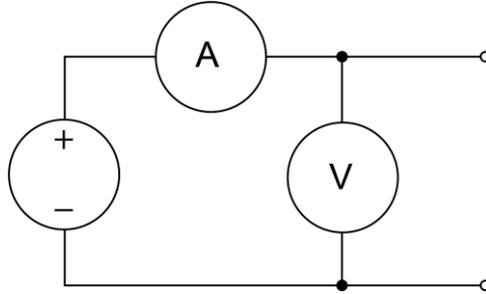
On some sensitive or easily damaged devices under test (DUTs), the instrument power-up and power-down sequence can apply transient signals to the DUT that may affect or damage it. When testing this type of DUT, do not make final connections to it until the instrument has completed its power-up sequence and is in a known operating state. When testing this type of DUT, disconnect it from the instrument before turning the instrument off.

To prevent any human contact with a live conductor, connections to the DUT must be fully insulated and the final connections to the DUT must only use safety-rated safety-jack-socket connectors that do not allow bodily contact.

---

The fundamental source-measure configurations for the 2600B are shown in the following figures. When sourcing voltage, you can measure current or voltage, as shown in the following figure.

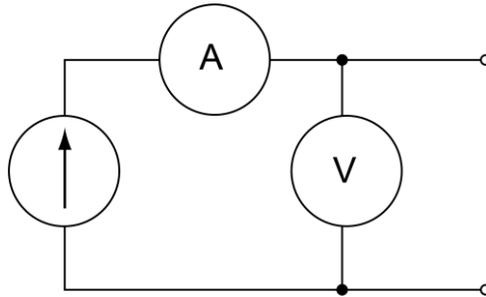
**Figure 21: Fundamental source-measure configurations: Source V**



|          |                |
|----------|----------------|
| <b>A</b> | Current meter  |
| <b>+</b> | Voltage source |
| <b>-</b> |                |
| <b>V</b> | Voltage meter  |

When sourcing current, you can measure voltage or current, as shown in the following figure.

**Figure 22: Fundamental source-measure configuration: Source I**



|          |                |
|----------|----------------|
| <b>A</b> | Current meter  |
| <b>↑</b> | Current source |
| <b>V</b> | Voltage meter  |

Refer to “Circuit configurations” in the *Series 2600B Reference Manual* for detailed information.

## Input/output connectors

The 2600B uses screw terminal connectors or triaxial connectors for input and output connections to devices under test (DUTs). The 2601B, 2602B, 2604B, 2611B, 2612B, and 2614B use screw terminal connectors. The 2634B, 2635B, and 2636B use triaxial connectors.

A screw terminal connector can be removed from the rear panel by loosening the two captive retaining screws and pulling it off the rear panel. Each screw in the terminal connector cable assembly (used with the SMU connector) can accommodate from 24 AWG (0.2 mm<sup>2</sup>) to 12 AWG (2.5 mm<sup>2</sup>) conductors.

Basic connection sequence:

1. With the output off and the connector uninstalled from the 2600B rear panel, make the wire connections from a connector to the DUT.
2. Reinstall the connector onto the rear panel.
3. If using a screw terminal connector, tighten the two captive screws.

---

### WARNING

**Hazardous voltages may be present on the output and guard terminals. To prevent electrical shock that could cause injury or death, never make or break connections to the 2600B while the output is on. Power off the equipment from the front panel or disconnect the main power cord from the rear of a 2600B before handling cables connected to the outputs. Putting the equipment into standby does not guarantee the outputs are not powered if a hardware or software fault occurs.**

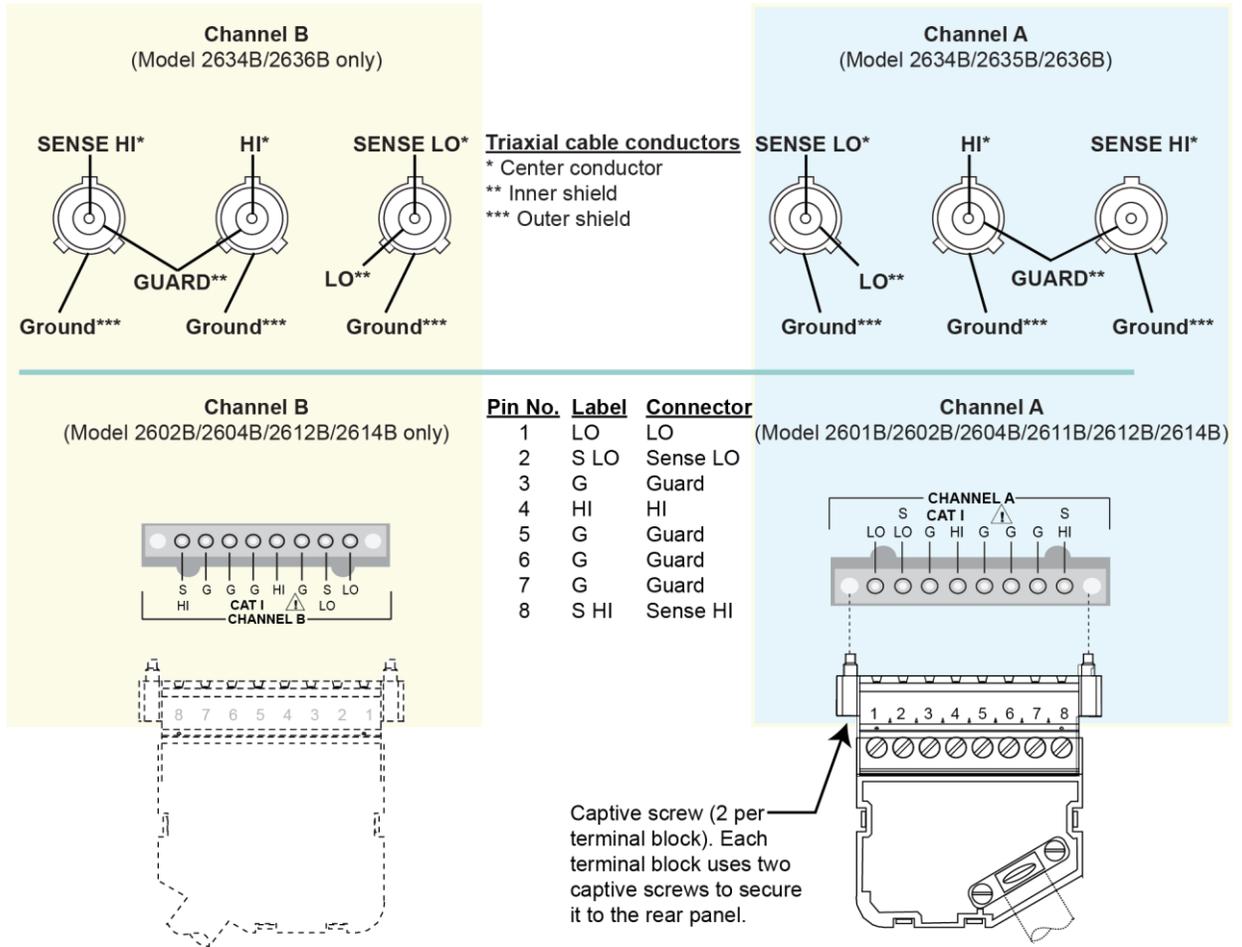
**Maximum floating (common mode) voltage for a SMU is 250 V. Exceeding this level could damage the instrument and create a shock hazard. See [Floating a SMU](#) (on page 4-26) for details on floating the SMUs.**

**The input/output connectors of the 2600B are rated for connection to circuits rated Measurement Category I only, with transients rated less than 1500 V<sub>PEAK</sub>. Do not connect the 2600B terminals to CAT II, CAT III, or CAT IV circuits. Connections of the input/output connectors to circuits higher than CAT I can cause damage to the equipment or expose the operator to hazardous voltages.**

**To prevent electric shock and/or damage to the 2600B, when connecting to a source with a greater current capability than the 2600B, a user-supplied fuse, rated at no more than 20 A SLO-BLO, should be installed in-line with the 2600B input/output connectors.**

---

Figure 23: Input/output connectors



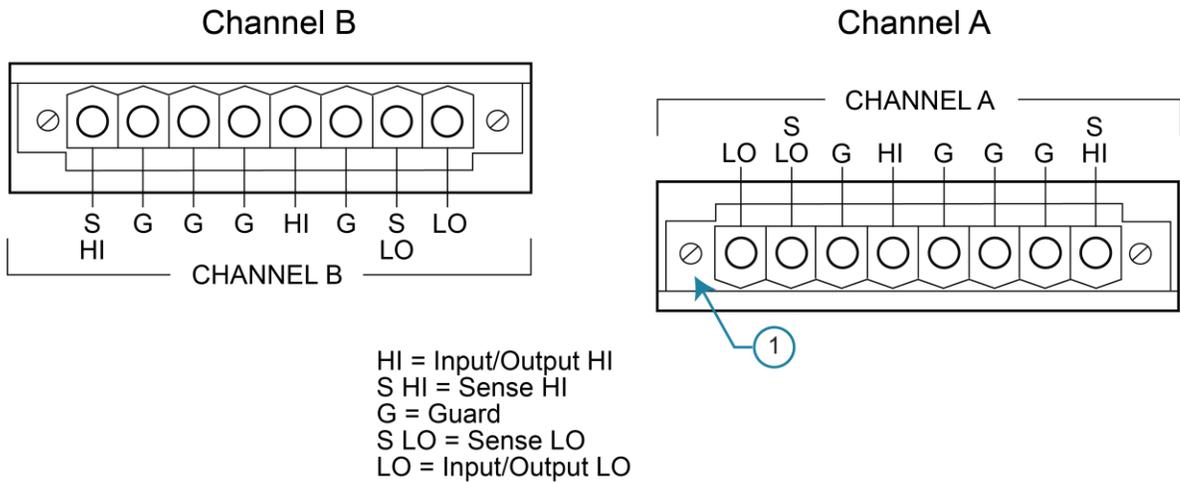
### Input/output LO and chassis ground

As shown in the following figures, SMU input/output LOs are available at the rear panel terminal blocks. Input/output LOs are not connected between channels and are electrically isolated from chassis ground.

### NOTE

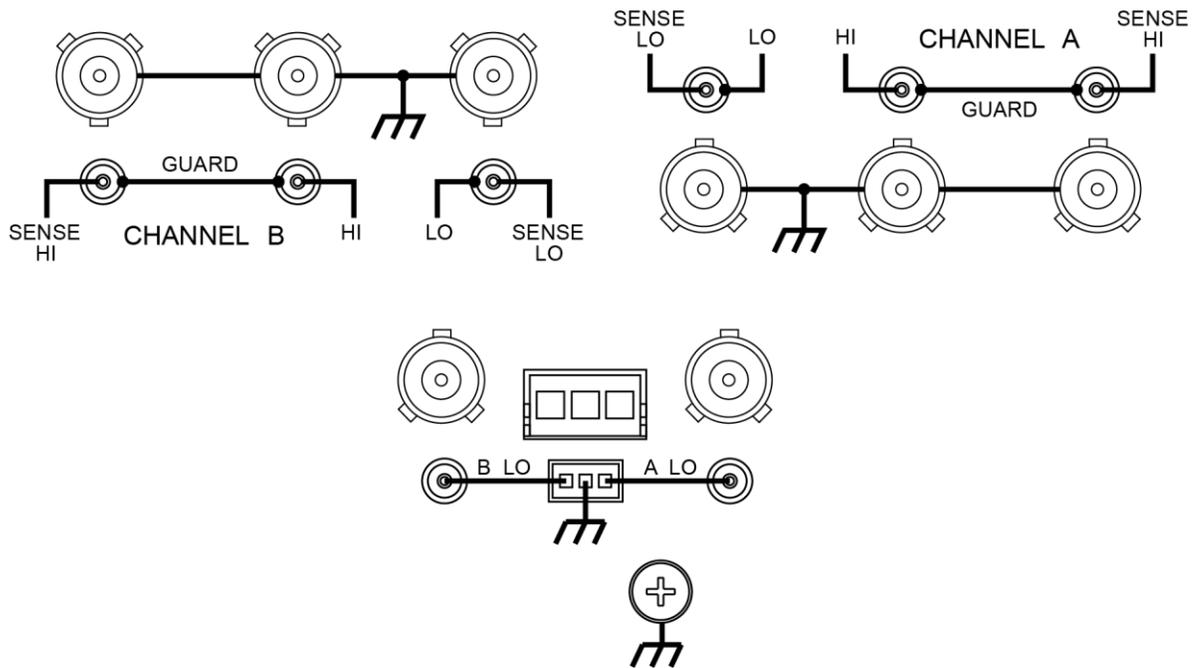
The chassis should never be used as a ground point for signal connections. High frequencies (more than 1 MHz) present on the chassis of the 2600B may result in higher noise. The chassis should only be used as a safety shield. Use the chassis screw for connections to the chassis of the 2600B. For 2634B, 2635B, and 2636B, connect to ground on the ground module, not to the chassis screw.

**Figure 24: Models 2602B, 2604B, 2612B, and 2614B input/output LO and chassis ground terminals (2601B and 2611B similar)**



1 Captive screw. Each terminal block uses two captive screws to secure it to the rear panel.

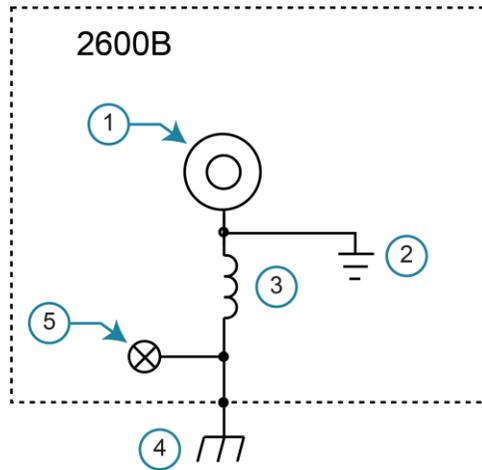
**Figure 25: Models 2634B and 2636B input/output and chassis ground terminals (Model 2635B similar)**



For the 2601B, 2602B, 2604B, 2611B, 2612B, and 2614B, there is a low-noise chassis ground banana jack that can be used as a common signal ground point for input and output LOs. This low-noise signal ground banana jack is connected to the chassis through a frequency variable resistor (FVR).

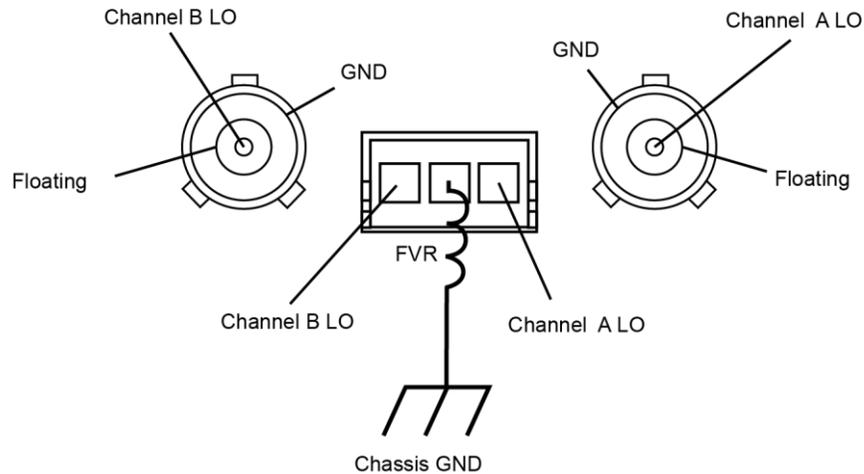
The FVR, shown in the following figure, isolates the SMUs from high frequencies that may be present on the chassis of the 2600B. As frequencies on the chassis increase, the resistance of the FVR increases to dampen its effects. For dc to 60 Hz, the FVR is a virtual short (0 ohms).

**Figure 26: Models 2601B, 2602B, 2604B, 2611B, 2612B, and 2614B low-noise chassis ground banana jack and chassis screw**



|  |
|--|
| 1 Low-noise chassis ground banana jack                                     |
| 2 A local signal ground, which is the low-noise chassis ground banana jack |
| 3 Frequency variable resistor (FVR)  |
| 4 Metal chassis of the 2600B   |
| 5 Chassis screw terminal; connected to the metal chassis of the 2600B      |

**Figure 27: Model 2634B and 2636B (Model 2635B similar)**



## **⚠ WARNING**

When connecting to 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B SMU outputs using cables that are not rated for voltages above 42 V, such as the 2600-ALG-2, you must disable the high voltage output by using the INTERLOCK function as defined in [Interlock](#) (on page 4-23). Leaving the high voltage enabled while not properly insulating the external connections to the instrument poses a shock hazard which could cause serious injury to the user. It is also recommended that the LO connection terminal not be allowed to float by connecting it to signal ground or another known signal reference.

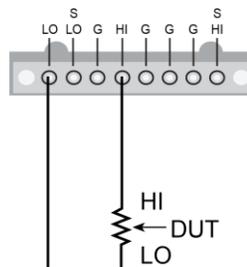
## 2-wire local sensing connections

You can use 2-wire local sensing measurements, shown in the following figure, for the following source-measure conditions:

- Sourcing and measuring current.
- Sourcing and measuring voltage in high impedance (more than 1 kΩ) test circuits.

When using 2-wire local sensing connections, make sure to properly configure the 2600B [Sense mode selection](#) (on page 4-30).

**Figure 28: Two-wire resistance connections**



## 4-wire remote sensing connections

When sourcing and measuring voltage in a low-impedance test circuit, there can be errors associated with lead resistance. Voltage source and measure accuracy are optimized by using 4-wire remote sense connections. When sourcing voltage, 4-wire remote sensing ensures that the programmed voltage is delivered to the DUT. When measuring voltage, only the voltage drop across the DUT is measured.

By default, the 2600B instruments are configured to use 2-wire (local) voltage sensing. If you choose to enable 4-wire (remote) voltage sensing, it is critical that you establish and maintain the proper Kelvin connections between the corresponding force and sense leads to ensure the proper operation of the instrument and to make accurate voltage measurements. Sense HI must be connected to Force HI, and Sense LO must be connected to Force LO.

When sourcing voltage with remote sense, the instrument relies on the voltage detected with the sense lines to provide the proper closed-loop control of its output voltage and to properly limit the voltage across the device-under-test. If a sense line becomes disconnected from its corresponding force line, an erroneous voltage is sensed. The output voltage may be adjusted to a level that is radically different than the programmed voltage level (possibly to hazardous levels, depending on the model). In addition, the voltage across the device may exceed the programmed source limit voltage, possibly causing damage to the device or test fixture.

In both cases, the voltage is not measured correctly if a sense lead becomes disconnected from its corresponding force lead.

## **⚠ WARNING**

**Even with the overvoltage protection set to the lowest value (2 V), never touch anything connected to the terminals of the 2600B when the instrument is on. Always assume that a hazardous voltage (greater than 30 V<sub>RMS</sub>) is present when the instrument is on. To prevent damage to the device under test or external circuitry, do not set the voltage source to levels that exceed the value that is set for overvoltage protection.**

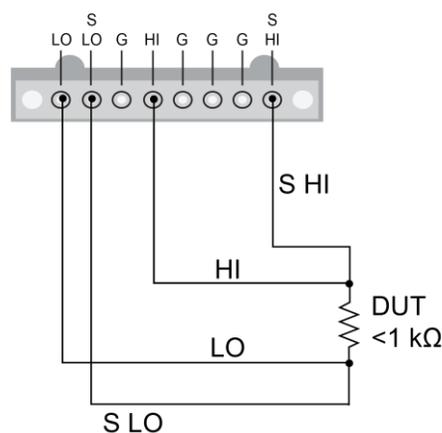
For the 2601B, 2602B, 2611B, 2612B, 2635B, and 2636B, you can use contact check to verify that the sense leads are connected before enabling remote sensing or before turning on the output. Refer to [Contact check measurements](#) (on page 4-14).

Use 4-wire remote sensing for the following source-measure conditions:

- Sourcing or measuring voltage in low impedance (<1 kΩ) test circuits.
- Enforcing voltage compliance limit directly at the DUT.

When using 4-wire local sensing connections, make sure to properly configure the [Sense mode selection](#) (on page 4-30).

**Figure 29: Four-wire connections (remote sensing)**



## Contact check connections

The contact check function prevents measurement errors due to excessive resistance in the source or sense leads. See [Contact check measurements](#) (on page 4-14) for operation.

Contact check requires both source and sense connections. Refer to [4-wire remote sensing connections](#) (on page 4-12) for the connection scheme.

## Contact check measurements

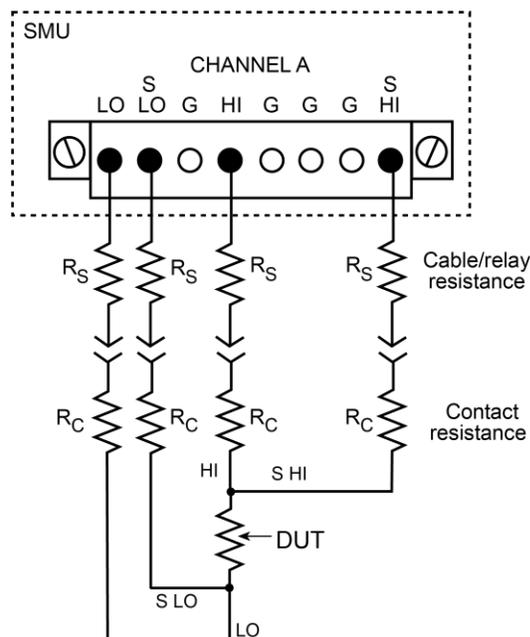
### NOTE

The Models 2604B, 2614B, and 2634B do not perform contact check measurements.

The contact check function prevents measurements that may be in error due to excessive resistance in the force or sense leads when making remotely sensed (Kelvin) measurements. Potential sources for this resistance include poor contact at the device under test (DUT), failing relay contacts on a switching card, and wires that are too long or thin. To use contact check, the current limit must be at least 1 mA (this allows enough current to flow when performing the test), and the source-measure unit (SMU) must not be in High-Z output-off mode.

The contact check function also detects an open circuit that may occur when a four-point probe is misplaced or misaligned. This relationship is shown schematically in the figure below, where  $R_C$  is the resistance of the mechanical contact at the DUT, and  $R_S$  is the series resistance of relays and cables.

**Figure 30: Contact check measurements**



When the source is off, `smuX.source.offmode` is set to `smuX.OUTPUT_ZERO`, and the effective current limit is less than 1 mA, contact check operations result in error code 5066, `source.offlimiti too low for contact check`. In the zero off mode,

`smuX.source.offlimiti` is ignored and the effective current limit depends on what the channel is sourcing when it is turned off. If the channel is sourcing:

- Voltage: The current limit is determined by `smuX.source.limiti`.
- Current: The current limit is determined by the greater of `smuX.source.leveli` or 10 percent of `smuX.source.rangei`.

## Contact check commands

The following table summarizes the contact check commands. For a more complete description of these commands, refer to the “TSP command reference” section of the *Series 2600B Reference Manual*.

### Basic contact check commands

| Command  | Description  |
|--|--|
| <code>flag = smuX.contact.check()</code>       | Determine if contact resistance is lower than threshold.   |
| <code>rhi, rlo = smuX.contact.r()</code>       | Measure the aggregate contact resistance.  |
| <code>smuX.contact.speed = speedSetting</code> | Set <i>speedSetting</i> to one of the following: <ul style="list-style-type: none"> <li>■ 0 or <code>smuX.CONTACT_FAST</code></li> <li>■ 1 or <code>smuX.CONTACT_MEDIUM</code></li> <li>■ 2 or <code>smuX.CONTACT_SLOW</code></li> </ul> |
| <code>smuX.contact.threshold = rvalue</code>   | Set resistance threshold for the contact check function.   |

## Contact check programming example

The following programming example illustrates the setup and command sequence for a typical contact check measurement. These commands set the contact check speed to fast and the threshold to 100 Ω. Then, a contact check measurement against the threshold is made. If it fails, a more accurate contact check measurement is made, and the test is aborted. Otherwise, the output is turned on, and the test continues.

```
-- Restore defaults.
smua.reset()
-- Set contact check speed to fast.
smua.contact.speed = smua.CONTACT_FAST
-- Set the contact check threshold to 100 ohms.
smua.contact.threshold = 100
-- Check contacts against threshold.
if not smua.contact.check() then
  -- Set speed to slow.
  smua.contact.speed = smua.CONTACT_SLOW
  -- Get aggregate resistance readings.
  rhi, rlo = smua.contact.r()
  -- Return contact resistances to the host.
  print(rhi, rlo)
  -- Terminate execution.
  exit()
end
-- Turn output on and continue.
smua.source.output = smua.OUTPUT_ON
```

## Guarding and shielding

You can optimize source-measure performance and safety with the effective use of guarding and shielding (noise and safety shields).

### Safety shield

---

#### **WARNING**

**A safety shield must be used whenever hazardous voltages ( $>30 V_{RMS}$ ,  $42 V_{PEAK}$ ) will be present in the test circuit. To prevent electrical shock that could cause injury or death, never use the 2600B in a test circuit that may contain hazardous voltages without a properly installed and configured safety shield.**

---

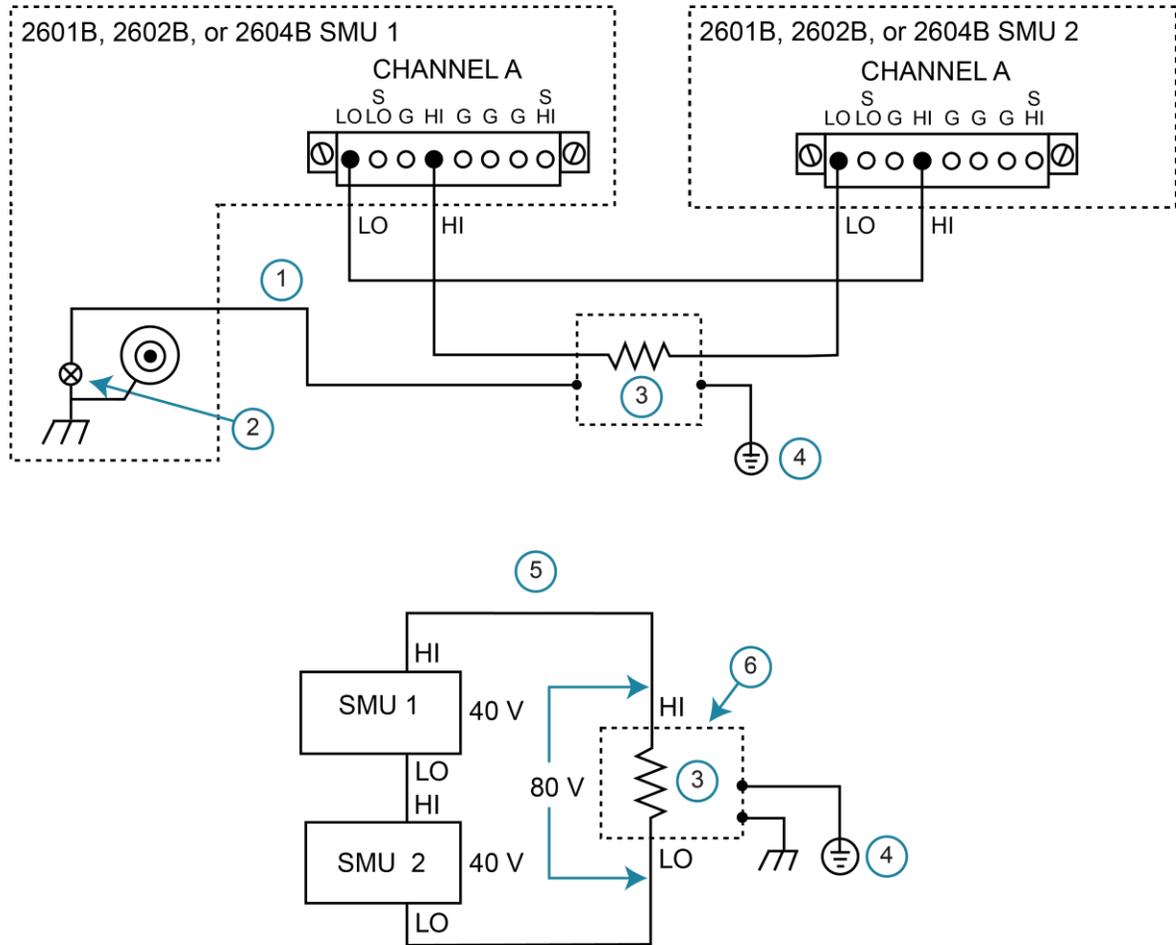
The safety shield can be metallic or nonconductive and must completely surround the device under test (DUT) test circuit. A metal safety shield must be connected to a known protective earth (safety ground). See [Test fixtures](#) (on page 4-24) for important safety information on the use of a metal or a nonconductive enclosure.

### Safety shielding and hazardous voltages

For the 2601B, 2602B, and 2604B, the maximum output voltage for a channel is 40 V, which is considered a nonhazardous level. However, using two 2601B, 2602B, or 2604B voltage sources in a series configuration or [floating a SMU](#) (on page 4-26) can cause test circuit voltage to exceed 42 V. For example, the source-measure units (SMUs) of two 2601B, 2602B, or 2604B instruments can be connected in series to apply 80 V to a device under test (DUT) (see the following figure). See “TSP advanced features” in the *Series 2600B Reference Manual* for information on using multiple System SourceMeter® instruments.

Use #18 AWG wire or larger for connections to safety earth ground and chassis.

**Figure 31: Safety shield for hazardous voltage combining two 2601B, 2602B, or 2604B channels**

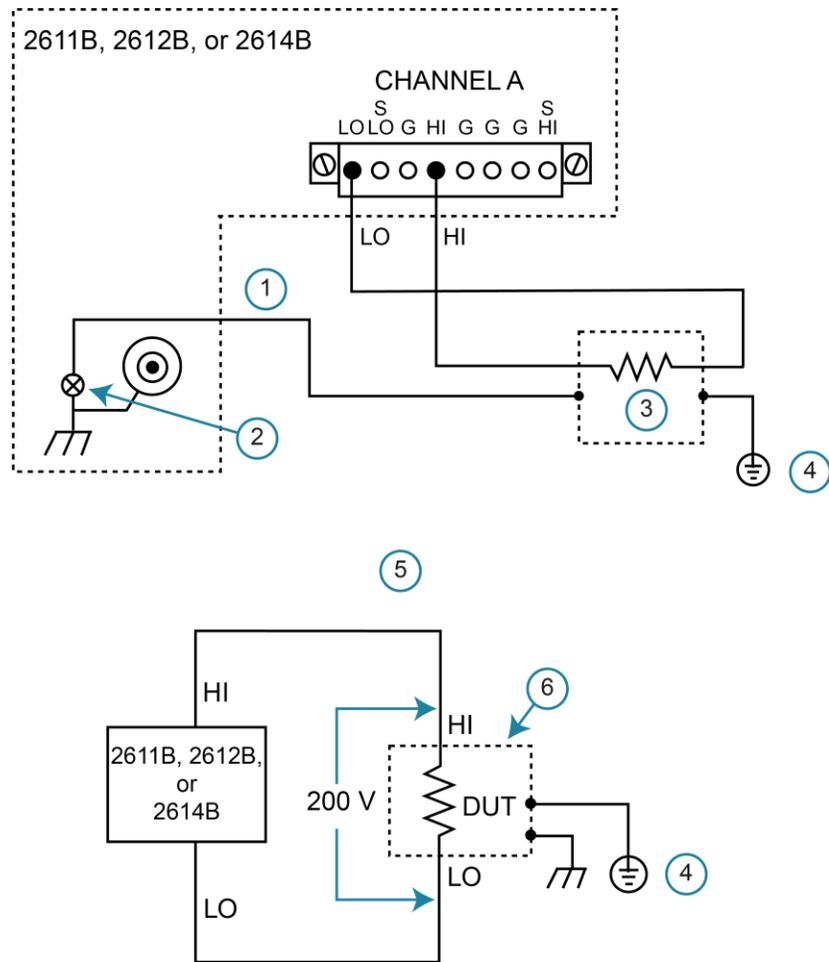


|                                    |
|------------------------------------|
| 1 Chassis                          |
| 2 Chassis screw                    |
| 3 Device under test (DUT)          |
| 4 Protective earth (safety ground) |
| 5 Equivalent schematic             |
| 6 Metal safety shield              |

For the 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B, the maximum output voltage for a channel is 220 V, which is considered hazardous and requires a safety shield. The following figures illustrate test connections for these models.

Use #18 AWG wire or larger for connections to safety earth ground and chassis.

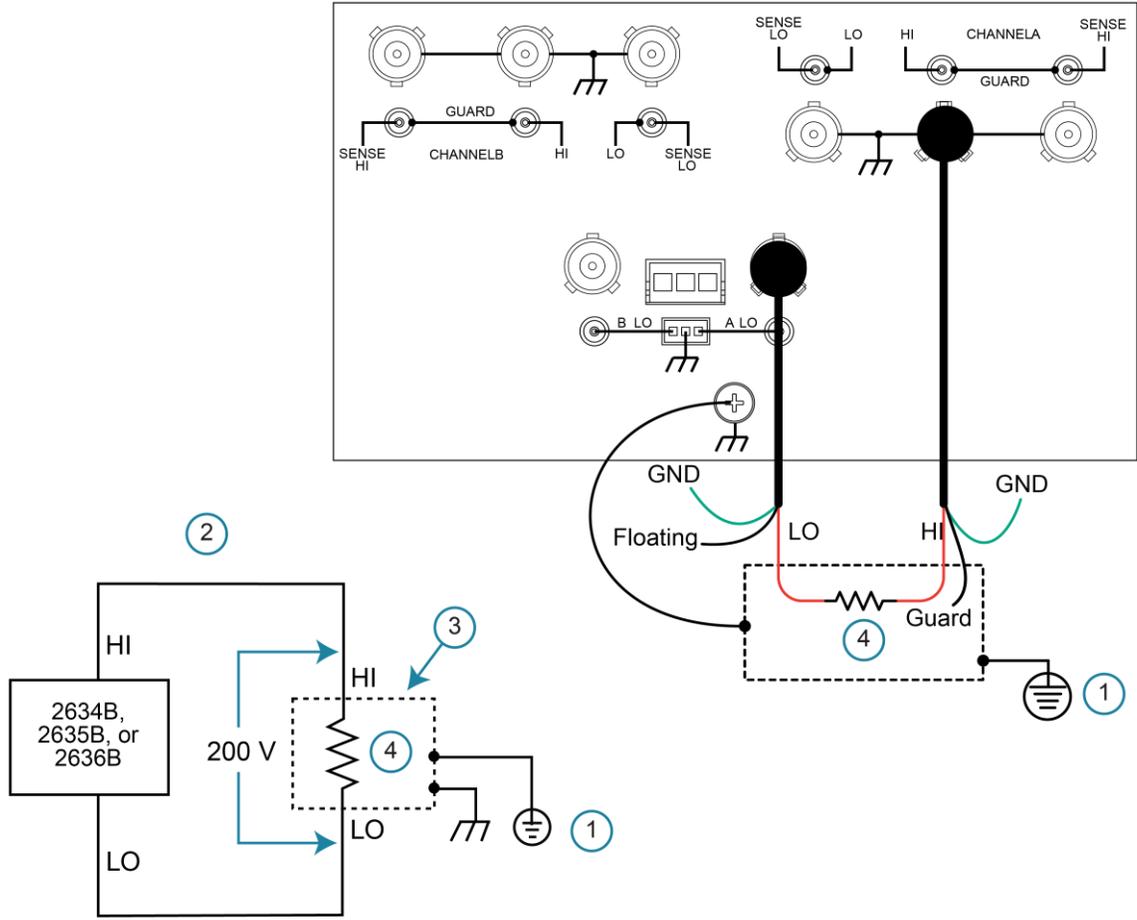
**Figure 32: Model 2611B, 2612B, or 2614B safety shield for hazardous voltage test circuit connections**



|                                    |
|------------------------------------|
| 1 Chassis                          |
| 2 Chassis screw                    |
| 3 Device under test (DUT)          |
| 4 Protective earth (safety ground) |
| 5 Equivalent schematic             |
| 6 Metal safety shield              |

**Figure 33: Model 2634B, 2635B, or 2636B safety shield for hazardous voltage test circuit connections**

2634B and 2636B (2635B similar)



|                                    |
|------------------------------------|
| 1 Protective earth (safety ground) |
| 2 Equivalent schematic             |
| 3 Metal safety shield              |
| 4 Device under test (DUT)          |

## Guarding

A driven guard is always enabled and provides a buffered voltage that is at the same level as the input/output HI voltage. The purpose of guarding is to eliminate the effects of leakage current (and capacitance) that can exist between HI and LO. Without guarding, leakage and capacitance in the external high-impedance test circuit could be high enough to adversely affect the performance of the 600B.

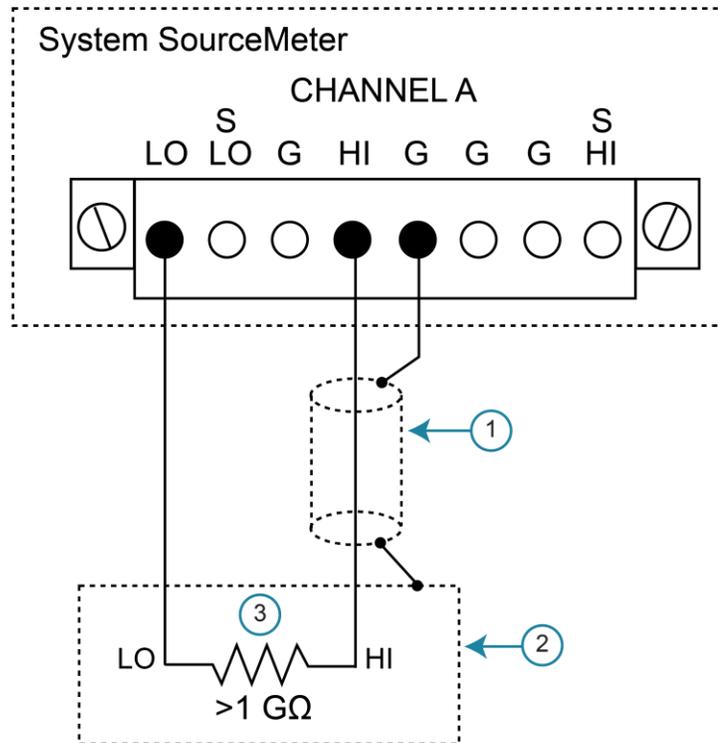
Guarding is recommended when test circuit impedance is  $>1\text{ G}\Omega$ .

### NOTE

See “Guard” in the *Series 2600B Reference Manual* for details on the principles of guarding.

The guard shield can be the shield of a coaxial cable or an insulated foil that surrounds the conductor.

**Figure 34: Connections for guarding**



|                           |
|---------------------------|
| 1 Guard shield            |
| 2 Metal guard shield      |
| 3 Device under test (DUT) |

## Noise shield

Use a noise shield (see following figure) to prevent unwanted signals from being introduced into the test circuit. Low-level signals may benefit from effective shielding. The metal noise shield surrounds the test circuit and should be connected to LO, as shown.

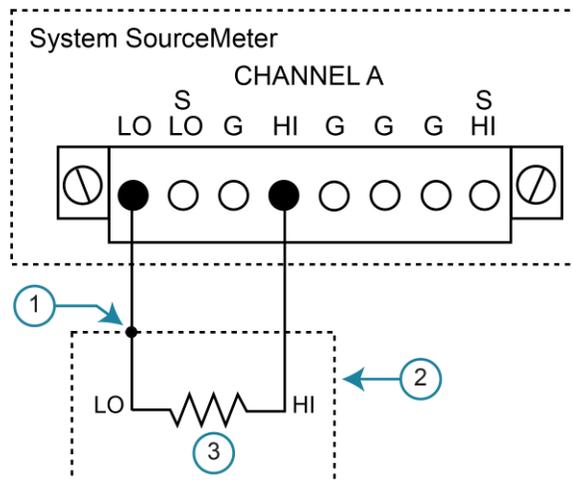
### **⚠ WARNING**

Connect the enclosure of all metal test fixtures to protective earth (safety ground). See your specific test fixture for information. Nonconductive test fixtures must be rated to double the maximum capability of the test equipment in the system.

### **⚠ WARNING**

Connections to LO on the 2600B are not necessarily at 0 V. Hazardous voltages could exist between LO and chassis ground. Make sure that high-voltage precautions are taken throughout the test system. Alternatively, limit hazardous levels by adding external protection to limit the voltage between LO and chassis. Failure to make sure high-voltage precautions are used throughout the test system or a failure to limit hazardous levels could result in severe personal injury or death from electric shock.

Figure 35: Models 2602B, 2604B, 2612B, and 2614B noise shield



1 Noise shield connected to LO

2 Noise shield

3 Device under test (DUT)

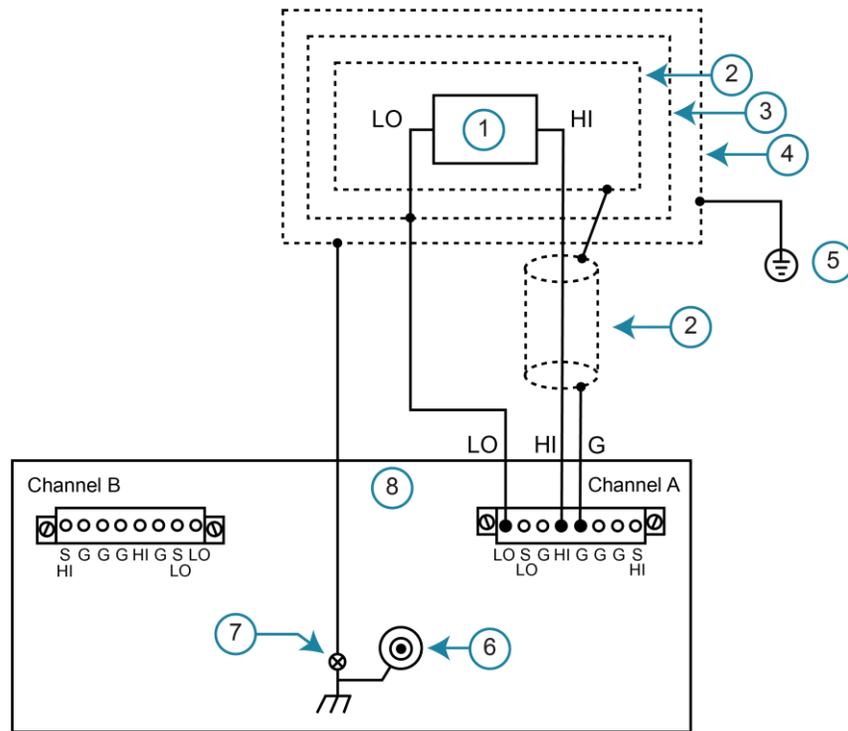
## Using shielding and guarding together

The following figures show connections for a test system that uses a noise shield, a safety shield, and guarding. The guard shields are connected to the driven guard (labeled G or GUARD, depending on your model) of the SMU. The noise shield is connected to LO. The safety shield is connected to the chassis and to protective earth (safety ground).

### **⚠ WARNING**

Connect the enclosure of all metal test fixtures to protective earth (safety ground). See your specific test fixture for information. Nonconductive test fixtures must be rated to double the maximum capability of the test equipment in the system.

Figure 36: Connections for noise shield, safety shield, and guarding



|   |                                      |
|---|--------------------------------------|
| 1 | Test circuit                         |
| 2 | Metal guard shield                   |
| 3 | Metal noise shield                   |
| 4 | Metal safety shield                  |
| 5 | Protective earth (safety ground)     |
| 6 | Low-noise chassis ground banana jack |
| 7 | Chassis screw                        |
| 8 | Chassis                              |

## Interlock

The interlock is available on the 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B only.

The digital I/O port provides the interlock line for use with a test fixture switch. When properly used, the output of the instrument turns off when the lid of the test fixture is opened. See "[DUT test connections](#) (on page 4-6)" in the *Series 2600B User's Manual* for important safety information when using a test fixture. Follow standard safety and electrical practices by verifying the correct operation of all components related to system safety, including the interlock.

---

### **WARNING**

**The interlock circuit 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.**

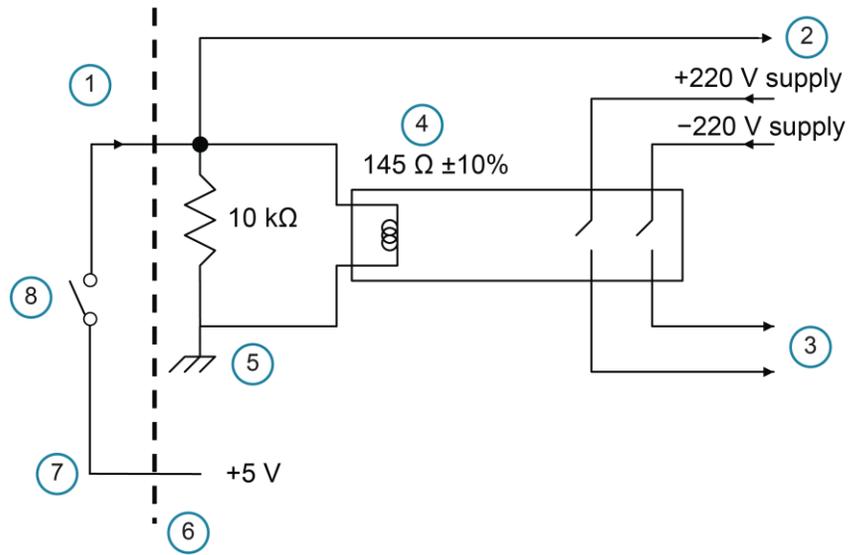
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## Interlock operation

When on the 200 V source range, the output of the 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B can only be turned on when the interlock line is driven high through a switch to +5 V (as shown). If the lid of the test fixture opens, the switch opens, and the interlock line goes low, turning the output of the instrument off. The output is not automatically turned on when the interlock line is set high. The output cannot be turned back on until the interlock line is set high.

A signal of > 3.4 V at 24 mA (at an absolute maximum of 6 V) must be externally applied to pin 23 to ensure 200 V operation. This signal is pulled down to chassis ground with a 10 k $\Omega$  resistor. 200 V operation is blocked when the INTERLOCK signal is < 0.4 V (an absolute minimum of -0.4 V).

**Figure 37: Using 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B interlock**



|  |
|--|
| 1 INTERLOCK pin (on DIGITAL I/O or INTERLOCK connector) pin 24 |
| 2 Read by firmware   |
| 3 To output stage  |
| 4 Coil resistance  |
| 5 Chassis ground   |
| 6 Rear panel   |
| 7 Pin 23   |
| 8 Closing switch enables 200 V operation                       |

## Test fixture

You can use a test fixture to house a device or test circuit. The test fixture can be a metal or nonconductive enclosure and is typically equipped with a lid and an interlock switch. When properly used, the output of the 2600B turns off when the lid of the test fixture is opened. The test circuit is mounted inside the test fixture. When hazardous voltages ( $>30 V_{RMS}$ ,  $42 V_{PEAK}$ ) will be present, the test fixture must meet the following safety requirements.

---

**⚠ WARNING**

To provide protection from shock hazards, an enclosure should be provided that surrounds all live parts.

Nonconductive enclosures must be constructed of materials that are suitably rated for flammability and the voltage and temperature requirements of the test circuit. Connect the enclosure of all metal test fixtures to protective earth (safety ground). See your specific test fixture for information. Nonconductive test fixtures must be rated to double the maximum capability of the test equipment in the system.

For metallic enclosures, the test fixture chassis must be properly connected to protective earth (safety ground). A grounding wire (16 AWG or larger) must be attached securely to the test fixture at a screw terminal designed for safety grounding. The other end of the ground wire must be attached to a known protective earth (safety ground).

---

**Construction material:** A metal test fixture must be connected to a known protective earth (safety ground) as described in the above warning. A nonconductive test fixture must be constructed of materials that are suitable for flammability, voltage, and temperature conditions that may exist in the test circuit. The construction requirements for a nonconductive enclosure are also described in the warning above.

**Test circuit isolation:** With the lid closed, the test fixture must completely surround the test circuit. A metal test fixture must be electrically isolated from the test circuit. Input and output connectors mounted on a metal test fixture must be isolated from the test fixture. Internally, Teflon™ standoffs are typically used to insulate the internal printed circuit board or guard plate for the test circuit from a metal test fixture.

**Interlock switch:** The test fixture must have a normally-open interlock switch. The interlock switch must be installed so that when the lid of the test fixture is opened, the switch opens, and when the lid is closed, the switch closes.

The 2600B digital I/O port provides an output enable line or an interlock line (dependent on the model number). When properly used with a test fixture, the output of the 2600B turns off when the lid of the test fixture is opened. The 2601B, 2602B, and 2604B have output enable (OE) line. The 2611B, 2612B, 2614B, 2634B, 2635B, and 2636B have an interlock.

---

**⚠ WARNING**

The digital I/O port of the 2601B, 2602B, or 2604B is not suitable for control of safety circuits and should not be used to control a safety interlock. The interlock pin on the digital I/O port for the 2611B, 2612B, 2614B, 2634B, 2635B, or 2636B can be used to control a safety interlock.

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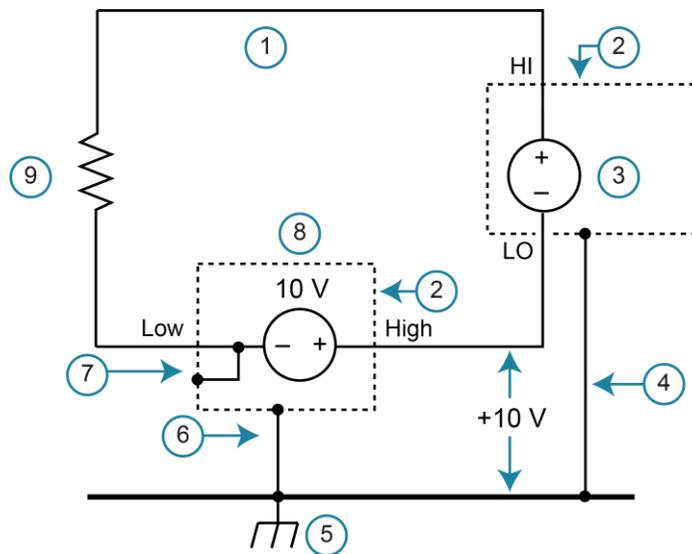
For information on the digital I/O port, see Model Series 2600B Reference Manual, "Digital I/O."

## Floating a SMU

Using an external source in the test system may require that a 2600B source-measure unit (SMU) float off chassis earth ground. An example of such a test system is shown below, which includes an external voltage source. Notice that output low of the external voltage source is connected to chassis earth ground.

For the test circuit shown below, the 2600B must float off chassis earth ground. As shown, LO of the 2600B is floating +10 V above chassis earth ground. If LO of the 2600B was instead connected to chassis ground, the external voltage source would be shorted to the chassis ground.

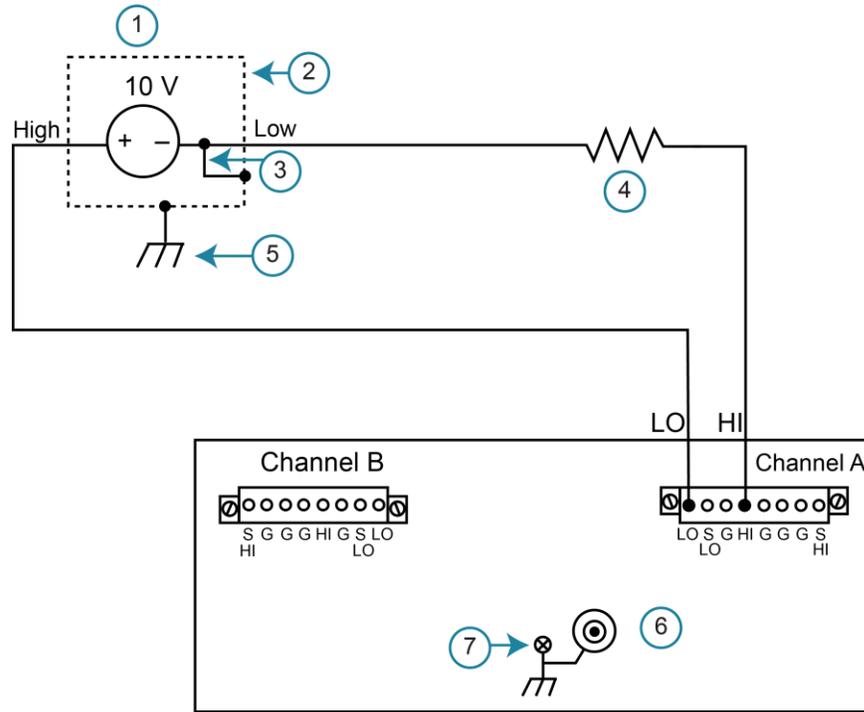
**Figure 38: Schematic of floating the Series 2600B**



|   |
|---|
| 1 2600B LO not connected to chassis ground (floating)                     |
| 2 Chassis   |
| 3 SMU voltage source  |
| 4 2600B chassis connected to chassis earth ground through the power cord  |
| 5 Chassis earth ground  |
| 6 Source chassis connected to chassis earth ground through the power cord |
| 7 Output low connected to chassis   |
| 8 External source   |
| 9 DUT   |

The 2600B connections for the floating configuration are shown in the following figure. This figure shows the 2602B, 2604B, 2612B, or 2614B shown. The 2601B and 2611B are similar.

Figure 39: 2601B, 2602B, 2604B, 2611B, 2612B, or 2614B SMU connections



|   |
|---|
| 1 External source   |
| 2 Chassis   |
| 3 Output low connected to chassis   |
| 4 DUT   |
| 5 Source chassis connected to chassis earth ground through the power cord |
| 6 Low-noise chassis ground banana jack                                    |
| 7 Chassis screw   |

**⚠ WARNING**

All measurement connections should be considered to be hazardous.

The maximum floating (common mode) voltage for a source-measure unit (SMU) is ±250 V. Exceeding this level may cause damage to the instrument and create a shock hazard.

Using an external source to float a SMU could create a shock hazard in the test circuit. A shock hazard exists whenever  $>42 V_{PEAK}$  is present in the test circuit. Appropriately rated cables or insulators must be provided for all connections to prevent access to live parts.

When  $>42 V$  is present, the test circuit must be insulated for the voltage used or surrounded by a metal safety shield that is connected to a known protective earth (safety ground) and chassis ground (see [Safety shield](#) (on page 4-16)).

## Front-panel source-measure procedure

Use the following procedure to perform the basic source-measure operations of the 2600B SMU using the front panel. The following procedure assumes that the 2600B is already connected to the device under test (DUT), as explained in [DUT test connections](#) (on page 4-6).

---

### **WARNING**

**Hazardous voltages may be present on all output and guard terminals. To prevent electrical shock that could cause injury or death, never make or break connections to the 2600B while the instrument is powered on. Turn off the equipment from the front panel or disconnect the main power cord from the rear of the 2600B before handling cables. Putting the equipment into standby does not guarantee that the outputs are powered off if a hardware or software fault occurs.**

---

### Step 1: Select and set the source level

*To select the source and edit the source value:*

1. Press the **SRC** key as needed to select the voltage source or current source, as indicated by the units in the source field on the display. The flashing digit (cursor) indicates which value is presently selected for editing.
2. Move the cursor to the digit to change, then press the navigation wheel to enter the EDIT mode.
3. Use the **RANGE** keys to select a range that accommodates the value you want to set. For best accuracy, use the lowest possible source range.
4. Enter the source value.
5. Press the **ENTER** key or the navigation wheel to complete editing.

### Step 2: Set the compliance limit

*To edit the compliance limit value:*

1. If the instrument has two channels (2602B, 2604B, 2612B, 2614B, 2634B, or 2636B) and is in dual-channel display mode, perform the following (steps a, b, and c). Otherwise, go to the next step.
  - a. Press the **CONFIG** key.
  - b. Press the **LIMIT** key and then select **CURRENT** or **VOLTAGE**.
  - c. Press the **ENTER** key or the navigation wheel.
2. If the instrument has only one channel (2601B, 2611B, or 2635B), or if it is a two-channel instrument that is in single-channel display mode, press the **LIMIT** key.
3. Move the cursor to the digit to change, then press the navigation wheel to enter the EDIT mode, as indicated by the EDIT indicator.
4. Enter the limit value, then press the **ENTER** key or the navigation wheel to complete editing.

## Step 3: Select the measurement function and range

### *To select measurement function and range:*

1. If the instrument has two channels (2602B, 2604B, 2612B, 2614B, 2634B, or 2636B), press the **DISPLAY** key to place it in single-channel-display mode (if not already). Otherwise, go to the next step.
2. Select the measurement function by pressing the **MEAS** key.
3. Set the measurement range with the **RANGE** keys, or enable **AUTO** range. When setting the range, consider the following points:
  - When measuring the source (such as when sourcing V and measuring V), you cannot select the measurement range using the RANGE keys. The selected source range determines the measurement range.
  - When not measuring the source (such as when sourcing V but measuring I), you can select the measurement range selection manually or the instrument can set it automatically. When using manual ranging, use the lowest possible range for best accuracy. When autorange is enabled, the 2600B automatically goes to the most sensitive range to make the measurement.

## Step 4: Turn the output on

Turn on the output by pressing the **OUTPUT ON/OFF** switch. The OUTPUT indicator light turns on.

## Step 5: Observe readings on the display.

Press the **TRIG** key if necessary to trigger the instrument to begin making readings. The readings are on the top line, and source and limit values are on the bottom line.

## Step 6: Turn the output off

When finished, turn the output off by pressing the **OUTPUT ON/OFF** switch. The OUTPUT indicator light turns off.

## Sense mode selection

You can set the sense mode to use [2-wire local sensing connections](#) (on page 4-12) or [4-wire remote sensing connections](#) (on page 4-12). The default sense setting is 2-wire local.

### Front-panel sense mode selection

**To check or change the voltage sense mode from the front panel:**

1. Press the **CONFIG** key.
2. Press the **SRC** or **MEAS** key. You can access and set the 2600B sense mode from either the V-SOURCE or the V-MEAS menu items.
3. If you pressed the SRC key: Select **V-SOURCE > SENSE-MODE**, and then press the **ENTER** key or the navigation wheel.  
If you pressed the MEAS key: Select **V-MEAS > SENSE-MODE**, and then press the **ENTER** key or the navigation wheel.
4. Select **2-WIRE** or **4-WIRE** as needed, and then press the **ENTER** key or the navigation wheel.

### Remote interface sense mode selection

To configure the 2600B SMU for 4-wire remote sensing, send the command:

```
smua.sense = smua.SENSE_REMOTE
```

The following table summarizes the commands to select the sense mode. See the “TSP command reference” section of the *Series 2600B Reference Manual* for details on using these commands.

#### Commands to select sense mode

| Command*  | Description                                    |
|---|--|
| <code>smuX.source.output = smuX.OUTPUT_OFF</code> | Turn off the source-measure unit (SMU) output. |
| <code>smuX.sense = smuX.SENSE_LOCAL</code>        | Select local (2-wire) sense.                   |
| <code>smuX.sense = smuX.SENSE_REMOTE</code>       | Select remote (4-wire) sense.                  |

\* `smuX` can be `smua` for channel A or `smub` for channel B

## Output-off modes

### CAUTION

Carefully consider and configure the appropriate output-off state, source function, and compliance limits before connecting the 2600B to a device that can deliver energy (for example, other voltage sources, batteries, capacitors, solar cells, or other 2600B instruments). Configure recommended instrument settings before making connections to the device. Failure to consider the output-off state, source, and compliance limits may result in damage to the instrument or to the device under test (DUT).

Turning off the 2600B output may not completely isolate the instrument from the external circuit. You can use the output-off mode to place the 2600B in a noninteractive state during idle periods. The available output-off modes are normal, high-impedance, and zero.

### Normal output-off mode

The normal output-off mode is the default output-off mode setting. When the source-measure unit (SMU) is in the normal output-off mode, you can select either the current or the voltage output-off function (see [Output-off function](#) (on page 4-32)). You can also specify current and voltage output-off limits ([Output-off limits \(compliance\)](#) (on page 4-33)).

When the output is turned off, the output goes to either 0 V or 0 A, depending on the selected output-off function. Voltage is the default output-off function.

### High-impedance output-off mode

For the high-impedance output-off mode (HI-Z), the output relay opens when the output is turned off. This disconnects external circuitry from the input/output of the source-measure unit (SMU). To prevent excessive wear on the output relay, do not use this output-off mode for tests that turn the output off and on frequently.

### Zero output-off mode

When the zero output-off mode is selected, the programmed source remains on the display, but internally, the voltage source is selected and is set to 0 V. Measurements are made and displayed.

When the selected source is voltage, the current compliance setting remains the same as the output-on value and compliance detection remains active.

When the selected source is current, the current compliance setting is the programmed current source value or 10 percent full-scale of the present current range, whichever is greater.

You can use the 2600B as a current meter when it is in zero output-off mode because it outputs 0 V but measures current.

**To configure the output-off mode from the front panel:**

1. Press the **CONFIG** key.
2. Press the **OUTPUT ON/OFF** control.
3. Select **OFF-STATE**.
4. Select **MODE**.
5. Select the output-off mode: **HI-Z** (high-impedance), **NORMAL**, or **ZERO**.
6. Press the **EXIT** key to return to the normal display.

**To select the normal output-off mode over a remote interface:\***

```
smua.source.offmode = smua.OUTPUT_NORMAL
```

**To select the high-impedance output-off mode over a remote interface:\***

```
smua.source.offmode = smua.OUTPUT_HIGH_Z
```

**To select the zero output-off mode over a remote interface:\***

```
smua.source.offmode = smua.OUTPUT_ZERO
```

\* smuX can be smua for channel A or smub for channel B

## Output-off function

This setting is used only when the output is turned off and the 2600B is set to the normal output-off mode (`smuX.source.offmode = smuX.OUTPUT_NORMAL`).

You can set the output-off function to **CURRENT** or **VOLTAGE** through the **CONFIG** menu on the front panel, or by using the `smuX.source.offfunc` attribute from a remote interface. **VOLTAGE** is the default output-off function.

When the output is turned off and the selected output-off function is **VOLTAGE** (`smuX.source.offfunc = smuX.OUTPUT_DCVOLTS`):

- The source-measure unit (SMU) sources 0 V.
- The current limit is set by the `smuX.source.offlimiti` attribute (default 1 mA).

When the output is turned off and the selected output-off function is **CURRENT** (`smuX.source.offfunc = smuX.OUTPUT_DCAMPS`):

- The SMU sources 0 A.
- The voltage limit is set by the `smuX.source.offlimitv` attribute (default 40 V).

When the output-off function is set to either voltage or current, the SMU may source or sink a very small amount of power. In most cases, this source or sink power level is insignificant.

## Selecting the output-off function

### NOTE

This setting is used only when the output is turned off and the source-measure unit (SMU) is in NORMAL output-off mode.

#### *To configure the output-off function from the front panel:*

1. Press the **CONFIG** key.
2. Press the **OUTPUT ON/OFF** control.
3. Select **OFF-STATE** and then select **FUNCTION**.
4. Select **CURRENT** or **VOLTAGE**.
5. Press the **EXIT** key to return to the normal display.

#### *To configure the output-off function remotely:*

To set 0 V output with current limit set by the `smuX.source.offlimiti` attribute:\*

```
smuX.source.offfunc = smuX.OUTPUT_DCVOLTS
```

To set 0 A output with voltage limit set by the `smuX.source.offlimitv` attribute:\*

```
smuX.source.offfunc = smuX.OUTPUT_DCAMPS
```

\* `smuX` can be `smua` for channel A or `smub` for channel B

## Output-off limits (compliance)

You can set output-off limits (compliance) for the current and voltage output-off functions using the CONFIG menu on the 2600B front panel, or by setting the `smuX.source.offlimitY` attribute from a remote interface. The output-off limits only apply when the output-off mode is normal.

### Setting output-off limits

Setting the output-off limit for CURRENT (`smuX.source.offlimiti`) specifies the current limit for the voltage source; setting the output-off limit for VOLTAGE (`smuX.source.offlimitv`) specifies the voltage limit for the current source.

#### *To configure the output-off limits from the front panel:*

1. Press the **CONFIG** key.
2. Press the **OUTPUT ON/OFF** control.
3. Select **OFF-STATE** and then select **LIMIT**.
4. Select **CURRENT** or **VOLTAGE**.
5. Set the limit value and then press the **ENTER** key or the navigation wheel.
6. Press the **EXIT** key to return to the normal display.

**To set the current limit in NORMAL output-off mode remotely:\***

```
smuX.source.offlimiti = iValue
```

**To set the voltage limit in NORMAL output-off mode remotely:\***

```
smuX.source.offlimitv = vValue
```

\* smuX can be smua for channel A or smub for channel B

## Remote programming output-off states quick reference

The content of the following table is a quick reference of commands for programming output-off states from a remote interface.

### Output-off state programming quick reference

| Command*                                  | Description  |
|---|--|
| smuX.source.offmode = smua.OUTPUT_NORMAL  | Selects normal output-off mode.  |
| smuX.source.offmode = smua.OUTPUT_HIGH_Z  | Selects high-impedance output-off mode.  |
| smuX.source.offmode = smua.OUTPUT_ZERO    | Selects zero output-off mode.  |
| smuX.source.offfunc = smua.OUTPUT_DCVOLTS | Sets 0 V output with current limit specified by the smua.source.offlimiti attribute. |
| smuX.source.offfunc = smua.OUTPUT_DCAMPS  | Sets 0 A output with voltage limit specified by the smua.source.offlimitv attribute. |
| smuX.source.offlimiti = iValue            | Sets current limit in normal output-off mode.  |
| smuX.source.offlimitv = vValue            | Sets voltage limit in normal output-off mode.  |

\* smuX can be smua for channel A or smub for channel B

**In this section:**

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## Introduction

This section describes routine maintenance of the instrument that an operator can perform.

## Line fuse replacement

A fuse on the 2600B rear panel protects the power line input of the instrument. See the following instructions to replace the fuse. You do not need to return your instrument for service if the fuse is damaged.

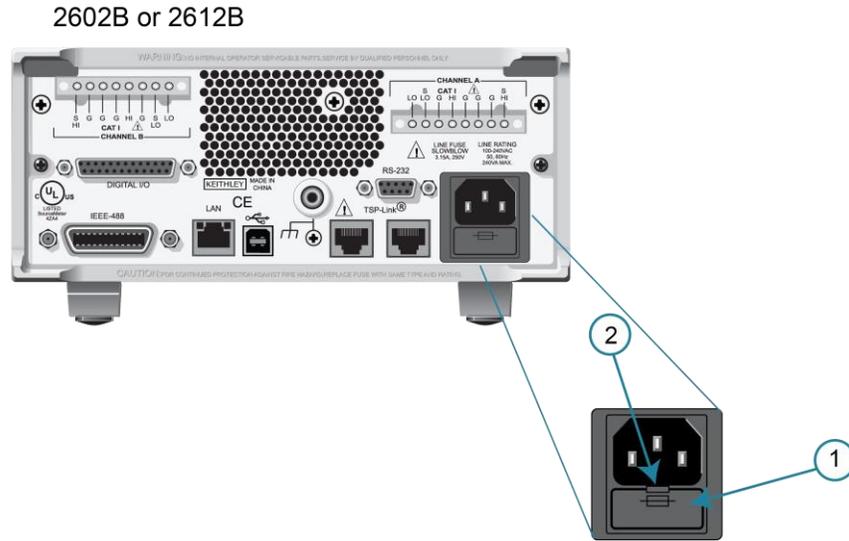
---

** WARNING**

**Disconnect the line cord at the rear panel and remove all test leads connected to the instrument before replacing a line fuse. Failure to do so could expose the operator to hazardous voltages that could result in personal injury or death.**

---

Figure 40: Fuse replacement



## NOTE

Line fuse is in a similar location on the other 2600B models.

## ⚠ WARNING

To prevent injury, death, or instrument damage, use only the correct fuse type (see the Line Fuse table below).

### To replace the line fuse:

1. Power off the instrument and remove the line cord.
2. The fuse drawer (item 1 in the previous figure) is below the ac receptacle. A small tab is on the top of the fuse drawer (item 2). Use a thin-bladed knife or a screwdriver to pry this tab away from the ac receptacle.
3. Slide the fuse drawer out to gain access to the fuse (the fuse drawer does not pull completely out of the power module).
4. Snap the fuse out of the drawer and replace it with the same type (the fuse is specified in the following table).
5. Push the fuse drawer back into the module.

If a fuse continues to become damaged, a circuit malfunction exists and must be corrected. Return the instrument to Keithley Instruments for repair.

### Line fuse

| Line voltage   | Rating                             | Keithley part number |
|----------------|------------------------------------|----------------------|
| 100 V to 240 V | 250 V, 3.15 A, Slow Blow 5 x 20 mm | FU-106-3.15          |

## Front-panel tests

The front-panel tests test the functionality of the front-panel keys and the display.

---

### NOTE

In the following procedures, highlight the menu item and press the **ENTER** key to select it. You can also select a menu item by pressing the navigation wheel.

---

## Keys test

This test checks the functionality of each front-panel key.

### *To run the KEYS test:*

1. If the instrument is in remote mode, press the **EXIT (LOCAL)** key once to place the instrument in local mode.
2. Press the **MENU** key.
3. Navigate through the menus by turning the navigation wheel. Press the **ENTER** key to select the menu items as follows: **DISPLAY > TEST > DISPLAY-TESTS**.
4. Turn the navigation wheel until the **KEYS** menu item is highlighted.
5. To start the test, press the **ENTER** key. When you press a key while the test is active, the label name for that key is displayed to indicate that it is functioning properly. When you release the key, the message `No keys pressed` is displayed.
6. To test the **EXIT (LOCAL)** key, press the **EXIT (LOCAL)** key once.
7. To exit the test, press the **EXIT (LOCAL)** key twice consecutively. You exit the test and the instrument returns to the **FRONT PANEL TESTS** menu.
8. Press the **EXIT (LOCAL)** key multiple times to exit out of the menu structure.

## Display patterns test

This test lets you verify that each pixel and indicator in the vacuum fluorescent display is working properly.

### *To run the display test:*

1. If the instrument is in remote mode, press the **EXIT (LOCAL)** key once to place the instrument in local mode.
2. Press the **MENU** key.
3. Navigate through the menus by turning the navigation wheel, and then pressing the **ENTER** key to select the items as follows: **DISPLAY > TEST > DISPLAY-TESTS**.
4. Turn the navigation wheel until the **DISPLAY-PATTERNS** menu item is highlighted.

5. To start the display test, press the **ENTER** key. There are three parts to the display test. Each time the **ENTER** key or the navigation wheel is pressed, the next part of the test sequence is selected. The test sequence is as follows:
  - Checkerboard pattern and the indicators that are on during normal operation
  - Checkerboard pattern (alternate pixels on) and all the numeric indicators (which are not used) are illuminated
  - Each digit and adjacent indicators are sequenced; all the pixels of the selected digit are on
6. When finished, abort the display test by pressing the **EXIT (LOCAL)** key. The instrument returns to the FRONT PANEL TESTS menu. Continue pressing the **EXIT (LOCAL)** key to exit out of the menu structure.

## Upgrading the firmware

You can load a newer or older version of firmware to the instrument. The process takes about five minutes.

To load the firmware, you can use a USB flash drive or select a file from a computer.

From the front panel, you must use the USB flash drive. Make sure the USB flash drive is empty except for the firmware file.

From the web interface, Test Script Builder, or remote interface, you can select the file from the computer.

Firmware files are available for download from the [Product Support and Downloads web page \(tek.com/product-support\)](http://tek.com/product-support) in the category "Software." After downloading the file, unzip the file. The file with the extension .x is the firmware file.

---

### CAUTION

**Disconnect the input and output terminals before you upgrade or downgrade.**

**Do not remove power from the instrument or remove the USB flash drive while an upgrade or downgrade is in progress. Wait until the instrument completes the procedure and shows the opening display. If you are upgrading an instrument with no front panel (NFP), the LAN and 1588 LEDs on the front panel blink in unison during the upgrade and stop when the upgrade is complete.**

**Do not initialize or reset TSP-Link before starting the upgrade.**

**If you are loading an older version, check the release notes and verify that the version of firmware you are loading is compatible with your hardware.**

**Before starting the upgrade, turn the instrument power off, wait a few seconds, then turn the instrument power on.**

---

***To upgrade or downgrade the firmware using the front panel:***

1. Turn the instrument power off. Wait a few seconds.
2. Turn the instrument power on.
3. Copy the firmware file to a USB flash drive.
4. Disconnect the input and output terminals to and from the instrument.
5. If the instrument is in remote mode, press the **EXIT (LOCAL)** key once to place the instrument in local mode.
6. Insert the flash drive into the USB port on the front panel of the 2600B.
7. From the front panel, press the **MENU** key
8. Turn the navigation wheel to go to the **UPGRADE** menu item, and then press the **ENTER** key.
9. Turn the navigation wheel to select the file on the USB flash drive that contains the appropriate version of firmware.
10. Press the **ENTER** key to select **Yes**. The status of the upgrade is displayed.

The instrument reboots automatically when the upgrade is complete.

***To upgrade or downgrade the firmware from the web interface:***

1. Turn the instrument power off. Wait a few seconds.
2. Turn the instrument power on.
3. Open a web browser on the host computer.
4. Enter the IP address of the instrument in the web browser address box. For example, if the instrument IP address is 192.168.1.101, enter 192.168.1.101 in the browser address box.
5. Press **Enter** on the computer keyboard to open the web interface of the instrument.
6. From the left navigation area, select **Flash Upgrade**.
7. Choose **Select File**. A file selection dialog box is displayed.
8. Select the firmware file.
9. Select **Start**. A progress dialog box is displayed. When the upgrade begins, you can also see progress on the front-panel display.

After the instrument automatically restarts, it is ready for use.

## Using TSB to upgrade the firmware

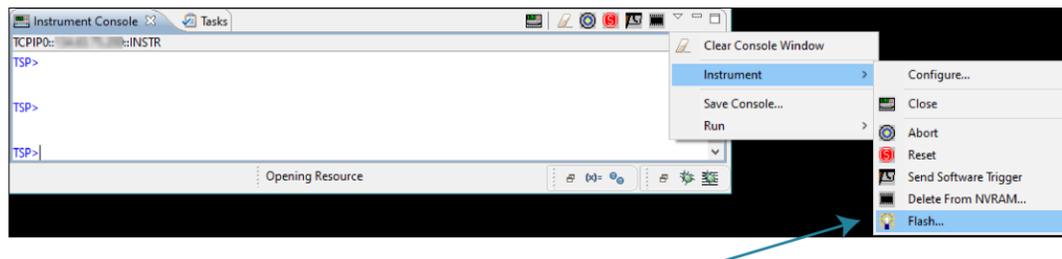
After downloading the flash file from [tek.com/keithley](http://tek.com/keithley), you can use Test Script Builder (TSB) to upgrade the firmware of your 2600B.

**To upgrade the firmware using Test Script Builder:**

1. Start Test Script Builder.
2. On the Instrument Console toolbar, click the **Open Instrument** icon.

**Figure 41: Open Instrument icon**

3. Select your instrument from the **Select Instrument** dialog box.
4. On the Instrument Console toolbar, select the down arrow and select **Instrument > Flash**.

**Figure 42: Flash menu option**

5. For **Select or enter a firmware image file**, use the browser to select the new firmware.
6. For **Select a replacement mode**, select **Upgrade** to install a newer version of firmware or **Downgrade** to install an older of firmware.
7. Wait until the upgrade or downgrade is complete and the instrument shows the opening display.

## Displaying the serial number

The instrument serial number is on a label on the rear panel of the instrument. You can also access the serial number from the front panel using the front-panel keys and menus.

**To display the serial number on the front panel:**

1. If the 2600B is in remote operation, press the **EXIT (LOCAL)** key once to place the instrument in local operation.
2. Press the **MENU** key.
3. Use the navigation wheel to scroll to the **SYSTEM-INFO** menu item.
4. Press the **ENTER** key. The SYSTEM INFORMATION menu is displayed.
5. Scroll to the **SERIAL#** menu item.
6. Press the **ENTER** key. The 2600B serial number is displayed.

#### In this section:

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### Additional 2600B information

For additional information about the 2600B, refer to the Keithley Instruments website ([tek.com/keithley](http://tek.com/keithley)), which contains the most up-to-date information. From the website, you can access:

- The *Series 2600B Reference Manual*, which contains complete instrument information, including descriptions of the TSP commands.
- *The Low Level Measurements Handbook: Precision DC Current, Voltage, and Resistance Measurements*
- *Semiconductor Device Test Applications Guide*
- Application notes
- Updated drivers
- Information about related products, including:
  - Series 2600B System SourceMeter® Instruments
  - The Model 4200A-SCS Semiconductor Characterization System
  - The 2651A High Power System SourceMeter Instrument
  - The 2657A High Power System SourceMeter Instrument
  - The 2400 Series SMU SourceMeter Instruments

In addition, your local Field Applications Engineer can help you with product selection, configuration, and usage. Check the website for contact information.

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